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On the ontology of colours: Are colours heterogeneous or homogeneous? Are they two-dimensional or three-dimensional?

Abstract

My answer to the first question that is posed in the title of this thesis is that colours are homogeneous, which means each and every colour is only one in number. This means that colours are not heterogeneous, that is, they are not compounds or mixtures. For example: orange is often said to be red and yellow, and grey is often said to be white and black. In other words: orange and grey are both claimed to be heterogeneous. However, my conclusion that colours are homogeneous simply excludes that heterogeneity can be the case.

My answer to the second question is that colours are two-dimensional, which means that colours stretch out in length and breadth, but not in depth. This conclusion gainsays naïve realistic conceptions about colours, for example that they can be objects like a piece of blue cobalt, or that there can be voluminous coloured light beams passing in three-dimensional space from a light source and, when they hit objects, mix with their colours. For example, one use to say that yellow and purple beams colour a landscape at sunset. The conclusion on two-dimensionality also gainsays the more sophisticated theory of identification of colours with brain events. That is, colours cannot be identified with brain events because the latter are three-dimensional while the former are two-dimensional.

These two conclusions are drawn from three general propositions, which I call Basic Suppositions.

The first says there is concomitance between colours and their extensions. This means that any colour has a certain extension and that this extension cannot be separated

from the colour itself. It follows that colours are homogeneous because if heterogeneous, like the contention on orange, the implication will be orange is twice its own extension, and this contradicts the first basic supposition.

The second says that colours can only relate beside each other. This basic supposition gainsays naïve realistic conceptions which include that colours might exist behind each other and have different directions in three-dimensional space.

The third says that only colours can limit colours, which means there can be no empty space or "clear air" between any two colours, i.e., it cannot be a blank or a gap between them, which is not a colour.

In addition, my inquiry results in two other basic suppositions, namely that colours might be identical notwithstanding difference in figure, size or position, and that two or more different colours cannot be identical with one and the same colour.

All these propositions will be clarified and defended in the discussion to follow.

Method

I proceed by naming colours. For example; this black is infield to which this white is outfield: X In this example, I denote the figure in question, the capital letter X, simply by naming it black. And also, I name its surroundings by the colour name white. That is, I am not trying to define particulars. And the common name colours refers to all particulars including white, black and grey.

From there I detect their relational properties by using the substantival mode. The important thing to note is that when the substantival mode is used colour names function as subjects in sentences. This mode needs not only be used to characterizing colours by their positional relations, like the infield-outfield relation. Other characterizations are also possible. For example, a certain red in a white outfield may be a square. This means it has a certain relation to white, namely a square relation. But I can also characterize the same red by a sort of causal relation and for example contend it is a positive after image.

The opposite is the adjectival mode which characterizes things or what is taken to be observable physical objects, by their colour properties, which is a naïve realistic approach. For example; this tomato is red, but that tomato is green. By this mode colour names function as predicates or adjectives in sentences.

In some naïve realistic sciences, for example those of Goethe and Chevreul, whom I discuss in this thesis, the two modes are used together. For example, a contention is that red pigment mixes with yellow pigment into orange. Here red and yellow are used as adjectives respectively characterizing two different chemical materials, and orange characterizes the mix of those. However, a general contention might be that orange is a compound of red and yellow, and this latter contention conforms more clearly to the substantival mode.

As I explain in General Introduction, section 1.5 below, the tradition from Hering to Hardin, does not, in the first place, bring causes into their determinations of particular

colours, and so, it is the substantival mode which is in use. However, determinations like orange is both red and yellow is some sort of defining colours by other colours, and gives reasons to believe in heterogeneity of colours. On the other hand, adherents of the tradition sometimes claim that such determination is purely psychological, i.e., without ontological implications. I discuss both options in the first section of General Introduction.

In psychophysics, colours are characterized by their causes, and so also that discipline can be said to use the substantival mode. But these causes are theoretical entities, that is, they are in principle not observable. The talk is about differences of wavelengths of radiant energy, different purities of any one dominant wavelength, and differences of luminance which concerns intensity of radiant energy.

These and purely neurophysiological causes are in themselves not colours and therefore not of concern to my exploration, though I give the principal explanatory structure considerable attention, especially in section 1 of General Introduction.

My general contentions, i.e., the basic suppositions, are arrived at by observations and determinations of particular colour relations. And therefore, induction is fundamental to my method.

From the basic suppositions I finally draw my conclusions.

The structure of this thesis

The text is divided in two, namely General Introduction and Chapters. General Introduction comprise the solutions to the problems discussed and the arguments for those solutions and is therefore not a short foreword, but a comprehensive text in where all the basic suppositions, except for number V, are formulated and defended. My reason for the divide is that the chapters relate to my findings and by that expand in orientation, addressing particular problems in colour philosophy.

In section 1 of General Introduction, I address the contention that colours are heterogeneous, and argue that the terminologies both in naïve realistic sciences on colour, and in modern psychophysics, suggest that colours are judged heterogenous, and that this for apparent reasons can be a conviction about the ontology of colours.

In section 2, I explain and defend my method and move into several themes related to the question if colours are homogeneous or heterogeneous, until I, in the last section, present and justify my argument in favour of colours' homogeneity. In this run I also justify my general contention that colours can be identical notwithstanding difference in figure, size or position.

In section 3.1, I first present my argument that colours are two-dimensional, and in sections 3.1.1 and 3.1.2, I give substantial justifications for the basic suppositions I use, respectively that colours can only relate beside each other and that only colours can limit colours. In this argumentation I address naïve realistic conceptions while paying them very much respect. In the last section 3.2, I consider most of psychologist Katz's outlines of naïve realistic colour conceptions and conclude that those stand strong both in daily life and in science on colour, and that the belief in

colours' two-dimensionality must be reserved for special colour conceptions, for example in psychophysics and eye-brain surgery.

In the second part, which is divided into chapters, I try to show the relevance of my findings relating them to different themes.

In chapter I, section 1, I present in brief all the basic suppositions. In section 2, I proceed to basic definitions, and in section 3, I present the main implications that can be drawn from the basic suppositions and definitions. I must confess that some definitions are not presented and defended in General introduction and that the implications are more than the two that answer the questions posed in the title of this thesis. However, I think the explanations I give in chapter I, are likely to be easily understood and accepted as sufficient justifications.

In chapter II, I consider causal explanations in naïve realistic and realistic sciences. In relation to the former I gather conceptions from both Aristotle, Goethe and Chevreul. These are contrasted with the latter, represented by renaissance philosophy on colours, with focus on epiphenomenalism. I end the chapter by giving a brief outline of Eliminativism, a position defended both by Hardin and Arstila.

In chapter III, I first discuss Hardin's definition of unique colours, thereafter I repeat my critique on the lacking conceptual criteria for dividing colours into chromatic and achromatic. Then I present and discuss some theories of opponent colours within pigment colour systems. Further, I address some difficulties within colour systematics which arise from the detection of so-called forbidden colours. In the next sections I address the Swedish Natural Colour System and explain my reasons for not accepting that the use of the term natural is sufficiently counted for.

In chapter IV, I discuss the problem of sorites series, which concerns degrees of likeness between colours. I refute the idea that two colours can be different while at the same time matching or being identical with a third colour.

In chapter V, I address especially the difference between colours and touch in relation to spatial characteristics. I argue that touch is not a spatial sense, something which seems to oppose Berkeley's own consideration in his New Theory of Vision. Particulars under other determinables too, are, likewise touch, only existing in time, either simultaneously or in a time series. I argue that the only determinable under which particulars are two-dimensional, is colours.

In chapter VI, I discuss after images in relation to my contention on identity. After images are taken to be only two-dimensional: and, if an after image can be said to be identical with the colour of which it is an after image, I contend the preceding colour must itself be two-dimensional. I also go further into Chevreul's mixed contrast and argue that, from his own premises, it follows there is no neutral ground onto which a negative after image shows itself in its purity.

Finally, in chapter VII, I explain and defend my definition of colour totality. I compare it with some different definitions of visual field and argue that the definition of colour totality is the only one that exclusively refers to colours. The notions on visual field which I consider contain in a greater or lesser degree, causal connections. I first defend the implication that a distance between any two or more colours, must

itself be a colour. Furthermore, I discuss the implication that a colour totality is infinite, that is, it has no limitation from without. Both these implications follow from basic supposition III, which says only colours can limit colours.

I give cross-references to sections and chapters throughout the whole text and make clear in which part to find them. In General Introduction I refer to Chapter etc. and in the Chapters I refer to General Introduction by the abbreviation GI.

After the chapters follows Post Script, Bibliography and Index.

Content

General Introduction

Section 2
Methodological and ontological considerations

Section 3
On colours' two -dimensionality vs. naïve realistic conceptions

Chapters

Section 1
Colour terminology in naïve realistic science and in psychophysics

1.1

First, in sections 1.2, I explain the first part of the problem. Then in section 3, I present some notions on heterogeneity propagated by Goethe and Chevreul. In section 1.4 I explore into psychophysics by the aid of the book from the American Committee on Colorimetry. I continue this theme in section 1.5 by the aid of the two first chapters in Hering's book Outlines of a Theory of the Light Sense.

1.2 The first part of the problem

is to decide whether colours are homogenous or heterogeneous, or whether some colours are homogeneous and some are heterogeneous.

As both Euclid and Berkeley point out, it depends on our choice whether and when to treat any conglomeration of entities as a unit. This allows for a unit to be a manifold, i.e. to be two, three, etc. in number. Accordingly, colour heterogeneity means that one colour is a unity of two or more colours. For example: orange is often said to be red and yellow, and grey is often said to be white and black.

My conclusion to the first part of the problem is that all colours are homogeneous, which means, each and every one is only one in number. If this proposition is accepted, it should lead to a revision of the prevailing colour terminology.

1.2.1 Some thoughts about grammar

In grammar, nouns, adjectives and pronouns are all called nominals. Colour names can therefore be used purely as adjectives or purely as nouns. Examples: *The curtain is purple* and *Purple calms me down*.

In most colour systems the latter function is prevalent in colour determinations: *Purple is a bluish red* and *Pink is a light bluish red*.

In the two latter examples the subject of the sentence is the name of a colour.

In the sentence *colours are homogeneous or heterogeneous*, the name *colours* functions as noun and is the subject, while *homogeneous* and *heterogeneous* function as adjectives. This is essential to an understanding of the problem, i.e. it is not colours that characterize something else, which is not a colour, but, on the contrary, it is colours that are characterized.

The use of colour names as subjects in sentences conforms to Johnson's substantival mode, i.e., characterization of adjectives. I explain further the substantival mode in

accordance with Johnson in section 2.1, below. In section 2.3, I explain the procedure of naming in more detail, by giving examples.

This is why the name *colours* do not need to be defined, even though the adjectives *homogeneous* and *heterogeneous* are defined. *Colours* is a common name meaning that it has different references. Groups of such references might also in turn be named *yellows*, *reds*, *purples*, *blacks*, *greys*, etc. And as for the common name *colours*, so for these other names: They need not be defined, and therefore, just as the name *colours*, they function as common names.[1]

This method of naming does not imply any conviction or presupposition of ontological character, for example that colours are properties of physical objects or are qualities pertaining to the mind only.

It is estimated that nine to ten million different colours can be perceived. (Gerritsen, 1975, p. 68; Hardin, 1988, p. 88) Using a computer, they can all, in principle, be named by giving them numbers. (Goto, 1998, 143) This being so, it should be possible to type one of the names on the keyboard and have the named colour appear on the monitor, before proceeding to the next one etc.: the names being 1, 2, 3, 4 etc.

The first part of the problem can therefore be reformulated in this way: Are the references to 1, 2, 3, and 4, etc., homogeneous or heterogeneous?

This is not to say the name *colours* in principle cannot be conceptualized. One example is that *colours* means *the proper objects of vision*, which we have from both Aristotle and Berkeley. See in this connection section 2.1 below, about Carnap's type theory.

1.2.2 Logical possibilities

The predicates *homogeneous* and *heterogeneous* exclude each other, which means they cannot predicate one and the same colour without contradiction.

This means that it is possible, at least at the outset, that all colours are homogeneous, but also that all colours are heterogeneous.

If both possibilities are refuted there is still a possibility left, namely that some colours are homogeneous and some are heterogeneous.

1.3 Goethe and Chevreul's contention that some colours are heterogeneous and some are homogeneous

My intention in this section is to explain the idea of colour heterogeneity by examples

[1] I write these names in plural just to underscore that they are common names for a lot of particular colours. I have noticed, for example, that Johnson uses the singular form *colour*, but to me this form alludes too much to connotative terms. I make it clear, though, in section 2.6.1, that Johnson and I agree, that is, neither the term colour nor the term colours has connotation.

taken from two classical contributors to colour theory.

In the colour theories of both Goethe and Chevreul some colours are determined to be homogeneous and other are determined as heterogeneous. The latter are said to be combinations or mixtures of the first. I call these contributions to colour theory naïve realistic because they treat of (some) colours as existing in space, independent of the observer, but which it is possible to observe. In section 3 below, I take a closer view on naïve realistic conceptions.

1.3.1 Goethe

For Goethe (1749–1832), whose theory of colour has been very influential for many artists and in art education, heterogeneous colours are not restricted to pigment colours, which are, in his terminology, chemical colours, but include optical colours too, which he calls physical colours, and likewise so-called subjective colours, which he calls physiological colours. That is, heterogeneity concerns all the three main kinds of colours within his colour theory from 1810.

For example, Goethe maintains in a general way that "If yellow and blue, which we consider as the most fundamental and simple colours, are united as they first appear, in the first state of their action, the colour which we call green is the result." (Goethe, 2002, § 801) In the following paragraph he also maintains that the two elementary colours yellow and blue "can be mixed in perfect equality so that neither predominates."

In paragraph 552 Goethe points out that pigment colours, that is, pigment hues, all are mixes of three primary or elementary hues. "Yellow, blue and red, may be assumed as pure elementary colours, already existing; from these, violet, orange and green, are the simplest combined results."

The physical colours, that is, light colours, follow the same natural rule as applies to green. Goethe takes as his starting point the refraction phenomenon, which is known in literature as Newton's explanandum in optics, namely the demonstration of how a beam of sunlight that shines into a dark room (camera obscura), is refracted through a triangular prism and thereby split into red, yellow, white, blue and violet on the (white-painted) wall. When the angle of refraction increases, Goethe sees the merging of yellow and blue and green appears. When the angle increases to the maximum, yellow and blue both disappear and only green is left together with red and blue on each side. "The yellow and blue (…) can by degrees meet so fully, that the two colours blend entirely in green." (Goethe, 2002, § 216)[2]

[2] Nowadays, in popular science, pigment mixing is explained as subtractive colour mixing, which in fact does not depart very much from Goethe's conception. However, Goethe's explanation of refraction is contrary to the way the gradual development of the spectrum is explained in popular science. Here, white is conceived as a mixture of yellow and blue, while yellow is explained as a mixture of red and green, and blue (cyan) as a mixture of green and violet (reddish blue). The colour words used may cause some confusion; the blue to which Goethe refers is usually called cyan, and the violet blue. Anyway, what is happening, according to the popular scientific explanation, is that the development of the spectrum finally results in red, green and blue, which are the primary colours in additive colour

Also, physiological colours too mix with other colours, be they chemical or physical. One example is shadow colours. These are physiological according to Goethe, which means they are subjective reactions to the lighting conditions in the surroundings of the shadow area. They follow the same mixture rules as negative after images. Goethe explains, "Physiological colours admit, in like manner, of being mixed with others. If, for example, we produce the blue shadow (…) on a light yellow paper, the surface will appear green. The same happens with regard to the other colours if the necessary preparations are attended to." (Goethe, 2002, § 562)

1.3.2 Chevreul

In his 1839 treatise, Chevreul (1786–1889) described a system of colours (i.e. hues) based on pigment mixing. Birren (1981) has translated his treatise completely and furnished it with substantial historical comments and conceptual analyses. Therefore, whenever I refer to Birren's book, I make it clear whether the primary source is Chevreul or Birren.

If you mixed two of what Chevreul called the three primary or basic hues, red, blue and yellow, you would create, he reported, three secondary hues. (Birren, 1981, p. 80) According to Chevreul, violet is a blend of red and blue pigments, green is a blend of yellow and blue pigments, and finally orange is a blend of yellow and red pigments.

While Chevreul's system is based on pigment colour mixing, his division of colour contrasts shows that he did not restrict mixing to pigments. In this matter, he is in accordance with Goethe. In Chapter 1 of his treatise, § 81, he writes that also subjective colours mix or blend with object colours and, accordingly, the result is a heterogeneous colour.

> The distinction of *simultaneous* and *successive* contrast renders it easy to comprehend a phenomenon which we may call the mixed contrast; because it results from the fact of the eye, having seen for a time a certain colour, acquiring an aptitude to see for another period the complementary of that colour, and also a new colour, presented to it by an exterior object; the sensation then perceived is that which results from this new colour and the complementary of the first. (Birren, 1981, p. 64)

1.3.3 The concept of colour mixing

Both Goethe and Chevreul take departure in observable mixing processes. This can be illustrated by, for example, pigment mixing. Very small bits of respectively yellow and blue pigments are blended and the resulting blend, which contains both pigments, is green. Afterwards one can in principle separate the yellow pigments from the blue ones, and green disappears.

Mixing and separating pigments can therefore be considered causes respectively of how green comes into being and of how the existence of green ends.

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mixing, i.e. the RGB colours. In the fully developed spectrum red is totally split from green, and on the opposite side blue (violet) is also totally split from green.

However, the continuation of green is explicable in terms of standing causes, namely as long as yellow and blue pigments keep their relative positions in the blend green continues to exist.

Determination of green as the compound of yellows and blues follows by induction from such an empirically well-founded explanatory component theory. Green is determined as heterogeneous, and yellow and blue are determined homogeneous. However, this is done within a naïve realistic conception. I can accept that observing a mixing process earns as empirical evidence in naïve realistic conception. And, as announced, I use the substantival mode in determining colours and by doing that I arrive at other conclusions.

Another example that can illustrate such a naïve realistic determination of heterogeneous colours is so-called additive colour mixing. Rather than involving pigments, it involves light. Take, for example, two circular light spots of the same size, one red and one green, and bring them together. When they unite yellow appears. When they separate yellow disappears. The same way of reasoning as in the foregoing example should therefore lead to the conclusion that yellow is heterogeneous and green and red are both homogeneous.

I want to enlighten the inductive character of the colour mixing theory. As I have shown, the empirical concept of colour mixing might be threefold: first comes the unification process; then the continuation process; and lastly the separation process. Both the unification process and the separation process help confirm the determination of a colour as heterogeneous. In the continuation process the colour constituents seem to be understood as *standing causes*.

However, some theoreticians still consider such determination to be upheld even if the unification and separation processes are not involved. This is to take green as a sign for heterogeneity without testing the general contention further.

Both Goethe and Chevreul seem to induce upon every instantiation of green that green is heterogeneous in spite of the fact that green might occur without unification of yellow and blue, and without any empirical means of separating the instantiated green into these two components. One example is when green occurs as successive contrast (after image). The only condition for instantiation is that you look at a red spot in white surround for about 30 seconds. Green appears without any observable unification of yellow and blue, and it disappears without separating into yellow and blue.

Again, not only Goethe and Chevreul but also psychophysicists describe colours as heterogeneous. It seems the idea of *standing causes* prevails, that is, even if no claims as to empirical evidence are made in the form of either unification or separation or both, the idea that one colour can consist of two or more other colours appears to prevail. The following sections, in which I discuss colour terminology in respectively modern psychophysics and Hering's outlines of a colour theory, will further demonstrate the prevalence of this terminology, in spite of the fact that theoreticians may disagree in their determinations, for example of green.

1.4 Colour determinations in psychophysics

The book *The Science of Colour* is a contribution to the development of psychophysics on colours, initiated by The Optical Society in America in 1933 and finished twenty years later. The Committee that carried out the work had the objective in view that the book

> should contain not only all of the technical discussion and data required by the specialist in this field, but also a discussion sufficiently elementary and interesting to attract and hold the attention of casual readers, and a gradual transition from that introduction to the more advanced exposition. (Committee on Colorimetry, 1953, p. 5)

In this section I want to discuss whether the Committee's colour terminology implies colour heterogeneity or not. Although I am not dealing with colours from a technical point of view, the Committee's more philosophically related considerations and convictions suit my purpose.

The Committee carried out its work in close connection with Commission Internationale d'Eclairange (C.I.E.), which in our culture is the principal source to causal colour determinations and therefore one may assume the Committee's terminology to be representative of how psychophysicists are apt to think about colours also nowadays. For example, as I show in the following pages, Hardin (1988) promote ideas about colours that are fundamental also to the Committee.

1.4.1 Sense data and perception

The Committee categorizes colours as simple sense data.

> The simple sense data are undoubtedly the most fundamental realities of conscious life. Innumerable introspections represent the attempt to describe them, and the whole theory of the physical world the attempt to explain them. Although the intimate nature of sensation remains a mystery, a working conception is perfectly possible. (Committee on Colorimetry, 1953, p. 101.

When the Committee categorizes colours as simple sense data one might think the meaning is that colours are homogeneous, because of the term *simple*. However, as will become clear, the Committee's colour terminology indicates rather the opposite opinion, namely that colours are heterogeneous.

In the quotation above the Committee emphasizes that sense data are considered to be the explanandum and physical entities and events the explanans. But insofar as colours are concerned, the Committee calls the specific sense data colour sensations, which then must be the explananda.

> Colour sensation may be defined as the primary conscious response to excitation of the visual mechanism. Colour sensations can be regarded as the prototype and limiting case of colour perceptions, all of which involve greater or lesser interpretation by the sensing observer. Both the sensations and perceptions normally are initiated by the incidence of light upon the retina, and both are resulting conscious responses. (Committee on Colorimetry, 1953, p. 101)

Hering seems to adhere to such divide.

> Apparently there is a need in psychology to assume for the colours of which visual things are composed a kind of primitive state in which they have not yet passed through the remodelling hand of experience, and to give to this raw stuff a different name from that given to those colours that are further worked over mentally; therefore the former is designated as pure sensation and the latter as concept or perception. (Hering, 1964, p. 6)

Even though Hering relates the distinction between colours as raw stuff/pure sensations and perceptions of colours to a need in psychological science, thereby indicating some sort of normative appeal, it could be that the distinction is true. I stress this point because seemingly the Committee tends to confuse colour and perception, and before I take my discussion further, I must work out a clear and hopefully acceptable interpretation of the following.

> The similarity in the conceptions of colour sensation and relatively simple colour perception is evident, further, from a consideration of the five attributes or dimensions commonly assigned to both of them. Both have the general attributes of duration and extent, which means that the responses exist in time and space, that is, that the colour might be seen for some time as of some size. Both achromatic and chromatic colour responses possess in common the additional attribute of brightness. All chromatic responses possess two further attributes, hue and saturation, which are collectively called chromaticness. (Committee on Colorimetry, 1953, p. 101)

My objections are two.

First, two of the five attributes or dimensions the Committee refers to are duration and extent. But, in my opinion, it is only duration that can be said to be common for colour and perception. This is because a perception involves either pure awareness or both awareness and conception, both are states of mind and it is meaningless to assign extent or size to a state of mind. See in this connection my discussion in section 1.5.3.

Second, the same kind of objection applies to hue, brightness and saturation, on the (disputable) condition that each of these terms connotes concepts. If they do, these concepts themselves cannot have the same properties as colours, simply because they are concepts or thoughts, i.e. a concept is neither hued, nor saturated, nor bright.

What I therefore take the Committee to mean is that brightness is an ontological property of all colours, that is, all colour sensations, both chromatic and achromatic, while hue and saturation are ontological properties of chromatic colour sensations.

Not leaving duration and extent out of the ontological property list, this is to say that in simple colour perceptions, according to the Committee, one may conceive of colours in terms of duration, extent, hue, brightness and saturation. However, duration and extent are not often mentioned by the Committee, its focus being on hue, saturation and brightness.

There is reason to stress the distinction between colours and perceptions of them because, in relevant literature, it seems to be common not to talk of colour properties but of properties of perceived colour. Hardin offers an example. “We may distinguish three dimensions of perceived colour: hue, brightness and saturation.” (Hardin, 1988,

p. 25)[3] But my point is exactly that it cannot be perceived (chromatic) colours having these dimensions but that a hue itself must have them, if anything has. Perception is a kind of conception or acquaintance and those cannot have hue, saturation and brightness as properties. See in this connection section 2.11.2 on acquaintance.

In a net-source explication of C.I.E. (URL) concepts on colours looked up July 15, 2014, the first sentence enlightens my point. "The properties of colour which are inherently distinguishable by the human eye are hue, saturation and brightness." Here the meaning must be that a chromatic colour, i.e. a hue, has these properties.

1.4.2 A closer look at colour properties

According to the Committee, achromatic colours are white and greys, all of which can be ordered in a regular series. White is the brightest colour and black the darkest colour, that is, black is considered the very least bright colour.[4] The achromatic colours are ordered from white through greys, each of which, according to the terminology, contains less brightness than its preceding neighbour.

The Committee first refers to hues as red, yellow, green, and blue. It states that a hue (i.e. a chromatic colour) has the same brightness as one (and I should make this clear, it means one only) of the achromatic colours in the grey series. "Saturation is the degree to which a chromatic colour sensation differs from an achromatic colour sensation of the same brightness; (…)."(Committee of Colorimetry, 1953, p. 101)

On the same page the Committee also mentions some intermediates: reddish yellow and bluish green. Intermediates are, together with the four primaries red, yellow, green and blue, maximally saturated colours, which means they are placed furthest from their brightness-matching colour in the grey scale. However, every other hue is increasingly unsaturated and is therefore to be placed relatively nearer to the grey scale.

Johnson explains the relation between hue, saturation and brightness in accordance with my interpretation of the Committee. (Obviously he means by the term *colour* precisely what the Committee means by the term *chromatic colour*.)

> A colour may vary according to its hue, brightness and saturation; so that the precise determination of a colour requires us to define three variables which are more or less independent of one another in their capacity of co-variation; but in one important sense they are not independent of one another, since they could not be manifested in separation. The determinable colour is therefore *single*, though complex, in the sense that the several

[3] In this quotation Hardin seems to be using the term colour as if all colours are hues. This cannot, however, be Hardin's meaning, because elsewhere he clearly states there are two colour classes, namely achromatic and chromatic colours, of which hues belong to the latter class.

[4] The Committee relates colours to light excitation on the retina. The lower the luminance the darker the colour. However, if luminance is zero, there will be no colour at all. That is, if colours are considered effects of light excitation, even the darkest colour must have some degree of brightness. See 1.4.3 below.

> constituent characters upon whose variations its variability depends are inseparable. (Johnson, 1921, p. 183)

In his article from 1984, *Are 'Scientific' Objects Coloured?* Hardin seems to agree that hue, brightness and saturation are essential properties of colours.

> Every colour is specifiable by three dimensions: hue, brightness and saturation. Colours of a given hue may be linearly ordered according to brightness, if saturation is held constant, and according to saturation if brightness is held constant. Holding both brightness and saturation constant, the hues may be ordered in a closed array. (Hardin, 1984, p. 491)

It should be noticed that Hardin too must have substituted *chromatic colour* for *colour* also in this quotation. It is only brightness that is common for all colours, according to the Committee, that is, hue and saturation are do not characterize achromatic colours.

1.4.3 Difficulties in observing or determining hue, saturation and brightness

In the quotation above Hardin states that every (chromatic) colour is specifiable by the three dimensions hue, brightness and saturation, as if no practical problems are connected to such determination. However, these properties are not always perceived, not even under controlled observations. The Committee explains.

> Observations under relatively simple conditions have revealed a tendency to concentrate on one or the other of the attributes to the partial or total exclusion of others. Thus an observer might find himself unable to report about brightness if he had been concentrating on hue or saturation; or unable to report about saturation if he had been concentrating on duration. The range of consciousness being as limited as it is, the effect or set or instruction is often striking and is regularly selective. Sometimes no one of the attributive dimensions stands out clearly. It may be added that the capability ever to discriminate or identify hue, saturation and brightness appears to be not native but rather acquired on the basis of differential experience, nor is that surprising in view of the principles involved in learning to discriminate everything. (Committee of Colorimetry, 1953, p. 102)

It turns out that Hardin shares the view that specification in the three dimensions is not always plain or simple to carry out, but for more specific reasons. In a note, Hardin restricts his general statement on determination of the three dimensions to light spots: "Only spots of coloured light against a neutral surround may be *totally* specifiable in this way. So-called 'surface colours' are more complex." (Hardin, 1984, p. 491, note 2)

In order to shed light on Hardin's exception, I must take a short step into the area of Katz's colour psychology. It seems, namely, that Hardin uses common sense or naïve realistic conceptions explored by Katz, in explaining basic colour properties in psychophysics. I return to Katz's in section 3.2.

The term *surface colour* is known from Katz (1935). But because it is usually written in the singular, one might get the impression that only one colour is meant, but precisely therefore it is important to stress that Katz's term is much richer in content.

Katz's term *surface colour* can indeed comprise a conglomeration of different colours perceived as belonging to the same surface. For example, Katz says that a piece of

paper has surface colour, however its surface may be orientated in space in different directions at the same time. You can, for example, fold it or you can roll it into a cylinder. Normally a paper in such situations shows up with different lightings on the visible parts of its surface, meaning that different colours may be perceived to belong to one and the same surface, provided colour constancy is not interfering. It may also be the case, and I find it probable that Katz would agree, that the paper is many coloured, in which case a lot of colours could be understood as belonging to one and the same surface. "The colour of a paper", Katz maintains in *The World of Colour*,

> can assume any orientation whatsoever with reference to the direction of vision, for its plane is always that of the surface of the coloured paper. If it appears in frontal parallel orientation, this is to be considered simply as a special case. (Katz, 1935, pp. 8-9)

Furthermore, Katz points out, a surface colour can be wrinkled, that is, it reaches a very high level of complexity.

> The surface of an object can be either smooth or wrinkled, and according as it is the one or the other the surface colour, too, will be either smooth or wrinkled. Surface colour follows all the wrinkles of the surface of the object, and presents, too, its finest structure and texture. (Katz, 1935, pp. 11-12)

A surface colour presents in addition the finest structure and texture of the object (with or without wrinkles), according to Katz. This is a dimension that gives rise to the discrimination of different materials, for example, lead is judged to be different from carbon and silk from wool, etc.

In his book *The World of Touch*, Katz extends his description of structure and texture. Texture might be coarse, that is, thickly grained and stranded, or it might consist of tiny differences in very small areas.

> These elements are so small that a greater number of them probably could be discovered within only a square millimetre. There is an astonishing variety among these elements. We might even say that regularity within irregularity of elements is the law of texture. There are materials in which the smallest formal elements are combined into structures of higher order, and these, in turn, into structures of an even higher order, which then give the material its characteristic texture. (Katz, 1989, pp. 56-57)

However, a surface colour does not need to exhibit different orientations, wrinkles or textures; there are exceptions, and Katz mentions one: "If we stretch a sheet of exceedingly smooth paper, which is not shiny, across a pane of glass, and view it from a sufficiently great distance, we shall have a surface colour from which all texture is completely absent." (1935, p. 12)

Katz's concept 'surface colour' is exclusively a perceptual category and concerns perception of a part of the surface of an object, the part determined by the perspective of the observer. In other words, an observer cannot see all sides of an object at once.

Hardin does not specifically explain why hue, saturation and brightness are not an easy match to figure out with respect to surface colours. He only says a surface is complex, but does not add that it may be a complex of different colours.

When the parts of a surface that someone perceives are oriented in different directions, there must at the very least be different areas of light and shadow, and if

wrinkled a lot of those areas will be internally differentiated in addition. If texture is also pronounced, the amount of internal variation must exceed the observer's ability to discern them. That is, surface colour is only exceptionally one colour; it is normally a lot.

It seems to me meaningless to operate with average values of different colours that constitute a surface. At least, according to the Committee, different colours have different values, be they in hue, saturation or brightness. If you have a photograph made up of different hues and blacks, whites and greys printed on a paper, all these colours will be perceived as belonging to the same surface, and you can bend and fold the paper, and the variations that occur will still belong to the same surface.

The solution seems to be that if surface colour is to be judged according to hue, saturation and brightness, the surface must presumably have no internal variation, just as Katz exemplifies with smooth paper stretched out on a pane of glass.

Both Hilbert and Arstila seem to share a somewhat similar comprehension of these matters as myself. Hilbert (1987, p. 47) uses the term surface colour, but not understood as a complex. "A colour typically occupies a more or less clearly defined place on the surface of an object." It is very likely that Hilbert takes surface colour to have no inner variation, and that if different colours all are parts of a surface, then they must be clearly discernible colours in order to identify them with their proper reflection values from the parts of the surface. Arstila (2005, p. 152) underscores this point: "Colours are related to processes that make us perceive surfaces as homogeneous areas."

1.4.4 Colour sensation

The Committee is fully aware of Katz's great contributions to colour psychology.

> Katz was the first to describe in a systematic way modes of appearance, or *Erscheinungsweisen*, in 1911. He included perceptions of film, surface, volume, luminosity, glow, lustre, sparkle, glitter, transparent film colours, transparent surface colours, mirrored colours and the illumination of empty space. Katz pointed out that the opaque surface colour perceptions completely dominate the other modes in our world of visual perceptions. (Committee on Colorimetry, 1953, p. 145)

The Committee's aim was, however, to develop a functional psychophysical concept of colours and tended therefore to rely on the term *colour sensation*. One must be aware, though, that the members of the Committee did not easily agree upon that term. Some of the members suggested some of Katz's psychological terms instead. (Committee on Colorimetry, 1953, pp. 7-8)

Nearly all Katz's colour modes include perceptions of objects of which colours are understood as properties and therefore do not satisfy the psychophysical aim for functionality, according to the chairman of the Committee. Katz's modes are far too interpretative.

> The more interpretative or meaningful a perception is, the more it differs from pure sensation; the more sensory or uninterpretative the experience, the closer it approximates pure sensation.

> The receptive apparatus seems to be built for sensation, and the concept of sensation is indispensable in describing the sensory function. (Committee on Colorimetry, 1953, p. 7)

However, on pages 56-57 Katz (1935) can be interpreted to mean that the modes of appearance are only perceptual variations of the same colours. This has to do with film colours, which are also called aperture colours. For example, when uniform surface colours are viewed through an aperture in a screen, the aperture blocks all the colours' interpretative connections to its actual surroundings. This blocking is called reduction of colours. Katz contends that if the aperture is completely and uniformly filled with the same light as the area that is isolated, the reduction involves no change of retinal accommodation.

> One of the essential facts about the reduction of colour is that it usually involves a change in the way it fills out space. After reduction the colour (the film colour) always appears at an indefinite distance behind the aperture screen. It is only in unusual cases that the accommodation of the observer's eye remains the same after reduction as before. In view of this change in accommodation, it might be suggested that reduction must then involve a physical change in the receptorial process, which would affect the intensity of retinal excitation. This, however, is not the case as long as the aperture in the screen remains completely and uniformly filled with the same light. (Katz, 1935, pp. 56-57)[5]

In his introduction, p. 8, the chairman of the Committee refers in this connection to Katz's contention on page 57, namely that "The fact of most immediate importance is that different modes of appearance of the same colour are all based on the same retinal processes."[6] Katz adds: "Another way of stating it would be as follows: There is no colour impression which *after* reduction is not exactly equal to a corresponding member of the film-colour system." However, the chairman takes the former statement to indicate that Katz too may be said to operate with a concept of colours close to the meaning of the term *colour sensation*.

> It seems that even the modern psychologist who would restrict the significance of sensation to an almost meaningless abstraction must, at times, fall back upon the concept in the discussion of certain of the perceptual aspects of colour, and, moreover, that while he advocates the addition of modes of appearance to the attributes of colour, he admits that the *same colour* may have different modes of appearance. This is interpreted by the chairman as an admission that the mode of appearance does not change colour *per se*, and that the concept of sensation is useful. (Committee on Colorimetry, 1953, p. 8)

1.4.5 Colour sensation in relation to physical light

The Committee links colour sensation to radiant flux via the physical eye-brain causal chain in order to secure a functional concept of colours. It therefore seems to be a term that not only includes purely perceptual determinations of various colours but also physical explanatory concepts of them.

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[5] It might be discussed whether Katz's term *film colour*, echoes in all aspects the Committee's term *colour sensation*, insofar as, for example, light sources are taken by Katz to be "filmy". This may mean that film colour is a property of a light source.

[6] It should be remarked in this connection that physical processes are brought into the discussion. Retinal processes are not colour sensations; the latter the Committee characterizes as purely subjective, which means it is purely psychic.

The Committee links physical light or radiant energy to colour perception via the three dimensions hue, saturation and brightness: Hue depends on (dominant) wavelength, saturation on purity of wavelength, and brightness on luminosity. The connection is causal and goes from the physical to the psychological: if wavelength, purity, and/or luminance are changed, then, respectively, hue, saturation, and/or brightness are changed.

In the index to *The Science of Colour*, hue, saturation and brightness are defined by reference to different kinds of radiation. Each kind is supposed to yield differences in quality:

> *Hue*: quality of sensation according to which an observer is aware of differences of wavelengths of radiant energy.
>
> *Saturation*: quality of sensation by which an observer is aware of different purities of any one dominant wavelength.
>
> *Brightness*: attribute of sensation by which an observer is aware of differences of luminance.

These definitions are relational because, according to the Committee, they state the "distinctions between these concepts – light and colour – and the concepts related to them in the fields of psychology and physics." (Committee of Colorimetry, 1953, p. 220)

On the same page, relational definitions are contrasted with operational definitions: "In the final analysis, all quantities, such as length, time, or temperature, can be defined only by prescribing the methods and conditions for their measurement." The quantitative properties of light are defined through operational definitions. On the other hand, colours are defined or determined in qualitative terms. But according to the Committee, there is an intimate connection between the two kinds of definition.

> Light and colour are psychophysical concepts according to both the relational and the operational definitions. These definitions are equivalent in significance, although the first type is most useful for guidance as to the correct use of the terms in general discussions and the second is essential for the precise definition of the concepts with which the measurements are concerned. (Committee of Colorimetry, 1953, p. 220)

On page 221 a reservation is stated.

> Colour is not identified with radiant energy, nor is it identified with sensation. The characteristics of light which constitute colour can be specified in terms of (1) the appropriate photometric quantity, (2) dominant wavelength, and (3) purity. In a general way these characteristics of light correspond to the attributes of visual sensations – brightness, hue and saturation.

Remark that the correspondence or connection between physical light and sensation is said by the Committee to occur normally, that is, frequently: "Both the sensations and perceptions normally are initiated by the incidence of light upon the retina, and both are resulting conscious responses." (Committee on Colorimetry, 1953, p. 101.) There are two implications to be drawn from this.

First. Radiant energy (i.e. light excitations on the retina) is not always a sufficient cause. For light to be a sufficient cause of colour, the retina, the visual nerve and the

visual pathways in the cortex must all function appropriately. If not, there will be no adequate colour response to the physical inputs.

Second. There cannot be a necessary link between the physical light stimuli and colour responses either, because, and this is well known, colours may appear without light affecting the retina. Just as Goethe and Chevreul both pointed out in the beginning of the 1800s, other causes than light are sometimes effective. Both in this case were building moreover on discoveries in the late eighteenth century. Furthermore, the Committee explicitly makes this clear on page 102.

> Although radiant energy is the normal visual stimulus, it is far from the only means of initiating visual impressions of colour. Colour responses can be produced by mechanical pressure on the ocular structures, chemical or physical irritation of the sensory fibres, electrical currents, powerful magnetic fields, certain drugs, certain diseases, and direct stimulation of the primary visual areas of the brain. Such results show that conscious colour response is a less restricted conception than colour, for the latter has been defined with respect to light excitation alone.

It is important in this connection to note that the Committee, in the last quotation, does not introduce a divide between colours caused by light and colours not caused by light with respect to the properties hue, brightness and saturation.

This probably means that the Committee considers a chromatic colour to have these properties whatever the causal chain. For example, if a person has an impression of the evening sun caused by such and such rays, the positive after image of the sun, which is a colour caused by physiological processes only, will be just as bright, saturated and hued as the colour caused by radiant energy. See in this connection Chapter VII for a detailed explanation of positive after image.

1.4.6 Colour heterogeneity and brightness

It is time to ask whether the Committee's terminology implies colour heterogeneity. Remember, colour heterogeneity means that one colour is a unity of two or more colours.

Colour sensations are described by the Committee as bearers of colour, that is, substantives that have certain properties, i.e., they are either chromatic or achromatic.

The first thing to note, however, is that the term *colour sensation* is really unclear. Remember, the Committee itself admits to the vagueness of the term. "Although the intimate nature of sensation remains a mystery, a working conception is perfectly possible. (Committee on Colorimetry, 1953, p. 101)

However, it is not obvious that the claimed property brightness allows either chromatic or achromatic colours to be qualified as heterogeneous. The Committee contends, namely, that all colours or colour sensations have this property. That being the case, it seems to follow that brightness cannot itself be a colour. That is, on the one hand, you have all colours, chromatic and achromatic, and on the other, there is something that belongs to each and every colour, an attribute they all share, namely brightness.

For example, a white is both white and bright, and a red is both red and bright; that is, red is just as bright as one grey among the achromatic colours. And, accordingly, one specific grey is both grey and bright. But since it seems apparent that white, red and grey would be just as different without the brightness component, it is really difficult to understand what the brightness term's contributive factor actually consists of.

The Committee links brightness to luminosity, which is a causal term, and it might be said that luminosity is the contributive factor. But the objection must then be made that a colour cannot visually carry a property that is its own physical cause. In psychophysics the causes of colours are not to be found among the colours themselves. The physical is not part of the psychical. See in this connection section 1.4.5.

A narrow reading reveals that in its use of the term *brightness* the Committee on some occasions seems not to agree with itself. On page 52, the Committee discerns between brightness and lightness.

> (…). The extent of the brightness scale obtainable with uniformly illuminated reflecting samples, such as we are using in this experiment, is limited by the physical characteristics of reflecting surfaces. These characteristics of diffusely reflecting surfaces are perceived as differentiating white from grey, and light from dark coloured objects, and the perception is called *lightness*. Since, however, we are using printed samples merely for convenience in manipulating and illustrating colours of light, we shall continue to refer to brightness of the colours rather than to the lightness of the printed samples.

The same divide is repeated on page 67 where the physical, psychophysical and psychological concepts are listed in a scheme, and under the psychological colonna brightness and lightness are united in a disjunction. This suggests that the Committee does not distinguish very clearly between brightness and lightness. The same is apparent on page 135 where achromatopsia is explained: "Thus it is that a pure case should experience brightness or lightness only."

Finally, in a scheme on page 151 the Committee traces the difference between brightness and lightness back to Katz's modes of appearance of colour. Brightness in that scheme is explained as an exclusive property of illuminants, illumination and film colour, whereas lightness is explained as an exclusive property of surface and volume colour.

In *Colour for Philosophers* (1988), Hardin too distinguishes brightness from lightness. Brightness is apparent when, as he says, colours are seen through apertures or when they are perceived as self-luminous. If neither of these categories pertain, it will be lightness that is the variable factor, according to Hardin.

> Finally, colours seen through apertures or perceived as self-luminous will vary along a range, with very dim colours at one end of the range and very bright or dazzling colours at the other. The colours ranged in this way vary in *brightness*. Objects that are not seen through apertures or perceived to be self-luminous vary in *lightness*. (Hardin, 1988, pp. 26)

If there is a difference between brightness and lightness, about which both Hardin and the Committee seem to agree, it cannot be the case that all colours have brightness as a property. Hardin and the Committee share the same terminology in these respects and both therefore create confusion and bewilderment because of such apparent inconsistencies.

Giere explains the contemporary science of colour vision, but without noticing the difficult distinction between brightness and lightness. It is as if he identifies the two. “Colours differ in (…) brightness, that is relative lightness or darkness.” (Giere, 2006, p. 18)

Maybe Giere thinks along the same lines as Hering. In section 1.5 I focus on Hering’s colour theory and have occasion to present his view on brightness, that is, his identification of brightness degrees with proportions of white. On the one hand, such an identification would simplify the Committee’s colour terminology, but on the other, the terminology would then more clearly express colour heterogeneity.

1.4.7 The terms hue, saturation degrees and intermediates, involve colour heterogeneity

There are, however, connections between different colours that the Committee explains without bringing in the brightness component; that is, brightness makes no difference because it is held constant.

One such connection is the series going from one most saturated hue to the least saturated hue, in which every particular is supposed to have the same brightness value as one grey in the achromatic series: “Saturation is the degree to which a chromatic colour sensation differs from an achromatic colour sensation of the same brightness.” (Committee of Colorimetry, 1953, p. 101)

This means that different saturation degrees can only be understood as quantitative determinations, because, according to the Committee, it is the same hue that shows up in different saturations.

For example, the same red has different saturations in the series from red to grey. There are in this case no other factors than red and grey to bring in. For this to work you have to think proportionally, that is, in quantitative terms: the amount of red is reduced while the amount of grey is increased. But it follows nonetheless that all colours in the saturation series are conglomerations of red and grey, and therefore heterogeneous.

Another kind of series in which brightness/lightness is held constant may be arranged as a hue circle. The Committee says that the particular hues in such a circle might have the same saturation. See in this connection the Committees Plate 17. However, the intermediates between the primaries within such hue circle cannot be understood without quantifying terms. For example, in a series from red to yellow, the amount of red decreases while yellow increases, according to the terminology. This means the terminology includes that intermediate hues are heterogeneous.

1.5 Hering’s radical view on colours

In this subsection I discuss chapters 1 and 2, respectively, “The Nature of Colours” and “The Natural Colour System”, in Hering’s book *Outlines of a Theory of the Light*

Sense, published for the first time in German 1905, and published in English for the first time in 1964.

First, I explore his conception of brightness which deviates manifestly from the Committee's. I then discuss Hering's attempt to find a neutral determination of colours, that is, a determination that neither connects to psychophysical causal terms, nor to for example Goethe and Chevreul's theories on colour mixing processes, nor to what known under the names additive and subtractive colour mixing.

Lastly, I show that Hering's colour determinations are based on quantitative terms, like those of the Committee, see section 1.4.7 above. My conclusion is that if Hering's terminology is taken to indicate his ontological conviction on colours, all colours in his opinion are heterogeneous.

It is a matter of course that science searches for causes of colours. Hurvich and Jameson (1964, p. xix) trace some of the scientific benefits of Hering's theory: His division of the opponent hue pairs red-green and yellow-blue was very much accepted (in their time), thanks to the successful theory of physiological opponent processes in the retina as Hering had suggested. However, again I must stress that my aim is not to explore scientific explanatory theories, only to cognize how colours are determined.

Hering provides a wellspring of thoughts about colours, and much too many of them are of general philosophical interest. I have had to pick out those that are most relevant to the problems raised in this present thesis.

1.5.1 Hering's conception of brightness presumes colours' heterogeneity

Hering's conception of brightness is not in agreement with the Committee's. First, Hering uses the terms *bright* and *light* synonymously. "Every colour that actually occurs has its own particular brightness-darkness quality, and, depending on whether the brightness or darkness is more pronounced, we call it a light colour or a dark one." (Hering, 1964, p. 64)

Second, Hering identifies the brightness dimension with white and black and their intermediates, i.e. greys. On page 64 he continues the explanation. "This is obvious for the black-white colours; depending on whether the black or the white component is clearer, we call the colour a bright or dark one."

Hering accentuates this identification on page 60: "In the achromatic colour series the brightness or darkness is determined simply by the ratio of whiteness to blackness."

Hering's use of the brightness term may seem a little strange because black is not usually thought of as a brightness degree but, on the contrary, as zero bright. While colours are thought of as produced by light, black is not. See section 2.10.4 below, about Hume, p. 90. However, Hering sees pure black as an ideal colour.

> As we already said, such a numerical expression would be conceivable only if we were able to continue the colour scale either to absolute black or to absolute white. But we have already pointed out these two colours are only imagined, and however many equally different colour

> steps we may line up on both sides of our scale, using all conceivable techniques, we could never assert that with the deepest black we produced we had attained the deepest black *possible* to perceive, let alone the hypothetical absolute black, and just as little would the lightest white that we obtained necessarily represent the lightest possible white, let alone absolute white. (Hering, 1964, p. 38)

Hering's appeal to imagination, is maybe not appropriate, because, when you imagine a colour, it is already instantiated. See in this connection section 2.9 below.

Rather, I agree with Hospers in that what is logical possible does not necessarily involve imagination. "Whether I can imagine it or not, a thousand-sided polygon, an animal that's a cross between a walrus and a wasp, and a colour different from any we have ever seen, are *all logically possible*; we need not to stop to ask whether we can *imagine* them." (Hospers, 1961, p. 97)

Any way, it seems that Hering considers all whites and blacks that are practically possible to produce as heterogeneous colours. The verb "produce" must here be understood in a wide sense, including, for example, how achromatic colours are produced by light causing retinal processes. Among the producible colours the whitest of the whites is a little bit blackish and the blackest of the blacks is a little bit whitish. Ideal black and white are the only ones that can be considered homogeneous, according to Hering's terminology. But one might ask if ideal colours are colours at all. In Chapter III, section 7, I discuss in greater depth what ideal colours might be in relation to the Swedish Natural Colour System, NCS, to which Hering might be considered a precursor.

Hering also seems to accentuate heterogeneity of all chromatic colours because of their intrinsic brightness value.

> On the basis of what has been said and other facts and considerations to be presented later, I believe that we have to distinguish three qualitatively different brightnesses, white, yellow, and red, and likewise three darknesses of different kinds, black, blue, and green. Brightness is thus a property that is intrinsic to the three primary visual qualities, white, yellow and red, and darkness a property that is intrinsic to the three primary qualities, black, blue and green. (Hering, 1964, p. 63)

In this quotation it seems like brightness and darkness are something other than white and black, but this cannot be the case according to Hering's previously introduced identification of bright with white and dark with black.

It may sound more puzzling, though, that yellow and red are kinds of brightness, although when Hering says these hues have brightness as intrinsic property, it follows that they have white as a property because of the identification of brightness with white or colours close to white.

When black, blue and green are characterized as three kinds of darkness, it must be because of the reversed relationship.

There is therefore no real dichotomy between bright and dark colours in Hering's terminology because every colour in the white-black series is different only according to which proportion of white or black is the more pronounced. And also concerning the hues, both white and black are always present but in different proportions.

I find it relevant to refer to Goethe in this connection. It is as if Hering were echoing Goethe on the characterization of yellow and red as brightness hues and blue and green as darkness hues. However, as I make clear in the following, although the characterization is the same, there is a crucial difference in method and, therefore, also in the connotations that are involved.

Goethe develops colour determinations based on the empirical or observable conditions for appearance or instantiation. Within all of his three colour classes – physiological, physical and chemical – the same symmetry is, according to him, recognizable. Goethe's main thesis is that hues appear under two opposite processes, one is a darkening of white and the other is a lightening of black.

In short, in Goethe's terminology the substantives are respectively white (lightness) and black (darkness), and the chromatic colours are judged to be properties of those. See in this connection my explanation below.

It appears that Goethe and Hering disagree on which colours are properties of other colours. At least, Hering expresses himself as if he thinks it is a matter of choice and without any further ontological implications.

> In order to offset the one-sided concept of veiled colours implied by the mode of designation that I happen to have selected, it is useful to remember that the concept of veiling can be applied not only to the chromatic quality (the chromatic component) of colour, but also to its black-white quality (the black-white component). Let us imagine, for example, a clearly red colour that verges into grey. It might also be regarded as a grey more or less veiled by red; furthermore it might be regarded as a black veiled with a specific white-red, or as a white-red veiled with black. Finally, it might be regarded as a black veiled with a specific white-red, or as a white-red veiled with black. (Hering, 1964, p. 52-53)

But, according to Hering's terminology, it seems to follow by logical implication that hues are properties of whites – greys – blacks. The basic reason for this is already stated, namely that hues contain black/white intrinsically, while blacks/whites can exist without the hues. In other words, chromatic colours always contain achromatic colours, but not the other way around. Black/white may exist independently of the hues, but the hues cannot exist without them.

According to Goethe (2002), yellow is a chromatic darkening of white. "This is the colour nearest the light. It appears on the slightest mitigation of light, whether by semi-transparent mediums or faint reflections from white surfaces." (§ 765) If the darkening continues, red-yellow appears: "As no colour can be considered stationary, so we can very easily augment yellow into reddish by condensing or darkening it. The colour increases in energy, and appears in red-yellow more powerful and splendid." (§ 772) At § 774 it is said, "As pure yellow passes very easy to red-yellow, so the deepening of this last to yellow-red is not to be arrested." In Goethe's theory these chromatic colours are all conceived of as darkenings of white to different degrees.

Goethe is not equally clear about blue but my main impression given his descriptions is that he considers blue as chromatic lightening of black. At § 778 he states, "blue still brings a principle of darkness with it", and at § 782 he continues, "Blue gives us an impression of cold, and thus, again reminds us of shade. We have before spoken of its affinity with black." At § 155 Goethe gives an example of the conditions under which different blues might appear.

> If the darkness of infinite space is seen through atmospheric vapours illumined by the daylight, the blue colour appears. On high mountains the sky appears by day intensely blue, owing to the few thin vapours that float before the endless dark space: as soon as we descend in the valleys, the blue becomes lighter; till at last, in certain regions and in consequence of increasing vapours, it all together changes to a very pale blue.

It is also likely, moreover, that Goethe means that when yellow and blue unite the result is a darkening or deepening in relation to yellow, which, in his opinion, means green is a darkness colour. It is darker than both yellow and red, but lighter than blue.

Both Goethe and Hering therefore determine hues with relation to white and black (brightness and darkness). The great differences in the methods of the two theoreticians are, however, not to be denied. Goethe grounds his ontological view on colour appearances and their observable causal conditions, i.e. his theory is a synthesis of experiments that can be reconstructed and controlled by everyone. Goethe's method is empirical in an Aristotelian sense. In Chapter II I return to both Aristotle and Goethe in order to explicate in more detail the connection between them in relation to their colour theories.

One may ask if the Committee on Colorimetry conceives of saturated primary and secondary hues, as properties of achromatic colours.

The Committee says a saturated hue has the same brightness value as one grey in the axis between white and grey. And it seems to me that the Committee means that no hue can be just as bright as white or just as dark as black. But, since it is difficult to sort out what the Committee exactly means with brightness, see in this connection section 1.4.6, I cannot answer the question.

However, it seems that Hilbert shares Hering's view. "A room with yellow walls will appear to be more brightly lit than a room with blue walls. A person unable to distinguish blue from yellow would still be able to distinguish the different light levels in the two rooms." (Hilbert, 1987, p. 78)

In this quotation Hilbert does not differentiate between light and bright, and so, maybe, he thinks of proportions of white and black intrinsic in yellow and blue. And, it seems to follow, the person Hilbert talks about, though not able to tell yellow from blue, is, as I interpret Hilbert, able to judge the achromatic differences of the walls in the two rooms, to which, normally, the hues belong or are properties of.

It is not clear what Hardin thinks about the relationship between hues and achromatic colours. See in this connection my discussion in Chapter III, section 1.1. However, in his article on materialism and qualia from 1987, pp. 286-287, he seems to suggest that portions of black/white are produced simultaneously with the hues.

> The resulting theoretical picture may be crudely sketched in the following way: Red and green are coded on one chromatic channel, which we shall call the **r-g** channel, and yellow and blue on another, which we shall call the **y-b** channel, with black and white represented on a third, achromatic channel. Each channel has a spontaneous basal activity level that codes a darkish grey.

It does not follow from Hardin's sketch that hues are dependent on greys for their existence. On the other hand, it seems to me that Hardin suggests greys are always within a hue, intrinsic to them, like also Hering describes it. I think his mention of the

basic activity level indicates this. If this is correct, and since greys on the black-white axis can exist without hues, hues are at least bound to greys in an ontological crucial way.

Any way, if hues intrinsically contain greys, all hues, it follows, are heterogeneous. And the same for the greys in the white-black axis.

1.5.2 Hering on theory dependency

In colour determination, Hering uses a method of direct observation that, he says, prevents causes or causal conditions from interfering. He is convinced he is performing an analysis and classification of colours that is "independent of the conditions of their appearance and (…) based solely on the properties of the colours themselves." (Hering, 1964, p. 24)

In the theory of science, the question of theory dependency has been widely discussed in the 20th century. Popper sees theory dependency as a great problem, and tries to reduce the danger of reading data in light of theory by his falsification principle. (Popper, 1980.) According to Popper, the researcher should endeavour to find data that refute hypotheses instead of looking for data that most probably will confirm them. If a hypothesis resists attempts at refutation, it will be strengthened in the sense of more trustworthy than a hypothesis the researcher deliberately tries to rescue from falsification. Popper's thought seems to be that the data with which we might expect to falsify a hypothesis cannot be understood or observed in light of the theory from which the hypothesis stems. However, they might be understood in light of a competing hypothesis, and consequently the struggle for theory independency is a never-ending procedure.

Hering strives for a neutral conception of colours, but not because he wants to test explanatory causal hypotheses about them, such as Popper prescribes, but to determine the basic relations between the colours per se.

Kuhn is a proponent of a doctrine that no scientific data are neutral or independent of scientific theoretical conceptualizations. According to Kuhn, data are understood entirely in light of a theoretical system, that is, a paradigm. Under this paradigm, practical research, i.e. normal science, proceeds according to fundamental theoretical presuppositions, which, because they are never seriously doubted are therefore never tested. Kuhn's book *The Structure of Scientific Revolutions* (1962) urges one to believe that scientific observation is to interpret or understand data in light of theories, i.e. proper science is so to say by definition to operate with theory dependent observations.

> Though it is obviously preliminary and need not be correct in all details, what has just been said about sensations is meant literally. At the very least it is a hypothesis about vision, which should be subject to experimental investigation though probably not to direct check. But talk like this of seeing and sensation here also serves metaphorical functions as it does in the body of the book. We do not *see* electrons, but rather their tracks or else bubbles of vapour in a cloud chamber. We do not *see* electric currents at all, but rather an ammeter or galvanometer. Yet in the preceding pages, particularly in Section X, I have repeatedly acted as though we did perceive theoretical entities like currents, electrons, and fields, as though we learned to do so

> from examination of exemplars, and as though in these cases too it would be wrong to replace talk of seeing with talk of criteria and interpretation. (…). (Kuhn, 1962, p. 196)

Hering, who died in 1918, blames the psychophysicists of his day for theory dependency with relation to the brightness dimension of colours. Hering wishes to "learn to ignore completely the way the colours are produced, to restrict oneself merely to observing the colour itself, and not to keep dragging in the properties of the light rays to characterize the colour." (Hering, 1964, p. 53) He explains how colour characterization might suffer from theory dependency.

> Since colours become brighter with increasing intensity of radiation under otherwise constant conditions, involuntarily the idea of increasing brightness becomes confused with the idea of increasing light intensity, and, since the latter is solely a quantitative change, one becomes accustomed to treating the former as the same, and neglects to investigate the qualitative changes in colour that accompany each brightness change. (Hering, 1964, p. 61)

As I interpret Hering, psychophysics on colours taken as an interdisciplinary research program has an obvious need for a neutral conception of colours, i.e. one that is not dependent on any psychophysical causal conceptualization. Psychophysics of colours must, according to my interpretation, ascertain a neutral conception because it deals with different kinds of causes. These are connected in a chain and if concentration on any particular type or class in the causal chain were, in a specific mode, to influence the conception of colours there would be no agreement whatsoever on the explanandum, which exactly is the colours.

Hering says. "The whole visual world and its content is a creation of our *inner* eye, as we may call the neural *visual system* (*retina, optic nerve, and related parts of the brain*), in contrast to the dioptric mechanism, which may be designated the outer eye." (Hering, 1964, p. 1)

Indeed, Hering has an extensive conception of psychophysics. Physical light radiation should not be excluded. "The creative capacity of our inner eye produces those colour forms through the impact of excitations aroused in the eye by radiation from *real* external objects." (Hering, 1964, p. 1.) Nor should retinal and cortical processes be excluded.

> Furthermore, although we must regard the nervous system in particular as the bearer of the processes that we conceive as the somatic correlates of mental life, it would be rash to regard the cortex alone as the locus of "psychophysical processes" and to exclude everything else, especially the retina. For the fact that one can still have optical sensations even after losing the retinas does not mean that under normal circumstances retinal activities do not also belong to the somatic correlates of visual sensation and therefore have a contributory psychophysical function. (Hering, 1964, p. 23)

On these grounds, Kuhn's conception of theory dependency seems incompatible with regards to Hering's conception of psychophysics. As long as a psychophysicist is concerned with the whole chain of causes of colours, i.e. the dioptric mechanism, the retinal processes, the optic nerve and the related parts of the brain, they must rely on a conception of colours that is neutral in relation to the different kinds of causes involved. If not, research into the specific areas will be dealing with different explananda.

1.5.3 Hering and the subjectivity thesis

As I have shown in the previous subsections, the Committee on Colorimetry holds onto the term *colour sensation* and defines colour "as a sensation and thereby as a purely subjective concept." (1953, p. 6)

But it seems to me that Hering tries to create neutral ground also in relation to subjectivity and determine colours free of any psychophysical theoretical conceptions whatsoever. However, let it be said, I am not trying to explore what Hering may have thought on these matters; my discussion is really not about Hering in a historical sense but about a philosophical position concerning colours to which his text is relevant.

> If we designate the latter, namely red, yellow, green, blue, and their intermediates, that is, all colours of definite hue (…) as chromatic (…) or hued (…) colours, but white and black with their grey intermediates as achromatic or hueless colours, then we could dispense here with the word "sensation" and subsume all qualities of the visual sense under the one word "colour."(Hering, 1964, p. 4)

Neutrality is not obtained simply by substituting the word "colour" for the expression "colour sensation". Hering has a psychological explanation. For Hering, something is subjective only in so far as it is perceived as belonging to or as going on in the perceiver's own body. Therefore, if colours were seen as subjective, they should, according to Hering, be seen as localized somewhere in the perceiver's visual system or as events that are happening within that system, but, he maintains, they are never perceived as such.

According to Hering, colours are perceived as existing independent of the perceiver's visual system and therefore outside the body. (Hering, 1964, pp. 4-6) Katz supports Hering in this connection. "Colour phenomena are always characterized by objectification; they are always seen "out there" in space." (Katz, 1935, pp. 36-37)

I return to this issue in Section 3.

But in order to elucidate the subjective/objective controversy I think it is better to take departure in Descartes' philosophy. Classification of colours as subjective is built on his dualism of the physical (Res extensa) and the psychological (Res cogitans). If something is psychological, it is subjective. Following the Cartesian tradition, colours are not physical and this contention therefore inevitably leads to the conclusion colours are subjective.[7]

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[7] Hardin contends that colours are subjective; likewise, Arstila. However, their discussion is very confused in relation to Descartes because the objectivistic position they argue against does not deny that colours are subjective or psychological reactions from physical stimuli. What Arstila's so-called objectivists are claiming is that "colours are surface spectral reflectance properties of an object or at least associated with them." (Arstila, 2005, p. 47) Hardin describes the objectivist position in a very loose manner (Hardin, 1988, p. 65); however, Hardin's Eliminitavism rejects any necessary relationship between physical light radiations and colours. Colours are not, Hardin concludes, in any reasonable way, connected to objects in the outer world. See in this connection Chapter II, section 4.

To me, Descartes' dualism feels very uncomfortable because it seems to imply that thoughts and colours have some properties in common, i.e. both are thoughts. (Meditations, number 2, §§ 8 and 9.) Both Hering and a contemporary of his, namely Mach, seem to be just as uncomfortable with Cartesianism on this point, although not exactly for the same reasons perhaps. I shall return to Hering and Mach soon, but first I would like to enlighten the problem with some short comments.

In my view, concepts of, or propositions about, colours and their relations, are thoughts, be they true or false. Neither the colours themselves, nor their relations can be identified with either conceptual or propositional thinking; they are simply facts that must be sorted out in cognition. Therefore, one has to discern colours from thoughts.

Kim sees a crucial difference between sensory and intentional states. A colour in Kim's terminology is a sensory, not intentional state. This is Kim's challenge.

> A question to which we do not as yet have an answer is this: In virtue of what common property are both sensory states and intentional states "mental"? What do our pains and beliefs have in common in virtue of which they fall under the single category "mental phenomena"? To the extent that we lack a satisfying answer to this question, we fail to have a unitary conception of what mentality consists in. (Kim, 1998, p. 23)

Mach is well known for his monism. He considers colours to be elements that we now judge subjective, now objective, although in all judgements they are constantly the same.

> A colour is a physical object as soon as we consider its dependence, for instance, upon its luminous source, upon other colours, upon temperatures, upon spaces and so forth. When we consider, however, its dependence upon the retina (…), it is a psychological object, a sensation. Not the subject matter, but the direction of our investigation, is different in the two domains. (Mach, 1996, pp. 17-18)

All sensations are elements according to Mach. "We may then reasonably expect to build a unified monistic structure upon this conception, and thus to get rid of the distressing confusions of dualism." Furthermore,

> If ordinary "matter" must be regarded merely as a highly natural, unconsciously constructed mental symbol for a relatively stable complex of sensational elements, much more must be the case with the artificial hypothetical atoms and molecules of physics and chemistry. The value of these implements for their special, limited purposes is not one whit destroyed. As before, they remain economical ways of symbolizing experience. But we have little right to expect from them, as from the symbols of algebra, more than we have put into them, and certainly not more enlightenment and revelation than from experience itself. We are on our guard now, even in the province of physics, against overestimating the value of our symbols. Still less, therefore, will the monstrous idea of employing atoms to explain physical processes ever get possession of us; seeing the atoms are but the symbols of those peculiar complexes of sensational elements which we meet with in the narrow domains of physics and chemistry. (Mach, 1996, pp. 311-312)

Hospers agrees:

> Sense-data are, as it were, the *raw material* out of which we *construct* both the mental and the physical realms. Sense data are *given*, and the given – the colours, the shapes, the smells, and so on, of which we are immediately aware – is neither mental nor physical; the colours we see are not given *as* either. (Hospers, 1961, p. 427)

Given his realistic view on colours, that is, his theory about the psychophysical causal chain, Hering obviously does not adhere to Mach's monism. But it seems as though he does agree with the conception of colours as elements. According to this elemental view, colours are of a nature that can be categorized neither psychologically nor physically. That is, the subjective/objective controversy does not apply to this conception of colours. Hering gives this definition of colours. "Colours are the stuff out of which visual phenomena are built up." (Hering, 1964, p. 1)

Hospers (1961, pp. 408-409) echoes Hering[8] in refuting the physical causal dimension of the sense datum term, and joins him in identifying a sense datum with colours, sounds, etc., i.e. with what is directly experienced.

> But what is it that we *see*? Suppose that now we answer, "Colours," or "Colours and shapes" (We mean here of course, not the light-waves of the physicist – *these* are clearly not what we see – but red, greens, yellows, and other colours which we can distinguish but can't define except ostensively.) These are "that which we immediately and directly experience." (Hospers, 1961, p. 409)

In Hospers' sense, colours (and other qualities/sense-data) seem to be determined negatively as something that is neither physical nor mental, that is, neither objective nor subjective, and he says nothing commits us to believe they are either. (Hospers, 1961, p. 413)

This accords with my own view and makes it possible to treat colours not as thoughts but as facts about which I can think either truly or falsely, an activity that certainly is purely psychological.

It is customary to treat also propositions as facts when judging them respectively to be false or true, for example. Colours are, however, in my opinion, neither true nor false. Their givenness has nothing to do with truth-values. Johnson (1921, p. 1, § 1), supports me by saying only propositions have truth value, that is, a proposition is either true or false. "A proposition is that of which truth and falsity can be significantly predicated. The sentence may be summarily defined as the verbal expression of a judgement or of a proposition."

The Cartesian conception gives rise to two more complications.

First, if colours are thoughts they should, from one point of view, be non-dimensional. Res cogitans is the not extended substance, while Res extensa is the three-dimensional substance identified by the synthesis of length, breadth and depth. In opposition to Res extensa, Descartes, in his second meditation, paragraph 8, defines mind or the thinking substance, and a mind feels, which means feeling is thinking.

"But what then am I? A thing which thinks. What is a thing which thinks? It is a thing which doubts, understands, affirms, denies, wills, refuses, which also imagines and feels."

Some sentences in his following paragraph makes it clear that the word "feels" in this connection denotes also seeing, i.e. experiencing colours: "Finally, I am the same who

[8] He does not, however, refer to Hering.

feels, that is to say, who perceives certain things, as by the organs of sense, since in truth I see light, I hear noise, I feel heat."

But the idea that colours are not extended seems to fly right in the face of most people's beliefs, be they ordinary persons or scientists. The Committee on Colorimetry (1953, p. 101) is clear that extension is a general attribute of colour. Also, Hering seems to find the very thought that colours ontologically are not extended quite absurd. His idea of colours as "raw stuff" would have no practical bearing if extension were not considered part of the concept: "But since I can conceive no usefulness for a colour that has no spatial properties and thus no extent, I do not know where to start with "pure" visual sensations if they are to be entirely nonspatial." (Hering, 1964, p. 6)

But how is this link between colours and extension justified? Hospers (1961, pp. 142-142) relies on judgement rationalism which is a claim that reason itself provides humans with an a priori truth that colours are extended.

> *All colours are extended*. The word "colour" here refers to experienced colours, not to light-waves, and "extended" means simply "spread out." The statement is not restricted to saying that all coloured *physical things* are extended (though this is doubtless true enough), for colours are sometimes experienced without the presence of physical things, as in hallucinations, after-images, spots before your eyes, dreams, and the like. What is asserted is that all colours, in all these experiences, are extended. Nor need they be extended in *physical* space: if you see red spots before your eyes, or see stars when somebody hits you on the head, it is doubtful whether these colours are locatable in physical space, but still they are spread out or extended.

Hospers continues on page 142 and asks "Don't we know, and know *a priori*, that all colours, past, present and future, are extended?" And he furnishes reasons for his claim it is an a priori truth, not analytical but synthetic.

This is problematic however, because, as I in different connections argue, especially in section 2.3, 'colour' is not at term with connotation, it is a common name for different particulars. See also section 2.4 in which I discuss Johnson on betweenness and his contention that 'colour' is a determinable and not a concept.

Rather, it is observation and determination of colour relations that leads to a conclusion that colours are extended. Indeed, I think that Hospers' statement that colours are spread out is a determination based on observation. Colours are observed to exist beside, under, above and around each other. And these descriptions are parts of the connotation that can be given to the expression *colour extension*.

Second, one can of course say that it is only the synthesis of the three dimensions that is denied in the Cartesian dualism, and that colours still may be two dimensional and yet be thoughts. In his first meditation, paragraph 6, Descartes talks about colours as something "simple and more universal, which are real and true; and of these just in the way as with certain real colours, all these images of things which dwell in our thoughts, whether true and real, or false and fantastic, are formed."

If so, however, logically it would follow that mind is extended, as a plane or an area, all the time one or more colours exist. Or since colours are supposed to be thoughts

and thereby parts of mind, if there is concomitance between colour and extension, at least some thoughts must have both length and breadth as properties.

Other parts of mind as concepts and propositions are never understood in terms of length and breadth, that is, as planes or areas. How these two very different sorts of things can be united in one and the same substance is therefore an obvious problem.

It is Descartes that treats of the soul or mind as substance – a more modern and commonly accepted way of dealing with the problem seems to be to change it into the relation between a main category and sub categories. The problem to be solved then turns out to be the one that Kim addresses, see the quotation from Kim above, namely how to find the common feature shared by colours, on the one hand, and concepts and propositions, on the other, a feature that can justify the claim both are sub categories of the same main category mind.

Berkeley (4, 1974) addresses the problem of mind and extension in *Principles of Human Knowledge*, § 49: "Fifthly, it may perhaps be objected, that if extension and figure exist only in the mind, it follows that the mind is extended and figured; since extension is a mode or attribute, which (to speak with the Schools) is predicated of the subject in which it exists."

According to Berkeley it also would follow that mind is coloured. But, in the same paragraph, he refutes that extension, figure and colour are modes or attributes of mind. Instead he says these things are ideas that are perceived.

> I answer, those qualities are in the mind only as they are perceived by it, that is, not by way of *mode* or *attribute*, but only by way of *idea*; and it no more follows, that the soul or mind is extended because extension exists in it alone, than it does that it is red or blue, because those colours are on all hands acknowledged to exist in it and nowhere else.

And, still in the same paragraph, he rejects the substance-attribute ontology altogether. Different ideas can only be observed or perceived at the same time, and this togetherness in time is what an object is. Ideas are not properties of an object or a substance different from them, but exactly a conglomeration of those ideas.

> As to what philosophers say of subject and mode, that seems very groundless and unintelligible. For instance, in this proposition, a die is hard, extended and square, they will have it that the word *die* denotes a subject and substance, distinct from hardness, extension and figure, which are all predicated of it, and in which they exist. This I cannot comprehend: to me a die seems to be nothing distinct from those things which are termed its mode or accidents. And to say a die is hard, extended and square, is not to attribute those qualities to a subject distinct from and supporting them, but only an explication of the meaning of the word *die*.

According to Fields many commentators on Berkeley interpret him therefore to mean ideas like colours are objects, immaterial of course, but still something that may be thought about; however, in Fields' own words, as such they are "entirely distinct from minds". (Fields, 2011, p. 38)

Winkler (2005, pp.128) is representative. He says that Berkeley "generally characterizes ideas not as acts of thinking but as objects of thought."

Berkeley (4) § 139, p. 121, says: "I answer, all the unthinking objects of the mind agree, in that they are entirely passive, and their existence consists only in being perceived: whereas a soul or spirit is an active being, whose existence consists not in being perceived, but in perceiving ideas and thinking."

On this background it appears that the first problem of my thesis: are colours homogeneous or heterogeneous, is not and cannot be understood in connection with mind as substance, it concerns only the colours themselves. Neither can the other problem: Are colours three-dimensional or two-dimensional. It is solely the ontological status of colours that is at issue.

1.5.4 Hering on perceptual practice

Hering's aim is to characterize colours and their qualitative relations independent of the perceiving mind's ability to work them over by the hand of experience and to remodel them into object properties. That is, he wants to contemplate them as the stuff they are. This implies giving different colours different names. Indeed, his aim is to name colours meaningfully, thereby classifying "the great multiplicity of colours to get a systematic perspective of them, and designations for them such that the reader is given a comprehensible expression as precise as possible for every colour, so that he can mentally reproduce any colour with some degree of exactness." (Hering, 1964, p. 25)

In this project, Hering faces a new challenge in what he calls secondary circumstances that affect observation and hinders neutral comparison of colours. These secondary circumstances are not physical but psychological; they are stiffened colour conceptions achieved in ordinary life.

According to Hering, memory colour is a sort of psychological mechanism that provides for colour constancy. His example is a heap of snow. Whether it is seen in broad daylight or in the shade on a sunny day, or in the evening when sunlight makes it yellow or even red, the heap of snow is still perceived as white. Hering explains this by the influence of memory colour: white is fixed in the memory of the object and will therefore overrule the judgement of the colour of snow even when the colour that appears in direct observation is not white.

> For the colour in which we have most consistently seen an external object is impressed indelibly on our memory and becomes a fixed property of the memory image. What the layman calls the real colour of an object is a colour of the object that has become fixed, as it were, in his memory; I should like to call it the *memory colour* of the object. (Hering, 1964, p. 7)

It seems that Hering's contemplations on memory accord with those of later thinkers in both philosophy and psychology. "Vision", the phenomenologist Merleau-Ponty contends, "is already inhabited by a meaning (sense) which gives it a function in the spectacle of the world and in our existence." (Merleau-Ponty, 1981, p. 52) The cognitive scientist Leeuwen stresses that colour judgements are, what concerns ordinary persons, really dependent on perceptions of objects. "Interpretation is an inextricable part of sensation." Leeuwen explains colour interpretation as a way of judging colours according to the material in which they are believed to inhere:

> With meaningful objects, interpretation will influence how we judge elementary sensory qualities such as the hue of a colour (….): the same colour patch is judged to be redder if a person is told that it belongs to a tomato than if told that it belongs to an apple. (Leeuwen, 1999, p. 268)

Hering says that memory colour will inflict not only the judgements of ordinary people, but also scientists and professionals.

> However, as often as he thinks, say, of snow, he continues to imagine it as white; and it is the same with all people, whether they have thought a great deal or not at all, about the nature of colours. Whether it is the mineralogist, for whom snow consists of an accumulation of small colourless transparent water crystals, the chemist, for whom these crystals are in turn built up from countless molecules and atoms, or the physicist, who deals not with molecules and atoms but only with energies: they all inevitably associate the colour white with the idea of snow. (Hering, 1964, p. 7)

Furthermore, as Hering accentuates, even psychophysicists in scientific practice belong to ordinary life or a common-sense world. So, when Hering wants them to judge colours and colour relations only, he has to prescribe some arrangements in which effects of memory colour interfere only to a minimal degree.

> A completely reliable comparison of two colours is possible only in case these secondary circumstances, even if they are not excluded, are at least the same for both colours. Therefore both colours, except for their being side by side, should appear localized in precisely the same way and each of the two colours should be so completely homogeneous that they show no internal variation, and are seen not at all as belonging to a specific external object but only as independently existing plane or space-filling qualities. Thus, for example, each half of the visual field of a telescope can be illuminated in such a uniform way with achromatic or coloured radiation that the two colours to be compared fulfil all the requirements just stated. (Hering, 1964, p. 12)

Remark that Hering calls a colour patch, which shows no internal variation, homogeneous. I prefer to use his negative expression “no internal variation” or simply the expression “no inner variation”. In this present thesis I reserve the term *homogeneous* for an ontological characterization of colours that tells that this or these or all colours can be only one in number and are not constituted by two or more colours.

However, this means that a heterogeneous colour – if there are such colours – might yet be perceived as an area with no internal or inner variation. The point to be underscored is that Hering in this sense does not seem to take the existence of a uniform patch to be proof that the colour in question is homogeneous.

While not having inner variation is the first condition, the second condition of neutral colour determination, according to Hering, is that the patch or patches should not be seen (read: perceived) as object colours but as independently existing plane or space-filling qualities.

In this connection Katz has indirectly pointed to a difficulty. According to Katz “Hering would limit all comparative studies of colours to film colours.” (Katz, 1935, p. 52) Remember, a film colour, according to Katz, is often described as an aperture colour, that is, when uniform surface colours are viewed through an aperture in a screen the aperture ensures that all the colour’s interpretative connections to its actual surroundings are blocked. See in this connection section 1.4.4 above.

It may be discussed if film colours always are perceived as independently existing plane or space-filling qualities, just as Hering requires. But if they are, then Hering's first condition, namely that a colour patch should have no internal variation, seems not to be satisfied insofar as Katz also characterizes film colours as somewhat spongy and deep. (Katz, 1935, p. 8) And these characteristics a colour patch cannot be perceived as having, it seems, without showing some internal variation.

Hering does not mention this difficulty. However, from this standpoint he starts to determine the colours.

1.5.5 Hering's colour terminology

When focusing on qualitative differences Hering finds four hues, namely yellow, red, blue and green to be distinguished in the sense of not being like each other at all. Yellow is neither red, nor blue, nor green and this characteristic is reciprocally negative for each. Hering calls them primary hues. While some of them can constitute intermediate hues, red and green, on the one hand, and yellow and blue, on the other, cannot constitute any intermediate hues and Hering calls them opponent colours. Hering says there are no intermediate hues between respectively red and green, on the one hand, and yellow and blue, on the other.

> Therefore, since redness and greenness, or yellowness and blueness are never simultaneously evident in any colour, but rather appear to be mutually exclusive, I have called them *opponent colours*. To begin with, this term is used to characterize the way they occur without implying any sort of explanation. Two intermediate hues that belong to two opposite quadrants of the colour circle, such as the red-yellow and the green-blue, are opponent in two respects; but if they belong to two adjacent quadrants, such as the red-yellow and the green-yellow, then they are opponents in only one respect. (Hering, 1964, p. 50.)

Hering suggests, however, that an intermediate between red-green or yellow-blue is "either not possible at all or is possible under quite special, unusual circumstances." (Hering, 1964, p. 50) In Chapter III, Section 1.7 I describe and discuss the so-called forbidden colours in relation to recent research, which ascertains their existence. See in this connection, for example, Crane and Piantanida, 1983, and Billock, Gleason and Tsou, 2001, Chapter III, section 4.

So far, one might say that according to Hering there are four primary hues, namely red and green, and yellow and blue. When a colour is determined to be primary, one would usually understand it as elementary, that is, not heterogeneous. But remember the primary hues already have intrinsic brightness and darkness values, Hering insists, even in their clearest manifestations or instantiations.

> The brightness or darkness of a chromatic colour, according to this view, is the result of the intrinsic brightness and intrinsic darkness of the individual primary colours, which, as the essential components of that colour, determine its colour quality in accordance with their different clarity ratios. (Hering, 1964, p. 64.)

Primary hues manifest themselves in the intermediate hues, namely orange (red-yellow), violet (blue-red), blue-green and yellow-green. The differences between the intermediates depend on which elementary hue is the more pronounced.

On the other hand, both the primary and the intermediate hues contain proportions of black and white. The light hues are red and yellow, which contain more white than the dark hues green and blue, which in turn contain more black than the former.

All whites and blacks are conglomerations of white and black in greys, i.e. in practice there are no pure whites and blacks.

There are two colour classes, namely hues and white/blacks. These two classes make up the totality of colours and are designated respectively chromatic and achromatic colours.

So, it is time to pose the question: Is Hering's colour terminology based on notions of colour heterogeneity? The answer seems at first hand obvious. The terminology indicates that all colours are heterogeneous except for the ideal black and white. Hering uses the verb "comprise" (1964, p. 64) which usually can be substituted for words and expressions like "include", "consist of", "constitute", "make up", all of which indicate that any colour is a conglomeration of other colours.

However, diverse authors seem to be cautious about assigning to Hering an ontological conviction on heterogeneity. In his paragraph on Hering and Ostwald, Briggs (2013) says, "In Hering's view all colours could be considered as mixtures of full colours (pure hue), white and black components." Certainly, Briggs is here referring to Hering's view on chromatic colours; it cannot be *all colours* because, in Hering's view, the achromatic colours do not comprise any hue. Apart from this, my point is that the expression "could be considered" does not express a clear-cut ontological conviction, and therefore it seems that Briggs is careful not to ascribe to Hering a definitive belief in colour heterogeneity.

Seim (2009, § 2.1) writes, "'Unique hues' were first described by Ewald Hering (1878).[9] He proposed that any hue can be described by its redness or greenness and its blueness and yellowness." Again, Hering is not interpreted in an ontological sense because a proposal does not necessarily entail a conviction. If someone says X *can* be described as such and such it does not follow that that someone entertains a conviction that X is such and such.

Seim (2009, § 2.1, figures 1a and 1b) presents a research result on how people commonly select elementary colours in a "chart consisting of 40x8=320 equally spaced Munsell chips." Seim concludes, "Today the perception of elementary hues is a well established concept, accepted by most people, independent of culture and language." And he adds an explanation pointing to some innate faculty.

> People with normal colour vision seem to be in no doubt about what we mean when we ask for an elementary hue, like unique red. Somehow we have a built in understanding of what red

[9] Actually, according to my knowledge, it is Hardin who introduces the terms unique and binary. In the English translation Hering's text contains the terms primary and intermediate colours. I found a page from his Grundzüge der Lehre vom Lichtsinn on the net (http://www.deutschestextarchiv.de/book/view/hering_lichtsinn_1878?p=126), in which the terms Grundempfindug vs. Mishcempfindung are used but also the terms Grund- und Mischfarbe. These latter terms seem to reflect a conviction that primary colours mix or are mixed in the intermediates.

> is. When we are given a set of coloured samples and asked to select the red that is neither yellowish nor bluish, we normally find the task is easy.

Arstila seems to express the same caution in connection with his mention of Hering's opponent process theory; "(…) the four basic colours (red, green, yellow and blue) are all experienced as unique colours, which means they are not experienced as mixtures of any other. Binary hues, on the contrary, are experienced as a merger of two unique hues." (Arstila, 2005, p. 31)

No ontological determination is involved in Arstila's explication: It can be that colours are experienced such and such, but it does not follow that colours really are such and such.

Nida-Rümelin and Suarez adhere to this view on colour perception and, as I interpret them, defend a modality thesis on colour experiences which says that binary colours necessarily are experienced x-ish and y-ish, but basic colours, i.e., red, green, blue and yellow are necessarily not experienced as binary.

> To say that orange is phenomenally composed of red and yellow is to say that the colour at issue looks necessarily (as we will argue) reddish and yellowish. Talk of phenomenal composition can be reduced to talk about looking x-ish and y-ish (where x and y stand for basic colours). (Nida-Rümelin and Suarez, 2009, p. 348, note 3)

But already at the next page they mention that Brentano judged green to be composed of yellow and blue. I think they could also have mentioned both Goethe and Chevreul, and all the students that have gone through their art education on the base of their theories. Besides, I guess many people in their childhood have learnt from experience that mixing yellow and blue pigments yields green.

Hardin (1988, p. 163) makes another point in this connection, namely that American or English language does not contain specific words for yellow-green and blue-green, in the same way as orange and violet are specific words for yellow-red and red-blue.

To me this indicates that perception of colours are not based only on observation free from earlier experiences like Hering sets up as an ideal, and therefore I think Nida-Rümelin and Suarez should have brought this important exception into consideration when the talk is about colour perception in general.

It must also be noted that experienced pigment colour mixing very likely supports other claims on perception. When red and yellow pigments are mixed, orange occurs. When blue and some red pigments are mixed, violet occurs. This might amount to empirical laws. And so, a claim that for example violet always and necessarily is perceived as both red-ish and blue-ish may have a strong support because of many peoples actual experiences, and not because of their intuition or some innate capacity to perceive violet such and such.

But now, after having made these reservations about colour perception it must also be noted that proponents of Hering's system sometimes express themselves as if ontological determination is involved. For example, as Arstila contends, "Furthermore, all hues necessarily have the property of being unique or binary hue." (Arstila, 2005, p. 50)

Arstila does not in this connection characterize perception of colours but directly the colours themselves. And it is a very strong claim to say about the hues that they necessarily are either unique or binary. Apparently, Arstila can be taken to mean that some hues are homogeneous and some heterogeneous, necessarily.

Also, Hardin brings in necessity when distinguishing between unique and binary hues.

> (…) what conception do we have of hues except insofar as we experience them? Surely we can have alternate access to hues only through some theoretical account of them. But under what circumstances are we entitled to suppose that a theoretical identification or reduction or whatever is adequate? Only, I submit, if it can model the necessary properties of hues. (Hardin, 1984, p. 493)

In *Colour for Philosophers*, Hardin makes his point even more clearly.

> But hues do have certain characteristics necessarily. This is a central truth, no less true for having been so frequently overlooked. If we reflect upon what it is to be red, we readily see that it is *possible* for there to be a red that is unique, i.e., neither yellowish nor bluish. It is equally apparent that it is *impossible* for there to be a unique orange, one that is neither reddish nor yellowish. Since there are necessary properties of hues, nothing can be a hue without having the appropriate properties necessarily. (Hardin, 1988, p. 66)

It should also be noticed that Hering's statements too, differentiate substantially between connotations to descriptions of perceptual inclinations and ontological convictions. Indeed, he uses the verb *to be* in a fashion that strongly indicates ontological determination. For example, writing about black and white he says, "in the manifold of achromatic colours, pure white and black are the two variables or mixture elements." (Hering, 1964, p. 36) Furthermore, Hering seems to explain similarity among hues according to their real content of primary hues. What he says about orange seems to be exemplary for all intermediate hues.

> All hues of this small range are *similar* insofar as (1) they are all reddish, and (2) they are all yellowish, and in fact if we scan the colours in one direction redness increases and yellow decreases, whereas in the opposite direction yellow increases and red decreases. (Hering, 1964, p. 43.)

1.5.6 Quality vs. quantity

Hering refers to quantitative variations of the same hues (i.e. two primary hues) within different hues when he talks about yellow increasing and red decreasing (and visa versa).

Hering says: "A chromatic colour can generally be regarded as comprising four primary components, two chromatic and two achromatic (white and black); a *single* chromatic primary component characterizes only those colours that have a primary colour hue." (Hering, 1964, p. 64.) This implies for example that orange is characterized by or consists of or is composed of yellow, red, black and white, while blue, for example, is composed of blue, black and white.

In section 1.3.3 above I introduced a concept of colour mixing consisting of three parts, namely the unification process, the continuation process and the separation process. It is if Hering relies on the two latter concepts. That is, while he does not

seem to demonstrate any factual separation process, he carries it out in thought or imagination: from orange he separates the elements yellow, red, black and white. This is an idea of separation.

In other words, Hering transfers all different hues between red and yellow back to four constant, qualitatively unchangeable components, namely red, yellow, black and white. Whatever instantiation of orange that may occur the components are the same in quality.

This is the crucial point to be contemplated in this connection: while quantity, figure and relative position all can change, Hering's component colours cannot change in quality. This means that no matter how much the quantity of yellow is increased the remaining quantity must still be the same quality, namely yellow, and no matter how much red is decreased, the smallest quantity must still be the same red as the greatest. The same holds for black and white. In communication, this transference in and of itself does not, therefore, seem functional.

Remember, from section 1.5.4, Hering wants to "classify the great multiplicity of colours to get a systematic perspective of them, and designations for them such that the reader is given a comprehensible expression as precise as possible for every colour, so that he can mentally reproduce any colour with some degree of exactness. (Hering, 1964, p. 25)

But the differences between some hues called by the same name of orange are not at all communicated by telling that each and every one is a compound of the same yellow, red, white and black.

One could therefore consider it evident that Hering's natural colour system is a colour mixing system in which different proportions of the primary hues, black and white are the mixing elements. At least, it is reasonable to conceive of Hering's compound colours as a result of mixing, even if the mixing process cannot be demonstrated.

It follows, a tiny quantity of yellow occupies the whole area of orange, presupposed that particular orange is very close to red. And if red decreases, the smaller and smaller quantities must in each case be spread out over the same area.

Since the qualities of this compound are the same, it can only be their quantities that explain different instantiations of orange. But I think Hering's reasoning meets a difficulty here. It is, namely, hard to fancy how a relatively tiny quantity of red or whatever hue can spread out or occupy the initial area, just as it seems Hering presupposes, without changing in quality and by that explain a difference between for example orange 1 and orange 2.

1.5.7 Hering's method

Hering dismisses colour mixing. On page 46 (1964) Hering says, "But in all these colour designations we are concerned only with what is actually seen in the colour, not with the light mixture or the pigment by which this colour was produced and which the colour may *bring to mind*."

Here, Hering accentuates the privileged position he has established for colour determination. The comparable colours exist already; it is not like having white, black, red, green, blue and yellow and watching what happens when some of them somehow are being united, i.e. mixed in different proportions.

This 'givenness' is further accentuated when it comes to hues. Because, given Hering's contention that each hue already contains black and white, no matter if it is primary or intermediate, it follows there exists no such colour as a hue without black and white. Therefore, it is in vain to try to determine by observation how a hue came to be both black and white, it is simply a matter of seeing these components within a given hue.

Against this background it seems that Hering uses the term *see* as synonymous with *intuit*: he first observes the given colours and by intuition grasps the truth about them. It is also likely that Hardin operates with such a method; look up the two last quotations from Hardin in section 1.5.4.

Hospers classifies this kind of method as *judgement rationalism*. What Hospers says in the following could indeed be addressed directly to Hering, though it is not.

> What we did become acquainted with empirically are the *concepts* of colour, extension, shape, size, and so forth. The judgement rationalist may well be a concept empiricist. Without experience we would never have come by such concepts; but, once experience has given us the concepts, we do not need any further experience to know that *the judgement involving these concepts is true*. We think about these concepts and we just see that there is a connection between the two of them which holds necessarily. The word "see," of course, is being used figuratively here, since it does not refer to visual experience. Presumably it refers to intuition. In the final analysis the rationalist holds intuition to be a method of knowledge: he "sees," "intuits," that all A is B and always will be, and that it is necessarily so. (Hospers, 1961, p. 153)

By this purely observational procedure, he sees/intuits the opposite of Goethe's determination, namely that green is a primary hue, that is, green is not a compound of two hues.

However, Hering *sees* that green contains black and white. In general, he sees that all colours are compounds, that is, heterogeneous. This *seeing* is the final argument he provides.

But, obviously, others can see the opposite, namely that colours are not heterogeneous, but homogeneous.

It is impossible, Hume insists, for a colour to be a compound. He offers no decisive argument for his claim, merely maintaining that is true beyond any shadow of doubt that colours are simple ideas. It is worth the while to read his meditations on the subject because they explain very fairly what homogeneity implies in connection with likeness relations:

> 'Tis evident, that even different simple ideas may have a similarity or resemblance to each other; nor is it necessary, that the point or circumstance of resemblance shou'd be distinct or separable from what in which they differ. *Blue* and *green* are different simple ideas, but are more resembling than *blue* and *scarlet*; tho' their perfect simplicity excludes all possibility of separation or distinction. (…). These resemble each other in their simplicity. And yet from their very nature, which excludes all composition this circumstance, in which they resemble,

> is not distinguishable from the rest. 'Tis the same case with all the degrees in any quality. And yet the quality, in any individual, is not distinct from the degree. (Hume, 1969, note, pp. 67-68.)

Carnap, too, takes qualities to be elementary or unanalysable. He uses colours as examples. Colours may wrongly be taken to consist of parts, but this is due to observation of some likeness relations, says Carnap. I will try to explain the point he is attempting to make using orange as an example. This colour is more like yellow and red, respectively, than other colours of Hering's primaries with which it might be compared. But, according to Carnap this does not mean it is a compound of yellow and red, it only means it is partly similar to both. Part-similarity is not an identity relation. Therefore, you cannot analyze orange in the meaning "split it into parts", which means that the sentence *orange is a binary colour* is a quasi-statement, relying on what Carnap calls *quasi analysis*.

> In summary, analysis or, more precisely, quasi analysis of an essentially unanalysable entity into several quasi constituents means placing the entity in several kinship contexts on the basis of a kinship relation, where the unit remains undivided. (Carnap, 1967, p. 116.)

In section 2.4 I explicate Johnson's term 'betweenness' and in 2.4.2 I show that there is no reason to infer heterogeneity from the fact that one colour can be just as like another colour and a third. In order to explain this, I give an example, namely that red is between orange and purple. However, it does not follow that red is a mixture of both or that red contains both as constituents. And likewise, an orange might be just as like red as it is like yellow, but it does not follow that yellow and red constitute orange.

Both Hume and Carnap, however, seem to think that since a patch may be uniform, that is, have no inner variation, just as Hering says, it must be simple or homogeneous. But this is exactly what Hering denies, and therefore, some other argument than uniformity must be brought in to the discussion.

See in this connection section 2.12.1

1.5.8 Two interpretations of Hering

I have made clear that Hering's colour terminology involves colour heterogeneity. If we take the terminology as an indication of Hering's ontological view on colours, it would follow he was convinced that all colours are heterogeneous. The only exceptions are ideal white and black, both of which are not, in Hering's view, of any practical relevance.

On the other hand, Hering can be interpreted along lines that do not involve ontological convictions. He could be understood as developing a communication system for colours and colour relations based on how people in general conceive of colours. In this perspective, ontological claims are not relevant. Hering makes several appeals to 'no one' in this connection, that is, he relies on an assumption that all people really perceive colours in the way he describes them.

> There may be some question whether a given green should be accepted as primary green, or whether it may still have a trace of blueness or yellowness. But no one would assert that a

> green can be clearly both yellowish and bluish, in the way that a violet appears simultaneously bluish and reddish, and no one would call a green blue-yellow or yellow-blue in the same sense as one unhesitatingly designates a violet as red-blue or blue-red. (Hering, 1964, p. 47)

The expression ‘phenomenal colour’ is perhaps suitable for the psychological approach to colours which also Hardin and Arstila defend.

But I have shown that those philosophers, are not sufficiently clear when it comes to differentiating between appeals to perceptual practice and ontological claims. In Chapter III, from section 6, I challenge their contention of how people commonly perceive colours in relation to a discussion of the Swedish Natural Colour System, of which Hering is a precursor.

Section 2
Methodological and ontological considerations

In this section I explore and discuss different views on colours, both scientific and philosophic. I relate these different views explicitly to the first part of the problem addressed in this present thesis. I also explain and give examples of the use of the substantival mode in several sections. I clarify and defend both basic suppositions on identity between colours, and on concomitance between colours and their extension. In the last section I use the latter to argue against the view that (some) colours are heterogeneous. Some arguments are relevant also for the second part of the problem, but I come back to them in Section 3.

2.1 On taxonomy and type theory

Johnson explicates the rules of building up a taxonomical hierarchy.

> Here it will be apposite to consider the traditional account of the principles of logical division where a class (of substantives) is represented as consisting of subclasses. This process is governed by the following rules: (1) the sub-classes must be mutually exclusive; (2) they must be collectively exhaustive of the class to be divided; (3) division of the class into its co-ordinate sub-classes must be based upon some one 'fundamentum divisionis'. (Johnson, 1921, p. 173)

As Johnson explains, the reason for grouping different individuals or particulars into classes is that they share or are characterized by "some the same adjective or combination of adjectives." (Johnson, 1921, p. 175.) It follows that particulars are those things that cannot be further divided into subclasses and on which the taxonomic hierarchy is built, i.e., it is the 'fundamentum divisionis'.

It also follows that the upper class, i.e. the 'summum genus' contains some adjectives or combinations of adjectives that all particulars or individuals share.

Johnson introduces his term *substantive* as a designation of something that is characterized by an adjective. The relationship he posits between substantive and adjective differs, as he says, from the "metaphysical notion of substance and inherence" by including occurrences. (Johnson, 1922, p. xii.)

On the same page he adds, "The term adjective, in my application, covers a wider range than usual, for it is essential to my system that it should include relations."

Furthermore, also on the same page, he divides substantives into two subclasses, namely substantives proper and quasi.

> A substantive proper cannot characterise, but is necessarily characterized; on the other hand, entities belonging to any category whatever (substantive proper, adjective, proposition etc.) may be characterized by adjectives or relations belonging to a special adjectival sub-category corresponding, in each case, to the category of the object which it characterises. Entities, other than substantives proper, of which appropriate adjectives can be predicated, function as quasi-substantives.

Accordingly, as far as colours are concerned they must be quasi substantives when taken as substantives. Johnson says colours cannot be ordered in a taxonomic upset,

and I agree. See in this connection section 2.4. However, colours can be characterized in accordance with Carnap's type theory, which I present below.

It is perhaps somewhat misleading to say that a class is divided into subclasses, at least when the talk is about how to construct a taxonomical hierarchy. One does not start with a class but the opposite, namely with the 'fundamentum divisionis'.

Aristotle says that individual things are known by experience because the senses "give the most authoritative knowledge of particulars" (Aristotle, 981b, 10-15, MacKeon, 1947) and "science and art arise when from many notions gained by experience one universal judgement about a class of objects is produced" (981a, 1-5).

For example, Aristotle divides substances into living things and non-living things; the universal judgement seems to be that individuals of the first class have a property individuals of the latter lack, namely self-nutrition: "Among substances are by general consent reckoned bodies and especially natural bodies; for they are the principle of all other bodies. Of natural bodies some have life in them, others not; by life we mean self-nutrition and growth (with its correlative decay)." ((412a 10-15) MacKeon, 1947).

Furthermore, Aristotle finds three differentiating properties among living things: plants have nutrition alone, animals have both nutrition and sense, and humans have nutrition, sense and reason. The summum genus of both living and non-living things is that they consist of form (actuality) and matter (potentiality).

It follows therefore, that in the construction of a taxonomical hierarchy the direction of characterization always goes from a lower level to a higher, not from a higher to a lower. The latter may be called the failure of inverted characterization. For example, since Plato is a substantive proper and cannot, according to Johnson, characterize, it is an obvious failure to say *man is Plato*.

When the 'fundamentum divisionis' consists of substantives proper some of which may share "some of the same adjectives", according to Johnson (1921, p. 175), and when these adjectives are sorted out by a definition, the individuals are classified.

Carnap's type theory conforms to taxonomies in that there is a zero level of which properties and relational characteristics are predicated. However, type theory does not relate to taxonomies especially but to all kinds of characterization.

> The *theory of types* consists in the fact that all concepts, both properties and relations, are classified according to "types". For simplicity's sake, let us restrict ourselves to properties. A distinction is made between "individuals," i.e. which are not properties (zero level); properties of individuals (first level); properties of properties of individuals (second level) and so on. (Carnap (1), 1959, p. 140)

Also, Carnap warns against the fault of inverted characterization and proposes that one should strictly abide the following rule in order to avoid pseudo-sentences: "a property of the nth level is applied only to concepts of the level n-1." And he adds: "A particularly important special case follows from this: The assumption that a certain property belongs or does not belong to itself can be neither true nor false, but is meaningless."

Price agrees. "Where A stands for a colour-patch which I am acquainted with and b for its redness, I do not and cannot *take* A to be b at all. I am just immediately aware of an actual instance of *b*-ness: and this makes the 'taking' it to be b both unnecessary and impossible." (Price, 1964, p. 65).

In addition, Carnap explains a kind of error which he calls "type confusion". "Another very frequent violation of logical syntax is the so-called '*type confusion*' of concepts. An artificial example is the sentence 'Caesar is a prime number'." (Carnap, (2) 1959, p. 75).

The zero-level suggested by Carnap seems to connect to English empiricists' denial of the existence of substances.[10] For example, Berkeley's ontological view on substances and properties is found in *Principles of Human Knowledge*.[11]

> As to what philosophers say of subject and mode, that seems very groundless and unintelligible. For instance, in this proposition, a die is hard, extended and square, they will have it that the word *die* denotes a subject or a substance, distinct from the hardness, extension and figure, which are predicated of it, and in which they exist. This I cannot comprehend: to me a die seems to be nothing distinct from those things which are termed its modes or accidents. And to say a die is hard, extended and square is not to attribute those qualities to a subject distinct from and supporting them, but only an explication of the meaning of the word *die*. (Berkeley, 1975, p. 91, § 49)

In this connection it is time to trace the line back to the formulation of the first problem in my thesis. It is about particular colours: Are they homogeneous or heterogeneous – or are some homogeneous and others heterogeneous?

This problem is, as I see it, perfectly understandable and decidable without relating colours to a zero level or to a substantive proper. The terms homogeneity and heterogeneity are both defined. See Section 1.2.1 above.

These definitions are, at the outset, possible true characterizations of all colour particulars. They need not be classes in a taxonomical sense; I use them in accordance with Carnap's type theory. Types are categories meaning they include or exclude individuals by a definition; however, they need not be categories in a taxonomical sense.

Of course, if someone finds that some colours are heterogeneous and some are homogeneous, then all colours are divided into two classes; however, while there is

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[10] Whether such denial is compatible with Johnson's substantive proper, is somewhat unclear.

[11] Fields doubts whether Berkeley really believed in his own explanation. "For Berkeley claims not to understand the very ontology that he uses to categorize minds and ideas." (Fields, 2011, p. 39) However, from the context it follows that the relation between mind and ideas, not between ideas, is what concerns Fields. This, I think, is an important distinction, because it is agreeable that ideas are not properties of material substance regardless of the question of whether ideas are properties of the mind, which is what Fields discusses. In her article *How Berkeley Can Maintain That Snow Is White*, Atherton (2003) seems to share my view on Berkeley whereby snow and other things are not substances but names of ideas that are often or regularly connected.

no guarantee that a summum genus is attainable, it is demanded in a taxonomical setup, and therefore type characterization seems to be more practical.

Other classifications according to types are always possible. For example, one might say of a certain red that it is a negative afterimage. (For an explanation of the difference between negative and positive afterimages, see Chapter VII.) Red is then on level one, while the characterization *negative afterimage* is on level two. One might further characterize negative afterimages as film colours, which, in conformity with type theory, would be a property on level three.

The difference in relation to taxonomy is that the concept negative afterimage does not characterize a colour or a set of colours by some essential property. The red in question might namely appear in other instances without being an afterimage. That is, identical colours may sometimes be afterimages, other times not.

This means that type theory gives opportunity to characterize colours. In Johnson's terminology this is a substantival mode. Johnson says colours and other qualities are quasi substantives, but this is to me of no importance. Colours may be characterized according to both occurrence and relation and especially the latter is essential to my approach.

2.2 The Committee on Colorimetry – a critical analysis

The Committee of Colorimetry defines a colour sensation as "the primary conscious response to excitation of the visual mechanism." (Committee on Colorimetry, 1953, p. 101). On the same page it says that colour sensation is a subclass of sense data. It follows that a sense datum may be defined as the primary conscious response to excitation of a sensible mechanism. This, then, is the summum genus for diverse subclasses, namely colour sensation, sound sensation, tactual sensation, etc.

These categories are relational, that is, a causal relation defines them. According to the Committee there are levels further down the line from colour sensation, i.e. achromatic and chromatic, and subclasses of the latter, that is, hue and saturation. Other place the Committee seems to provide causal connections for them too.[12]

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[12] As I explained in Section 1.4.5, in the index of *The Science of Colour,* hue, saturation and brightness are defined with reference to different kinds of radiation. Each kind is supposed to yield differences in quality:

> *Hue*: quality of sensation according to which an observer is aware of differences of wavelengths of radiant energy.
>
> *Saturation*: quality of sensation by which an observer is aware of different purities of any one dominant wavelength.
>
> *Brightness*: attribute of sensation by which an observer is aware of differences of luminance.

These definitions, according to the Committee, are relational because they state the "distinctions between these concepts – light and colour – and the concepts related to them in the fields of psychology and physics." (Committee of Colorimetry, 1953, p. 220.)

But in the place referred to, the Committee substitutes causal definition of saturation for this: “Saturation is the degree to which a chromatic colour sensation differs from an achromatic colour sensation of the same brightness.” (Committee of Colorimetry, 1953, p. 101)

And this seems to be a demonstrative definition, pointing to a positional relation in the plates that the Committee offers. (Committee of Colorimetry, 1953, plates 12-18.) But a demonstrative definition is certainly not a classification. And if the Committee intends to construct a taxonomic hierarchy demonstrative definition is not appropriate.

Indeed, I would find it much more appropriate to start with particulars, pick out some common properties among some of them, and then start constructing a hierarchy.

For example: Grey is achromatic. Yellow number x is saturated, and yellow number z is less saturated. Saturation of both kinds is chromaticness. Furthermore, chromatic and achromatic particulars are colour sensations. Colour sensations are sense data.

This upset seems to follow taxonomical rules, but for it really to work the terms saturation, chromatic, and achromatic all should be properly defined. But this is something the Committee does not do satisfactorily.

In the same paragraph the Committee contends, “Both achromatic and chromatic colour responses possess in common the additional attribute of brightness.” However, instead of characterizing classes the Committee’s contention ought to be that all particulars, each and every one, possess brightness: According to the Committee, grey is bright and so is red (albeit possibly to different degrees), etc.

In this connection brightness could function as a type in Carnap’s meaning, see the foregoing section. But Carnap says “a property of the nth level is applied only to concepts of the level n-1.”, and it follows, brightness should characterize particulars which belong to level 1, that is, brightness is on level 2.

A further characterization of brightness lacks. It cannot be chromaticness and achromaticness because those classes only divide particular hues from particular members of the grey scale.

Furthermore, in the same paragraph the Committee says about colour sensation that it has “the general attributes of duration and extent, which means that the responses exist in time and space”.

Again; colour sensation is defined by the Committee as a causal relation between the excitation of the visual mechanism and conscious colour response. Such a relationship has duration as a property, but it is obviously inappropriate to attribute extension or size to it because a relation between a physical cause and a psychical effect cannot have size. To me the sentence therefore seems to be an example of type confusion such as Carnap explains it.

However, the Committee adds in the same sentence that it is the particulars that are extended and exist within a certain time period: ”the colour might be seen for some time as of some size”, and in this I agree.

I point to these malfunctioning expressions because I suspect the Committee to believes chromatic and achromatic colours are types or categories that characterize particulars. But my point is exactly that this belief is not justified. See the two following sections.

2.3 Naming particulars – proper names and common names

In Section 1.2.1, I write “Colours” is a common name, meaning that it has different references. Groups of colours might in turn also be named, for example, *yellows*, *reds*, *purples*, *blacks*, *greys*, etc. And as for the common name *colours*, so for these other names: they need not be defined, and therefore, just as the name *colours*, they function as common names.

In this section I explicate the procedure of naming colours.

Naming is not to commit oneself to any particular ontological view on colours. That is, even if you have an ontological conviction and, for example, subsume all particulars directly under sense data, or you share the daily life view that colours are properties of observable things, naming can be carried out nonetheless. Johnson expresses himself in accordance with the daily life view.

> Our first approximate account of the given name is then, that the intended application is to an object – whether it be substantive or adjective - which is identical with the object to which it may have been previously understood as applying in another proposition. For example, to explain what I mean by ‘orange’ I could say: ‘You understand the word colour: and I shall mean by “orange” the colour which you can discern as characterising the object to which I am pointing. And when you identify the colour of any object with the colour of this, its colour is to be called “orange”.’ The possibility of such appeal presupposes that colour can be perceptually identified in different objects, apart from any other agreements or differences that the object may manifest. (Johnson, 1921, p. 83)

The intended function of names is to sort out one or several instances or groups of particulars. This intention or purpose implies that naming is normative.

In conformity with Johnson, I do not mean that naming demands a complete purge of other concepts involved in the observation settings. For example, I am aware I am now sitting in my kitchen contemplating the different reds respectively of the top of the screw cap on the soya sauce bottle, the label on the coffee bag and the colour of the cigarette packet. I am also aware that the cap is made of plastic, the bag of metal and the packet of paper. However, since the three reds are different, I give each a proper name, namely red-x, red-y and red-z.

But, in this example, would it not suffice to just call all the compared particulars simply x, y and z? Yes, that would suffice if my purpose had only been to name them separately. But now I also want to mark them out with a common name because of their relationship to other colours in the observation settings. All three are namely less

different from each other than they are from the brown coffee bag, the black soya sauce and the ochre table on which my cigarette packet is laying.

So, giving x, y and z the common name red or reds is not a matter of classifying but only of the use of the word red in order to group x, y and z.

It is not necessary for common names to apply only to colours that are very like each other. For example, as a visual artist, I may need to name groups of particulars. Though position and extension vary from composition to composition, the particular colours might not vary, and hence I call any combination of black, brown, ochre, red-x, red-y and red-z simply Q.

Naming in daily life presupposes abstraction, just as Johnson points out in the last sentence of the quotation above. That is, when picking out identity, likenesses and differences between particular colours, one has to exclude the material differences from the other settings.

The need for abstraction is more obvious if two colours are identical. If I had found the red label of the metal bag was identical to the red of the paper packet, I would not at the same time be obliged to contend that the paper and the metal are identical. That would be a flat contradiction.

However, abstraction concerns not only material conditions but also extensional properties. Extension may vary in size, position and figure, but since all particulars can vary in this way, no extensional trait can be used to divide a group of colours from other groups according to taxonomic rules.

That is, one particular is marked out from all others by being different from them, not in size, figure or position, but in essence, namely that essence that can only be given a proper name: red, grey, blue, brown, orange, etc. Therefore, these proper names do not indicate anything that is or may be common for the particulars, but the opposite. They point out differences.

I can show what it means to point out a particular colour by keeping size and figure identical. Take a look at this example.

r is different from r

The first r can be given the proper name black, the other the proper name red. However, since both are different from each other also in another respect, namely position, it may cause some confusion as to which property I am referring to.

But juxtaposing two identical particulars can solve this problem.

r is identical to O

Both particulars may be given the proper name *red* because of identity, and their differences in extension, figure and position indicate indirectly what is identical.

Even if these two particulars look different to somebody, making the identity claim appear untrue, the claim itself functions as a guide to the crux of the matter.

This conception of identity relation conforms to Johnson who maintains that for two or more objects to be identical they must differ in some other respect. They can therefore only be part identical.

> When we assert that *A* is identical with *B* we are also involved in the assertion that *A* is different from *B*. The plausibility of this dictum depends upon a certain looseness in the application of the word 'implies'; thus the statement that identity implies difference is correct in the sense that the *asserting* of identity between one pair of terms implies our having implicitly or tacitly *asserted* difference between another pair of terms. This follows from what has been said above; e.g. when identifying the colour of this with the colour of that, we are implicitly differentiating 'this' from 'that'; and thus the identification and the differentiation may properly be said to be component parts of a single mental act. But, to give a more precise statement of this implication, it would be necessary to say that, when *A* is identical with *B* in a certain respect, then *A* is different from *B* in some other respect. (Johnson, 1921, p. 188)

If all particulars are to be named with one word, we can use the common name colours, which is exactly what I do in this present thesis.

I should underscore that naming particular colours cannot solve the two problems discussed in this present thesis. The first problem is to decide whether colours are homogeneous or heterogeneous, and these characteristics or adjectives are defined. And the second problem, whether colours are two-dimensional or not, involves a definition of dimensionality. The solution to either cannot therefore follow from naming, because naming does not result in definitions.

2.3.1 Naming and conceptions

Naming might be a complicated operation, as I have shown above, because, although naming of itself does not involve a definition of the named particular, other concepts are involved in the observation settings.

Naming procedures can occur in science without anybody noticing. Two examples might help illustrate how difficult it can be to detect them.

First, consider the sentence quoted in the previous section: "Saturation is the degree to which a chromatic colour sensation differs from an achromatic colour sensation of the same brightness." (Committee of Colorimetry, 1953, p. 101)

It follows from the Committee's definitions of hue, saturation and brightness (see note X in the previous section or see Section 1.4.5 above) that *same brightness* is an identical ratio between wavelengths of light. That is, between short wavelengths (S), middle wavelengths (M) and long wavelengths (L) a certain degree of brightness (intensity or strength) stays the same however much any of the three S, M or L varies in dominance. When no one dominates, the ratio of same brightness results in an achromatic colour, according to the theory.

One might be puzzled by this and believe that when some particulars are caused by the same ratio between light waves, i.e. the same brightness, they must also share some the same observable property.

But such assumption should be rejected, just as Hering did, see in this connection Section 1.5.2.

Although Hardin does not address the issue discussed here in particular, his general dismissal of any necessary connection between colours and radiation supports Hering's view. Hardin explains that light inputs are only linkages in a causal chain. They affect the retina, but from that point on, the ensuing processes have no resemblance with light at all.

> Remember that the eye is a very coarse harmonic analyzer because it contains only three types of colour receptors, their response curves are broad and overlap markedly, and each one will generate a signal whenever it captures a photon anywhere within its response range. Once a photon is absorbed, the wavelength information that it bears is lost. All the nervous system "knows" is whether or to what degree each of the three receptor types has been excited. Any two events that produce the same response pattern will be seen the same way. (Hardin, 1988, pp. 62-63)

Since both brightness and saturation are defined by a certain ratio between light waves, which is per definition not observable, it seems the only way to discern particulars from each other is to name them. And this is what the Committee really does. An example from *The Science of Colour* is the picture caption ostensibly showing so-called brightness and saturation variations of a certain red: "Rectangular array of red samples, with (…) saturation increasing towards right from corresponding lightness[13] of grey series at left." (Committee on Colorimetry, 1953, plate 13.)

This presentation contains no definitions of the particulars that are presented; the words saturation and lightness/brightness correspond only to a positional array. When the Committee says that saturation is the degree to which a chromatic colour sensation differs from an achromatic colour sensation of the same brightness, one has to find the saturated colour in the display by counting steps of difference. Of course, difference is a concept and 'most different' is also a concept, but both have to do with relationships between the particulars and are only means by which to pinpoint the particular in question.

It appears that naming is carried out by the Committee in between a thick layer of different concepts. It is easy, therefore, to feel bewildered, and think that both terms – saturated and saturation degree – together with chromatic and achromatic are adjectives that differentiate some particular colours from others by definitions of some common properties among some of the particulars themselves. However, the truth is that each term functions just as a common name.

The use of the names saturation, saturation degree, chromatic, achromatic should therefore be grounded normatively.

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[13] In this quotation, the Committee has substituted 'brightness' for 'lightness' (see in this connection Section 1.4.6). The Committee is aware, and indeed says that the plate is used just as an illustration: "Since, however, we are using printed samples merely for convenience in manipulating and illustrating colours of light, we shall continue to refer to brightness of the colours rather than to the lightness of the printed samples." (Committee on Colorimetry, 1953, p. 52) In the illustration then, lightness is substituted for brightness yet degrees of saturation are not defined but pointed out, i.e. named.

One can in some situations discuss whether the norms are violated or not. This, too, might cause some confusion and make someone believe concepts are involved and a contradiction committed. I have myself suffered from such wrong beliefs.

Take as an example Sanford's expression "a fully saturated, bright example of red". (Sanford, 2006, p. 7) When I first read it, I was convinced his term contained a flat contradiction, because a saturated red cannot be bright red. However, now that I understand the Committee is not dealing with concepts in this connection, I do not have to blame Sanford for operating with contradictory terms, I only need to convince Sanford that his expression does not follow the Committee's actual naming rules.

Sanford's term violates the Committee's positional rules. Plate 13 says that saturated red is farthest away from the white, grey, and black scale while bright red is nearer to white. But this means exactly that the particulars called respectively saturated and bright red are pinpointed according to position. Hence, Sanford uses the terms fully saturated and bright red in a way that is forbidden by the naming rules set out by the Committee.

It seems to me that Clark (1993, p. 183), although he does not mention naming, has something of the same understanding of the difference between physical/physiologic stimuli and identification of colours;

> "identity criteria cannot be framed to include particular stimuli (since all those stimulus coordinates can be changed). But even after the shift, what makes that quale a quale of pale red (as opposed to saturated red) is just its place in the solid – that it is closer to the white axis than is the spectral locus."

My second example seems particularly appropriate in this connection. In Section 1.5.3, I explained Hering's struggle to achieve a neutral determination of particulars. He gets to an epistemological zero point where particular colours are just given. It follows, then, that he can only proceed by naming. However, he seems to think that grouping different particulars under the same common name is to conceptualize them.

> If we designate the latter, namely red, yellow, green, blue, and their intermediates, that is, all colours of definite hue (…) as chromatic ([…) or hued (…) colours, but white and black with their grey intermediates as achromatic or hueless colours, then we could dispense here with the word "sensation" and subsume all qualities of the visual sense under the one word "colour". (Hering, 1964, p. 4)

What Hering really does is to list the names of the particulars he is considering before calling the first group colours of definite hue. Thereafter he changes this common name into adjectival terms like chromatic or hued, as if he had observed some property each particular shared, in addition to being different from each other. But if such a property were observable it could be defined. Hering, however, provides no definition.

Hering does not follow the same procedure when he deals with black-grey-white. Instead he applies some negative characteristics to the series. For example, he says they lack the property the particulars in the other group share, and he says they are hueless or achromatic. So, in this case he does not even claim that particulars in the black-grey-white series have a common property, which to me means the only reason

they are grouped together is because they are different from the so-called chromatic particulars.

However, all particulars in both groups are different, and my point is that observation of mere differences does not yield concepts other than difference and degrees of difference. Therefore, in this connection, Hering's way of grouping particular colours into chromatic and achromatic seems to be a normative procedure which is naming.

By this I do not deny that to define for example orange as a compound of red and yellow is conceptual. To say that some or all colours are heterogeneous is exactly to conceptualize them.

2.4 Betweenness

In this section I first (2.4.1) explain Johnson's term *betweenness*. Sanford has objected to this term, and I discuss his objection, shedding light in the process on certain constraints with concern to its application. Then, in 2.4.2, I discuss betweenness in relation to the first part of the problem considered in this present thesis.

2.4.1 Johnson's term betweenness and Sanford's objection

In order to explain how colours can be ordered, Johnson uses the term adjectival betweenness.

> A second characteristic of many determinates under the same determinable is that the differences between different pairs of determinates can be compared with one another; so that if *a, b, c,* are three determinates, there are cases in which we may say that the difference between a and c is greater than that between a and b; e.g. the difference between red and yellow is greater than that between red and orange. In this case the several determinates are to be conceived as necessarily assuming a certain serial order, which develops from the idea of what may be called 'adjectival betweenness.' The term 'between' is used here in a familiar metaphorical sense derived from spatial relations, and is figuratively imaged most naturally in spatial form. Thus if b is qualitatively between a and c, and c qualitatively between b and d, and so on, the whole series has its order directly determined by the nature of the adjectives themselves. (Johnson, 1921, pp. 181-182)

Here is an example.

r is more different from r than from r

But it can also, in accordance with Johnson, be expressed in this way.

r is between r and r

However, as Johnson says in the above quotation, the difference relation is figuratively imaged most naturally in the spatial form of: r r r

In Johnson's formula, it seems to be implicit that the difference between a, b, on the one hand, and the difference between b, c, on the other, constitutes a qualitative connection between a, c, independent of spatial arrangement.[14]

It seems also to be the case that truth and falsity are grasped intuitively in such cases, according to Johnson.

Johnson's three-place relation can be predicated truly or falsely on some given determinates or particulars: It is true to say that r is between r and r while it is false to say that r is between r and r.

Sanford's interpretation of Johnson's betweenness seems to be this: If any two colours are more different than one of them is from a third colour then the latter is between the two former.

Sanford makes this objection to Johnson.

> The three-place relation (*Dabc*) *the difference between a and c is greater than that between a and b,* however, does not by itself provide an adequate definition of 'between'. […] For example, the difference (or distance) between red and yellow is greater than the distance between red and purplish red, but purplish red is not between red and yellow. (Sanford, 2006, pp. 5-6)

But Sanford only clarifies the difference between two pairs in the three-place relation; he says nothing about the difference between purplish red and yellow. The greatest difference in his example is that between those colours, which means his example is confusing. According to Johnson a, c is a sign for greatest difference.

To further support my objection to Sanford, I instantiate three determinates.

r r r

Call these colours a, b, c (respectively, yellow, red, purplish red).

Viewed like this Sanford's example does not seem to work as a counter example to Johnson's Dabc relation, at least it does not function very well. It may perhaps be true that the difference between yellow and red is greater than the difference between red and purplish red, just as Sanford postulates, but the fact also seems to be that the difference between yellow and purplish red is greater than the difference between

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[14] My point is that determinates under other determinables manifest the Dabc relation in time. It is true that colours manifest the same relation also in spatial arrays but this is not essential for colours. As I wrote in Section 1.2: "It is estimated that nine to ten million different colours may be experienced. (Gerritsen, 1975, p. 68; Hardin, 1988, p. 88.) Using a computer, they can all, in principle, be named, each and every one, by giving them numbers. (Goto, 1998, 143.) This being so, it should be possible to type one of the names on the keyboard so that the named colour appears on the monitor screen, one after another, the names being 1, 2, 3, 4 etc." That is, both colours and, for example, pitches manifest betweenness in time: now, before and after.

yellow and red, which is, at the outset, the crux of the matter in Johnson's concept betweenness.

However, in accordance with Johnson, there are a few complications to address in this connection. The first is that betweenness cannot be predicated of all observed three-place relations.

In the quotation that introduces this section, Johnson makes a restriction: "there are cases in which we might say that the difference between a and c is greater than that between a and b." This I take to mean that there are cases in which it is not meaningful to predicate betweenness.

Hence, if I have understood Johnson correctly on this point, there should be cases in which a three-place relation manifests only difference. Johnson seems to exemplify with red, green and yellow. "What is most prominently notable about red, green and yellow is that they are different, and even, as we may say, opponent to one another." (Johnson, 1921 p. 175.)

An enlightening question in connection with this example is: which colour is between which of yellow, green, red? Indeed, it doesn't seem possible to detect the Dabc relationship at all.

This means that in Sanford's example there are two instances of colours being just different; the difference between yellow and red, and the difference between yellow and purplish yellow.

What is more, Sanford seems to identify greater or smaller differences with countable steps between any pair of determinates. He seems to think that the series between yellow and red contains more steps than the series between red and purplish red. But he does not mention anything about how these steps are constituted, though most likely they are based on Johnson's betweenness. As Johnson explains in the first quotation of this present section: "Thus if b is qualitatively between a and c, and c qualitatively between b and d, and so on, the whole series has its order directly determined by the nature of the adjectives themselves."

The reason for my guess about Sanford is that he explicitly connects difference degrees with geometrical distance.

> A diagram helps us to illustrate this point. Assume for the purpose of diagramming that *the difference between a and c* specifies a certain distance in quality space. A circle with centre *a* and radius *ac* represents points in the space at distance *ac* from point *a*. Any distance between point *a* and any point *b* within this circle is less than the distance between *a* and *c*. A point *b* within this circle represents *Dabc*. (Sanford, 2006, pp. 5)

Sanford's identification of difference degrees with distance is not well grounded in Johnson's outlines because Johnson's term betweenness concerns quality relations in general, i.e., the same relation occurs between sounds, smells, etc., in where geometrical distance is absent. "In fact, whatever sensational determinable we take, whether it be colour, or sound, or smell, the determinate characterisations under any such determinable would lead to the same forms of generalisation." (Johnson, 1921, p. 185)

Betweenness must in any case be manifested factually, not just exemplified with distance, as Sanford does. I admit that it is a special case with colours, but Sanford's geometrical figure and lines tell us nothing about connections between determinates unless he can point to which determinates he is considering. If it were not for his concrete example of yellow, red, purplish red, his circle scheme with the radius and a line from the centre to point b within the circle, would tell his readers nothing.

However, there is another aspect to Sanford's concrete example that must be addressed. In most hue circles, connections between yellow, red, purplish red, are pictured somewhat like this: Between yellow and red there are different instances of orange and between red and purplish red there are different instances of purplish red, and the steps are fewer in the latter compared to the former case.

Based on ordinary colour circles the claim that yellow is more different from red than red is from purplish red seems to be justified simply by counting the number of steps between each pair.

But such a conception of degrees of difference leads inevitably to inconsistencies or plain contradictions. The initial observation is that between red and purplish red there is no yellow. But if you, now, continue the steps further, from purplish red to blue, and from blue to green, and then again from green to yellow, you are back at the starting point, namely yellow. And if distance according to the number of steps could be identified with betweenness, just as Sanford seems to suggest, it appears that yellow is between red and purplish red after all. That is, between red and purplish red there is no yellow and between the same determinates there is yellow.

Another example that shows the same: A certain w-yellow and white are minutely different and so are a certain w-blue and white. So, the Dabc relation is established, and the difference between w-yellow and w-blue is two steps greater than that between w-yellow and white, and therefore white is between w-yellow and w-blue.

However, there are numerous hues that are minutely different from white, and these can be ordered according to the Dabc relation so as to obtain, say, two hundred steps between the actual w-yellow and w-blue in each direction in a circular array.[15] The question therefore has to be asked: is the difference degree between w-yellow and w-blue two steps or two hundred steps?

Johnson shows that this is not a rhetorical question without an answer. His answer is precisely, or seems to be, that difference degrees given as regular difference steps can only partially be used as a measure, because between three colours like yellow, green, red, there is only difference and no betweenness.

Again, Johnson insists on degrees of difference between determinates, but without mentioning identity as a limiting case in such serial orders. Instead, he suggests infinite discernibility among determinates, that is, in Johnson's conception, betweenness may be established in an endless array. He says, "It follows from this

[15] This possibility can perhaps be realized in print in accordance with NCS, which Seim introduces. "In the following we name the elementary hues Red R, Yellow J […], Green G and Blue B. […]. In the Natural Colour System (NCS), 100 steps are used between two elementary hues. (Seim, 2009, text under Figure 1b)

account of continuity that, between any two determinates which may be said to have a finite adjectival difference, may be interpolated an indefinite number of determinatives having a finite difference, and this number becomes infinite as the differences become infinitesimal." (Johnson, 1921, p. 183) I address Johnson's suggestion in Chapter IV.

2.4.2 The Dabc relation and colour's heterogeneity

Since determinates according to Johnson are given, any manifestation of the Dabc relation is to be grasped intuitively. A certain manifestation cannot, therefore, say anything about colour's heterogeneity or homogeneity. Even if orange is between yellow and red, nothing more is given, an implication that orange is a mix of yellow and red cannot be drawn. Neither is the contrary granted.

That is, the Dabc relation is a characterization when applied to some three colours, but the characterization does not involve or imply other characterizations or predicates, such as, for example, mix or compound.

On the other hand, Johnson does not seem to exclude compound colours. When he accentuates or underscores that red, green and yellow are just different, he also adds that they are primary.

> What is most prominently notable about red, green and yellow is that they are different, and even, as we may say, opponent to one another; is there any (secondary) adjective which analysis would reveal as characterising all these different (primary) adjectives? (Johnson, 1921 p. 175)

That is, it may seem as if Johnson does permit some colours to be heterogeneous, but not the primary ones. However, Johnson does not discuss this subject explicitly.

However, my point is that Dabc cannot justify any claim that colours are heterogeneous. It does not follow from the Dabc relation orange, red, purplish red,

that red is a compound of its neighbours: r r r

Hence, nor does it follow from this relation r r r that orange is a compound or mix of yellow and red.

It is clear to me that it leads to a contradiction if one takes the Dabc relation to prove a betweenness colour is a compound of its neighbours. If the latter colour example were to prove that orange contains red, but red does not contain orange, then the former example should prove that red contains orange, and that these contentions contradict each other.

Another point worth noting is that one determinate or particular can occur between lots of different colour pairs, like white in the circle example above. However, also red is between several pairs of particulars. For example, it is between whitish red and blackish red, and also between greyish red and brownish red, etc. The same is the case for orange, which is between whitish orange and blackish orange, and also between greyish orange and brownish orange, etc. If betweenness were used to distinguish

homogeneous from heterogeneous colours, the result would be contradiction upon contradiction.

Therefore, in order to classify some colours as heterogeneous one has to submit arguments independent of Dabc. Dabc only tells us that three colours are different to a certain degree. It does, by the way, neither tell anything about homogeneity.

A last point in this connection: It seems to me that the Dabc relation could replace descriptions of colours that involve hue, saturation and brightness. The Committee on Colorimetry suggest this definition of pink; "For instance, a typical pink is a red of low saturation and high brightness." (1953, p. 101) Here, red is substantive and saturation and brightness are characteristics. But such a definition implies heterogeneity of colours; see my argumentation in Section 1 above. If the thesis on colours' heterogeneity is rejected, a fairly good compensation, it seems to me, could be made by saying that on a scale from red to white, pink is more like white than red.

2.5 Do black, grey and white belong to colour understood as a determinable?

Betweenness, according to Johnson, is the glue that holds determinates together and discerns determinables from each other, that is, sounds from colours, colours from feelings, feelings from sounds, etc.

> *Difference* when applied to adjectives under the *same* determinable has a certain meaning which is distinct from any meaning of difference applicable to substantives or to adjectives under one and another determinable. As regards the latter, difference can only mean mere otherness; but as regards the former, difference may mean more than mere otherness; viz. something that can be measured as greater or smaller. (Johnson, 1921 p. 192)

Since a three-place relation is not dependent on the relata that constitute it, it follows that Dabc is the same for determinates under every determinable. For example, there can be no relational difference between, on the one hand, notes d, e, f, and, on the other, orange, red, purplish red, because both relations manifest Dabc.

Dabc does not manifest any additional characteristic which can be revealed by analysing determinates under each determinable. When some three determinates manifest betweenness, it is always a matter of degrees of difference, i.e. greater or smaller, but such quantification is common for determinates under any determinable and not peculiar to them.

Johnson underscores his point .

> What is here true of colour is true of shape, pitch, feeling, tone, pressure, and so on: the ground for grouping determinates under one and the same determinable is not any partial agreement between them that could be revealed by analysis, but the unique and peculiar kind of difference that subsists between the several determinates under the same determinable, and which does not subsist between any one of them and an adjective under some other determinable. (Johnson, 1921, p. 176)

On the same page he adds, "in fact, the several colours are put into the same group and given the same name colour, not on the ground of any partial agreement, but on

the ground the special kind of difference which distinguishes one colour from another."

It is apparent then that Johnson's determinable is a common name that refers to determinates, i.e. particulars. See in this connection Section 2.3 above.

Any naming performance must start with observed determinates. But naming is anarchistic in the sense that it also allows you to group determinates from different determinables like, for example, red, warm and sweet, by calling each of them by the common name X.

On the other hand, Johnson's Dabc can be used as criterion in order to tell which determinable each of the three determinates belongs to: red belongs to colour, warm belongs to feeling, and sweet belongs to taste. And, as I understand it, "belonging to," understood in connection with determinables, means exactly being a member of this or that serial order.

I think Johnson's assumption must be that determinates under one determinable are parts of one serial system, and that in order to decide if one determinate belongs to this or that determinable you must check if it hangs together with some other determinates in a natural order.

This means it is a matter of experience which determinates hang together. For example, you observe that sweet is not between any pair of colours and therefore it cannot belong to colour.

So, if you ask if black, grey, white belong to colour you can decide the matter by pointing to some serial order in which betweenness is instantiated. As I have argued in the previous section, white can be between a lot of so-called hues. And it is obvious the same goes for black and grey. Also, remember the colour triangle described in Section 2.3 above; it is a manifest demonstration and can be carried out not only with red, but with all hues, which shows that any hue may be linked to black, grey and white in natural series. Hence, the answer to the question is yes; black, grey and white belong to colour, that is, they can legitimately be named colours because they join in the natural series which earlier has been named colours.

2.6 Concepts vs. determinables

In Section 2.6.1 I explore the difference between geometrical shapes and colours. Shapes are definable in taxonomies but colours are not. Furthermore, I discuss Sanford's reading of Johnson, i.e., "that a determinable-determinate relation does not require the impossibility of a conjunctive definition." (Sanford, 2006, p. 4)

In Section 2.6.2 I explicate Hering's attempt to unify geometrical entities with each other and question his suggestions by a *reductio ad absurdum* argumentation.

Thereafter, in Section 2.6.3, I explain the attempts of colour theorists Kandinsky and Itten to unify shape and colour, and point to the fact that in so doing they have to forget all about definitions of shapes.

Lastly, in Section 2.6.4, I discuss some of Rosch's findings concerning natural categories with respect to colours and shapes. The focus is on prototypes within taxonomies.

2.6.1 Shape vs. colour

In taxonomies, a class name is defined, i.e. the name has connotation. But Johnson's determinable, colour, cannot have connotation.[16] Particular colours or determinates under colour are identified by observation of differences and given proper names. As Johnson says, "it seems legitimate or possible to define a proper name as a name which *means* the same as what it *factually indicates*." (Johnson, 1921, p. 93) And he adds,

> the proper name (…) is non-connotative, this does not amount to saying that the proper name is non-significant or has no meaning; rather we find, negatively, that the proper name does not mean the same as anything that could be *meant* by a descriptive or connotative phrase; and positively, that it does precisely mean what could be indicated by some appropriate descriptive phrase. (Johnson, 1921, p. 96)

As I understand Johnson, every determinate, be it a substantive proper or an adjective (i.e. a property), can be given a proper name. Taxonomical conceptual engineering starts after the name giving procedure. In some cases, as with colours, no concepts can be achieved; but in the case of shapes concepts might be developed because of part identity. Take as an example the now familiar three r's.

r r r

These r's can be named according to the procedure explicated in Section 2.3 above. In such a procedure one has to abstract, i.e. not taking into consideration extension, figure or place.

But the r's can also be defined according to figure or shape, and then of course one has to abstract or look away from the differences in colour and position.

That is, each r can be given a connotation or defined according to figure. Now, it is perhaps difficult to precisely define the figure of r since it consists of both rectilinear and curved lines. Other figures or shapes consist of either rectilinear or curved lines, for example these two:

[16] Carnap, it seems, is of another opinion. See in this connection his explanation of type theory in Section 2.1 above. "Let us take for example bodies to be individuals; then 'square' and 'red' are properties of the first level; 'spatial property' and 'colour' are properties of the second level." (Carnap, (1) 1959) If colour is to be understood as a predicate or a property at a second level, it ought to have a definition; Carnap, however, does not furnish one. Dancy seems to mean the terms red and colour both have connotation. He uses the sentence "Red is a colour" as example of expressing a truth that can be known, so to say, a priory just like 2+3 = 5 is known. (Dancy, 1985, p. 213) But Dancy does not furnish a definition either of colour, or of red.

This means you can carry out a classification of the objects that you in the first instance pointed to with a common name. Obviously, you can divide these shapes or figures into three classes, namely rectilinear, curved and a combination of both.

In classical geometry, shapes or figures are taken to be real things and ordered according to genus-species definitions. Euclid defines figure or shape as that which is contained by any boundary or boundaries. This is a summum genus. Euclid says rectilinear is a subclass or species under figure. Furthermore, according to his definitions, quadrilateral is a species of rectilinear. Both square and rectangle belong to quadrilateral figures, i.e. they are species of that category, because square is defined as a right-angled equilateral, while rectangle is defined as a right-angled but not equilateral. (Euclid, 1991, pp. 439-441, definitions 14 and 22)

As I have shown, Johnson does not find any property among determinates under colour that can be used to classify them. Hence, his term colour must be a common name. This result, Johnson remarks, is a special case in which determinates are considered fundamentum divisionis.

> Now although, grammatically speaking, words like colour and size are substantival, they are in fact abstract names which stands for adjectives; so that the fundamentum divisionis is, in the first place, an adjective, and in the second, an adjective of the particular kind illustrated by "colour" when considered in its relation to red, blue, green, etc. Superficially this relation appears to be the same as that of a single object to some class of which it is a member: thus two such propositions as "Red is a colour" and "Plato is a man" appear to be identical in form; in both, the subject appears as definite and singular, and in both, the notion of a class to which these singular subjects are referred appears to be involved. Our immediate purpose is to admit the analogy, but to emphasise the differences between these two kinds of propositions, in which common logic would have said we refer a certain object to a class. (Johnson, 1921, pp. 173-174)

Sanford takes Johnson to mean that when genus-species definitions are impossible, only then does one need to establish a determinable-determinate relation. However, this is a division to which Johnson only gives "equivocal support" according to Sanford. (Sanford, 2006, p. 4)

Sanford says this is because, in Johnson's explanation, colour does not seem to be a paradigmatic example of determinables. Sanford points to the fact that Johnson also includes definitions of the genus-species kind. Sanford quotes from Johnson's *Logic*, 1921, p. 174: "I propose to call such terms as colour and shape determinables in

relation to such terms as red and circular which will be called determinates."[17] This makes Sanford conclude:

> So circular is a determinate of the determinable shape despite the existence of a proper definition that distinguishes circles from other shapes. Different shapes are incompatible and are therefore under the same determinable. Being related by incompatibility (in the right way) appears to be necessary and sufficient for items to be determinates under a single determinable. Some determinates such as red cannot be differentiated by a traditional, conjunctive genus-species definition. Others such as square and circular can be so differentiated. Johnson's example of shape shows that a determinable-determinate relation does not require the impossibility of a conjunctive definition. (Sanford, 2006, p. 4)

According to Sanford's reading of Johnson, a necessary and sufficient condition for being a determinable is that it's determinates are "related by incompatibility in the right way". But this suggestion seems to me utterly mysterious and in article Sanford provides no satisfying explanation.

In my opinion it is much more probable that Johnson simply has made a mistake in contending that both colour and shape are determinables. Anyway, it is inconsistent in my view to characterize both colour and shape as determinables. The former is a determinable and the latter is a summum genus in taxonomy, as I explained above.

2.6.2 Hering's inclined line

Hering tries to defend his heterogeneity thesis on colours by his line-angle example.

> Of course every given neutral grey has its own quality and is neither white nor black; however, here this issue is only one of different degrees of *similarity* with purest *black* on the one hand and purest *white* on the other. In the same way, if one imagines any number of straight lines passing through a point in a vertical plane, one can also say that the direction of a straight line deviating about 20 degrees from the vertical is more similar to the vertical direction than to the horizontal, and the direction of a line inclined about 45 degrees is just as similar to or deviates just as much from the horizontal as the vertical, it has just as much of the character of one as of the other, just as much horizontality as verticality. To object that a direction cannot be simultaneously vertical and horizontal, that it is always unitary, and not composed of two directions, would be just as irrelevant as to object that grey cannot be simultaneously white and black and that it is a simple and not a compound sensation. (Hering, 1964, p. 32)

First of all, I must remark that Hering's argument apparently is circular. He first supports his thesis that grey is a compound of black and white by way of his example of the inclined line: If the inclined line is heterogeneous, then the same might be the case with colour. Then he defends his contention of the inclined line, i.e., that it is both vertical and horizontal, by contending that it is ridiculous to deny that grey is a compound of black and white.

Even though Hering does not refer to sense experience, his readers might very well think they have strong evidence to agree with Hering in his contention about grey. The heterogeneity thesis concerning grey has very strong empirical support. From

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[17] Johnson also says, "What is here true of colour is true of shape, pitch, feeling, tone, pressure, and so on." (1921, p.176) That is, shape is taken to be a determinable along with colour.

childhood, human beings are confronted with colour mixing in various materials, and that when white and black are mixed, grey appears.

However, what is interesting is Hering's attempt to bring heterogeneity into geometrical entities. Now, if the inclined line should be both vertical and horizontal because it deviates from both directions it follows the same would be the case of an equally inclined line on the other side of the vertical line. This being the case, the vertical line is the deviating line between two vertical-horizontal lines, which means, in conformity with Hering's kind of reasoning, that the vertical line unites both, i.e. it is vertical and horizontal at the same time.

But this argument is a *reductio ad absurdum*. Hering's suggestion implies another absurdity of the same sort. The vertical line is perpendicular to the horizontal line. It follows, still in conformity with Hering's logic, that the vertical is horizontal-horizontal. The vertical is now, namely, the deviating line in relation to the two horizontal lines.

Hering's example also brings allusions to Johnson's Dabc relation. The vertical is more different from the horizontal than it is from the inclined line.

But betweenness cannot be about the lines. The lines in Hering's example are, namely, all partly identical because they are straight. Betweenness occurs only when three different relata are considered.

On the other hand, Hering mentions a 20-degree inclination, and maybe it is the angle between the vertical line and the inclined line he is referring to. I am not saying that Hering talks about angles explicitly; however, since he mentions angles in his example I am curious to find out where that mention of angles may lead if examined.

20-degree is a measure of one part of the circumference. So, if the Dabc relation were to function in this connection the contention would be that the difference between the 90-degree and the 20-degree angles is greater than the difference between the 20-degree and the remaining 70-degree angles. However, it would then be absurd to conclude that the 20-degree angle is a compound of the 90-degree and the 70-degree angles.

Therefore, there is only the loose or indeterminate term direction that might be of some support to Hering's argument. It is usual in daily life to say that a direction is a mix of two opposite directions. For example, one frequently says about the wind that it is coming from the northeast.

However, the support such examples give to Hering's heterogeneity thesis on geometrical entities is too weak. And therefore, since the heterogeneity of such entities need to support the heterogeneity thesis of colours, the latter is not strengthened at all.

2.6.3 Colour and shape united – form colourism

Kandinsky and Itten, both of whom were teachers at Bauhaus in Germany, exerted a strong influence on the development of abstraction in the fine arts. Unification of

shape and colour was one of their endeavours. This project goes in two steps. First Kandinsky points out which figures primary colours have and then Itten explicates the consequences with respect to the figures secondary colours have.

Kandinsky, 1979, p. 74, provides no geometrical definitions at all, and gives only emotional associative reasons for uniting yellow with triangle, red with square, and blue with circle.

Yellow has an essentially triangular form, according to Kandinsky, even if the colour may unify with other geometrical figures as he admits. Red is likewise essentially square and blue essentially circular.

Furthermore, yellow, red, and blue in Kandinsky's pigment colour mixing system are primary colours, while orange, green, and violet are secondary colours, that is, compounds of respectively yellow and red, yellow and blue, and red and blue.

Now, from Kandinsky's initial unification, Itten (1995, pp 75-76) developed a somewhat extended theory. The logic is: since violet is a compound of red and blue, and red unites with square and blue unites with circle, then it follows violet unites with ellipse.

Furthermore, since yellow unites with triangle, and orange is a mix of red and yellow, and red unites with square, it follows that orange unites with a trapezium.

Lastly, since the mix of yellow (triangle) with blue (circle) is green, it follows that green is united with a triangle and made of curved, convex lines.

Itten's underlying presupposition seems to be, just as it is for Hering, that forms unite: an ellipse is both a square and a circle.

But for this to work one has to neglect the definitions of circle, square and ellipse. If definitions are involved, such unification would be contradictory. It is, for example, impossible to unite the definitions of square and circle. One obvious reason is that curved and straight lines cannot unite. A circle is a curved line and a square contains, according to Euclid, only four straight lines. Besides, an ellipse, just as a circle, does not contain any straight lines at all.

It therefore seems to me that use of the Dabc relation is involved in Itten's outlines. A circle differs more from a square than from an ellipse; therefore, ellipse is between circle and square.

Even if this is granted it does not follow from such a relation that an ellipse is a compound of circle and square. Betweenness does not say or imply anything about compounds. See in this connection Section 2.4, last part.

2.6.4 Colours as natural prototypes

In her article on the Dani, Rosch finds a discrepancy in the research subjects' abilities to point out good exemplars or prototypes within the domains of colour and form

(shape). However, Rosch does not unite shape and colour;[18] the domains are explored separately. My guess is that the discrepancy may be explained by the fact that while colours cannot be ordered in a taxonomical hierarchy, shapes can.

According to Rosch, strict genus-species definitions are lacking in daily life perceptions.

In her article *Natural Categories* (1973, p. 328), Rosch explains both the method and the results of an inquiry on how a Stone Age tribe, the Dani of Indonesian New Guinea, learned new colour names. They had only two colour names from before, i.e. black and white. "The hypothesis of the study was that the domains of colour and form are structured into non-arbitrary, semantic categories which develop around perceptually salient 'natural prototypes'."

One of Rosch's observations is that the Dani "were unwilling to designate one of the colour chips as the most typical member of the three-chip category." (1973, p. 340). As I understand her description a three-chip category can be illustrated as the one presented in Section 2.6.1, namely

r r r

The following is speculation: Why Rosch calls the three colours a category in her article seems be grounded in an assumption that all three chips have red as a property; however, another of her presuppositions in the inquiry seems to be that the r in the middle is the most typical, that is, an exemplar of a perceptually salient natural prototype and maybe this is the reason she expected the Dani to point it out as such.

Rosch refers to Berlin and Kay's evolutionary theory of cultures to develop colour names in language. Given that Hård, 1996, p. 19, and Hardin both refer to Berlin and Kay's investigation, I shall quote Hardin on the general tendencies:

> All languages contain terms for white and black.
> If a language contains three terms, then it contains a term for red.
> If a language contains four terms, then it contains a term for either green or yellow (but not both).
> If a language contains five terms, then it contains a term for both green and yellow.
> If a language contains six terms then it contains a term for blue.
> If a language contains seven terms, then it contains a term for brown.
> If a language contains eight or more terms, then it contains a term for purple, pink, orange, grey, or some combinations of these. (Hardin: 1998, pp. 165 – 166.)

Both Hård and Hardin take this scheme to show that NCS's unique colours are in fact the first six basic colour terms to enter language, providing, to their mind, crucial support to the validity of the theory of unique colours.

Rosch (1973, p. 340) expected to find a somewhat similar learning curve among the Dani, but was disappointed. "The order of difficulty for learning colour categories in the present study was: red, green, pink, blue, purple, yellow, brown, orange. The rank

[18] If she had, it would be, according to my knowledge, the first time Kandinsky/Itten's theory on colour and form unification was tested in a proper enquiry.

order correlation of this order with the specific order proposed by Berlin and Kay did not reach significance."

Rosch says about this mismatch:

> Of course, the above is not evidence against Berlin and Key's proposed evolutionary order; there need be no simple relation between order of individual acquisition of terms and linguistic evolution. The present study only represents a case in which a possible evolutionary order could have been, but was not, reflected on the level of individual learning. (Rosch, 1973, p. 341)

In spite of the mismatch she contends that her study gives support to Hering's four basic or primary hues (i.e., Hardin's unique hues), being natural prototypes, on the ground that the "Dani could learn the presumed natural prototypes of colour categories and sets in which those stimuli were central faster than they learned other stimuli or sets organized around other areas of the colour space."

Towards the end of her article (1973, pp. 348-49) she underscores how her conclusion is "now supported by physiological evidence of opponent colour cells in the primate lateral geniculate", that is, the theory initiated by Hering.

However, this last point seems to me to inverse the direction for supporting evidence. The Norwegian writers on cognitive psychology, Lundh, Montgomery and Waern (1996, p. 60), hold that the methodological principle within cognitive psychology is that the empirical evidence of how people perceive colours should support a general hypothesis whereby these perceptions have common neurophysiological causes.

This is the strategy that both Hering and Hardin find compelling, see in this connection section 1.5. Hering says,

> What we want is to classify the great multiplicity of colours to get a systematic perspective of them, and designations for them such that the reader is given a comprehensible expression as precise as possible for every colour, so that he can mentally reproduce any colour with some degree of exactness. To do this we must at first disregard altogether the causes and conditions of their arousal. For a systematic grouping of colours, the only thing that matters is *colour* itself. (1964, p. 25)

> Moreover, I shall later propose that, corresponding to the four hue variables I have assumed, there are four physiological variables. This proposal will then answer the objections to my view on the part of those who want to order colours not according to their own properties, but on the basis of correlated physiological processes. (1964, p. 48)

Hardin adheres to Hering's methodology: "The hues are qualities with which we are acquainted. One can succeed in the task of identifying the hues with some physical structures only if that structure captures the essential features of the hues as these are displayed to us in experience." (Hardin, 1988, p. 66.)

In her article *Principles of Categorization* (1988), Rosch gives a more general description and explanation of categorization according to prototypes. Prototypes are within taxonomies the members of those classes that have the most representative value of all members of the class.

For example, on page 315, she says the main category Furniture is too extensive or too abstract to point to an exemplar that represents its members by imagery; however,

subclasses such as chair, table and lamp may be substituted for an image that represents the members of the subclass. Such subclasses are basic she says. They represent the subordinates, that is, subclasses at the basic level, respectively kitchen chair and living-room chair, kitchen table and dining room table, floor lamp and desk lamp. These are too specific to inform all the members of a class by imagery.

It turns out that prototypes are found at a level that "provides maximum information with the least cognitive effort". (Rosch, 1988, p. 312)

On the one hand, as I see it, one can easily define for example chair by its function. This means that in Rosch's example, the prototype may be a combination of conceptualization and imagery. On the other hand, it could be either.

Now, it seems to me, that in her inquiry on the Dani, Rosch treats colours in the same way. For Rosch, it seems to be that colour names have connotations. She talks about the concepts of "red" and "square" as if both were categories. (Rosch, 1973, p. 328) On the next page she says, "some stimuli are better exemplars of the concept than others", and for colours she exemplifies with "a good red vs. an 'off' red".

I suspect that Rosch thinks of red as a subclass of the main category *colour* and that a specific red is representative of subclasses like, for example, off red. Strand (2008, p. 106) has a similar suggestion "the property of being red relates to the property of being scarlet". That is, red is taken to be both a representative colour and the name for a class definition.

In her Dani inquiry Rosch tells that "Although Dani Ss (subjects, my comment) had been unable to pick a most typical example of the colour categories, they easily made this judgement in the case of the forms." (Rosch, 1973, p. 346)

I speculate: may be the reason is that the Dani subjects combined forms or shapes with tentative definitions of circle, square and triangle, and surely, they are easier to define than the irregular shapes that were also presented to them.

Anyway, it seems to me that the difference between the form experiment and the colour experiment may be a conceptual component in the former that is lacking in the latter.

My main objection to Rosch is that she seems to confuse colour names with taxonomic classes. She does not discuss whether this is possible, which persuades me that she is not critical enough with respect to her own framework in the inquiry.

There is also another objection to Rosch that can be supported by the Hering tradition itself. There are good grounds, in Rosch's opinion, why yellow, red, blue, green can be said to be representative of other hues. However, both Hardin (1988, p. 66) and Valberg characterize these hues as neither-nor colours. Consider what Valberg says in his article on *The Enigma of Unique Hues*:

> Unique yellow is characterized by being "neither reddish nor greenish". It is thus determined purely subjectively by means of the two closest unique hues on the hue circle. Unique blue satisfies the same definition. (Valberg, 1998, p. 110.)

But this may mean that unique colours cannot represent other colours, because they have no likeness to them, as the contention goes. Smedal, a prominent Norwegian advocate of the Swedish Natural Colour System (NCS), says, in my translation, "An elementary colour is per definition a colour that only looks like itself." (Smedal, 1996, p. 36)

At the very least, this should make Rosch less convinced that Hering's primary colours can serve as prototypes.

Hardin takes Rosch's report on the Dani as confirmation that neither-nor colours in NCS are easy to learn. (Hardin, 1988, pp. 117 and 168) However, he does not embrace Rosch in her claim that those colours are representative to the extent that they form a natural category. I cannot see that he mentions her notion of natural categories at all.

On the other hand, Rosch's finding that Dani do not see unique vs. binary hues is a challenge to both Hering and Hardin. According to them, ordinary people are naturally aware of the divide. See in this connection Sections 1.5.5 and 1.5.8 above. I find reason to quote Hardin once again, because it is apparent the Dani were not in the necessity mode Hardin insists on.

> But hues do have certain characteristics necessarily. This is a central truth, no less true for having been so frequently overlooked. If we reflect upon what it is to be red, we readily see that it is *possible* for there to be a red that is unique, i.e., neither yellowish nor bluish. It is equally apparent that it is *impossible* for there to be a unique orange, one that is neither reddish nor yellowish. Since there are necessary properties of hues, nothing can be a hue without having the appropriate properties necessarily. (Hardin, 1988, p. 66.)

In Chapter III, I discuss in detail the claim that NCS is a Natural Colour System and what "natural" may mean in this connection. But clearly, Rosch's natural categories are not actual issues in NCS of which Hering is a forerunner and Hardin a defender.

2.7 Universals

Terms like redness, whiteness, etc., frequently appear in philosophical texts about colours. In some cases, these terms are explicitly considered conceptual, i.e. the claim being that connotations are involved.

Russell, for example, holds whiteness as a universal and explains universals as things that exist in and of themselves, like Platonic ideas, which people can think of, or be acquainted with, but which are not acts of thought. "Awareness of universals I called *conceiving*, and a universal of which we are aware is called a *concept*." (Russell, Chapter V, URL 2015)[19]

I assume it is common knowledge among scholars that Plato holds, for example, that mathematical ideas are universals in somewhat this sense. It should also be common

[19] I refer to Russell's Philosophical Problems; however, the URL text is not paginated.

knowledge that Plato excludes colours from the universals because colours are products of the senses and sense is material and not ideal.

However, in opposition to Plato, Russell tells that also whiteness is a universal.

> Hence, if the ambiguity is not guarded against, we may come to think that whiteness is an idea in the other sense, i.e. an act of thought; and thus we come to think that whiteness is mental. But in so thinking, we rob it of its essential quality of universality. One man's act of thought is necessarily a different thing from the same man's act of thought at another time. Hence, if whiteness were the thought as opposed to its object, no two different men could think of it and no one man could think of it twice. That which many different thoughts of whiteness have in common is their *object*, and this object is different from all of them. Thus universals are not thoughts, though when known they are the objects of thoughts. (Russell, Chapter IX, URL 2015)

In the same paragraph Russell says of whiteness, "If we believe that there is such a universal, we shall say that things are white because they have the quality of whiteness." This means, so it seems, that particular whites are conceived by the concept – at least I find this interpretation appropriate.

From Russell's explanation it follows that whiteness is not something that can be conceived of by contemplating particular whites. The universal may in fact be grasped without any perception of any white. However, when it is grasped and you meet with some particulars, you understand them according to the concept.

But Russell gives no justification: if whiteness is a concept it should be explicable according to a definition, but he provides no definition.

2.8 Perception and conceptualization

Russell contrasts his explication of universals with Berkeley's theory of ideas. It seems that the latter to Russell implies an extreme kind of nominalism, i.e., a denial of the existence of universals; only particulars exist and the only means to cope with them is to name them. Russell takes Berkeley to mean particular ideas can be either sense impressions or memories.

> In order to understand his argument, it is necessary to understand his use of the word 'idea'. He gives the name 'idea' to anything which is *immediately* known, as, for example, sense data are known. Thus a particular colour which we see is an idea; so is a voice which we hear, and so on. But the term is not wholly confined to sense data. There will also be things remembered or imagined, for which such things also we have immediate acquaintance at the moment of remembering or imagining. All such immediate data he calls 'ideas'. (Russell, Chapter VI, URL 2015)

However, Berkeley does not say definitions are impossible. In the introduction to Principles he says,

> To which I answer, that though the idea I have in view whilst I make the demonstration, be, for instance, that of an isosceles rectangular triangle, whose sides are of a determinate length, I may nevertheless be certain it extends to all other rectilinear triangles, of what sort or bigness soever. And that, because neither the right angle, nor the equality, nor determinate length of the sides, are at all concerned in the demonstration. It is true, the diagram I have in view includes all these particulars, but then there is not the least mention made of them in the proof of the proposition.[…] And here it must be acknowledged that a man may consider a

> figure merely as triangular, without attending to the particular qualities of the angles, or relations of the sides. So far he may abstract. (Berkeley, (4), Introduction, p. 70, § 16)

To me it is apparent that Berkeley in this paragraph allows for a concept.[20] In § 18 he discusses the generality of a definition of *triangle*, the definiens being *plain surface comprehended by three right lines*:

> [I]n the definition it is not said whether the surface be great or small, black or white, nor whether the sides are long or short, equal or unequal, nor with what angles they are inclined to each other; in all which there may be great variety, and consequently there is no one settled idea which limits the signification of the word *triangle*. (Berkeley, (4), Introduction, p. 70, § 18)

Russell's apparent accusation that Berkeley is an extreme nominalist falls in this connection to the ground. Winkler supports my contention. He is clear that Berkeley "generally characterizes ideas not as acts of thinking but as objects of thought" (Winkler, 2005, pp. 128-129), which to me means particulars are objects of thought, not intentional states, and might therefore be conceptualized, i.e. understood in light of a concept. That is, a perceived triangle, whether it is a sense datum or imagery in Russell's terms, is a conception of an idea, not an idea only.

It is enlightening, in this connection, to read Johnson on perception.

> As regards the term "thought" which enters into my definition, its application is intended to include perceptual judgements which are commonly contrasted with rather than subsumed under thought, for the reason that thought is conceived as purely abstract while perception contains an element of concreteness. But properly speaking even in perceptual judgement there is an element of abstraction; and on the other hand, no thought involves mere abstraction. It follows, therefore, that the processes of thinking and of perceptual judgement have an essential identity of character which justifies their treatment in a single systematic whole. It is the distinction between sense-experience and perceptual judgement, and not that between perceptual judgement and thought, that must be emphasised. The essential feature of perceptual judgement in contrast to mere sense-experience is that it involves activity, and that this activity is controlled by the purpose of attaining truth; further it is the presence of this purpose which distinguishes thought from other forms of activity. Thought may therefore be defined as mental activity controlled by a single purpose, the attainment of truth. (Johnson, 1921, p. xvi)

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[20] In his Essay Concerning Human Understanding (B.4. C. 7. Sect. 9), Locke tells that the general idea triangle "must be neither oblique, nor rectangle, neither equilateral, equicrural, nor scalenon, but *all and none* of these at once." Berkeley, who quotes this passage from Locke (Berkeley, (4), Introduction, p. 70, § 13), comments: "If any man has the faculty of framing in his mind such an idea of a triangle as is here described, it is in vain to pretend to dispute him out of it, nor would I go about it." Of course, it is not possible to frame an idea of Locke's triangle because his description is a contradiction in terms; i.e. all and none cannot be the case simultaneously. And this only goes to show how Berkeley's case against Locke is based on concepts, because no two or more particular ideas can contradict each other. However, as I see it, Locke is not necessarily seeking to unite equilateral and equicrural, etc., because he talks about part identity. A universal according to Locke is "an idea wherein some parts of several and *inconsistent* ideas are put together." (ibid.) To me, abstraction in this case means identifying the few properties shared by all triangles, i.e. three angles and three rectilinear sides put together so as to constitute a figure. A particular triangle is either equilateral, or isosceles (equicrural), or scalene (scalenon), but in each you can always find the common features, i.e. the part identical properties on which the definition of the category triangle is grounded. And really, in these respects, Berkeley seems to share the same point of view. In § 16, his argument turns out to be not too dissimilar from those explicated here.

Fields accentuates difference in method, that is, the one between selective attention and separation. The first she describes as follows: “Through selectively attending to what is essential in the particular triangle perceived, ignoring what is particular to it, one can form a higher-order, abstract idea able to represent all triangles of the kind perceived.” (Fields, 2011, p. 122) On page 125 she explains how the separation method lacks a perceptual foundation.

> Furthermore, the particularizing circumstances of those first-order ideas are what make them perceivable. To strip them away is to extinguish the idea itself because ideas are essentially perceivable; and since higher-order abstract ideas necessarily take first order ideas as their objects, if the first order ideas are extinguished, then so are the higher-order ideas. A higher-order idea that is separated from the first order ideas that are its objects lacks a source for its content.

Fields might agree that Russell’s universal, whiteness, is distinct from all the particulars it according to Russell helps to enlighten. In Fields’ words it is separated from its first order ideas. (See in this connection the previous section.)

Anyway, according to Fields, Berkeley relies on selective attention theory. “Berkeley denies the method of abstraction in terms of separation.” (Fields, 2011, p. 138) Atherton, in her exploration of Berkeley’s *New Theory of Vision*, interprets Berkeley along the same lines.

> Determined lengths or colours are the ways in which lines or surfaces as we experience them take up space or are extended. You can’t remove from the idea all determined lengths or particular colours and have any extension left at all. In the actual conditions in which we are aware of the qualities of extended bodies, we are aware of them as determined in various ways perceivable by our sensory apparatus. Being coloured is the way in which the things we experience take up space visually. (Atherton, 1990, pp. 180-181)

Atherton focuses in this quotation on something else Berkeley stresses, namely the unification of colour and extension. Berkeley himself gives this example: If some colour is moving you have three properties that can be selectively attended to, namely the colour, the extension and the movement. But he denies that these properties can exist separately. “It is agreed on all hands, that the qualities of modes of things do never really exist each of them apart by itself, and separated from all others, but are mixed, as it were, and blended together, several in the same object.” (Berkeley, (4), Introduction, p. 66, § 7)

In the following paragraph, the eighth, Berkeley gives three examples of the separation method, which he argues against. I quote him first on motion.

> And in like manner by considering motion abstractedly not only from the body moved, but likewise from the figure it describes, and all particular directions and velocities, the abstract idea of motion is framed; which equally corresponds to all particular motions whatsoever that may be perceived by sense.

In paragraph 10 he addresses, among other things, this claimed abstract idea of motion: “And it is equally impossible for me to form the abstract idea of motion distinct from the body moving, and which is neither swift nor slow, curvilinear nor rectilinear; and the like can be said of all other abstract general ideas whatsoever.”

The second example of separation is about extension.

> Again, the mind having observed that in the particular extensions perceived by sense, there is something common and alike in all, and some other things peculiar, as this or that figure or magnitude, which distinguish them from another; it considers apart or single out by itself that which is common, making thereof a most abstract idea of extension, which is neither a line, surface, nor solid, nor has any figure or magnitude but is an idea entirely prescinded from all these.

Since ideas are different, they all have some traits proper to them, such as line, surface and solidity, and since extension supposedly is common, the negation method seems to be the way to achieve pure abstraction, that is, extension without any conceptions of qualities or modes in one particular extension. But this method is obviously what Berkeley rejects. In paragraph 10 he does not mention extension explicitly, but what he says about motion strongly indicates that he also means an abstract idea of extension is impossible to form.

Finally, Berkeley refers to colours. His contention seems to be that when all determinates or particulars are denied or negated there is nothing left to understand or conceptualize.

> So likewise the mind by leaving out of the particular colours perceived by sense, that which distinguishes them from another, and retaining that only which is common to all, makes an idea of colour in abstract which is neither red, nor blue, nor white, nor any other determinate colour. (Berkeley, 1975, (4), Introduction, p. 67, § 8)

It is important to note that there is one crucial difference between colours, on the one hand, and extension and motion, on the other.

While both motion and extension are different in mode, Berkeley only mentions particular colours by names. This agrees with Johnson's and my contention that colours cannot be classified according to taxonomy because particular colours do not have modes or qualities that are common for some but not for all. See Sections 2.3, 2.4 and 2.5, above.

In this connection I must object to Fields' reading of Berkeley. It seems that she, in spite of context, interprets Berkeley as allowing for something I have explained he rejects. Concerning colour, she refers to paragraph 8 saying: "He (Berkeley) speaks of the mind 'making an idea of colour in abstract'" – a general notion – "by leaving out of the particular colours that which distinguishes them one from another."

That is, Fields takes Berkeley as allowing for abstraction in the case of colours. "one can 'consider' (or as I read Berkeley, selectively attend to via a general notion) a perceived quality – say, blue – and perceive that it is the same as a quality perceived in another perception." (Fields, 2011, p. 137)

Fields does not explain further what this general notion can be. However, she gives an account on pages 122–123 of Locke's *Essay* II.xi.9, which to her mind is an example of the selective attention method in achieving general ideas, and it seems to me she takes Berkeley as thinking along the same lines.

> Thus, the same colour being observed to-day in chalk or snow, which the mind yesterday received form milk, it considers that appearance alone, makes it a representative of all of that kind; and having given it the name whiteness, it by that sound signifies the same quality wheresoever to be imagined or met with; and thus universals, whether ideas or terms, are made. (Locke, 1971, p. 126)

Fields does not mention that this paragraph could be interpreted as if it concerned identical colours – that is, instances of the same white – but this is a possibility. Identical colours are, of course, instantiated from time to time, but if this is Locke's meaning, it seems to me that "considering the appearance alone" must be taken as meaning to remember or imagine the same colour. And if such imagery is possible, the image is likewise an instantiation of the same colour. Thus it is not a conceptualization or notion or higher order idea because it is a particular colour.

A second interpretation, which is probably more in agreement with Field's reading of the paragraph, is that Locke is talking of different whites. If that is the case, it can only mean the imagined white is a particular, but is now different from the others. In order to find what is common to all, it seems therefore the negation method is needed and this is exactly what Berkeley says leads to nothing.

2.9 Concepts as memories of colours

Hering says,

> If we wish to call colours concepts either on account of their spatial properties or because they are located in front of us and not in us, and especially not in that place where we feel our eyes to be or imagine them to be, this is likewise a matter of convention. But it seems to me more to the point to restrict the word concept to colours and visual things that do not appear in sensory freshness and immediacy but that are only reproduced in memory. (Hering, 1964, p. 6)

Hering does not in this connection elaborate his thought that colours are concepts when reproduced in memory. However, elsewhere, it seems as if he means that memory colour may in some way contribute to, that is, inflict on people's understanding. See in this connection Section 1.5.4 above.

A contemporary of his, the psychophysicist Mach (1996, pp. 315-316)), says that to memorize is to understand, and, if you remember a certain event in all its detail, your cognition of the event is complete.

> Our knowledge of a natural phenomenon, say of an earthquake, is as complete as possible when our thoughts so marshal before the mind all the relevant sense-given facts of the case that they may be regarded almost as a substitute for the phenomenon itself, and the facts appear to us as old and familiar figures, having no power to occasion surprise.[…] – then more insight than this we cannot have, and more we do not require.

Hume seems to be the classical philosopher in holding memories as concepts. Hume treated the general distinction between lively and faint as a fundamental ontological principle and criterion of epistemology. "All the perceptions of the human mind," he contended, "resolve themselves into two distinct kinds, which I shall call IMPRESSIONS and IDEAS." (Hume, 1969, p. 49.)

Hume contends that memories, that is, ideas, are conceptions, and that both judgment and reasoning are just as much conceptions themselves, that is, they are surveys of different arrangements between different ideas. (Hume, 1969, note, pp. 144-145, Book I, Sect. VII)

Furthermore, simple impressions, Hume says, are the causes of simple ideas, which are only faint copies of their originals:

> I venture to affirm, that the rule here holds without any exception, and that every simple idea has a simple impression, which resembles it; and every simple impression a correspondent idea. That idea of red, which we form in the dark, and that impression, which strikes our eyes in sunshine, differ only in degree, not in nature. (Hume, 1969, p. 51, Book I, Sect. I)

There is something remarkable about Hume's division, because at first glimpse it seems taxonomic. He says that on the one hand there is a class of colours in which all particulars are strong and lively, and, on the other, there is a class of colours in which all particulars are weak and faint.

However, Hume allows for exceptions to his general rule:

> Thus in sleep, in a fever, in madness, or in any very violent emotion of the soul, our ideas may approach to our impressions: As on the other hand it sometimes happens, that our impressions are so faint and low, that we cannot distinguish them from our ideas. (Hume, 1969, p. 49, Book I, Sect. I)

These exceptions ought to lead him to condemn his categorical characteristics, strong and lively vs. weak and faint. But on next page Hume reasons further without making anything of the exceptions. "The one seems to be in a manner the reflexion of the other; so that all the perceptions of the mind are double, and appear both as impressions and ideas."

His double thesis leads to somewhat absurd consequences, because if people can distinguish about 9 million colour impressions, as both Hardin and Gerritsen suppose, Hume's ontology would double the number. Supposedly, Hume did not envisage the possibility of such a large amount, see in this connection Chapter IV, Section 2.1.

Nes (2008, p. 123) discusses this problem as well. The exceedingly great number of colours which, in principle, can be discriminated, makes the thought that each and every one should be understood by memories different from them but just as "fine-grained", overwhelming.

According to Lundh, Montgomery and Waern (1992, Chapters 3 and 4) there is no discussion in cognitive psychology on whether colours can be memorized, that is, human beings might see colours by contemplating the past.

However, they do not contend that weakness and faintness are properties that make someone perceive that they are now thinking of some past impressions.

Aristotle (1972, 450b11) says that a memory in the form of an image is a contemplation of "the image as being a copy of something distinct". And to recognize it as a copy is to remember the past. This is not always done because you can contemplate the image in its own right.

> For the figure drawn on a panel is both a figure and a copy, and while being one and the same, it is both, even if the being of the two is not the same. And one can contemplate it both as a being and as a copy. In the same manner one must also conceive of the image in us to be something in its own right and to be of another thing. In so far, then, as it is something in its own right, it is an object of contemplation or an image. But in so far as it is of another thing, it is a sort of copy and reminder. (1972, 450b20)

Aristotle continues: “The possibility of regarding, or not regarding, one’s image as a copy helps to explain four phenomena. (a) Doubt as to whether one has a memory. (b) Suddenly switching to remembering. (c) Wrongly supposing one has a memory. (d) Memorizing.”

It is time to go back to Hering’s suggestion that memory colours are concepts; see the quotation with which I introduce this present section. If memorized colours were concepts they should bring some understanding into play, that is, one’s memory should somehow elucidate the remembered colour.

But, as I think my discussion shows, there are two reasons that go a long way to proving that this cannot be the case.

First. If the memory is identical with the original, nothing new is added.

Second. If the memory is different from the original, it is simply not a memory of that colour. It can be like it, but the memory cannot elucidate the original any more than the original can elucidate the memory.

My guess is that Hering has in mind a memory process in which the perception of a particular makes him remember some other colours that are very different from the particular. For example, he may have thought that perception of orange makes him remember the four primaries yellow, red, white and black. See in this connection Section 1 and 1.5.6 above.

My opinion is, however, that the memory of the four colours cannot conceptually elucidate the particular orange. In fact, all you might say about these four memorized colours is that they all are different from orange, some more, some less.

2.10 Colour figure – patch – spot - shape

In Section 2.6.1 above, I present Euclid’s definition of figure, namely as that which is contained by any boundary or boundaries. (Euclid, 1991, pp. 439-441, definitions 14 and 22)

However, this definition might be understood as if boundaries were separated from colour instantiations. See in this connection my discussion of separation method and method of selective attention in Section 2.8.

In *A New Theory of Vision* ((1), § 124, pp. 44-45) Berkeley defines figure as the termination of magnitude. This definition is better, but not accurate, because it does not say how the termination is realized.

Section 2.1 Leonardo line

I found a definition that explicitly links both magnitude and termination to colours in Leonardo da Vinci’s *A Treatise on Painting*, where he says one colour is terminated by another colour. 2.10.1 From a definition of line to a definition of figure

Leonardo da Vinci defines a line as the place where a colour ends and another begins. That is, he advises against using the word "line" for this relationship, because, as I interpret him, "line" should be reserved for drawn lines or contours marked by dark outlines, which, according to da Vinci, are real lines.

> The boundaries which separate one body from another are of the nature of mathematical lines, but not of real lines. The end of any colour is only the beginning of another, and it ought not to be called a line, for nothing interposes between them, except the termination of the one against the other, which being nothing in itself, cannot be perceivable; therefore the painter ought not to pronounce it in distant objects. (Da Vinci, 1897, p. 106, § 224)

To me it is apparent that Leonardo does not deny that what he calls mathematical lines are instantiated both in painting and in nature, and are perceptible. On the other hand, what he certainly denies is that objects seen from a great distance do manifest such a line relationship, and therefore urges painters not to depict distant objects by such lines, if they are eager to imitate just what they observe.

Furthermore, he says something crucial and fundamental to my argumentation in this thesis, namely that "the end of any colour is only the beginning of another". This is an ontological statement about colour relations. To me it implies that a colour cannot end in nothing or simply end without a new colour or some new colours limiting it. See in this connection Chapter VIII, on colour totality and infinity.

However, it would be an obvious mistake to take him as alleging that all colour relations are line relations. This is exactly opposite of what he is trying to explain in the quotation above, namely that borderlines dissolve under certain circumstances.

This implies that colours may manifest sliding scale relations. A sliding scale is a continuous juxtaposition of different colours. (See BD II, Chapter I, Section 2.)

In sliding scales, lines are not manifested, that is, you cannot point out the place where one of the colours ends and the other begins.

Now, a sliding scale taken as a unit between its members may itself end just where another colour or some other colours begin. See in this connection Picture 2 in Chapter I Section 2, BD II. This picture exemplifies or instantiates a sliding scale that is infield and white is outfield.

I present this extended definition of a Leonardo line in Chapter I, Section 2, BD I; *A line is the place where one or more colours end, and one or more others begin*. The definition secures that also sliding scales can relate in lines.

Leonardo says this line is of the nature of mathematical lines, and I believe that nothing has a better claim to be the empirical counterpart of Euclid's third definition in the *Elements*, Book I, namely, "A line is length without breadth".

However, this is not to say that the definition conforms to all Euclid's definitions, and I restrict my use of it only to colour relations, that is, I do not challenge Euclidian geometry. In order to avoid any misunderstandings on this point I want to make clear some crucial deviations from Euclid in Chapter I, Section 5 and elsewhere.

Since Leonardo's definition of line implies differences and deviations from the Euclidian system, I like to call such lines Leonardo lines.

Leonardo lines may exist independently of figures, but not the other way around. See in this connection Picture 3, BD IX, in Chapter I, Section 2.

Let me try to explain using a convenient example. When you look at the horizon between the calm sea and the blue sky the colour of the sea ends just where the blue sky begins. The horizon is a Leonardo line. However, while keeping your focus steady, this line dissolves in a sliding scale both to the left and right. Above the horizon there are no lines, only a sliding scale in blue that diffuses into the unclear or diffused presence of you eyebrows, and the same with the colours of the sea in the opposite direction; it diffuses into the colours of your nose and your upper cheeks.

Now, if you hold a small brown frame before your eyes and mark out a part of the sky the colours meet in a line, the end of the blue and the beginning of brown is a Leonardo line. But this line is continuous, it does not dissolve and the blue (or the sliding scale in blues) is therefore an infield to which the brown is an outfield.

Observations like this led to my definition of figure see BD VIII, in Chapter I, Section 2:

A figure (spot/patch/shape) is either one colour or a sliding scale, which relates to another colour, or some other colours, in a Leonardo line in all directions.

Two examples: r and O

To the left: red is an infield against which white is an outfield and the direction goes from red to white and vice versa.

The o is a middle field, that is, white is outfield and (an identical) white is infield.

I wonder if many people ever have considered Necker's cube as a middle field, but it is so according to the definition figure. It is a middle field that is usually presented in a white outfield, the cube usually being a black, continuous, so-called outline with seven white infields.

Combinations of infield and outfield can therefore be many in number. The concepts 'infield', 'middle field', 'outfield', etc., help to determine which field is in play.

If only two continuous fields appear, of which one is infield and the other outfield, and each field is either a sliding scale (s) or has no inner variations (v), there are four possible combinations: s-s, s-v, v-v, v-s.

2.10.2 Colours as substantives

Johnson allows for adjectives to play the role of substantives. But then he calls them quasi substantives. See Section 2.1 above. Anyhow, this means that colours are characterized themselves but do not characterize anything else.

However, I often encounter expressions like “this patch is red” or “this spot is blue”.

Johnson’s explication of colour incompatibility may serve as an example.

> We may illustrate the relation of incompatibility amongst adjectives by *red* and *green* regarded as characterising the same patch. It is upon this relation of incompatibility that the idea of the contradictory *not-red* depends; for *not-red* means some adjective incompatible with *red*, and predicates indeterminately what is predicated determinately by *green*, or by *blue*, or by *yellow*, etc. (Johnson, 1921, p. 15, § 7)

In the quotation Johnson uses patch as substantive but he may be thinking of an infield. Infield is a relational term which I use to characterize colours by their positional relationship to other colours.

Sentences used to describe a relationship, should therefore use colour names as the subject. That is, a certain colour is infield or middle field or some other variant of infield.

For example, *this red is infield and this white is outfield*:

r

In the conjunctive sentence above, red and white are proper names, while the relational terms infield and outfield are predicates.

Indeed, it is usual to express oneself like “this spot is red” and as long as the real meaning is acknowledged no harm is done. But if it is not acknowledged, one commits the mistake Carnap ((1), 1959, p. 140) warned against (see in this connection Section 2.1 above), namely: “The assumption that a certain property belongs or does not belong to itself can be neither true nor false, but is meaningless.”

When red is infield, the sentence “this spot is red” might say, “this infield is red”. But because red is infield it means red is red, which is a patent break with Carnap’s rule.

In this connection I feel a need to criticize Jackson (1977) because he consequently uses expressions that to me seem to violate Carnap’s rule.

On p. 22 he says, “whenever something is seen, there is an immediate object of perception and it is always a coloured shape or expanse” as if shape is something that has colour as property. On the same page he continues, “The immediate objects of perception have at least colour, shape and extension.” And on p. 67, he provides this explanation: “to have a red square afterimage is to be in a certain relation to a mental object which has as distinct properties redness and squareness.” On p. 88 he says that seeing always involves a coloured patch and that “this coloured patch bears the apparent properties”.

It seems to me that Jackson has not for a moment considered what a patch is or reasonably can be. And so, his statements cause confusion and bewilderment.

2.10.3 Is the visual field patches?

Ostwald seems to believe that what he calls the field of vision is built up of patches, that is, spots or figures understood in the sense explained above.

> Everything we see consists directly of colours that are spread out in the field of vision as larger and smaller parts or areas. Where two or more areas meet, borderlines are created, the continuity of which brings about the forms or figures from which we sense the presence of objects seen.
>
> The colours are, therefore, the basic components or elements of our sensation of vision. (Ostwald, 1969, pp. 21 –22)

Lewis (1966, p. 357) calls a view like Ostwald's for Colour-Mosaic Theory: "Those in the traditions of British empiricism and introspectionist psychology hold that the content of visual experience is a sensuously given mosaic of colour spots, together with a mass of interpretive judgments injected by the subject." A mass of interpretative judgments is a percept, according to Lewis.

It is, however, a problem how to decide whether Ostwald's contention or the colour-mosaic theory of Lewis is true. Is it possible to confirm by observation that the visual field consists of spots? It seems to be presupposed that these spots are made of colours with no inner variation. Lewis (1966, pp. 358-359) seems to suggest that only professional psychologists and artists are able to observe such mosaics, and this must be done by a gradual reduction of interfering percepts.

> Percept and colour-mosaic theorists would agree that visual experience may be made to contain nothing but a mosaic of colour spots – a visual experience which could be reported exhaustively by a set of "I am ostensibly seeing that something of colour c is located in direction d" clauses for all discriminable directions. To produce this pure colour-mosaic experience we must concentrate, to the exclusion of all else, of the visual qualities of the smallest discriminable regions considered in isolation from their surroundings. Firth calls this the operation of perceptual reduction. It is a difficult task practised by artists and by introspectionist psychologists.

Berkeley denies implicitly that this can be done. In A New Theory of Vision (NTV), § 83, he explains that the visual faculty labours from two defects. The first is that it is limited. This notion is widely discussed in Chapter VIII, Section I, and I will not consider it for the moment.

> Secondly, our sight is defective in that its view is not only narrow, but also for the most part confused: of those things that we take in at one prospect we can see but a few at once clearly and unconfusedly: and the more we fix our sight on any one object, by so much the darker and more indistinct shall the rest appear.

It appears to me that the difference between Ostwald/Lewis and Berkeley is that Berkeley allows both for sliding scales and patches. What he calls a defect is obviously combinations of colours in sliding scales which occur in peripheral vision. For a further discussion of Ostwald, see Chapter IV on sliding scales, Section 2, and Chapter VIII on totality.

But why does Berkeley consider sliding scale combinations a sight defect? It seems to me he believes that without this defect all colours would relate as patches. And, by implication, although colours really relate as patches, we cannot see (all of) these relations in one view.

Berkeley does not discuss or explicate this issue further. But I think many will recognize in themselves a commitment to the same ontological belief. I think analogously when I look at printed text without my reading glasses. The letters float, but I am sure they would not if I only could find my glasses and put them on. That is, I believe the confused text is due to a defect of my sight while the letters I actually look at really are distinct infields in the same outfield.

But when I think this matter through I must confess that I do not believe colours exist in relations other than those observed. Really, all I can say from these experiences is that first, without the reading glasses, there are sliding scales, and with my glasses on, the letters I focus on are uniform infields.

Maybe it is only the context in the situation that triggers belief in a split between observed colour relations and real colour relations. In other situations, unclear vision is clear, that is, the expectation is not the same. When you, for example, know there is a blanket of thick fog outside and you go out and see, you are in no need of glasses; you just accept the sliding grey scale to be a fact. In other words, you clearly see that colours relate in a sliding scale and to see this kind of relation is also what you expected.

Hardin confronts Hume in a related theme. Hume says,

> Secondly, 'tis confest, that no object can appear to the senses; or in other words, that no impression can become present to the mind, without being determin'd in its degrees both of quantity and quality. The confusion, in which impressions are sometimes involv'd, proceeds only from their faintness and unsteadiness, not from any capacity in the mind to receive any impression, which in its real existence has no particular degree nor proportion. (Hume, 1969, p. 66, Book I, Sect. VII)

Hardin seems to mean that colour relations are of certain kinds and that some of these relations contain colours that are not determinate in degree and proportion.

> So according to Hume, cases of apparent indeterminacy are to be ascribed not to the inherent properties of impressions, but to their "faintness and unsteadiness". But if faintness and unsteadiness are properties of the impressions themselves, what could they be except indeterminacies in "degree of quantity or quality"? It must be, rather, that the mind has, under these circumstances, difficulty in making out the "particular degree or proportion" of the impression. (Hardin, 1988, p. 97)

Sliding scales are continuous relations between different colours and therefore you cannot distinguish one particular from another, because there is no place where one colour ends and another begins.

However, I hesitate in taking Hardin's view as direct support of my own view. The reason is that neither Hume nor Hardin mentions sliding scale relations, but both use the term faint. This term is very difficult to understand; are they not talking about sliding scale relations, but instead about particulars having a property faint?

I cannot make sense of what a faint colour is. I do not think any colour can be faint if it is presented to me as an infield with no inner variation. On the other hand, I admit there can be faint differences between two colours, including in a relation between infield and outfield. But none of the relata is faint by itself, a fact that can be demonstrated by keeping the one and substituting the other for a new colour. Say, a

grey, very close to white, is infield and white is outfield; there is a faint difference. But when you substitute black for white the initial grey contrasts with black very strongly. This shows that the grey is not faint in and of itself.

There may be objections to this, i.e., that contrast effects will also change the infield, but I presume that an identical grey, as in the first relation, is obtained in the second. This might be difficult to instantiate, but it is practically possible.

So back to sliding scales in order to clarify the concept of determinacy.

Daily life experiences show us that colours might combine in sliding scales so that the whole field of vision is without any lines or patches. Take as an example the pleasant situation when you lie down in the grass on a warm sunny day watching a cloudless sky. You observe that there are no lines and therefore no patches, only the blue sliding scale of heaven dissolving into the sliding scales marked by your nose and eye sockets.

It seems to me impossible to pick out all the nuances in that sliding scale and I therefore hold the members to be indeterminate; it is under such circumstances determination is impossible.

My readers can check this kind of indeterminacy by observing the sliding scale spot in Picture 2, Chapter I, Section 2.

What I mean by determination in this connection is to give every colour a proper name or to match each of them with a screen of infields (none of which has inner variations) in a colour chart.

Another kind of indeterminacy is what Hume calls unsteadiness. This can also be observed in Picture 2; while studying that figure the colour relations may after a while seem to change continuously, a phenomenon that adds to the former kind of indeterminacy.[21]

In connection with unsteadiness, Hardin (1988, p. 101) points to another complication. “The periphery is apt for detection of motion, and we are indeed able to notice that something is moving in the far periphery without becoming cognizant of anything about its shape or colour.”

This point ought not to be disputed either by me or anybody else. One can only move one’s fingers in the right place to confirm the phenomenon by observation. And I must add to this that when blinking fast, indeterminacy of colour and figure also occurs.

One cannot, however, from this latter kind of indeterminacy, conclude that the motion is not a single or several colours. That would be to deny that the so-called visual field is built up of colours, i.e. that the visual field sometimes consists of both uniform spots and of sliding scales.

[21] I define colour change too; see BD IV, V and VI.

Now, while I agree that some colour relations imply indeterminacy, I think that Hume's contention on this subject can be somewhat modified in light of the hypothesis that there is a limited number of particulars.

I stated in Section 1.2.1 that it is estimated that people can experience nine to ten million different colours. (Gerritsen, 1975, p. 68; Hardin, 1988, p. 88) Using a computer, they can all, in principle, be named each and every one by giving them numbers. (Goto, 1998, 143) This being so, it should be possible to type one of the names on the keyboard and have the named colour appear on the monitor screen, and then proceed from one colour to another, the names being 1, 2, 3, 4 etc.

In such a procedure, the colours appear as infields. The outfield must sometimes be adjusted to the infields in the case of faint relations. But, practically speaking, there seems to be no hindrance to execute the procedure.

Therefore, since the hypothesis is that there is a limited number of colours to be observed one must logically conclude that the indeterminacy relations must also consist of the same colours that in some infield–outfield relations are determinate.

Goodman seems to cast doubt on whether there are any spots with no inner variation.

> We normally take experience in larger chunks, and if we try to pulverize it by focusing attention on particles within which no further differences are detected, we usually find ourselves puzzled and uncertain. Paradoxically enough, 'least-discernible' particles are seldom discerned. Thus the data of matching used for construction of order are perhaps more often inferential and derivative than immediate. (Goodman, 1977, p. 203.)

Indeed, if anyone should examine an immediately given spot that at first glimpse looks uniform, the simultaneous contrast effect might interfere within 20 to 30 seconds, and the uniformity gets lost. However, in many cases a short look may confirm identity between colours, see for example these two: 2 2

It is, in my opinion, likewise difficult to confirm betweenness and therefore immediacy in observation vanish, especially when difference degrees are small and the relating colours are many. One has to move one's eyes.

I think that these latter considerations adds to the points made by both Berkeley and Hardin, and leaves the total colour mosaic that Lewis proposes very much implausible. His appeal to professional psychologists and artists as witnesses seems likewise to be not trustworthy.

Lewis holds his colour-mosaic theory to be a variant of sense-data theory. That variant excludes indeterminacy. Hardin's discussion is directed against this feature of sense-data theory and he provides other examples of indeterminacy than peripheral vision, but maybe some of these bear too much weight from percepts, that is, what Lewis explains as a mass of interpretive judgements, something which I think especially characterizes Hardin's discussion of the so-called waterfall illusion. (Hardin, 1988, p. 102)

In sections 2.11.2 and 2.11.4 I explore further into some other features in sense-data theory and in particular into Russell's theory on acquaintance.

2.10.4 Some reasons why some people seem to ignore or hold for untrue the definitions of line and figure

First.
The Swedish colour theorist Lenning (1954, pp. 23-24) shares the conceptions of lines, figures and sliding scales put forward in Section 2.10.1. Colours, he contends, are primary and figures are secondary, by which he means (in my translation), "figures are dependent on colours for their existence".

But he observes that most people are apt to consider figures to be the basic elements of vision. This he explains partly by how children learn colouring in schemes where the outlines are given and thereby experience that the same figures can be coloured differently.

It may be seldom that a child uses the same colour as the outline when filling in. But as Lenning points out, if someone did, he or she would see that the same figures remain without the outline, because the filled in colour now does away with the outline and ends just where the outline ended before, that is, it ends in a Leonardo line in all directions.

Lenning also says that in nature, colours often change because of changes in light conditions, for example, while figures remain constant. Lenning seems to think that ordinary people take what remains constant as a substantive and will therefore consider figures primary, while they really are not. Colours are primary.

Second.
Some philosophers seem to believe that figures may exist without any differences in colour between infield and outfield. Berkeley and Hume earn as my examples.

Take as example this infield: 

and compare it to this infield which is identical in form:

What is imaginable is possible; this is what Hume says. However, I am sure it is impossible to imagine a figure of the same colour as the outfield. When I try, I see before me either an outline of an r with white as infield, or an r very much like the outfield, but different enough to make a figure. In both cases, differences between colours occur and satisfy the definition of figure.

Mach describes how he solves geometrical puzzles in his imagination. It is difficult, he says, because imagined lines disappear during the procedure.

> When I draw a geometrical figure in imagination, it is as if the lines faded immediately after they are drawn, as soon as my attention is directed to other lines: when one comes back to them they have vanished, and must be reproduced over again. This is the principal reason of the advantage in point of convenience which an actual geometrical drawing possesses over a merely imagined one. (Mach, 1996, p. 200)

Apparently, Mach does not believe the lines exist anyway, because, as he says, he has to reproduce them.

Armstrong criticizes Berkeley's theory of minima visibilia in *An Essay Towards a New Theory of Vision* (NTV). I introduce some of Berkeley's thoughts about visual minima in order to explain Armstrong's reasons.

The visual faculty, Berkeley writes, "can take in at one view but a certain determinate number of *minima visibilia,* beyond which it cannot extend its prospect." (NTV, § 83.) That is, the visible field is always of the same size, whatever the number of things that are seen. See in this connection a further discussion in Chapter VIII.

Berkeley defines a point as a visual minimum, that is, a colour, which is too small to be divided into parts. Then he defines a line as a series of such points juxtaposed. (NTV, § 112.)

To me it seems that Berkeley's whole idea is linked to a genetic conception in which minima visibilia constitute all other kinds of colour extension. It is as if Berkeley clings to a causal explanation where visual minima are considered causes.

Armstrong's objection to Berkeley is this: "In fact most lines and surfaces look continuous, and if they look continuous, then, on Berkeley's view, what is immediately perceived is continuous and so not made up of minima." (Armstrong, 1965, p. 44.)

Armstrong could also address Hume in this connection. Hume seems to agree with Berkeley's line definition and considers a line to consist of points. (Hume, Book I, sect. IV, 1969, p. 92) And he says, "a point terminates a line", but where is the point? You can observe the end of for example a continuous black line, but no point in Hume and Berkeley's sense.

Berkeley expresses himself as if the visual minima are immediately given. At § 82 he says: "Of these visible points we see at all times an equal number."

It is therefore possible that Berkeley holds the view that visual minima need not contrast with other visual minima. That is, a visual minimum may be an infield that is identical in colour with the visual minima that are its outfield.

But to my knowledge, Berkeley never stated this explicitly. A more generous interpretation seems appropriate.

Maybe Berkeley thinks as people do in ordinary life. Say, I contend the breadth of my writing desk is 90 centimetres. No one would contradict me and say, hey, the surface colour of your writing desk is continuous and no centimetres are immediately given and therefore the breadth does not consist of 90 centimetres. Instead, one would of course test the objection by applying a standard where centimetres are marked.

This seems to me to be Berkeley's thought. According to him, the so-called visual field is limited, albeit varied from time to time in larger or smaller (continuous) areas. But if it were a standard consisting of only visual minima that could somehow measure every field, Berkeley's seems to think it would show that the number of minima is exactly the same all together, no matter how varied the fields may be from time to time.

Unfortunately, there is no such standard and therefore Berkeley's contention cannot be tested.

Third.
Seemingly, the following example is an argument against my definition of figure.

Say, you throw a red ball up in the air. You see it as a circle but believe no colour is the outfield because you perceive the ball is surrounded by clear air. Clear air is, according to the ordinary view, without colour. You do not count the blue sky as an outfield because you perceive it as situated far behind the ball, i.e., detached from it.

Here is another example of the same. Say, you're standing on your veranda looking down on some green leaves on a tree. You focus on one leaf; you cannot see its stalk but think there must be a stalk anyway, since the leaf is hanging a few metres over the pavement, which you also look down to. You are therefore apt to think the green is a surface colour surrounded by clear air just as the ball.

But the argument from clear air does not hold. It must be rejected because whatever clear air is meant to be, it is certainly not a colour. What I dispute is how colours relate; that which is not a colour cannot say anything about colour relations.

Rather, the observable fact is that the green (leaf) ends just where the grey (pavement) begins. There is no distance between the two colours or better, the two sliding scales, and this is exactly how Leonardo describes the line relation, "the termination of the one against the other, which being nothing in itself". (Da Vinci, 1897, p. 106, § 224)

The red ball and the blue sky, that is, red and blue, relate in an identical way as green and grey: the red which is infield ends where the blue begins in all directions.

A contradiction seems to be involved here, but it is because ordinary people's ontology interferes. In daily life, people think that colours are properties of physical objects, like balls and leaves, and that these objects exist in three-dimensional space together with other objects. Since colours belong to their objects and these objects have different places in space, there must logically be a distance between the colours too.

But descriptions based on observations are contrary to ordinary people's view: sometimes there is no distance between colours. And if there is a distance it is because one or more colours occupy an intermediate position.

Therefore, one has to decide whether one should trust ordinary perception or colour observations. That means the question is whether one shall follow the adjectival mode or whether one shall follow the substantival mode when the task is to describe colour relations. To me the answer is obvious: the colours are subjects and as such they must be characterized.

In section 3 I explore further into daily life conceptions or naïve realistic conceptions. I have no doubt these are fundamental to our well behaviour and therefore they also are obstacles in the understanding of colours as subjects.

Fourth.
In Book I, Sect. VII Hume (1969, pp. 64 -73) discusses abstract ideas. In that connection (pp. 65-66) he explains his principle of separation.

> We have observ'd, that whatever objects are different are distinguishable, and that whatever objects are distinguishable are separable by the thought and imagination. And we may here add, that these propositions are equally true in the *inverse*, and that whatever objects are separable are also distinguishable, and that whatever objects are distinguishable are also different. For how is it possible we can separate what is not distinguishable, or distinguish what is not different.

However, according to Hume, some distinctions can be made while there is still no possibility of separation. On pp. 72-73 Hume explains *distinction by reason*, which is based on likeness relations.

Let me illustrate by these figures.

According to Hume, resemblances may go two ways: the r in the middle resembles (or is identical to) the other r in form, while it resembles (or is identical to) y in colour.

> After a little more practice of this kind, we begin to distinguish the figure from the colour by a *distinction of reason*; that is, we consider the figure and colour together, since they are in fact the same and undistinguishable; but still view them in different aspects, according to the resemblances, of which they are susceptible. (Hume, 1969, p. 72)

But while Hume denies that red can be separated from its figure, it seems to me he takes it as self-evident that it can be separated from its outfield.

This is not about changing the outfield. You may see red in a white outfield just as it occurs on this page, and you can then imagine the same red in a blue outfield, and so it is separated from the white by thought.

The question is rather whether a figure can be separated from all outfields by thought and imagination. If this were the case, Leonardo's thesis, "The end of any colour is only the beginning of another" (Da Vinci, 1897, p. 106, § 224) would be untrue.

One might say that Leonardo's thesis is an ontological generalization based on impressions, and impression is a term used by Hume. According to Hume, an impression is copied in memory and the copy is an idea.

Now, if you never have had an impression of a colour that ends without another colour that begins in the same place, it seems spurious, in relation to Hume's system, to state that mind or memory can separate the one colour from the other, that is, separate an infield from any outfield, the infield still being a figure.

Furthermore, the termination of that figure must consequently be in nothing. But nothing is not imaginable according to Hume's divide; his basic assertion is that any idea is dependent on a forgoing impression, and because no one can ever have an impression of nothing, it follows that no one can have an idea of nothing.

But Hume's own reasoning within these matters is about darkness. "That idea of red, which we form in the dark." (Hume, 1969, p. 51, Book I, Sect. I) Darkness, according to Hume, is nothing but a negation, and hence red is separated from its outfield: "'Tis evident the idea of darkness is no positive idea, but merely the negation of light, or more properly speaking, of coloured and visible objects." (Hume, 1969, p. 104, Book I, Sect. V)

Furthermore, Hume contends (p. 106) darkness is "without parts, without composition, invariable and indivisible".

Here, it seems to me, Hume denies indirectly that darkness is an impression; consequently, it cannot be a positive idea either. And logically, in conformity with his system, in the negative idea darkness, red can be separated from any outfield.

An obvious objection to Hume is that darkness is the name of a colour. Darkness is, namely, identical to those colours that are elsewhere named black or perhaps deep grey. After the acceptance of Hering's colour theory (see Section 1.5 above), many scientists and philosophers agree that black is the name of a colour. For example, The Committee on Colorimetry (1953, pp. 13-14) notes:

> It should be mentioned also that during the evolution of the psychophysical treatment the old question of excluding the grey series from the category of colours was raised. No strong arguments in favour of such a course developed and the Committee is in favour of continuing to regard the black-white-grey series as colours.

See in this connection Chapter V for a broader discussion. See also my explanation on why black, grey and white belong to the determinable colour, in section 2.5.

If identification between darkness and black holds, my definition of figure also holds; Hume's red ends exactly where his darkness begins, in all directions.

On the other hand, actually, there seems to be a possibility to separate red completely but then the figure vanishes. This is the case when the whole visual field is only one red. At least, in Ganzfeld (URL) procedure it is said that when half translucent ping-pong balls cover someone's eyes, then "a red floodlight directed towards the eyes produces an undifferentiated visual field".

It is maybe possible that any hue and grey/white/black may be isolated in one or another somewhat similar way.

Aristotle uses white as an example:

> Had we no sense but sight, and that sense no object but white, they would have tended to escape our notice and everything would have merged for us into an indistinguishable identity, because of the concomitance of colour and magnitude. (De Anima, Bk. III: Ch. 1, 425b.) (McKeon, 1947, p. 208.)

Now, I think Aristotle's and Hume's descriptions of isolated colours is a key to the understanding of the visual field; namely that it is without end. If there is no lines, there are no limits either. See in this connection Chapter I, section 2, BD IV. See also section 3, IMP V. Furthermore, in Chapter VII I discuss this theme in broader light.

However, I use Aristotle's postulate on concomitance in another respect when I reject the thesis on colours' heterogeneity. See in this connection section 2.12.1 below.

2.11 Jackson's knowledge problem

Frank Jackson's knowledge problem and its discussion is well known, see Nida-Rümelin, 2009.

In section 2.11.1, I argue there is a reasonable solution to Jackson's knowledge problem, a solution that agrees with traditional psychophysics.

In section 2.11.2, I bring in Tye, Conee and Lewis who all defend physicalism and try to refute Jackson's own solution to his knowledge problem.

In section 2.11.3, I discuss identification theory. I show that such a theory might furnish a solution to the knowledge problem which is unlike mine. The rest of this section concerns some ontological and epistemological problems that identification theory leads to. In this connection I touch on adverbialism on colours.

In section 2.11.4, I argue that both physicalists and Jackson overlook the existence of colour relations, and that true propositions about these relations are achievable, independent of any physical information. Against this background I reject as false Jackson's version of physicalism, which he himself rejects for other reasons than mine, namely the thesis "all (correct) information is physical information". (Jackson, 1982, p. 127)

2.11.1 Jackson's version of physicalism in relation to psychophysics

Jackson presents a thought experiment about Mary. She is a physician who knows everything about the physical causes to any qualia including hues, but who has not herself experienced or seen any hue, only black, grey and white. While she has the physiological capacity to see hues, until now she has been imprisoned in environments where the physical inputs provide only colours that usually are called achromatic, that is, the colours Jackson designates black and white.

Jackson's aim with introducing the experiment is to refute Physicalism, i.e., the physicalist's thesis "all (correct) information is physical information". (Jackson, 1982, p. 127)

To me it seems he reaches his goal by bringing in a psychophysical presumption. That is, my interpretation of Jackson in this subsection is his claim that Mary learns the truth of a bridge principle. But this interpretation is not very obvious because Jackson mostly talks about Mary seeing a certain colour. His focus is not primarily on her ability to conceptualize this colour as associated with a certain brain process X, but, as I shall show, he mentions this possibility.

Jackson describes Mary as a person who

> knows all the physical facts about us and our environment, in a wide sense of 'physical' which includes everything in *completed* physics, chemistry and neurophysiology, and all there is to know about the causal and relational facts consequent upon all this, including of course functional roles. (Jackson, 1982, p. 127)

To this Jackson adds: "If physicalism is true, she knows all there is to know. For to suppose otherwise is to suppose that there is more to know than every physical fact, and that is just what physicalism denies."

Jackson asks what will happen when Mary is released from her black and white room: will she learn something? And he answers:

> It seems just obvious that she will learn something about the world and our visual experience of it. But then it is inescapable that her previous knowledge was incomplete. But she had *all* the physical information. *Ergo* there is more to have than that, and Physicalism is false. (Jackson, 1982, p. 130)

In another article on the same subject Jackson underscores his claim about learning. "For when she is let out of the black-and-white room or given a colour television, she will learn what it is like to see something red, say. This is rightly described as learning – she will not say 'ho, hum.' Hence, physicalism is false." (Jackson, 1986, p. 291)

Finally, on p. 293, 1986, Jackson resorts to psychophysics, but without stating it very explicitly, i.e. without using the term *psychophysical bridge-principle*: "The whole trust of the knowledge argument is that Mary (before her release) does *not* know everything there is to know about brain states and their properties, because she does not know about certain qualia associated with them."

This last quotation may be interpreted as follows: What Mary does not know beforehand is that physical process X is associated with a certain hue, red or r, because she herself has never observed r. But she knows that X leads to a certain hue which is different from all whites – greys – blacks. To this a second premise must be added, namely that Mary at time t knows that she undergoes physical process X. At the same time, she becomes aware of a particular hue which she therefore calls r. She can then conclude that both she and all people (with the same physical constitution) see r when X. In other words, to know what it is like to see r is to know the psychophysical connection between X and r.

These are, however, not Jackson's words but mine. My view, moreover, has support in the tradition of the modern theory of science.

Hempel (1966, pp. 72-73) says a theory needs bridge principles in order to be sound.

> Broadly speaking, then, the formulation of a theory will require the specification of two kinds of principles; let us call them internal principles and bridge principles for short. The former will characterize the basic entities and processes invoked by the theory and the laws to which they are assumed to conform. The latter will indicate how the processes envisaged by the theory are related to empirical phenomena with which we are already acquainted, and which the theory may then explain, predict or retrodict.

But Mary is not already acquainted with the hue r or any other hue. Therefore, she has never been able to contribute to research in bridge principles on hues. She has been condemned to learn only about the physical processes and this science she can contribute to, but she must have been told what to explore by colleagues who hypothesize about the relevant psychophysical connections.

That Mary will see the same red as everyone else (with the same physical constitution) is therefore dependent on the truth of the bridge principle that X relates to r. Before her release she knows X but is not acquainted with the hue and therefore not the bridge principle expressed in a singular sentence.

Therefore, at her release, if it is presupposed that Mary at the same time knows her brain is in state X; she is entitled to acknowledge that the hue she actually sees for the first time is r, r being the name of the hue she sees. She can say to herself: "My brain process X relates to or is a cause of this r."

In my opinion this is clearly a proposition which may be true. And if this is admitted, the physicalist thesis can be rejected on Jackson's behalf because the admittance implies that psychophysical propositions are informative, i.e., it is not only physical propositions that are informative.

However, the expression Hempel uses in the quotation above, namely "related to empirical phenomena", does not say precisely what kind of relation he is thinking about, for example, if it is causal or some kind of co-instantiation. Likewise, Jackson's term "associated with" is too loose in this respect.

In his enlightening article on modern colour science, the Norwegian psychophysicist Valberg (Proceedings, 1998, p. 108) suggests that the psychophysical research programme on colours aims at finding both sufficient and necessary causes of colours. This maybe too strong an option.

After Hume's criticism of the concept of causality, it seems many philosophers are cautious about using the terms 'cause' and 'effect' at all.

Mach is one. Although he talks about sensations as conditioned by the physical, he suggests this only amounts to parallel events. Apparently, this is due to his rejection that physical and psychical processes are ontologically different:

> Again, we refuse to distinguish two different aspects of an unknown *tertium quid*; the elements given in experience, whose connexion we are investigating, are always the same, and are of only one nature, though they appear, according to the nature of the connexion, at one moment as physical and at another as psychical elements. (Mach, 1996, p. 61)

However, Mach's parallelism thesis is very strong and in practice may function just as potently as sufficient and necessary causes.

> I do not of course maintain that a (psychologically) simple sensation cannot also be conditioned by very complicated circumstances. For the circumstances would hang together as the links of a chain extended to the nerve. But since the sensation may also appear in the form of a hallucination, namely when no physically conditioned circumstances are present outside the body, we see that a certain nervous process, as the final link in the chain, is the essential and immediate condition of the sensation. Now we cannot think of this immediate condition

> as being varied without conceiving of the sensation as being varied, and *vice versa*. For the connexion between this final link and the sensation we will regard the principle which we have laid down as valid. We may thus establish a guiding principle for the investigation of the sensations. This may be termed the *principle of the complete parallelism of the psychical and physical*. (Mach, 1996, p. 60)

Hume refuses, like Mach, to investigate an unknown *tertium quid*, that is, he says it is impossible to know about underlying physical causes.

> As to those *impressions*, which arise from the *senses*, their ultimate cause is, in my opinion, perfectly inexplicable by human reason, and 'twill always be impossible to decide with certainty, whether they arise immediately from the object, or are produc'd by the creative power of the mind, or are derived from the author of our being. Nor is such a question any way material to our present purpose. We may draw inferences from the coherence of our perceptions, whether they be true or false; whether they represent nature justly, or be mere illusions of the senses. (Hume, 1969, Sect. V, p. 132)

But neither Hume nor Mach can be right according to Hempel.

> We have noted that if science were thus to limit itself to the study of observable phenomena, it would hardly be able to formulate any precise and comprehensive explanatory laws at all, whereas quantitatively precise and comprehensive explanatory principles can be formulated in terms of underlying entities such as molecules, atoms and subatomic particles. And since such theories are tested and confirmed in basically the same way as hypotheses couched in terms of more or less directly observable or measurable things and events, it seems arbitrary to reject theoretically postulated entities as fictitious. (Hempel, 1966, p. 81)

I share Hempel's standpoint. Therefore, when I say that Jackson's goal is to refute Physicalism, i.e., the physicalist's thesis whereby "all (correct) information is physical information" I assume the information is about underlying entities, that is, I consistently interpret "physical information" as information of physical processes that do not involve colours or any other determinables like sounds or smells etc. This means I do not buy Hume and Mach's monism. I believe in physical causes of qualia, causes which are not qualia themselves.

I think this agrees with Jackson. Mary knows about the underlying physical causes of hues, among them the neural states, though she has never experienced hues.

Tye (1986, pp. 2-4) brings three arguments into the discussion about Mary. Two of them seem not to be relevant to my discussion here, and I explain why below. I think, however, that the third has a logical force against my proposed solution to Jackson's knowledge problem.

Nevertheless, I must note that in order to justify the three arguments Tye refers to Hume's proposal that what is imaginable is possible. Hume, though, may not be the right man to converse with in this connection, because of his monism. According to my interpretation of Jackson, the physical concerns entities that one cannot observe directly, and consequently one cannot imagine things like, for example, radians, chemical processes in the visual nerve or neuronal firings in the visual cortex.

Or rather, Mary does not imagine such things. According to Jackson's postulates, she does know about them.

The question I take to be at issue in this connection is whether the arguments Tye brings to bear can weaken or refute my proposed solution to the knowledge problem.

First. The multiple realizability argument rests, according to Tye, "upon the claim that qualia can be multiply realized, that the neural state or property N, which realizes a given quale, Q, in me might be different from the neural state or property M which realizes that quale in you or in creatures of other possible species."

I don't think this argument can be used against my proposed solution. Jackson takes it for granted, namely, that Mary knows all about physical processes and therefore also knows about M; furthermore, she knows about other realizers of r like P and R, etc. Therefore, she can put the realizers into her psychophysical statement as a disjunctive series together with process X and it follows she has knowledge about the connection between X and r. (This is to admit X is only a sufficient realizer, but if there is a limited number of other realizers the disjunctive series itself might be considered as necessary.)

Second. The absent qualia argument has, according to Tye, "as its major premise the claim that two beings might be in states which are functionally identical in every respect and yet which are such that the one has a phenomenal character and the other lacks it."

But neither is this argument relevant to Jackson's Mary because it is a fundamental premise in his thought experiment that Mary sees red for the first time. Tye accepts this premise, and his discussion concerns mainly the question if Mary learns something when she sees it.

Third. The inverted qualia argument says, according to Tye, "two inner states might be functionally equivalent in every respect yet qualitatively different".

This argument opens up for the possibility that Mary sees green instead of red, and it follows that she is wrong in believing she knows what other people see when they are in brain state X. In fact, the argument makes it possible that Mary, although she sees hues, sees hues that are different from all the hues other people see. Jackson's own thought experiment about Fred (1982, p. 129) seems to involve such an option.

Tye says, "Advocates of the Inverted Qualia Argument maintain that cases of inverted functionally-equivalent qualitative states are perfectly imaginable and hence possible." Though I cannot accept this imaginability argument for reasons mentioned above, I still think inverted qualia are logically possible because an assumption of them does not entail a contradiction. It would only lead to a contradiction if the bridge principle is taken to be true a priori.

But bridge principles are hypotheses because they are suggested explanations of instantiations of specific qualia. These explanations contain propositions stated in universal form. It is common knowledge in the philosophy of science that the hypothetical deductive method can only strengthen or weaken a belief in the hypotheses when they are confirmed or disconfirmed.

It should be noted that Mary could never contribute to the psychophysical development of bridge principles concerning hues, because of her imprisonment. The day she is set free, the situation changes.

Now, Jackson's version of the physicalist thesis is that "all (correct) information is physical information". He never questions if the information is true, but only if the physicalist thesis is true.

On the other hand, since he does not explicitly bring in a presupposition that psychophysical bridge principles are true I must admit that the inverted spectrum argument can be applied against my suggested solution to Jackson's knowledge problem.

I can therefore only say that I do not believe in the argument. I use the word 'belief' in Hume's sense. "Belief consists merely in a particular feeling or sentiment." (Hume (2), URL) and "the belief super-adds nothing to the idea." (Hume, 1969, p. 151, Book I, Section VIII) That is, I believe bridge principles may be true but I do not believe in inverted qualia though I admit they are logical possible.

In opposition, Clark (1993, p. 12) seems to lose faith in bridge principles because of the inverted qualia argument. "It is disconcerting to find plausible arguments contradicting what seems an obvious fact. Either there is some error in the philosophical arguments, or the apparently successful explanations provided by contemporary visual science are bogus."

However, Clark's discussion of the inverted spectrum argument (pp. 10-11) takes as its point of departure Nagel's article *What is it like to be a bat?* Nagel says there is only one way to find the right answer to the question, namely to adopt the bat's point of view. But this, Nagel concludes, is impossible. "Reflection on what it is like to be a bat seems to lead us, therefore, to the conclusion that there are facts that do not consist in the truth of propositions expressible in human language." (Nagel, 1974, p. 441)

What Clark misses, however, is that Nagel finds it reasonable that humans can understand each other, that is, one person may adopt another person's point of view.

> I am not adverting here to the alleged privacy of experience to its possessor. The point of view in question is not one accessible only to a single individual. Rather it is a *type*. It is often possible to take up a point of view other than one's own, so the comprehension of such facts is not limited to one's own case. There is a sense in which phenomenological facts are perfectly objective: one person can say of another what the quality of the other's experience is. They are subjective, however, in the sense that even this objective ascription of experience is possible only for someone sufficiently similar to the object of ascription in the first person as well as in the third, so to speak. The more different from oneself the other experiencer is, the less success one can expect with this enterprise. In our own case we occupy the relevant point of view, but we will have as much difficulty understanding our own experience properly if we approach it from another point of view as we would if we tried to understand the experience of another species without taking up *its* point of view. (Nagel, 1974, pp. 441-442)

I think Nagel here offers a straightforward ordinary life conception of what it is like to adopt another person's point of view. My opinion is that such point of view in connection with colours may have two components, perspective and thought. In the

following section, last pages, I discuss if a third component like attentional organization should be brought into the picture.

Hardin (1988, p. 68) gives an example of perspective where he describes under which standard conditions Munsell's colour ships ought to be viewed: on a black background, viewed from a 45-degree angle and in daylight of a specified temperature. And he says "This is a good basic procedure for assigning a colour to many reflecting objects by visual match to a standard, and is fully adequate to its intended task."

In scientific research one must be able to see colours from somewhat the same point of view in order to test propositions. Let me illustrate further with the example from Katz discussed in section 1.4.3 above. Katz suggests this procedure in order to make an instantiation of a colour that has no inner variation. "If we stretch a sheet of exceedingly smooth paper, which is not shiny, across a pane of glass, and view it from a sufficiently great distance, we shall have a surface colour from which all texture is completely absent." (Katz, 1935, p. 12.)

Now, let Mary walk into Katz's laboratory and stay at the right distance and look at the paper which is, say, red. She sees red from somewhat the same point of view as Katz. This is the perspectival component.

But if she agrees with Katz that there is no texture in the red, which means, as I understand it, the red is uniform, or as Hering says, without inner variation, they may also think the same. That is, both may think of the red as a uniform infield of which grey (for example a grey wall) is outfield. This thought is about a colour relation.

But both can also understand or think of r as an effect of, or as realized by or related to, etc., brain process X.

Maybe Katz also thinks of r from a different point of view than Mary, because he understands it as a sheet of exceedingly smooth paper, something Mary cannot unless she is told or carries out her own investigations.

However, they may still share same points of view in other respects. For example, maybe both think of r in the way Hering does, that is, they conceive of r as a composition of three colours, namely red, black and white. Katz was a contemporary of Hering and Mary has probably read about heterogeneity of hues even if this is the first time she sees one. Besides, she has most probably thought about heterogeneous colours consisting of black and white from before, and takes every grey she sees to be a composition of the two.

2.11.2 Knowledge by acquaintance vs. knowing-how

As I stated in the beginning of the forgoing section Jackson's focus is mainly on Mary's observation of red. I repeat one of the quotations from him. "For when she is let out of the black-and-white room or given a colour television, she will learn what it is like to see something red, say. This is rightly described as learning – she will not say 'ho, hum.' Hence, physicalism is false." (Jackson, 1986, p. 291)

Here Jackson talks about what Mary learns when she sees red. An association with brain state X is left out of the story. Mary seems to be left with a something like "this is red". And it seems Jackson thinks that from now on her learning develops.

But in saying to herself this is red she is not uttering a proposition because "this" and "red" are both indicatives, i.e. they both function as proper names for the same particular colour.

So, if Jackson's contention about Mary above amounts to nothing more, her so-called learning is not stated in a proposition but only in saying "this" indicating a certain hue.

Both Tye and Conee seem to interpret Jackson in this way and their conclusions seem the same, namely that Mary's observation of the hue amounts to nothing more than acquaintance.

Tye (1986, p. 15) says that in a situation like Mary's a person "will not thereby learn anything. For surely to learn something is to acquire *genuinely new knowledge*." And he apparently thinks that a true proposition is a necessary condition for knowledge.

In his last paragraph (p. 17) he categorizes experiences like Mary's as subjective, and on p. 7 he traces thought experiments like Jackson's back to Russell "where they are associated with the famous doctrine of knowledge by acquaintance."

Conee (1994, p. 140, note 4) is more obvious in insisting on acquaintance than Tye.

> The main contention here is that Fred's knowledge of the special quality of his experience and Mary's of what it is like to see something red are initially matters of acquaintance with the relevant phenomenal qualities. Having this knowledge does not imply possessing of any sort of information.

Acquaintance is a philosophical term especially known from Russell and stands for a state of mind, i.e. immediate awareness of a sense datum. "Thus, whenever we see a colour, we have a sensation *of* the colour, but the colour itself is a sense datum, not a sensation. The colour is that of which we are immediately aware, and the awareness itself is the sensation." (Russell, 2015, Chapter I) In the same book, Chapter IV, Russell explains *acquaintance* as "the sense in which we know sense data."

> Again, it is by no means a truism, and is in fact false, that we cannot know that anything exists which we do not know. The word 'know' is here used in two different senses. (1) In its first use it is applicable to the sort of knowledge which is opposed to error, the sense in which what we know is *true*, the sense which applies to our beliefs and convictions, i.e. to what are called judgements. In this sense of the word we know *that* something is the case. This sort of knowledge may be called knowledge of truths. (2) In the second use of the word 'know' above, the word applies to our knowledge of *things*, which we may call *acquaintance*. This is the sense in which we know sense data. (Russell, 2015, Chapter IV)

In Chapter V, Russell says; "I know the colour perfectly and completely when I see it, and no further knowledge of it itself is even theoretically possible."

I find it peculiar to use the same term *know* about two different operations, namely judgement and acquaintance. However, this is common in relevant literature.

Judgement-knowledge is usually considered to be a true proposition which you believe is true and which you have good reasons to believe is true. Dancy says this threefold condition for knowledge – true proposition, belief in it and justification for the belief – is the standard account of knowledge. He designates it as propositional knowledge. But he also mentions knowing by acquaintance and knowing-how in opposition to the first kind.

> Because there are three parts to this definition it is called the tripartite definition or the tripartite account; it defines propositional knowledge, knowledge that *p*; it does not define knowledge by acquaintance as in '*a* knows James' nor knowledge-how, e.g. knowledge how to ride a bicycle, unless these can be shown to reduce to knowledge-that. (Dancy, 1985, p. 23)

In connection with Jackson's Mary, Lewis (1988) suggests Mary knows the hue in the meaning knowing-how. On page 18 he calls it ability. "The Ability Hypothesis says that knowing what an experience is like just is the possession of these abilities to remember, imagine and recognize." On page 19 he adds:

> If the Ability Hypothesis is the correct analysis of knowing what an experience is like, then phenomenal information is an illusion. We ought to explain that illusion. It would be feeble, I think, just to say that we're fooled by the ambiguity of the word "know": we confuse ability with information because we confuse knowledge in the sense of knowing-how with knowledge in the sense of knowing-that. There may be two senses of the word "know", but they are well and truly entangled. They mark the two pure endpoints of a range of mixed cases. The usual thing is that we gain information and ability together. If so, it should be no surprise if we apply to pure cases of gaining ability, or to pure cases of gaining information, the same word "know" that we apply to all the mixed cases.

Since Lewis does not explain exactly what he means by imagining, remembering and recognizing, there is hardly anything to gain from discussing his ability hypothesis in detail.

And besides, Conee argues that ability is of no importance in the Mary case, because Jackson's outline concerns only Mary seeing red for the first time. His contention that she learns something at that moment can therefore be countered by the acquaintance argument and does not require ability.

> This version of the case of Mary enables us to see that knowing what an experience is like requires nothing more than noticing the experience as it is undergone. That is all Mary did, and yet it was enough to justify her issuing an 'Aha!' exclaiming a revelation. Memory and imagination are unnecessary. In fact, no ability to do anything other than to notice an experience is required. This point does not require that we deny all role for abilities in the phenomenon that we call 'knowing what it is like'. *Continuing to know* what an experience is like may require mnemonic or imaginative abilities. But the knowledge argument against physicalism has no need of any such continued knowledge. (Conee, 1994, p. 139)

I do agree with Conee that ability need not play any role in relation to Jackson's knowledge argument. Therefore, I only address the acquaintance argument.

The sentence I propose as a solution to Jackson's knowledge problem, namely Mary's saying to herself, "My brain state X causes this r", cannot be reduced to mere acquaintance.

However, acquaintance is involved, because Mary indicates a particular by using "this" and "r". But in addition, she conceptualizes the colour she indicates, saying it is an effect of X. So, I think my reasoning rescues Jackson's contention that Mary learns something and Tye and Conee's acquaintance argument can be rejected.

On the other hand, I am further fascinated by Russell's explanation of the acquaintance act. It seems to be an all or nothing affair. This conforms to the Committee on Colorimetry (1953, p. 102) which says that colour sensations might be "perfectly pure or wholly devoid of meaning." It is like the acquaintance hypothesis demands that one empties one's mind, that is, purges all conceptions. On page 7 the Committee explains that "The more interpretative or meaningful a perception is, the more it differs from pure sensation; the more sensory or uninterpretative the experience is, the closer it approximates pure sensation."

Some philosophers deny the very possibility of attending to colours in this way. The Committee on Colorimetry (1953, p. 6) quotes James. "But it is obvious that such immediate sensations can only be realized in the earliest days of life. They are all but impossible to adults with memories and stores of associations acquired."

Without presenting them by names, Price refers to similar objections from other philosophers. Price's term The Given conforms at least in one way to sense datum as Russell and the Committee explains it, because Price says a sense datum might be "homogeneous or *undifferentiated*". (Price, 1964, p. 223)

> There is also what may be called the Empirical Thesis. This does not say that there is an absurdity in the very notion of givenness. It only says that we can never find anything which is given. And it concludes that either there is no Given at all, or if it is any, it is found only in the experience of new-borne children, idiots, and people falling into or just coming out of fainting fits: in which case (it is urged) the Given is clearly of no importance to the philosopher, for it is quite beyond the reach of investigation, and therefore cannot be appealed to as evidence for anything. (Price, 1964, p. 6)

One can perhaps ask whether I too believe in acquaintance. Since I hold, in agreement with Johnson, that naming includes no connotation of a particular colour, at least some likeness is involved.

However, in sections 2.3 and 2.3.1, I explain how it is to be confronted with particulars. It is not a matter of purging the mind; rather it is the recognition that no taxonomic categorization is possible with reference to this or that particular colour. This is not a state of mind next to unconsciousness but includes systematic observation and reasoning.

For example, the red in Katz's laboratory is a uniform infield of which the grey of the wall is outfield. The relation between red and grey makes red a figure which Mary maybe cognizes as a square.

Hospers seems to explain the naming situation in accordance with my description.

> What about the man who can see? Can he state a criterion for the use of the term "red"? He has a criterion, of course – otherwise he would not know when to use the word "red" and when not to. But the criterion is simply whether this particular shade of colour is present to his consciousness. *He* knows how to distinguish it from other colours, but there is no way of stating in *words* how to do this, (…). In short, he has a criterion for the use of the word "red,"

> but he cannot state it in words; all that can be stated in words turn out to be accompanying characteristics. The defining characteristics of "red" cannot be stated so as to distinguish it from other colours. Thus, you see, "red" is *verbally* indefinable. (Hospers, 1961, p. 62)

That is, in a naming situation you are not reduced to a baby child. You are still an intellectual, but one who admits that colours set limits for conceptualization.

Price seems to give up insisting acquaintance might be completely without propositional content. However, the given, i.e. that with which one is acquainted, is not affected Price says. That is, acquaintance is paired with conceptions of the circumstances under which the given is given.

> It is impossible to apprehend something without apprehending some at least of its qualities and relations. In the language of Cambridge logicians, what we apprehend is always a *fact* – something of the form 'that A is B' or 'the B-ness of A'. (…) But if we apprehend that it has these qualities and relations, we are not passively 'receiving' or (as it were) swallowing; we are actively thinking - judging or classifying – and it is impossible to do less than this.
>
> To this I answer, it is very likely true, but it is irrelevant. The argument only proves that nothing stands merely in the relation of givenness to the mind, without also standing in other relations: i.e. that what is given is always also 'thought about' in some sense or other of that ambiguous phrase. But this does not have the slightest tendency to prove that *nothing is given at all*. The fact that A and B are constantly conjoined, or even necessarily connected, does not have the slightest tendency to prove that A does not exist. How could it, since it itself presupposes the existence of A? That arguments of this sort should be so frequently used, and should be thought so conclusive, is one of the curiosities of philosophical controversy. (Price, 1964, pp. 6-7)

I agree, and my main example is the infield-outfield relation. When Mary sees r in Katz's laboratory, she also sees grey as outfield. Check in this connection the end of section 2.10.1 above. She knows the relation from before, without having seen r before, because she knows the relation from black-grey-white relations. Indeed, the only example I can figure out as relevant to complete acquaintance in Russell's sense is when only one colour makes up the visual totality. See in this connection section 2.10.4, the final paragraphs.

On the other hand, as I claim in section 2.1, it is perfectly meaningful to characterize particular colours in conformity with Carnap's type theory. And this is exactly what Mary does when she thinks the particular red is the effect from X.

That is, Mary's main attention on red and not on the figure or the outfield seems to be a matter of choice. This is what Watzl explains as attentional organization. Now, there will always be a lot of other experiences at the same time as Mary observes red. Maybe she is hungry, maybe she feels an itch on her shoulder, and maybe some musicians in the next-door room play saxophone and piano. And she might organize all these part experiences into centre and periphery in accordance with Watzl's concept 'attentional connection'.

> The idea that the field of consciousness has attentional structure is highly intuitive. When I focus attention on an itch there seems to be a sense in which the itch experience is central in the field of consciousness, while the feeling of elevation (…) becomes a mere periphery to that central experience. By contrast, when I start focusing on the melody being played by the saxophone, the itch experience moves from the centre to the fringe or margin of my field of consciousness. The piano experience is more peripheral than the sax experience, and the itch experience is in the periphery of even the piano. (Watzl, 2014, p. 65)

In his conclusion (p. 85) Watzl says; "Attentional connections create a unified subjective perspective out of qualitative states." In his Abstract this conclusion is more specified: "Conscious experience provides subjects with a subjective perspective, or point of view, because its various parts are structured by attention into what is more central and what is more peripheral."

In his article Watzl is not concerned particularly with the question of whether several parts of experience differ according to shifts in attentional organisation.

However, some colour researchers, in studying only colour relations, find that shifts in attention affect differences in colours. Others deny that this is a fact.[22]

Maybe an additional condition for Mary is appropriate, namely that she brings the red into her attentional centre. Shared perspective is perhaps not enough; the subjective factor of willingly attentional organization can certainly play a role.

The Committee on Colorimetry (1953, p. 156) underscores this point.

> Probably the most volatile and potent interpretive factor is attitude of the observer. Attitude and, more generally, interest comprise the internal control of attention and, by determining what is looked at and what is looked for, have much to do with what is actually seen or perceived. A synthetic or object-directed attitude is one which normally leads to the natural or naïve type of perceptual response which people usually make in recognizing in their ordinary course of events. The object attitude is one in which the individual is trying to perceive the object itself; and in so doing he tends to get impressions of size, shape, and colour which are characteristic of the object. An analytic or subjective attitude, on the other hand, is one in which the individual is not so much concerned with the general nature of the object as with the stimulation coming to him from that direction. In this attitude, for instance, the observer might notice that the shape of a red square as projected in his direction is not square, that it is smaller than the original, and that a shadowed portion has really a different colour from the unshadowed portion. This is the critical attitude assumed by the artist or technical colourist who is trying to detect or identify details and changes in details of the light pattern reaching his eye. This analytic attitude disfavours colour constancy, whereas the object attitude favours it.

And Hering (1964, p. 226-227) has noted something of the same.

> Anyone who wants to see always has the opportunity to see something, whether his retina is illuminated or darkened. But a person who closes his eyes sees nothing at all and thus does not even have any experience with the intrinsic colours of his visual field; for we see only what unintentionally or deliberately becomes the object of our attention; to everything else we are "mentally blind".

2.11.3 Identification of X with r

The three arguments on possibility, which I discussed in section 2.11.1 above, are usually addressed both to physicalism and the identity thesis, not to Jackson's story about Mary. As Tye explains (1986, p. 2), a physicalist wishes to identify a quality

[22] For example, Fuller and Carrasco (2006) suggest it is saturation changes, but not hue. Tse (2004) finds that brightness changes. On the other hand, Beck and Schneider (2017) doubt that experimental data can support such conclusions.

with a physical property, or more exact, as he says on page 4, identify "qualia with neural properties".

Kim (1998, p. 56) also expresses the physicalist's aim in somewhat the same manner: "The identity theory states that mental events are identical with brain processes."

But in my opinion such expressions are misleading and should not be taken literally. An analogy: the front and back of a coin are not identical though it is true they constitute, together with the side and the metal, one object. In the following discussion I use the word "identical" and related words in more or less the same meaning as "being constitutive of one and the same object". This seems to accord with Kim's real meaning.

As regards brain process X and colour r, identification does therefore not mean r is identical with X but that X and r constitute one object. Instead of a causal distinction between X and r the so-called identification leads to Xr, and Kim maintains (1998, p. 150) the two constituents are "perfectly simultaneous".

Kim also maintains "identities are empirical, not a priori, truths." (Kim, 1998, p. 57) It is clear to me they cannot be a priori truths; however, I see no reason to conceal the fact that knowledge of the physical constituent at best is a theoretical truth. In the Mary example Jackson presupposes Mary has knowledge of the physical but it must not be forgotten that this knowledge is about microphysical entities and processes the existence of which can only be tested indirectly. See in this connection section 2.11.1 above, where I present Hempel's view on bridge principles.

Indeed, identification leads to an alternative solution to Jackson's knowledge problem. Cortical process X has not yet been activated in Mary's brain and therefore she has not yet realized what all the constituents are. But, as the story goes, she knows all about X and she can confirm that such processes are going on in other people's brains.

First when she confirms her own brain is in exactly the crucial neuronal state she realizes both constituents. At this time Mary has a conception of red, namely that it is one constituent of Xr. This solution seems to be just as good as mine where Mary conceptualizes red as the effect of X. One can then ask which is the best solution, identification or causal relation. But there is, maybe, a third alternative, namely dumping both and replace them with equivalence relation between sentences.

At the outset Carnap (1935, p. 34) dismisses both identification and causal connection as metaphysical nonsense.

> For instance, if I speak about the psychical state described by the sentence S1 and the physical state described by S2, we may be tempted to raise the question whether they are really two states or only one and the same state regarded from two different points of view; and further, if they are two states, we may ask what relation there is between them to explain their simultaneous occurrence, and in particular whether this relation is the relation of causality or that of mere parallelism. Thus we find ourselves sliding into the midst of metaphysics – and that is sliding into the mud.

Carnap's own alternative is his formal method which focuses on equivalence between S1 and S2.

> The questions mentioned belong, indeed, to one of the most famous philosophical problems, the so-called psycho-physical problem. Nevertheless they are pseudo-questions, they have no theoretical sense. All the questions that have sense in this connection can be formulated in the formal mode, that is by referring to sentences. It is characteristic of the above metaphysical questions that they can only be expressed in the material mode, by referring to states, not to sentences.
>
> Among the formal questions which really have sense, perhaps the most important in this connection is whether or not to every psychological sentence S1 there is a corresponding physical sentence S2 that is equipollent with S1.

It seems to me that Carnap's suggestion leads, from one point of view, to the very question Jackson initiated with his knowledge problem. Does Mary learn something or not? If S1 is her own report about red, my discussion shows there are three alternatives: either she is in a state of acquaintance, or she contemplates the colour judging it an effect from X, or she identifies and therefore judges it a constituent of Xr.

It is the equivalence relation between S1 and S2 Carnap focuses on. How can he postulate equivalence? If S1 concerns acquaintance there can be no equivalence because acquaintance does not include knowledge, i.e. in that case S1 does not express a proposition that can be true or false.

But Carnap elsewhere in his explication refers to universal laws. And those laws are about psychophysical causal relations, not sentences. He says; "It is obvious that the sentence S2 can be deduced from S1 by the help of this law; and likewise S1 from S2." (Carnap, 1935, p. 32) Therefore it seems Carnap is trapped in the same metaphysical mud that he wants to rescue philosophy from.

Kim's discussion on identification concerns qualities like pains and colours, on the one side, and neuronal processes in the brain, on the other. Though Kim uses pain as a standard example, I think one colour is interchangeable with pain at least in some of his explications. He himself uses colours as example (see below) together with pain as if the two examples illustrate the same point.

It is, by the way, not the case that Kim dismisses causal relations. He accepts neuronal process X to be the cause of another neuronal process, but he then leaves out the other constituent r. (Kim, 1998, pp. 150-151) To me this seems inconsistent because the so-called identity comes to an end before X does the causal work. If their existence is "perfectly simultaneous" as Kim says, it follows Xr should do that work. One of Kim's intentions is to rescue colour philosophy from epiphenomenalism, but to me it seems that he by this move, not fulfils. See explanation of epiphenomenalism in Chapter II, section 2.

Before I bring my discussion further, let me underscore my attitude to these complex problems. It is not my intention to engage and favour causal explanations in psychophysics in relation to colours. That I leave to those who are concerned about the matter. For example, Valberg contends, "Neurophysiology has in the last quarter of the 20th century made a big step forward in giving such an overview (i.e. a theory of linking hypotheses) concerning the structure of the visual system and its function in different species of animals." (Valberg, 1977, p. 97, my translation.) Arstila adds to

this: “Some of the best-known areas in the brain are probably those that are involved with colour vision.” (Arstila, 2005, p. 33)

Indeed, I have a pragmatic attitude to psychophysics. Both traditions, i.e. causal explanation and identification, rest on hypotheses about the physical. I think theories therefore must be judged on their ability to make precise predictions and to develop technological items. If causal explanation is suitable in some areas and identification is suitable in others, so be it.

On the other hand, what I do not endeavour is to get the programs on causal explanation and identification to send a colour philosopher into the theoretical net of physics. I have throughout main section 2 used examples to clarify that knowledge about colour relations is obtainable independent of the physical aspect. See in this connection the following section and sections 2.11.4 and 2.12.1.

If I should rest on causal relation, the first problem in this present thesis, i.e. whether colours are heterogeneous or homogeneous, would have been answered in favour of the latter. If colours have sufficient physical causes the principle of no over-determination would exclude the possibility of heterogeneity. See in this connection Kim, 1998, pp. 147-153. An example: if orange consists of red and yellow, the mix is a cause of orange. However, in that case, a brain process is not the only cause and therefore the mix over-determines the physical process.

Furthermore, if colours are identical with physical processes in the brain it logically follows that colours must be three-dimensional. Adherents of identification theory simply have to dismiss the possibility that colours are two-dimensional. But in section 3, I argue that colours are two-dimensional. However, my arguments do not depend on bringing in theoretical entities. Anyhow, it goes to show that I cannot accept the dimensionality implication of identification theory.

But now I return to my discussion of identification and I address some aspects I find very problematic. My discussion includes adverbial theory on colours.

Kim traces the possibility of identification back to minimal physicalism which he defines by three principles:

> The mental supervenes on the physical in that any two things (objects, events, organisms, persons, etc.) exactly alike in all physical properties cannot differ in respect of mental properties. That is, physical indiscernibility entails psychological indiscernibility.
>
> There can be no purely mental beings (for example, Cartesian souls). That is, nothing can have a mental property without having some physical property and hence without being a physical thing.
>
> What mental properties a given thing has depends on, and is determined by, what physical properties it has. That is to say, the psychological character of a thing is wholly determined by its physical character. (Kim, 1998, pp- 10-12.)

The two arguments Absent Qualia and Inverted Spectrum, obviously go against physicalism, but the Multiple Realization argument seems not to be a threat. However, as Kim remarks, the latter is not compatible with the identity thesis, because if one colour has many sufficient realizers it cannot be identified with any of them. (Kim, 1998, p. 149)

The latter seems to be Hardin's argument against identifying colours with their physical realizers.

> Unique green, for example, is experienced by most subjects when they are stimulated by monochromatic light of 503 nm. But unique green is equally well evoked by a mixture of 490 nm and 540 nm or, indeed, by indefinitely many other wavelength pairs, none of which need contain 503 nm. Nor is there any relationship between unique hues and single wavelengths, or between binary hues and pairs of wavelengths. There is no wavelength relationship that corresponds to the opponent relationships either. An object may reflect equal amounts of 503 nm (which perceptually evokes unique green) and 650 nm light (which evokes a very slightly yellowish red) without producing a perception of greenish red. Instead, it is white or grey barely tinged with yellow which is seen. (Hardin, 1984, p. 495)

Kim (1998, pp. 69-70) presents many arguments in favour of the multiple realization principle. In reply he contrasts it with an implication from the identity thesis: "We should keep in mind that if pain is identical with physical state C, then pain is identical with state C not only in actual organisms and systems but in all possible organisms and systems."

However, Kim counts on strict identity and not part identity. He appeals to the Principle of Indiscernibles, that is, Leibniz's Law, in order to explain why pain and C-fibre excitation must be one and the same object assuming they are identical. (Kim, 1998, p. 58) According to Forrest (2010, introduction) Leibniz's Law "is typically understood to mean that no two objects have exactly the same properties". Hence, if pain and C are identical they cannot be two objects but one, or, as Kim explains; "If X is indeed identical with Y, there is here only one thing and not two."

Forrest (§ 1) formulates Leibniz's Law like this:

> The Identity of Indiscernibles (hereafter called the Principle) is usually formulated as follows: if, for every property F, object x has F if and only if object y has F, then x is identical to y. (…). This formulation of the Principle is equivalent to the Dissimilarity of the Diverse as McTaggart called it, namely: if x and y are distinct then there is at least one property that x has and y does not."

In my opinion this creates problems for Kim's so-called identification because it follows that no two occurrences of C-fibre excitations are strictly identical, and hence, no two pains can be strictly identical. Kim can be interpreted as if he means the contrary. But the principle of indiscernibles concerns singular occurrences of C-fibre excitations, that is, in each case it is a particular pain that is identical with a particular C in the meaning they constitute one and the same object.

For example: In the foregoing section I claim that Katz and Mary are both aware of red at the same time, that is, they are both aware of the same colour. However, according to Kim's identity thesis red is in each case strictly identical with brain process X which means there are two processes going on in two different places, namely Katz's brain and Mary's brain. And so there cannot be strict identity between the two which means Katz's red cannot be strictly identical to Mary's red. This follows from the principle of the Dissimilarity of the Diverse as Forrest formulates it in the quotation from him above: If x and y are distinct then there is at least one property that x has and y does not.

Kim is aware of this implication but he seems not to care. At least he does not problematize it in his explanation of type physicalism which he apparently endeavours to defend.

> There is another approach to events that make type physicalism a natural way (in fact, the only way) of formulating the identity theory. On this view, an event is the exemplification (or instantiation) of a property by an object at the same time. So my now being in pain (my instantiating the property of being in pain) is an event; your now being in pain and my being in pain yesterday are also events, but these events are all distinct. For events *e* an *e'* to be "the same event," on this account, they must be the instantiation of the same property by one and the same object at the same time; that is:
>
> The event of x's instantiating property P at time *t* = the event of y's instantiating property Q at time *t'* if and only if x = y, property P = property Q, and *t* = *t'*. (Kim, 1998, p. 60)

To me, talk about different places and times which are reduced to one and the same place and time not only smacks of contradictious but also is contradictive.

Apart from this problem in Kim's explication it is, as Kim says, true that strict identification of X with r cannot be defended unless both occupy the same place. At first hand it seems identification theorists claim colours might occur at the same place in the brain where the neuronal activity goes on. But this assumption is too naïve, according to Kim (1998, p. 64). "Or take an orangish yellow visual image. If the visual image is a brain state, then, by the indiscernibility of identicals, some brain state must be orangish yellow, which seems absurd or at best simply false."

Kim does not say why it is absurd. But I agree in his judgement and my reason is that neuronal firing is a process at the micro level and simply cannot be seen. Rather, neuronal excitation is a continuous interplay between microelements and they, according to Kim (1998, p. 54), "involve tens of thousands of cells, millions and billions of molecules and basic particles." As such it is a process or an event in the sense that it consists of ongoing interactions. Since, as I hold, these interactions can neither be seen nor imagined, to say a colour is constitutive of those interactions is simply a contradiction in terms.

Without further ado about this problem Kim changes his subject and says it is not the colour but the experiencing of it that is at stake. And he mentions two alternatives. "What is being identified with a brain state is the experiencing of an orangish yellow visual image, not an orangish yellow experiencing of a visual image. And this seems intuitively right." (Kim, 1998, p. 65)

To me it appears that Kim alludes to adverbial theory. It is, namely, difficult to accept identification between a colour and a neuronal process because when a colour is named it is because it is steady, not changing, while the neuronal firings go on and on. It seems Kim wants to treat the colour as a process and experiencing is more likely to be a process. But such move is also characteristic of the adverbial approach.

However, before I discuss adverbial theory, I feel a need to criticize Kim for his expression.

"What is being identified with a brain state is the experiencing of an orangish yellow visual image" is an expression that breaks with one of the rules in Carnap's type

theory: “a property of the nth level is applied only to concepts of the level n-1.” See in this connection section 2.1.

The expression “visual image” has a connotation, it serves to render a type characterization. And therefore, a visual image cannot be a subject that has colour properties, i.e., a concept cannot be coloured. Hence, a visual image cannot be orangish yellow as Kim expresses it, though some orangish yellow can be a visual image. If, for example, a visual image is defined as a patch, that is, an infield or a middle field, then it can be true to say that this particular with the name orangish yellow is a visual image. However, whether this proposition is true or false depends on whether the given orangish yellow satisfies the definition. See in this connection section 2.10 above and/or BD VIII, in Chapter I, Section 3.

Now, Tye (1984, pp. 195-196) says adverbial theory developed because of difficulties in sense datum theory. Arstila (2005, pp. 172-173) agrees: “the sense datum theory is simply too problematic and implausible to be true” and he holds adverbialism to be a reasonably good alternative. Arstila refers to Hardin’s critique (Hardin, 1988, pp. 96-109) as his reason for rejecting sense datum theory. In 2.10.3 above I present a central point in Hardin’s critique.

But I must remark that in his discussion Hardin attacks the view “that whenever seeing occurs there exists a non-physical coloured patch which is itself seen and has a determinate colour and shape.” (Hardin, 1998, p. 98) However, Hardin brings in Hume and Jackson as proponents for this view and I cannot agree that for example the Committee on Colorimetry shares the same view on sense data. See in this connection sections 1.4.1-1.4.7.

Indeed, I believe Russell’s explanation of acquaintance is basic for many sense-datum theorists. Remember this quotation in the foregoing section: “Thus, whenever we see a colour, we have a sensation *of* the colour, but the colour itself is a sense datum, not a sensation. The colour is that of which we are immediately aware, and the awareness itself is the sensation.” (Russell, 2015, Chapter I) In this quotation the talk is about one colour only. In the following section I mention that Russell and others also use the term “sense datum” to refer to many colours at one time, and it seems to me some of Hardin’s critique is more relevant for such use.

On the other hand, it is important to note that Russell separates awareness from sense datum. I take this to mean awareness is consciousness and therefore an act of mind, while the sense datum is an object and not mind. In my view Russell therefore leans on act-object theory.

Fields (2011, p. 50) explicates the diversity between act-object theory and adverbial theory.

> On the act-object theory, the act of perceiving is ontologically distinct from the object of perception. It is quite common to claim, for instance, that a perception of blue has two elements – an act of the mind and a distinct idea that is the object of the act, i.e. the blue sensation perceived. This distinction is rejected by the adverbial theory, with the “act” of perceiving now thought of as an event while the object of perception collapses into that event. According to the adverbial account, instead of saying one sees a blue sensation, it is correct to say that one sees “bluely”.

I must try to clarify Fields's expressions. With concerns to act-object theory Fields seems to break with Russell already when she says the object of the act is the blue sensation perceived. As I interpret Russell, sensation is simply being aware of blue and blue is a sense datum which consequently can exist without anyone being aware of it. Russell does not talk about a blue awareness of blue, which in my opinion would be meaningless. However, Fields does not refer to Russell and maybe she means something else with the word sensation than Russell.

It is also unclear what she in this connection means with "perception". In common or daily life language that term may mean sensing, but this cannot be Fields's meaning because her expression could then be translated to "the blue sensation sensed". Maybe she is mixing levels of type characterization just as Kim does. If she is, it is probable she is just referring to a colour by the name "blue" and so "perceived" can mean something like "being aware of". If this is the case, Fields conforms to Russell, that is, she treats the act-object relation more like acquaintance.

On the other hand, she may mean by "perceived" the same as "understood" or "cognized". In that case she might hold the act to include some kind of conceptualization of blue. However, that implies a proposition and would be an act of *knowing that*, which does not conform to Russell's explanation of acquaintance.

It is an indication that Fields thinks particular colours can be conceptualized; see my discussion in section 2.8, first pages. I find no cogent reason, however, to prolong that discussion here.

Now, when Fields says that according to the adverbial account the object collapses into the act of perceiving, she brings in a new term namely "see", but to me it is highly probable that she is using that term synonymously with "perceive". So, in my interpretation of Fields's outline, adverbial theory only transforms the expression "I see blue" into "I see bluely". The latter is, according to Fields, a characterization of an event.

Tye finds adverbialism an advantage first of all because it gets rid of "rigid connotationless names for qualitative characters." (Tye, 1984, p. 204-205) I think it highly probable the term *rigid connotationless names* means somewhat the same as the term *proper names* which I use in section 2.3 about naming colours.

But Tye does not explain which connotations adverbs such as bluely, redly, orangly or violetly etc., provide. They should provide connotations? Because if not there would be no difference in relation to proper names.

Arstila points to the notion that a certain red can be circular. According to Arstila, at the outset no problem occurs for adverbial theory because the relation can simply be transcribed *I see redly and circularly*. But as Arstila explains, adverbial theory ends up with the so-called "many properties problem" if no further ontological constraints are provided. He describes the problem:

> Consider for example two cases, one where we see a red circle and a green square and the other where we see a green circle and a red square. Since we perceive the difference between those two cases, any theory attempting to explain our visual experiences should also be able to distinguish between them.

> According to adverbialism, we sense redly and greenly and circularly and squarely in the first case. But the disjunction of adverbs describing what we sense in the latter case is exactly the same. Consequently, as adverbialism does not have satisfactory resources for distinguishing between the two cases, its account of the organization of the visual field is unsatisfactory. (Arstila, 2005, p. 175)[23]

On page 180 Arstila points to ontological features of form and colour in order to solve the problem: "Squareness has to be presented together with something, presented by some means: any colour will do, but some is required. Exemplifying a square by some colour is what makes it possible for us to perceive it. "

Arstila's contention conforms not only to Berkeley, see in this connection my discussion with concerns to separation method in section 2.8, but also to Hume, see in this connection section 2.10.4, theme four. Hume says, "We consider the figure and colour together, since they are in fact the same and undistinguishable". (Hume, 1969, p. 72)

But Hume's description conforms to act-object theory. The first part of the quotation from Arstila above also conforms to act-object theory. First when he transcribes his description into adverbial expressions he gets rid of the many properties problem: "This tying of two sensing events together as a bundle gives us the means to meet with the many properties problem, as sensing redly(circularly) and greenly(squarely) would be different from sensing redly(squarely) and greenly(circularly)." (Arstila, 2005, p. 181)

I can agree with Arstila that he brings a solution to the many properties problem, as it raised within adverbial theory. I also agree his solution answers Tye's question "Should we say 'redly' modifies 'circularly' or vice versa?" (Tye, 1984, p. 217) In my opinion normal language adverbs are taken as separate characterizations of an action or an event, which means they are equally worthy, and one cannot modify another.

On the other hand, I find it very difficult to understand the transcription from an act-object description of a circle to the adverbial description.

In accordance with act-object theory I might say I perceive the line which red constitutes (in relation to its outfield), as circular. My perception consists therefore partly of a conception, that is, of a definition, under which I subsume the given infield-outfield relation. The other part of my perception is something like acquaintance with red, or in my view, naming the colour. Acquaintance or naming is without connotation and it follows there are two kinds of perception: conception and acquaintance/naming.

My perception of the circle may therefore contain an element of cognition in that the conception can be true or false. I may know something about the actual red, namely that it is circular. But now, and here I use Fields's expression, in adverbial terms the

[23] In this quotation Arstila talks about "disjunction of adverbs", but to me it is highly probable he really means "conjunction of adverbs".

line itself “collapses into the perception”. Does this mean that the element of cognition disappears?

If so, it seems I could not even say I perceive circularly. It looks like cognition must prevail because circularly is something quite different from squarely. To me, this is a problem adverbialists have to solve: what is the difference between cognizing a circle and sensing circularly?

Anyway, both Arstila and Tye mean adverbialism involves identification.

> Adverbialism claims that sensed colours are neural events or processes occurring in the perceiver. Adverbialism gets its name from its identifying these neural events or processes with certain ways or manners of experiencing that are described using adverbs; rather than saying that someone perceives red, the adverbialist would say that she perceives redly. (Arstila, 2005, p. 173)

> One might hold, for example, that events are complexes of objects exemplifying properties at times, where the relevant constitutive properties are nomologically congruous microphysical properties. Then sensory properties exemplified by persons, for example, sensing redly, may be taken to be identical with such properties as being the subject of an event which is a sensing redly, where being a sensing-redly is an event characterizing property which supervenes upon the appropriate micro-physical properties. (Tye, 1984, p. 203)

It seems Tye treats adverbialism as a means to cope with the difference between microphysical processes and a “still life red”. When I observe a colour, it exists for a period of time and within that period nothing happens. I agree of course that both the occurrence and the disappearance are events but the maintained existence of red cannot be an event. To change the name red into the adverb redly does not cause a change of the colour.

Tye (1984, p. 208) obviously is of the same meaning and considers this a problem for adverbialism. He proposes a solution: “What I suggest the event theorist should say here is that sensory events are always momentary (even if they appear to persist through time without changing).”

An analogy: If neuronal firings are like continuous firings from a machine gun, i.e. a process or activity, one shot from a gun is also an activity. What Tye seems to suggest is that the duration of red should be considered like a gunshot. Certainly, a colour can occur and then disappear very fast and in such cases I too will consider it like a gunshot. But the fact still remains that some colours exist for a longer time. One can overlook this fact by deciding, but one should not deny the very fact.

Besides, I think some conscious states are not processes or events. I do not deny that a conscious state might occur and disappear, but, for example, my awareness of red may have a longer duration than a gunshot.

The same appears to be true of my conception of red as circular. I can contemplate the figure without any change in thought for some time. The enduring perception is not an event though the occurrence and the disappearance of it are.

In other cases, conception is a process. Mach (1996, p. 323) makes this observation concerning a heptagon: “In looking at or imagining a heptagon, the fact of its having

seven angles need not be present to my mind. This fact is distinctly cognized only on counting."

If the heptagon is manifested by a uniform colour, that is, the infield has no inner variation; the process of realizing the number of angles should then, in my understanding of adverbialism, be characterized as something like I perceive countingly. And the perception of the final number should be an adverb like sevenly, that is, I am perceiving (or experiencing or sensing) sevenly.

In the last quotation from Arstila, he says adverbialism characterizes "certain ways or manners of experiencing". It now seems this term is too loose. It is not only that the infinitive *to experience* often is substituted for to see, or to perceive, or to sense, but also that specifications lack.

Another example: It may sometimes be a process of finding out which of three colours is between the two others. See in this connection section 2.4 above, on betweenness. That process may be classified as an experience. However, to contemplate the relation afterwards is also an experience, but apparently different from the process of finding out.

My conclusion to this is that terms like experiencing, perceiving, etc., are general notions that do not provide sufficient information. I think that adverbialism faces new problems when specific experiences are taken into consideration. At least, my examples indicate that experiences should be divided into two classes: some are processes and some are not.

I have one further critic concerning identification and this I address specifically to adherents of the heterogeneity thesis. In section 1.5.1 I quote Hardin on the eye-brain channels of unique hues. "Red and green are coded on one chromatic channel, which we shall call the **r-g** channel, and yellow and blue on another, which we shall call the **y-b** channel, with black and white represented on a third, achromatic channel."

Arstila, concentrating on the chromatic channels, tells that these are due to opponent cells which explain why for example red and green cannot be produced simultaneously. If red is the result, the opponent part is not activated and visa versa. And if red and yellow is activated at the same time, a third colour occurs. "If on the other hand both channels are activated, a person perceives a combination of the colours, say a mixture of red and yellow – i.e. orange." (Arstila, 2005, p. 31)

As I interpret Hardin and Arstila there is no channels for binary hues. It follows, if for example orange is a compound of red and yellow, this unification cannot be identified with the two chromatic channels producing red and yellow, because those occupy different places in the brain.

One further implication, which does not directly concern identification, is that binary hues should be considered as effects from unique hues. This seems to be an apparent brake with physicalism which says that any mental property is supervenient on physical properties. Such description of colours as causes to colours opposes epiphenomenalism which says colours are effects from physical processes and that no colours can be causes to other colours. See in this connection Chapter II, section 2.

I think it is interesting that the Committee on Colorimetry (1953, p. 123) seems to reason somewhat along the same lines concerning colours' possibility to be causes to other colours.

> Great interest still attaches to the historic problem of whether red and green mix binocularly so that yellow is perceived. The chief reason for the persistent interest is that yellow is the only psychological primary which is not directly accounted for in the classical tricomponent theory of vision. The contention is that to demonstrate a yellow resultant from binocular mixture is to demonstrate that perception of yellow is a function of the central nervous system and so does not require a fourth class of receptor.

2.11.4 A middle colour which is not given – some last words about Jackson's Mary – and my own reason for refusing the physicalist's insistence that all knowledge is physical knowledge

Some philosophers believe it possible to imagine a middle colour when some colours close to each other are given. Hume is one of them and his example is a linear scale of blue shades with similar difference degrees except for one place where one shade is lacking. He then tells us that his general rule that an impression always must precede an idea of it has an exception and it is possible to imagine the one hue that lacks. See in this connection Chapter IV, section 2.1 for a closer view of Hume's example.

Hume's separation of impression and idea presents a difficulty, because it implies an idea is different from an impression, i.e., the idea is weaker and fainter. This implies that the idea cannot be identical with the missing colour. However, in the following I just ignore this complication and suppose the image to be the missing colour.

I discuss this theme according to betweenness relation (see section 2.4 above), and not according to Russell's theory on colour universals, which I discuss in section 2.7 above.

Ingarden tells a story that illustrates my point. In my translation:[24]

> Suppose we have before us a red smooth sphere, for example a billiard ball. We perceive it as red. But how does my grandchild paint it? She paints a circle with only one pigment so that an invariable red colour manifests it. (…) In order to elucidate the situation, we have to go back to the originally experienced appearance which we in the beginning did not realize sufficiently clear. And then we find that the alleged circle is many-coloured, but all the same red. It is shaded in different ways. On the one side it is dark red and on the other side it is not shaded but illuminated and the colour is light red. The red manifests itself both in the shade and in the illumination. If the sphere is smooth then it glistens in a certain place. And the sphere is a *sphere*; it has a certain form. Perhaps it is lying on the ground together with some yellow or green things. Then it reflects maybe in one place somewhat greenly, in another place somewhat violetly. (Ingarden, 1970, pp. 169-170)

[24] I have not found any link to Ingarden's book on the net, but in 1967 Ingarden gave 10 lectures at the University of Oslo as an introduction to Husserl's phenomenology, each lecture is translated from German into Norwegian by the Norwegian philosopher Per Fr. Christiansen.

Both Russell and Price suggest it is possible to imagine a middle colour like Ingarden's grandchild does before she manifests it on the paper. That is, I presume she imagines it first and that she has some reds to choose from and that the one she picks is identical with the one she imagined. Russell says this about a parallel setting:

> The colour which an object seems to have at any given moment will in general be very similar, though not quite the same, from many different points of view; we might thus suppose the 'real' colour to be a sort of medium colour, intermediate between the various shades which appear from the different points of view. (Russell, 2015, Chapter III)

Price talks about standard colour.

> It is obvious from these considerations that such an adjective as 'blue' is used with two distinct meanings. When applied to single sense data, it has a simple and not further analysable meaning: the quality for the possession of which it stands may be called *sensible* blueness. But when we say that a material thing is blue we mean something much more complicated, which is indeed defined by reference to sensible blueness, but is not reducible to it: we mean that there are various visual sense data belonging to the thing which have *various* sensible colours, and that among these sensible colours which they have blue is the standard one. (Price, 1964, p. 212)[25]

I do not think it very difficult to find examples from daily life that show that people are clever in judging the middle colour of something. Take a car as example; it shines, it reflects its environment sometimes in quite different proportions and colours, and still people judge one car to be green, another to be red, another to be black, etc.

In colour systematics I also find examples that show detection of a middle colour to be a reasonable explanation why observers agree in using one proper name instead of concentrating on variations within a certain patch or infield. Some of the colour samples the Committee on Colorimetry (1953) presents have inner variation that is not possible to ignore. The 20 hues in Plate 17 may serve as example. But instead of recognizing sliding scale variation (and sometimes pointillistic variation) only one colour name is used to denote it.

One of the earliest colour systematisers in modern times is Boogart who in 1692 had produced more than 800 different infields made from watercolours in an ordered colour chart. Google his name and the year: some of Boogart's samples are present for everyone to observe. And his rectangles are not uniform, rather they must be characterized as sliding scales, in which some colours are repeated, in others not. However, it seems his samples may do a relevant job of informing people about differences between particulars and most probably imagining a middle colour plays a crucial role.

It is to me likely that a question about which colour is the middle colour may be decided at least for colour samples like Boogart's. The procedure may be to tentatively order the existing varieties or shades into a linear scale consisting of separate infields and hopefully find an agreeable middle colour that must be added if

[25] Price suggests a similar kind of standard in geometry. "Thus, if I am not good at drawing and I make a number of attempts to draw a circle freehand on the blackboard, we find that none of the shapes produced is actually a circle; yet a circle may be called the common theme on which they are variations." (Price, 1964, p. 92)

it does not already exist among the given ones. Because of indeterminacy in the sliding scale, the result cannot be taken as decisive.

Such a procedure is obviously conceptual because it depends on betweenness; see section 2.4 where I explicate Johnson's Dabc relation. That is, neither the procedure nor the result is based on mere acquaintance but is understood or conceptualized, so that both can be described. In other words, it may be true that one of the shades is the middle colour.

In my discussion of Jackson's Mary, I have presupposed the colour he names red is one, that is, an infield with no inner variation. But it is not absolutely clear that he thinks in this way. In his 1986 article, p. 294 he says; "On her release she sees a ripe tomato in normal conditions, and so has a sensation of red."

By the term "sensation of red" I take Russell to mean awareness of red and no information or propositional knowledge about the particular. However, if red is an infield and varied, propositional knowledge may be involved, for example: this infield is varied. Jackson breaks with my presumption the infield is not varied when he introduces a ripe tomato. By this move he complicates his story about Mary and makes her something of a companion to Ingarden's granddaughter. From Ingarden's story it follows that Jackson at least should use the general name "reds" and not the proper name "red". Or, if he thinks about a middle colour, he should have mentioned it. But I shall not pursue this line further.[26]

It is important not to confuse ontological views in this connection. When people talk about red tomatoes in ordinary life they are most likely thinking in naïve realistic terms. However, in his 1982 article, p. 130, in which he introduces his knowledge problem, Jackson explicitly says it concerns "raw feels, phenomenal features or qualia". This agrees with the psychophysical tradition from Descartes to The Committee on Colorimetry and to, for example, Hardin's Eliminitavism.

It is usual to use names for objects within this tradition. Indeed, it seems indispensable for effective communication. But object names need not involve

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[26] On the other hand, Russell seems to think he is acquainted also with complexes of sense data. "Thus, the sense data which make up the appearance of my table are things with which I have acquaintance, things immediately known to me just as they are." (2015, Chapter V) By this move Russell really pushes sense data theory and acquaintance too far, in my opinion. Price also commits a sin like that: "a 'good' sense datum is a relatively *differentiated* one, containing a relatively large amount of detail (i.e. many distinguishable parts or qualities), while a 'bad' sense datum is a relatively homogeneous or *undifferentiated* one. Thus, the very distant view of the three is a bad one, because the sense datum is just a homogeneous purplish mass, with a very simple outline. The near view is the better, because the sense datum displays a great multitude of parts differing from each other in shape, position, size and colour, and forming a very complicated 'leafy' pattern." (Price, 1964, p. 223) Furthermore, Price explains: "When we are acquainted with something, we are aware at once of its wholeness; it is the parts and not the whole which we have to discover for ourselves, and this discovery is a 'holding apart', not synthetic; still less is it discursive, as reason is." (Price, 1964, p. 124-125)

commitment to an ontological view that there exist substances which have properties like colours, smells, sounds etc., as for example in naïve realism. In section 2.1 I explain what Berkeley most probably means with an object, namely a bundle of ideas. Hume and Mach share this view.

But when it comes to theoretical scientific hypotheses and confirmations of them, proponents of this view seem to dismiss the object talk and make a reduction to colour relations. Schlick explains the procedure.

> I observe two pieces of green paper and determine that they have the same colour. The proposition, which asserts the sameness of colour, is verified, among other ways, by the fact that at the same time I have two experiences of the same colour. The proposition: "there are two spots of the same colour before me now" cannot be reduced to any others; it is verified by the fact that it describes the given. It has a clear meaning: by virtue of the meanings of the words involved in the proposition, it signifies just the existence of colour sameness; and by virtue of linguistic usage the proposition expresses just that experience. (Schlick, (1), 1959. pp. 92 – 93.)

Schlick does not confuse such propositions with acquaintance. He insists they are synthetic statements. And I agree: if "spot" is used in the same meaning as "infield" both the subject and the predicate connote to concepts. Furthermore, Schlick says about such propositions that,

> The problem of the "basis" changes then automatically, into that of the unshakeable point of contact between knowledge and reality. We have come to know these absolutely fixed points of contact, the confirmations, in their individuality: they are the only synthetic statements that are not *hypotheses*. They do not in any way lie at the base of science; but like a flame, cognition, as it were, licks out to them, reaching each but for a moment and then at once consuming it. And newly fed and strengthened, it flames onward to the next. (Schlick, (2), 1959, pp. 226-227)

Now, Schlick's proposition concerns identity between the colours. It is not identity between the two bits of paper he is talking about but the colours abstracted from the materials. The proposition may be true and therefore amounts to knowledge by description.

From this singular statement and other observations of particulars it is possible to induce a general statement that *two or more colours can be identical, notwithstanding difference in figure, size and position*. See in this connection my explanation in section 2.3 above.

Although I believe in colour identity, I am convinced no one can prove identity. Therefore, I call the sentence a basic supposition, see Chapter I, section 1. See also section 2.12.1 below, where I further explain what I mean by the term basic supposition. I say it is a postulate, a proposition which I demand is true, but cannot prove to be true.

That two simultaneously existing colours are identical, or the one blue I observed yesterday is the same as the one blue I observe today, cannot be proven. Neither logical rules nor practical tests, I submit, will help justify completely a claim of identity between colours.

But we seem to count on the principle of identity, whether in daily life or in science. If colour identity were not the case, and if it still were true that we can see millions of

colours in quite a short time, then it would follow that every colour I observe throughout my life has never appeared before and shall never appear again. If such a world did exist, my memory of colours would be ruined completely.

Anyway, practical proof of colour identity is something one usually imagines being done by arranging the colours next to each other. But if that were possible, and the two were identical, it would not be proof of identity, because we would be observing a single colour, not two, because they ceased to be separate, which would have to be the case to claim identity.

Let us say I place a piece of red paper on the surface of my wooden red desk. If I do not discern two red colours any more, the area they now occupy would appear to me to be uniform. It does not, however, prove that my desk and the piece of paper are of the same colour, because in the presence of only one observable colour, the initial claim, that two units are identical, loses its efficacy.

This argumentation may sound a little bit weird in relation to practical matching procedures. However, in science concerning simultaneous contrasts, and the theory of negative afterimages, it is crucial. See Chapter VII, section 2.2.

It is also (implicitly) applied as an argument against Berkeley's doctrine of visual minima. See in this connection section 2.10, second theme. If two visual minima are identical in colour and juxtaposed, they form a unit and the one cannot be discerned from the other, that is, there is no longer a visual minimum just as there is no identical colours, but only one colour.

All this leads to the conclusion, as far as I can see, that we can only postulate – not prove – any instance of colour identity. That is, if we allow in principle for identity between colours, it can only be because we have a strong feeling about its rightness.

We have only our experience of being sometimes unable to tell the difference between two or more colours. This is what happens in colour matching, and it is the practical, observational criterion of identity.

Identity between colours is only a possibility, but it makes it much easier to think theoretically about special colour issues than the contrary assumption. For example, most colour systems are based on the premise that the same colours, and therefore also the same colour relations, can be established from time to time under the same kinds of conditions.

Also, Mach signals that colours are identical irrespective of ordinary object-adjective descriptions. Mach's contention is a generalization.

> Now in its dependence upon *B C D . . ., A* is a physical element, in its dependence on *X Y Z . . .*, it is a sensation, and can also be considered as a psychical element. The green (*A*), however, is not altered at all in itself, whether we direct our attention to the one or to the other form of dependence. I see, therefore, no opposition of physical and psychical, but simple identity as regards these elements. In the sensory sphere of my consciousness, everything is at once physical and psychical. (Mach, 1196, p. 44)

Being identical is one way colours might relate. Other places in section 2, I contend that other relations too, such as, for example, line, infield-outfield, sliding scale,

colours and geometrical figures, etc., are colour relations which might be known both in their singularity and described in possibly true general statements.

It is against this background I reject as false Jackson's version of physicalism, namely the thesis "all (correct) information is physical information". (Jackson, 1982, p. 127) That is, I have grounds other than Jackson's for rejecting it.

My discussion in this whole section 2.11 indicates very strongly that both Jackson and his physicalist friends ignore both the existence of colour relations and the fact that true propositions about these relations are possible, independent of any physical information.

2.12 Colour's heterogeneity rejected by Reductio ad Absurdum

In section 2.12.1 I argue against colour heterogeneity.

Thereafter, in 2.12.2, I use my argument against some philosophers that allow for heterogeneity in connection with the principle of colour exclusion.

2.12.1 The argument against heterogeneity

The argument takes departure in a conviction which I consider justified, namely that colours are extended. Extension in this connection means they can be stretched out, either only as length and breadth or as both length and breadth and depth. In section 1.5.3 I have discussed the Cartesian point of view that colours are not extended and dismissed it. Furthermore, my discussion throughout section 2.10 reveals that talk of colour relations involves terms of extension.

However, the argument concerns the relation between any one determinate colour and its determinate size. As I have explained, in some colour relations the particulars or relata are indeterminate. See Section 2.10.3 above. This means that only infields with no inner variations should be considered.

In relation to the argument, I find Aristotle's remark about colours and extension to be crucial. See in this connection section 2.10.4, fourth theme.

Aristotle alleges a concomitance of colour and magnitude. He does not ground this proposition any further, suggesting that he takes it as a first premise. My formulation is this:

There is concomitance between colours and their extensions.

This sentence is synthetic. The subject is the relation between any colour and its extension. The predicate is concomitance.

Since the name “colours” is a common name for particulars the proposition is about instantiations. There is no concept involved in the name, it has no connotation. See in this connection sections 2.3 and 2.4. However, “extension” has connotation.

I think my discussion in section 2.8 reveals that Berkeley has furnishes a solid defence for the proposition. According to Berkeley extension cannot be separated from a colour. The claim on concomitance should therefore be understood as a postulate.

Johnson’s distinction between hypothesis, postulate and axiom is enlightening. The difference between the three is in belief. “There is a single entity called the proposition that is the same whatever may be the attitude adopted towards it.” (Johnson, 1921, p. 6)

Johnson expands on this in note 2 on the same page.

> In further illustration of this point we may select certain prominent logical terms such as hypothesis, postulate, axiom. Each of these terms indicates the peculiar attitude *to be* assumed towards the proposition in question by *any* thinker: Thus, a hypothesis stands for a proposition which awaits further scientific investigation before being finally accepted or rejected; a postulate stands for a proposition which cannot be brought to the test of experience, but the truth of which is *demanded* by the thinker; and an axiom is a proposition the truth of which is self-evident to the thinker.

In other words, a postulate is a supposition. Therefore, it might be I one day change my mind, but for the time being, I find no good reasons to throw the proposition over board. I just demand that it is true. To me it is a basic supposition. Call the sentence BS I.

Since all contentions about colours are based on experience, a general proposition like BS I must be the outcome of induction. This is why it cannot be brought to the test of experience.

The heterogeneity thesis implies that (some) colours are not concomitant with their own size. This contention must be false if the proposition on concomitance is true.

Prominent philosophers and scientists believe in heterogeneity. I have explained in Section 1 that the terminology in psychophysics more than suggests that (some) colours are heterogeneous.

In section 1.4.7 I found that the Committee on Colorimetry at least in connection with saturation degrees and intermediate colours base differences between individuals on differences in quantity of their composites. I do not say that it is easy to understand how this can be, but one implication is that, since for example red and grey is stretched over the whole extension of one unsaturated red, their extensions must be added, i.e., understood as the double of the given colour.

In section 1.5.6 I make clear that this sort of reasoning also applies to Hering’s conception of heterogeneity. “A chromatic colour can generally be regarded as comprising four primary components, two chromatic and two achromatic (white and black); a *single* chromatic primary component characterizes only those colours that have a primary colour hue.” (Hering, 1964, p. 64.)

It follows, a binary hue like for example orange, contains four colours. These four other colours must be stretched out over the same area as orange. And since orange is a fifth colour it follows Hering's view implies orange is four times its own extension.

Therefore, no one can believe in the postulate of concomitance and at the same time believe some colours to be heterogeneous. My reasoning has a reductio ad absurdum structure.

Someone might object that my reasoning here somewhat begs the question. The reason for this suspicion could be based on a misunderstanding, namely that I take it as evident that a uniform colour, i.e., an infield with no inner variation, is 1 only. And it follows it cannot be 2 or more.

However, I have been cautious not to use such arithmetic argument, because adherents of heterogeneity contend exactly that 2 or more is the case. Arstila expresses himself very clearly on this point. In his explanation of forbidden colours, for example red-green, he seems to have no doubts whatsoever that red and blue can co-exist in the same colour.

> We can perceive novel colours that are not included in our well established colour structures and that violates our conceptions of traditional restrictions concerning colours (such as the notion that red and green cannot co-exist in the same colour in the same way that red and blue can). (Arstila, 2005, p. 97.)

This means, that in this discussion, the possibility of heterogeneity concerns uniform infields, and I think it would be impolite to dismiss that talk as nonsense, on the reason 1 cannot be 2. See in this connection especially sections 1.5.4 and 1.5.5.

I interpret Arstila's proposition as an ontological claim. But this might not be what he intends, because, as I conclude in section 1.5.8, it might be a claim about phenomenal colours, which concerns how colours are perceived.

But anyway, if people believe in their own perceptions, they have ontological beliefs about colours. And the argument against heterogeneity earns to weaken such beliefs.

Another objection to my argument might be that in daily life perceptions or in naïve realistic conceptions at least some colours are taken to be smaller than they are. That is, concomitance is not always conceived of as being the case because colours are perceived as properties of physical things. For example, the white of the wall one sees at a distance is taken to be of a smaller size than it really is. Since the colour is perceived as a property of the wall, it follows that the white seen now is smaller than it really is because of the presupposed concomitance with the wall.

I admit there is often a conflict between daily life perceptions and the substantival mode which I use in detecting colour relations. If daily life perceptions, common sense and naïve realistic conceptions in some respects share fundamental beliefs about the world, I think a quotation from Rescher is appropriate in this connection: Rescher (2005, p. 131), who discusses common sense in relation to philosophy and science, concludes: "Science has no quarrel with common sense because common sense knows better than to take issue with science."

On the other hand, the substantival mode deals with extensions as determinates. See in this connection section 2.4, about Johnson's betweenness relation and his explanation of determinables.

Hume gives a good example of the substantival mode in his explanation of how to produce a minimum visible. "Put a spot of ink upon paper, fix your eye upon that spot, and retire to such a distance, that at last you lose sight of it; 'tis plain, that the moment before it vanish'd the image or impression was perfectly indivisible." (Hume, 1969, p. 76, Book I, Part II, Sect. I)

In this example, a colour is subject, it is an infield, and diminishes until an indivisible size is achieved. But then it seems to be presupposed that it is not the ink that is the subject or substantive in Hume's argument, but the colour. Every new instantiation is different in magnitude, although the colour can be the same. In this respect it would be an apparent contradiction to say that the minimum visible is of the same size as the initial size of the infield.

Another objection, also made in daily life terms, might be supported by Gerritsen's demonstration of so-called subtractive colour mixing. (Gerritsen, 1975, pp. 85-93) He has plastic colour filters each covering one half of a circle and put on top of each other, on a white circular background. The first filter is cyan and it covers half of the white and then a magenta filter of just the same size covers some of the white and some of the cyan filter. The latter covering results in violet, which then is an infield with the form of a circle segment.

This colour is often called "blue" in colour systematics, Gerritsen has written in German, and he calls it "Blau". (Gerritsen, 1975, p. 82) The same name can in literature be used on different colours just as different names can be used on the same colour. Newton calls it Violet (URL, Gutenberg, Pg 122), and so do I, that is, some times I interchange the one for the other.

I perfectly agree that this subtractive procedure gives opportunity to object against my argument and say that I do not take the depth relation into consideration and that violet in this connection clearly depends on the white paper, and the filters of different colours. And so, one might continue, it is an empirical fact that violet is three times its own size. That is, the violet observed has a circle segment form, and the empirical knowledge indicates there are three circle segments that constitute violet by a depth relation.

However, it is difficult to comprehend all of the implications that follow from my naïve realistic interpretation of such subtractive mixing. One question is where the violet is situated. Of course, when seeing it in relation to the surrounding colours I judge it has a determinate size. But when I think of the three-place relation of the paper and the two filters, I wonder if violet penetrates the whole space, i.e. if violet goes from top to bottom. But then, since the paper and the filters lay on top of each other it is not in my power to figure out how violet can lay beneath the cyan filter and the white paper. Can it instead be possible that the white moves from bottom to top, and penetrates the magenta filter, and the cyan moves from its middle position and does the same?

I will not discuss what might be reasonable answers to these questions, but I take them to indicate a serious difficulty within a naïve realistic interpretation.

One must anyway be cautious not to induce from Gerritsen's demonstration with filters that violet in general is heterogeneous in the same way, because violet might exist without filters, as is for example the case with violet (most often called blue, for example in the RGB system) in the spectrum. And also, a fruit like for example aubergine lacks the described conditions. See in this connection section 1.3.3, in where I explain how Goethe generalizes and overlooks obvious exceptions.

Another objection along the same lines can be raised with concerns to additive colour mixing. Take as example a white wall on which two circles green and violet ("blue") are projected by light projectors. (Gerritsen, 1975, p. 119) They are of the same size. Then, by moving the projectors, the circles are moved into each other, and cyan occurs. And therefore, it seems, the two extensions are reduced to one. By moving the projectors in opposite directions violet and green separate, which earns as empirical evidence for the contention that cyan is heterogeneous.

But this reasoning seems to me to depend on a possibility to separate a colour from its extension. That is, one of the components, either green or violet, must somehow leave its own extension so that the mixing result is one identical extension but still two colours. However, this is not possible according to Berkeley, and in my view, he has given sufficient grounds for claiming that, see section 2.8.

In his famous book *Optics* (URL, Gutenberg), Newton's descriptions often adhere to naïve realistic conceptions and feed the popular notion that white light contains the hues. For example, already in the title the term *Colours of light* occurs, and his first proposition (Pg 21), says "Lights which differ in colour, differ also in degrees of refrangibility."

This contention is demonstrated by his descriptions of refraction experiments, within Pg 64-75. In these experiments he lets white light, that is, sunlight, into a dark room from an aperture in the wall. The popular understanding seems to be that this white light is a volume with the form of a cylinder, since the aperture is circular. However, no one sees this beam as such, if not smoke or something like is blown into the room. (Committee on Colorimetry, 1953, pp. 38-39)

The following from Ostwald gives an explanation:

> Rather, what governs is the amount of light falling on a surface that is reflected back. We call this BRIGHTNESS, because the colour of a surface will be brighter as it receives more light. If *all* the light is reflected (whereby it is dispersed in all directions and not mirrored in certain directions) the surface is called full *white*; if all is absorbed and none is reflected, it is called full *black*. If a part is reflected, it is called *grey*. (Ostwald; 1996, p. 23.)

But, and this is my point, neither these reflection beams can be seen. But they are taken as causes. This makes sense to Newtons denial there exist coloured lights at all, see below. This means that he describes his experiment in naïve realistic terms, without belief in the description.

He makes the white beam pass through a prism, by which it is refracted, and the result is the Spectrum which falls on a white wall. Colours spread out beside each other, and violet is refracted less and red most. Refraction is in this case a separation process.

In Part II, Pg 122-1213, Newton says that "All homogeneal Light has its proper Colour answering to its Degree of Refrangibility, and that Colour cannot be changed by Reflexions and Refractions." He lists the homogeneal lights by giving them these names, ordered according to their degree of refrangibility: Violet, indigo, blue, green, yellow, orange, red. However, he also says that the Spectrum contains colours of "intermediate Degrees in a continual Succession perpetually varying."

But let me now for the sake of simplicity just count the homogeneal lights. The popular understanding or naïve realistic conception of Newton's descriptions and demonstrations implies that white is a light with a determinate volume. But this popular view seems not to bother with another implication concerning extension, namely that white light contains 7 chromatic lights each of the same volume, from which it follows the volume of white is 7 times its own size. This implication contradicts BS I. A volume is an extension, and if it is not possible to separate a colour from its extension, the different volumes must be added.

But is not coloured lights of a completely different nature than other things? In my 1994 edition of Webster's Encyclopedic Unabridged Dictionary the meanings of the word spectrum are related to Newton's Spectrum, but also another meaning is listed, namely appearance. This alludes to the meaning which I find in a Latin-Norwegian dictionary from Cappelen Damm 2015, which says the word spectrum means the same as, here in English; ghost or spectre.

So, well, someone might perhaps find strategies to explain away the difficulties my criticism reveals, but I doubt that such strategy will influence the popular or naïve realistic view. This view rests on an adjectival use of colour names. In the two last examples lights or light beams are subjects and they are taken to be physical things spread out in the room, and they are all taken to be coloured.

However, now it is time to note once again that according to Newton coloured lights do not exist at all. He neglects the naïve realistic conception sketched above and thereby he seems to escape from my critique.

> The homogeneal Light and Rays which appear red, or rather make Objects appear so, I call Rubrifick or Red-making; those which makes Objects appear yellow, green, blue and violet, I call Yellow-making, Green-making, Blue-making, Violet-making, and so with the rest. And if any time I speak of light and rays as coloured or endued with colours, I would be understood to speak, not philosophically and properly, but grossly and according to such conceptions as vulgar people in seeing all these experiments would be apt to frame. For the rays, to speak properly, are not coloured. In them there are nothing else than a certain power and disposition to stir up a sensation of this or that colour. For a Sound in a Bell or musical String, or other sounding Body, is nothing but a trembling Motion, and in the Air nothing but that motion propagated from that Object, and in the Sensorium 'tis a sense of that Motion under the form of Sound; so Colours in the Object is nothing but a Disposition to reflect this or that sort of Rays more copiously than the rest; in the Rays they are nothing but their Disposition to propagate this or that Motion into the Sensorium, and in the Sensorium they are Sensations under the Forms of Colours. (URL, Gutenberg, Pg 125)

See in this connection Chapter II, section 2, in where I explain and discuss psychophysical colour theory which dominated his time.

It follows from his explanation that also the colours that Newton calls intermediate are not compounds of his homogeneal colours, they are instead effects from a mingle of rays. To me this may mean that any colour is homogeneous, at least this is a possibility within Newton's theory.

On the other hand, my intention is not to search support from physical theories. As I have made clear in section 1, a belief in colours' heterogeneity needs not be weakened from psychophysics, rather the opposite seems to be the case. And I have found a way to reason that not needs to involve psychophysical causal terms.

But now, Hering's dismissal of every thought about how colours are made can be brought into discussion. On page 46 (1964) Hering says, "But in all these colour designations we are concerned only with what is actually seen in the colour." See section 1.5.7 in this connection. This means Hering does not bother with how unification comes about.

However, though Hering is free to resist from explaining a unification process, he cannot escape the separation process, without which his talk about heterogeneity would be meaningless. Remember, I wrote in section 1.5.6 that,

Hering says: "A chromatic colour can generally be regarded as comprising four primary components, two chromatic and two achromatic (white and black); a *single* chromatic primary component characterizes only those colours that have a primary colour hue." (Hering, 1964, p. 64.) This implies for example that orange is characterized by or consists of or is composed of yellow, red, black and white, while blue, for example, is composed of blue, black and white.

The components must at least be imagined as separated from the initial colour in order to understand for example the contention about orange, and in that imagining there must be four colours exactly like in extension as the initial orange. And therefore, separation implies four extensions each of the same size as orange. To me it is apparent that this idea cannot be understood without involving addition.

BS I says that orange, and any colour, is concomitant with its own size. And if BS I is accepted it will be contradictious to say orange has a determinate size and yet still is heterogeneous, because this implies one determinate extension is the sum of four identical extensions.

It might be a strategy for proponents colours' heterogeneity just to ignore BS I or hold BS I for untrue. But I think my discussion in this section reveals serious difficulties anyway, that is, the talk of colours as compounds of others, rests on rather obscure ideas. In my mind, it would be better to throw the heterogeneity thesis over board and change terminology within psychophysics and colour systematics. I think Johnson's concept betweenness can be substituted for heterogeneity. That would in case remove a lot of inconsistencies within relevant scientific and philosophical research and debate.

2.12.2 The principle of colour exclusion

The principle of colour exclusion concerns uses of colour names as adjectives (or predicates) to characterize something that is not a colour. In this connection Johnson explains,

> Now adjectives under the same determinable are related to one another in various ways. One relational characteristic holds in all cases; namely that, if any determinate adjective characterises a given substantive, then it is impossible that any other determinate under the same determinable should characterise the same substantive: e.g., the proposition that 'this surface is red' is incompatible with the proposition 'this (same) surface is blue.' It has been usual to modify the above statement by adding the qualification – at the same time and at the same place; this qualification applies where the substantive extends through some period of time and over some region of space, in which case the existent substantive, having temporal or spatial parts, may be said to be extended. (Johnson, 1921, p. 181)

Hospers and Hilbert both allow for one colour to be a mix of two others, while at the same time thinking that it does not violate the principle of colour exclusion.

Hospers presents the principle of colour exclusion like this: "*No object has two different colours at the same place at the same time*." (Hospers, 1961, p. 142) But he also states that a result of mixing is not forbidden by the principle.

> The rationalist position is that the statement is synthetic and necessary. We know it to be true a priori, but it is not a tautology or an analytic statement. Of course, we could first paint the box red and then paint it blue, but that is not what is meant; we mean the colour of the surface, not of what is just under the surface. We can paint it red and blue striped, but this again is irrelevant: no one denied that it could be red in one place and blue in another. Or we can mix red and blue paints and paint the entire surface with this; but this again is irrelevant: we do not mean reddish blue or bluish red or any other colour that might result from the mixture, but we mean pure red all over *and* pure blue all over." (Hospers, 1961, p. 143)

Hospers does not explain what kind of mix he has in mind, but let me for my own part discuss pigment mixing using terms of ordinary language. Let us say the pigments are respectively pigment heaps of Holland rose and cobalt blue, and that each pigment is very small and equal in size to the others.

In order to imagine what is going on when they are mixed, you have to compare mixing peanuts and cashew nuts. They are united in a mix, and when the mix exists they lie side by side, over and under each other, and there is always the possibility that you can separate them

The difference between the two kinds of mixes is that peanuts and cashew nuts do not create a third kind of nut, but with the pigment mix, according to the story; a new colour is created, namely violet.

To understand this even partially, you cannot only imagine the different pigments lying side by side, because it would be red beside blue, the same blue beside another red, etc., and no third colour can arise. You therefore have to imagine that a grain of red pigment somehow gets bigger than it is and partially covers its blue neighbour, and that the same happens with the blue pigment. Already at this stage, the imagination leads to a contradiction in relation to BS I.

But since reds and blues must spread and so cover the whole size of the violet, it turns out that violet consists of two extensions, each being equal to its own size. Hence,

violet is twice the size of its own extension, and also this implication contradicts the postulate on concomitance.

Hilbert seems to agree with the idea that the principle of colour exclusion allows for heterogeneity.[27] His version of the principle is this: "One and the same thing cannot both have one colour (or set of colours) and at the same time have a different colour (or set of colours) all over. (Hilbert, 1987, p. 33)"

Hilbert argues (p. 35) that a pink surface may consist of colours different from pink. He says the reason why some philosophers deny this possibility is due to the fallacy of total information. They think that one observation gives all the information about the object it is possible to get. "Our perceptions never provide us with complete information of the objects we are perceiving. To assume that perception gives us total information about any property is to commit what I call the fallacy of total information."

Hilbert (p. 39) explains that the coloured parts of an object cause the colour of its whole. He says namely that the whole is made up of its parts. Hence, he speaks of colour mixing. "It is quite possible and quite common for the parts of an object to have properties significantly different from those of the object itself. Resting on this distinction is a distinction between seeing an object and seeing the parts of which it is made."

Hilbert (p. 35) clarifies his theoretical claims by the following example.

> If we look at a piece of cloth woven from red and white threads from a distance, it will appear to be pink. If we look at it from closer up it will appear to be composed of red and white threads. When we look at the cloth from a distance we see the colour of the cloth as a whole. When we examine it from closer up we see the colour of some of its parts, the threads from which it is woven. When we look at the cloth from a distance we cannot see the colour of the threads and from close up we cannot see the colour of the whole. Since the cloth is not identical with the threads from which it is woven, there is no conflict of appearances to which the exclusion principle could apply.

If Hilbert is right, the principle of colour exclusion does not prohibit heterogeneity of colours.

It seems, therefore, that the basic supposition of concomitance must do the job. In Hilbert's example, the red must cover white and white must cover red when it is seen from a distance. It cannot be the case that the threads cover each other; the colours somehow have to get bigger than they are. This contradicts the basic supposition of concomitance.

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[27] Hilbert's discussion is about the argument from microscopes introduced by Berkeley in the first dialog between Hylas and Philonous. (Berkeley (2), 1975, pp. 145-146) I address that argument in section 1in Chapter II.

Section 3
On colour's two-dimensionality vs. naïve realistic conceptions

In section 3.1, I argue that colours are two-dimensional. In the following section 3.1.1 I justify the basic supposition that colours can only relate beside each other. Then, in section 3.1.2 I justify the basic supposition that only colours can limit colours. In the last section 3.2, I explore into Katz's naïve realistic colour categories and conclude these stay strong in daily life and also in science, but that colours must be conceived of as two-dimensional in special occasions.

3.1 Why colours are two-dimensional

"Length" and "Breadth" are terms that usually denote two-dimensionality. The term "Depth" usually denotes the third dimension of three-dimensionality.

My argument takes departure in the following basic suppositions:

BS I: There is concomitance between colours and their extensions

BS II: Colours can only relate beside each other

BS III: Only colours can limit colours

See in this connection Chapter I, section 1.

See also IMP IV in the same chapter, section 6, where I present the following argument on colour's two-dimensionality:

BS II excludes that colours can exist in front of or at the back of each other.

BS III excludes that colours can have a front side and a backside because then space itself would limit them, but space is not a colour, and BS III says only colours can limit colours.

Hence, colours cannot be three-dimensional.

BS I says: There is concomitance between colours and their extensions.

In which way are colours extended?

Colours constitute lines as one kind of extension, namely length. Therefore, each colour in a line relation must be another kind of extension, namely breadth. It follows colours are two-dimensional.

3.1.1 Justification of BS II: Colours can only relate beside each other

I am fully aware that BS II goes right in the face of daily life perceptions. All our conscious actions and place orientations seem to depend on the opposite conception.

Jackson gives an example about looking in the mirror while driving a car. The mirror is in front of the driver but the colours he/she sees are perceived as if they are in the back.

It is obvious that without this kind of perception serious dangerous situations might occur. Likewise, if the driver does not perceive other colours surrounding the mirror as situated, some near, some further away, the result will be disastrous.

Such examples cause Jackson to admit "I am committed to this view that sense data are at various distances from perceivers and at various angles to their line of sight." (Jackson, 1977, p. 102)

In the same book, p.159 he tells his work aims at analysing "seeing in terms of relations between persons and things."

To this I can only say that his project is interesting and enlightening but that it concerns other things than colours only. That is, neither persons, neither perceivers, neither seeing, and neither angles of line of sight are colours.

When I ask if colours are two-dimensional or not, I have to justify my answer solely on my observations and descriptions of colour relations and the generalizations I make. It is the colours that are to be characterized.

Price maintains that colours not only have length and breadth but also depth by which they are directed different in relation to each other. In this connection he is solely occupied with the colours themselves.

> It is obvious that all visual sense data have the characteristic of *depth* or 'outness'. This characteristic of them is just as much 'given' as colour or shape, whether we can explain it or not. And there is another characteristic connected with this, which we may call that of *sensibly facing in a certain direction*. This too, is given. (Price, p. 218, 1964)

Though he in this quotation says depth is given, on page 242 he explains a method by which the depth of a certain colour can be known. This method he calls Method of Progressive Adjunction.

> (…), our belief that one visual sense datum is sometimes literally behind another can be justified in the following way. Let us take the case of the match-box. We find that we can sometimes apprehend two pairs of sense data in succession such that –
>
> 1. In each pair the members sensibly adjoin each other.
>
> 2. In each pair the two members face in sensibly different directions.
>
> 3. The two pairs have one member in common.
>
> 4. In each pair one member is sensibly to the right of another. (The relation might equally well have been 'to the left of', 'above' or 'below', provided it is the same in both pairs.)

> If these conditions can be fulfilled, then – calling the two pairs AB and BC – we know that C is beyond A. The procedure by which we reach this knowledge may be called the *Method of Progressive Adjunction*.

However, I think Price here is begging the question. His example is a match box, and thereby it is presupposed it is voluminous. It follows by pure logic that if the box is coloured its colours are orientated differently in relation to depth.

In section 1.4.3 I explain Katz's view on surface colours. This is pretty much in agreement with Price's example.

It concurs with a naïve realistic way of thinking which usually treats of colour names as adjectives, that is, colours characterize substances, though not always, because there are substances without colours and some colours are not properties of substances, for example after images and hallucinations.

I agree with Price in his notion on the name "naïve realism": "The name is not a very suitable one (for the view is hardly a faithful analysis of the unreflective assumptions of the plain or naïve man) but it is well known and serves as a convenient label." On the same page Price says:

> Naïve Realism holds that in the case of a visual or tactual sense datum, belonging to means the same as *being a part of the surface of*: in that literal sense in which the surface of one side of this page is part of the whole surface of this page. Thus, if we ask a Naïve Realist what sort of thing it is whose existence he knows of in an act of perceptual consciousness, he answers: it is that which visual and tactual sense data are parts of the surface of. And having a surface, it must be a three-dimensional entity located in space. (Price, 1964, p. 26)

Even though I hold naïve realistic conceptions and perceptions to be indispensable for humans, I cannot accept Price's conclusion. He overlooks namely the convincing argument that can be drawn from the observation of Leonardo lines. See in this connection my explanations and definitions in section 2.10.

A (Leonardo) line might be defined such: *A line is the place where one or more colours end, and one or more others begin.*

Now, in Price's example there is a match box of which two sides are presented at the same time. The top of the box is not presented, and for the sake of simplicity I just ignore both the bottom of the box and the foundation on which it stands.

However, there is one thing I cannot ignore, namely the background. This must itself have a colour which the match box is in front of, though Price does not take the background into consideration. Presume that this background is orientated such that both A and B relate to it in an angle of 45 degrees.

And so, we have the relation between sides A and B and according to Price's example they are orientated differently in the room. Since they have one side conjoined and I may suppose A and B have different colours, there can be no distance between those colours at that place. That is, the only visual information that can be gathered, using the substantival mode, is that the colour A and B constitute a Leonardo line.

But since the rest of A is observed against the background, its colour relates in a Leonardo line together with the background. And therefore, there is no distance between the colour of A and the background. The same is the case with B.

Someone might object that the line between A and B is further away from the background than the rest of those two sides. This is true according to logic, presupposed there is a three-dimensional match box which is considered.

But this objection is not relevant because the colours relations do not reveal such distance.

In this reply to Price I have ignored his Method of Progressive Adjunction. But if anyone will give it a try to fulfil it, the same argument against his example might be used.

Indeed, it is hard to accept my conclusion, at least at first hand, because, as it seems, naïve realistic conceptions always go hand in hand with observations and conceptions of colour relations. It is an apparent conflict between them, but naïve realistic conceptions are very likely to interfere when describing colour relations, even if you try the best as you can to follow the substantival mode.

In the adjectival mode colours are taken to characterize objects or substances. This accords with naïve realistic world view. In the substantival mode colours themselves are characterized. See in this connection section 2.1.

Take as example a red sheet of paper. “Red” is here characterizing the paper. But when I say red constitute a Leonardo line with every colour I see when I move the paper around, “red” is used in the substantival mood, and it is red that is characterized, not the paper.

Since it is impossible to observe any distance between that red and any other colour this should earn to acceptance of the general conclusion: depth cannot characterize colours, though length and breadth can.

I have discussed in some detail other examples of the same that show my conclusion is based on observation of colour relations. See in this connection especially section 2.10.4, third theme. See also section 2.11.4 in which I justify that my method is independent of physical information.

I find reasons to underscore this last point because Price maintains that a conviction that colours are two-dimensional is solely based on physical theory.

> It must be admitted that some philosophers would find a difficulty in condition (2), for some have held that the visual field is always two-dimensional. But this opinion is just obviously false. It is simply a fact that colour expanses do often face in sensibly different directions. The denial of this arises only from certain physiological hypothesis; and however plausible these might be in themselves (in point of fact they seem rather naïve) they are powerless against the patent empirical facts. Only inspection of sense data themselves can tell us what qualities and relations they actually have; and if it follows from some theory that they ought to have other ones, so much the worse for the theory. We may add that all physical science and therefore all physiology rests ultimately upon acquaintance with sense data, without which there would not be the acts of perceptual consciousness which provide its empirical premises; therefore, any

> physiological proposition which contradicts the information given by such acquaintance is certainly false. (Price, 1964, p. 242)

I have argued in section 1 that psychophysical terminology implies a conception of colours as heterogeneous. I must add here that this conception, though unclear, contains an understanding of colours as three-dimensional. This is because heterogeneity involves the thought that colours somehow can be mixed. This means Price does not consider colour's heterogeneity and that he has not justified his claim that a belief in colour's two-dimensionality "arises only from certain physiological hypothesis".

So far then, BS II must be considered true, that is, I take BS II to be a sound postulate.

3.1.2 Justification of BS III: Only colours can limit colours

Price (1964, p. 218) uses "outness" as synonymous with "depth": "It is obvious that all visual sense data have the characteristic of *depth* or 'outness'." Since this view concurs with both Katz and Hering, I repeat what I said in section 1.5.3:

According to Hering, colours are perceived as existing independent of the perceiver's visual system and therefore outside the body. (Hering, 1964, pp. 4-6) Katz supports Hering in this connection. "Colour phenomena are always characterized by objectification; they are always seen "out there" in space." (Katz, 1935, pp. 36-37)

For now, I only draw conclusions about naïve realism from this conception, namely that there is a room or space, maybe filled with clear air, between the observers eyes and the colours.

Furthermore, the conviction also entails an assumption that our gaze is directed from our eyes unto the colours. For example, it assumes that we can see objects as the moon, the sun and the stars "out there" as if human vision passes through empty space and so to say lands its gaze on those objects.

Besides, I think space is perceived as distance, not only between the perceiver and the objects, but as distance between objects independent of the perceiver. For example, I see two houses and judge the distance between them, a distance which I consider is independent of my own position.

This is a kind of conception according to which space is relative and not absolute. Absolute space is a sophisticated idea which Jammer says Newton not invented but promoted and expanded:

> He thought he had demonstrated that space has an existence proper to itself and independent of the bodies that it contains. In his view, it makes sense, therefore, to state that any definite body occupies just *this* part and not another part of space, and the meaning of such a statement does not presuppose a relation to any other bodies in the universe. (Jammer, 1960, p. 108)

Already Berkeley protests against the notion of absolute space.

> Now, locus is defined by moderns as 'the part of space which a body occupies,' whence it is divided into relative and absolute corresponding to space. For they distinguish between absolute space and relative or apparent space. That is, they postulate space on all sides

> measureless, immovable, insensible, permeating and containing all bodies, which they call absolute space. But space comprehended or defined by bodies, and therefore an object of sense, is called relative, apparent, vulgar space. (Berkeley, (5), 1975, § 52, p. 222)

Arstila dismisses absolute space and favours relative space.

> In Newtonian space locations are independent entities that can be connected to objects. Here, however, the location of every object, and the space itself, results from the inter-relations among objects and we cannot isolate any single relation as it is the sum of relations. Locations do not have a separate existence, independent of objects and their relationships. A space without bodies is truly nothing, since it finds its existence only when objects are present. (Arstila, 2005, p. 189)

Arstila traces the idea of relative space back to Leibniz, to whom also Jammer pays many respects. But Arstila does this in connection with his identification theory which I think goes far beyond any naïve realistic conceptions. This is one reason I will not follow him. Another reason is that identification presupposes that colours are three-dimensional and this is exactly what I oppose to in this section.

But Arstila's formulations in the above quotation appeals to me and may further enlighten the substantival mode I use in determination of colour relations. It is really the colours that are subjects and the relations are predicates or characterizations. If I select one of his sentences and substitute the word object for the word colours, it is strikingly fit for one explanation of the substantival mode: Locations do not have a separate existence, independent of colours and their relationships.

Rescher (2005, p. 131), who discusses common sense in relation to philosophy and science, concludes: "Science has no quarrel with common sense because common sense knows better than to take issue with science." On page 129 he explains some of his reasons:

> Does science not supersede common sense? Is not common sense wrong in ways that the more sophisticated knowledge of science ultimately brings to light? Did people in earlier, pre-Copernican times not see it as a matter of incontestable common sense fact that the sun moves around the earth? And don't we know better thanks to science?
>
> The answer is negative throughout. Of course if common sense were "common knowledge" – simply matters of generally accepted belief – then science would indeed unravel it. But as we have seen time and again, this is not so, common sense being something quite different and distinctive. And there is nothing wrong with common sense convictions in their commonsensical construal. Their very triviality – their standing apart from the realm of technical issues – is their unfailing safeguard.

As I note both in the preceding section and elsewhere naïve realistic conceptions always go hand in hand with observations and conceptions of colour relations. Rescher, in his presentation of the diversity between the plain man's conception of Eddington's table and the scientific conception of it, namely that it is a heap of atoms and reflected radiations, stresses that common sense is prior to science and that science depends on it: "From the angle of identification, the plain man's work-a-day table is basic – we would not even specify the scientist's table – could not identify what is at issue – if we did not already have the plain man's table at our disposition." (Rescher, 2005, p. 135)

I therefore do not want to say naïve realism or common sense must be concurred by philosophical arguments. But when I ask if colours are two-dimensional or not, my answer that they are two-dimensional is not a challenge to common sense. I leave philosophy and common sense apart. Rescher helps me doing this because of his explanation that science is descriptive, while common sense has a normative aspect.

> Commonsensical knowledge is something quite different from common knowledge. For common knowledge is something consensual and relates to pervasive knowledge or general belief – to "what everyone does know." Common sense knowledge, on the other hand, is a matter of "what everyone should know," given the basic realities of the human situation. Common knowledge is a purely factual matter, whereas commonsensical knowledge has a decidedly normative aspect. (Rescher, 2005, p. 23)

> Accordingly, common sense truths need not and will not be facts that everyone actually and overtly accepts. Rather, common sense truths are those facts – or types of fact – that people at large, circumstanced as they are, should accept on the basis of general experience and that therefore the vast bulk of ordinary (normal and adult) people would – unhesitatingly and unreflectively accept if the matter were ever raised with them. (Rescher, 2005, pp. 24-25)

Now, a most usual conviction seems to be that things seen have a backside that also can be seen, given some manipulations of the thing itself or, alternatively, that the observer moves around the thing. In every instance it seems to be presupposed that clear air or space is situated between the observers eyes and the thing.

But this conviction cannot be supported by colour observations. It is, namely, presupposed that clear air or space cannot be seen. But the objects of visual experience are colours.

If it were possible to gather information of depth from observation of the colours themselves, depth should reveal some colour relation that differs from other colour relations. But this is not the case. Therefore, from observations and descriptions of colour relations like those I furnished in the previous section, BS III can be induced: only colours can limit colours.

One objection might be proposed, namely that the space between my eyes and the colours, though it cannot be seen, it can be felt. Armstrong has one example about a billiard ball.

> If we put our fingers out towards the red sphere, then just at the point where the finger is seen not to be at any distance from the red sphere, just at that place we feel a hard surface. The solidity begins at exactly the place where the colour begins; the colour and the solidity are spatially coincident. (Armstrong, 1960, p. 33)

Armstrong is here not only supposing that the colour is surrounded by a room or space, which can be felt while he moves his hand; he also includes that feelings of touch can limit colours. Price supports this conviction: "For instance, when I lay my finger on top of a large tin, it is natural to say that the pressure-expanse which I feel is wholly surrounded by the colour-expanse that I see." (Price, 1964, p. 129)

But this objection, I must say, is refused by Berkeley in NTV. His exploration of the relations between touch and colours leads him to conclude that they have no concurrence. And if there is no concurrence how can space be felt as if it is in front of a colour? And how can a feeling be congruent with a colour expanse?

> That which I see is only variety of light and colours. That which I feel is hard or soft, hot or cold, rough or smooth. What similitude, what connection has those ideas with these? Or how is it possible that anyone should see reason to give one and the same name to combinations of ideas so very different before he had experienced their coexistence? We do not find there is any necessary connection betwixt this or that tangible quality and any colour whatsoever. (Berkeley, 1, § 103, p. 38-39)

Berkeley expands his explanation by discerning a felt point from a visual point.

> Or rather, to speak truly, the proper objects of sight are at no distance, neither near nor far, from any tangible thing. For if we inquire narrowly into the matter we shall find that those things only are compared together in respect of distance which exist after the same manner, or appertain under the same sense. For by the distance between any two points nothing more is meant than the number of intermediate points: if the given points are visible the distance between them is marked out by the number of intermediate points: if they are tangible, the distance between them is a line consisting of tangible points; but if they are one tangible and the other visible, the distance between them doth neither consist of points perceivable by sight nor by touch, i.e. it is utterly inconceivable. This, perhaps, will not find any easy admission into all men's understanding: however, I should gladly be informed whether it be not true by anyone who will be at the pains to reflect a little and apply it home to his thoughts. (Berkeley, 1, § 112, p. 41)

Armstrong (1960, p. 56) accuses Berkeley for not justifying properly his contention there is no distance between a tactile and a visual point. Fields (2011, p. 112) tries to rescue Berkeley, but I think she fails because of her analogies to mathematical lines and planes. I have already criticized Berkeley in this connection, see section 2.10.4, second theme.

I think rather there is no tactile point at all. Touch is about hard-soft, rough-smooth, hot-cold, wet-dry. If there should exist a tactile point it must concern one of these impressions, say, a particular hard that is very small. But what should it be? A pinprick? But the feeling of a pinprick has no size, it is some sort of pain, weak or strong. And a line cannot consist of, say, ten pinpricks in a row, because the pains exist only in time, one after the other. And the same goes for the pressure feeling that Price talks about; it has no size, it is not a plane, because it is no such things as a triangular, square or circular pressure and therefore it cannot exist as an infield to which a colour or some colours are its outfield.

Berkeley's general notion that touches and colours have no concurrence, sheds a clear light on the problem here discussed, namely if colours can exist outside our eyes, that is, in various distances from our eyes. In this connection it is crucial to acknowledge that normally our eyes can only be felt. And so, there cannot be any distance between the colours and the eyes, because feelings and colours have nothing in common by which the claimed distance can be measured.

In Chapter V, I discuss further how tactile experiences relate to feelings of muscle contractions, and how these latter feelings make us judge figures and forms. This point is not unknown to Berkeley who in §§ 16-20 in NTV explains felt eye movements as signs or clues for distance.

Johnson also, underscores that determinables are incompatible. The glue that holds determinates under one determinable together is, according to Johnson, the three-place relation that can be established between them, that is, one determinate is more different from this determinate than from that. But determinates under different

determinables cannot make any betweenness relations. See in this connection especially section 2.5, but for a wider exploration also section 2.4, on betweenness.

> *Difference* when applied to adjectives under the *same* determinable has a certain meaning which is distinct from any meaning of difference applicable to substantives or to adjectives under one and another determinable. As regards the latter, difference can only mean mere otherness; but as regards the former, difference may mean more than mere otherness; viz. something that can be measured as greater or smaller. (Johnson, 1921 p. 192)

In accordance with Johnson: Determinates under touch and colour cannot relate; one determinate touch cannot be more different from one colour than another, because touch is mere otherness with concern to colours.

On these grounds I take BS III to be a sound postulate. Even though it is hard to accept in daily life, and even though it seems to be a moral duty in daily life not to treat of colours as if they not reveal any depth, BS III must be considered true on rational reasons.

3.2 Some thoughts about Molyneux Man

Atherton, 1990, p. 186, refers to *Molyneux Man* as the name of a thought experiment, originally explained in a letter from Molyneux to Locke, and which Locke takes up to discussion.

Molyneux Man as described by Locke.

> Suppose a man born blind, and now adult, and taught by his touch to distinguish between a cube and a sphere of the same metal, and nightly of the same bigness, so as to tell, when he felt one and the other, which is the cube, which the sphere. Suppose then the cube and sphere placed on a table, and the blind man to be made to see: query, whether by his sight, before he touched them, he could now distinguish and tell which is the globe, which the cube? To which the acute and judicious proposer answers: Not. For, though he has obtained the experience of how a globe, how a cube affects his touch, yet he has not yet obtained the experience that what affects his touch so or so must affect his sight so or so; or that a protuberant angle in the cube, that pressed his hand unequally, shall appear to his eye as it does in the cube. I agree with this thinking gentleman, whom I am proud to call my friend, (…). (Locke, 1961, Book II, Chapter IX, § 8.)

In NTV, Berkeley proceeds with an extended and systematic exploration of this thought experiment, considering what is commonly perceived as three-dimensional objects, their magnitude, situation, number, position, figure and motion, as perceived both tactual and visual. The presumption is that Molyneux Man knows all these categories by touch, and the problem is whether the thought experiment gives reasons to contend there are common ideas to touch and sight. To which Berkeley answers no.

He denies for example that it is possible to abstract movement from both touch and vision and form an idea of movement that is common to them. If this were possible, Molyneux Man should be able to infer from his knowledge of tactual movement to visual movement and thereby at least have some sort of recognition when he at first was able to see. But this would imply abstraction that ends in separation: the common idea can neither be some particular touch nor some particular colour. I have at some length explained and discussed this issue in section 2.8

To me, Berkley's view in this connection is an example of profound philosophical reasoning. However, Armstrong has made an objection to Berkeley's project in NTV, which I think is worth consideration.

Armstrong seems to fear philosophical investigation turning into mere psychology.

> But before going on to consider whether these contentions of Berkeley are true or not we ought to think about a quite general objection that might be made to the whole proceedings. The question may be raised whether these issues are really matters for *philosophical* inquiry at all, and so whether they do not fall outside the sphere of our competence. The reason for raising this objection is that these inquiries seem to be empirical ones: it seems to be a contingent matter of fact whether or not Berkeley's assertions are correct. Now philosophy, it may be argued, moves in the sphere of logical necessity: it is concerned with, or can only profitably be concerned with, conceptual, or at any rate non-empirical, inquiries. For the philosopher to seek to discover the nature of reality is a presumptuous encroachment on the domain of science. (Armstrong, 1960, p. 61.)

Armstrong is, I think, at the outset, right in addressing the empirical character of Berkeley's considerations. Armstrong says "it seems to be a contingent matter of fact whether or not Berkeley's assertions are correct" and it follows from this that confirmations of his contentions are not logical valid proofs, but only contribute to generalizations based on induction. For example, in NTV Berkeley says:

> From what hath been premised, it is a manifest consequence that a man born blind, being made to see, would, at first, have no idea of distance by sight; the sun and the stars, the remotest objects as well as the nearer, would all seem to be in his eye, or rather in his mind. The objects intromitted by sight, would seem to him (as in truth they are) no other than a new set of thoughts or sensations, each whereof is as near to him, as the perceptions of pain or pleasure, or the most inward passions of his soul. For our judging objects perceived by sight to be at any distance, or without the mind is entirely the effect of experience, which one in those circumstances could not yet have attained to. (NTV, § 41.)

And then, in The Theory of Vision Vindicated and Explained (VVT, § 71) Berkeley confirms his thoughts about Molineux Man by quoting a report from real life, i.e. on the so-called Chesseldon Man, using the word "distance" instead of "depth":

> Before I conclude, it may not be amiss to add the following extract from the *Philosophy Transactions*, relating to a person blind from his infancy, and long after made to see: 'When he first saw, he was so far from making any judgements about distances that he thought all objects whatever touched his eyes (as he expressed it) as what he felt did his skin; and thought no object so agreeable as those which were smooth and regular, though he could form no judgement of their shape, or guess what it was in any object that was pleasing to him. He knew not the shape of anything, nor any one thing from another, however different in shape or magnitude: but upon being told what things were, whose form he before knew from feeling, he would carefully observe that he might know them again: but having too many objects to learn at once, he forgot many of them: and (as he said) at first he learned to know, and again forgot, a thousand things in a day. Several weeks after he was couched, being deceived by pictures, he asked which was the lying sense, feeling or seeing? He was never able to imagine any lines beyond the bounds he saw. The room he was in, he said, he knew to be but part of the house, yet he could not conceive that the whole house could look bigger. He said that every new object was a new delight, and the pleasure was so great that he wanted ways to express it.' (Berkeley (3), 1975, p. 250)

Berkeley's NTV is an exploration into the connections between visual and tactual phenomena. In order to understand the matter properly and to control his statements

his readers must consider data, i.e. colours and colour relations, touch and touch relations.

> Berkeley himself can't take the truth of his claims to await research on real-life Molyneux Men. He takes it instead to rest on arguments demonstrating the lack of necessary connections between the tangible means by which we experience distance and the visual cues that merely suggest distance to us. The function of the Molyneux Man is merely to help us pull apart and conceptualize something we already know about from our own experience: the differing content of the tangible means and the visual cues. (Atherton, 1990, p. 187)

But, remark, within these realms also a philosopher can carry out experiments, actual observations, and it would seem that observation is highly necessary in this case.

Indeed, Berkeley's discussion is partly about what Molineux Man perceives or not, and his theory on the language of nature I read as a psychological explanation. But when it comes to his insistence that touch and colours have nothing in common, he leaves psychology and passes into the region of colour ontology.

And this he does without considering physical causes. Rather, his project excludes physical causal explanation; he is merely concerned with qualities and their relationships. In this respect I take NTV to be a prototype or model for how philosophical investigation into colour ontology can be carried out, even though I do not agree in all things that Berkeley says. See in this connection Chapter

On these grounds it seems that Armstrong's worries can be laid aside. Armstrong alludes to Carnap's idea of philosophers role as semantic and syntactic analysers of scientific sentences, which I briefly mention in section 2.11.3.

Of course, I see a need for clarifying sentences and to test logical validity, but I think this program on non-empirical inquiries that Armstrong suggests reduces philosophical freedom because it leaves it up to scientists to gain knowledge about reality. And, as it may be acknowledged from this present thesis, empirical tests about colour relations can both enlighten and either strengthen or weaken beliefs in scientific contentions and theories about colours.

Let us now, more or less independently of Berkeley, investigate into Molyneux Man. He is escorted into a room in which a cube and a sphere lie atop a table. He might have heard about colours before, that some are pure and some are conglomerations. But in order to know which is which, he has to communicate with other people, because this is certainly nothing he can decide just by looking, for the first time.

Let us imagine that he can suddenly see all the colours in the room and can take as much time as he needs. In order to communicate, it seems he first has to name particular colours by any name he wishes, and then conceive of their relative positions. Without being able to sort out particular colours by their relative positions he will not have any means to communicate which colour has which name.

Let us for the sake of simplicity assume that he at first moves neither his eyes nor his head, i.e. his body movements are not involved. Despite this, colour changes occur slightly anyway. However, they are not many and he does not get confused.

Positional determinations involve concepts of relations such as infield-outfield, direction, sliding scale, etc., all of which are definable terms. Let us suppose Molyneux Man arrives at these positional definitions all by himself. By agreeing with others on the positions of the colours, he can translate his own colour names into the language of normal people.

The main point in this story so far is that Molineux Man uses the substantival mode, he names the colours and characterizes them by their relations. He has some difficulties when it comes to sliding scales, and peripheral vision, see in this connection section 2.10.3, but he overcomes, let me suppose.

Now, Gerritsen and a representative of the RGB system visit him. Green, they announce, is a pure colour, not a compound. Most likely Molyneux Man would not even understand the proposition.

As soon as these three gentlemen have left, Chevreul and Goethe knock on his door and tell him otherwise, namely that green is a compound. They tell him green is both yellow and blue. And they leave Molyneux Man quite distressed.

Let us call this STAGE ONE.

Now Molyneux Man starts looking around and learns how colours and their relations can change in step with the contractions and relaxations of his eye muscles, which he feels. He moves his head, and the colours move too. He moves his body and the same changes happen.

He soon discovers some colours vary with the movements of his hands, and after a while he is able to name both the feelings connected to his hands and these colours by the same name *hands*.

He is given the cube and the sphere. Because of regularity in combinations between touch and colours, the latter not only judged from one perspective, he can now separate the colour combinations, and he names them the cube combination and the sphere combination.

He has now learned to combine touch and colour, and other qualities, by their perceived co-existence, which is the most fundamental sort of practical knowledge he and anybody else possibly can achieve, according to Berkeley. It can be stated in propositions, but becomes after a while crucial to his behaviour without thinking, that is, it becomes tacit knowledge.

Call this STAGE TWO.

Molyneux Man is, however, already confined to common sense categories because he uses object predicates such as *is sweet*, *is sour*, *is crunchy*, *is liquid*, and *is tasty*. As soon as he gets a ripe apple in his hand, he notices touch and smell are somewhat co-existent with red, and he applies the predicate *is red*. He discovers, however, that there are no necessary connections between red and ripe apples. He is now learning to use colour names in the adjectival mode.

He also discovers that the surface of an apple may be red, while the apple is yellow inside. What he has done, before being made to see, was develop spatial predicates – for example *is inside my mouth*, *is outside my mouth* – and he soon begins to believe the red apple skin is red even when it is in his mouth where no one can see it.

Now Molyneux Man is ready to learn and accept all the common-sense or daily life colour categories that Katz has explored.

He thinks now of seeing as looking out in space.

> Inasmuch as space is always presented in colour form, it plays an important part in determining the colour impressions, which we receive. Without the spatial factor we should lack the wealth of spatially organized modes of appearance, which colours assume, and inasmuch as colour is always presented in spatial form it exercises a corresponding influence on the impression of space. (Katz, 1935, p. 2)

Katz is psychologist. "Our interest in colour is not the interest of a physicist, nor again is it with those aspects of colour which puzzle the physiologist. Our concern is rather with the purely psychological problems of colour." (Katz, 1935, p. 2) He continues on page 4 indicating his object of investigation is the naïve person. "The naïve individual, dominated by the natural attitude, deals with colours as properties of the objects of his environment, not with colours as anything in the nature of subjective experiences." To this he quotes Hering: "In general the individual gives no account of the colour which he has just seen. He never makes colour an object of special consideration , but uses it rather simply as a sign by the aid of which objects are recognized."

Merleau-Ponty adds to this: "We must not, therefore, wonder whether we really perceive a world, we must instead say: the world is what we perceive." (Merleau-Ponty, 1981, p. xvi)

According to Merleau-Ponty (1981, p. 305) normal perception is not occupied with considering colours apart from their materials but opposite, colours are not important, rather, materials are.

> The weakness of both empiricism and intellectualism lies in their refusing to recognize any colours other than those fixed qualities which make their appearance in a reflective attitude, whereas colour in living perception is a way into the thing. (…) As Scheler puts it, perception goes straight to the thing and bypasses the colour, just as it is able to fasten upon the expression of a gaze without noting the colour of the eyes.

Merleau-Ponty ends his discussion on colours on page 313; "A colour is never merely a colour, but the colour of a certain object, and the blue of a carpet would never be the same blue were it not a woolly blue."

Molineux Man has already discerned surface colours from transparent colours, the former being attached to the outside of objects, and this outside being oriented in different directions. See in this connection section 1.4.3.

An example of the latter may be a coloured liquid in a clear glass bowl: you can look through the liquid and observe objects on the other side. Katz designates such colours as volume colours.

In this connection Molineux Man gets interested in a claim of Wittgenstein's, that white is not transparent.

> "We shouldn't be able to conceive of white water that is pure…" That is to say: we cannot describe how something white could look clear, and that means: we don't know what description is being asked for with these words. (Wittgenstein, 1977, Part III, § 187.)

Wittgenstein does not deny that colour transparency is impossible in general; he only denies that white objects are possible candidates. Transparency is a sort of colour mixing, so the story goes, so if you look through a red filter, yellow things that appear behind the filter will take on the colour of the filter and look orange.

It seems that Wittgenstein's contention is taken to be true by some philosophers and scientists even today. Nes, for example, denotes transparent white as an imperceptible colour.

> Another class of systematicity failures have to do with colour. Modern colour science, and indeed armchair reflection, has taught us that there are certain interesting limitations on the kinds of colour experiences we can have. Some of these give rise to exceptions to systematicity in perceptual experience. For example, Wittgenstein, in his Remarks on Colour, noted that there is no such thing as transparent white. This gives us the following exception. I can have an experience as of something being transparently blue, and an experience as of something being white, but I cannot have an experience as of something being transparently white. (Nes, 2008, p. 175.)

But Molineux Man notices that scientists and philosophers contradict each other. Katz's observations of 1935 seem already to be contradicting Wittgenstein's contention.

> The voluminousness of a fog is given clearly only as long as objects can be perceived through it. If the fog becomes so thick as seriously to impair the perception of objects, or if one directs his gaze in such a way that objects can no longer be seen through it, e.g. if one looks at the sky, the voluminousness of the whitish colour disappears. The white which is still perceptible becomes then a limiting film colour. Under otherwise similar conditions the more one can see objects through a fog the more the thickness of the fog seems to recede. The question as to the extent to which clear air or, to express it differently, empty space is phenomenologically given will be considered in another context. (Katz, 1935, p. 21.)

Whether Katz refers to his own observations or to the perceptions of ordinary people is not easy to judge from the context. However, toward the end of the quotation he addresses naïve realism directly and the theory of a medium, e.g. white air, between our eyes and an object, which influences the colour of the object seen through it. I explain this theory in Chapter II, in the sections on Aristotle and Goethe, Sections 1 and 4, respectively.

This naïve realistic theory that air may be white and transparent and is opaque only in its most dense form is therefore nothing new. The belief that white fog can be transparent is doubtless quite common. And a lot of other white things may, under certain conditions, appear transparent too, like a white blouse, a white sheet of paper, and a special phenomenon, white reflections in a window pain, etc, etc. So, there is empirical evidence, it would seem, that normal people conceive of transparent white things.

One way of getting around this is to approach Wittgenstein's contention as analytic statement, i.e. a tautology. Maybe he meant white opaque things are not transparent. But this is to say not-transparent things are not transparent, and nothing new is communicated by the sentence. No opaque red or opaque blue things can be transparent either.

In his article *Whiteness*, Westphal tries to save Wittgenstein's contention from falsification:

> In his review of *Remarks on Colour* Nelson Goodman claims that Wittgenstein's question is "mistaken". He points out that " the glass in a white bulb sometimes is as transparent as that in a red one." This is, in a sense, true. But it is also not to the point. 'As transparent as' does not mean 'transparent,' any more than 'as full as' means 'full'. Two jugs which are not full can be as full as one another, e.g. half-full. Goodman has confused his true proposition, "A white glass can be as transparent as a red one," with a different and false proposition, "A white glass can be transparent." According to the O.E.D., 'transparent' means "having the property of transmitting light so as to render bodies lying beyond it completely visible, so that it can be seen through." Goodman's white light bulb is not transparent it is merely *translucent*. Translucency is only partial or semi-transparency. 'Translucent' means "allowing the passage of light yet diffusing it so as not to render bodies lying beyond clearly visible." The white (pearl) bulb can be seen not to be transparent by comparison with a completely transparent colourless bulb, in which the filament is clearly visible. (Westphal, 1987, p. 321.)

Westphal clearly interprets Wittgenstein as saying that white things cannot be clearly transparent, though they can be semi-transparent. Westphal does not, however, consider this contention as a description of how ordinary people perceive white things, but as a proposition that can be tested by observations of white things themselves.

From his own observations Molineux Man adheres to Katz's view on transparency. But he moves further and learns to discern a third category, as Katz has explained, i.e. film colours. Film colours are not attached to a surface, but they are not transparent either. They have the appearance of the blue of the sky or the white of thick fog; they have some depth but are not transparent. And they are oriented (almost) only in the frontal plane before him.

Merleau-Ponty (1981, p. 306) recognizes that science must deal with this sort of colour areas as he calls them, and seems to believe that film colours are not part of daily life observations:

> Hering requires that in the study and comparison of colours we concern ourselves with only the pure colour, leaving aside all the external circumstances. We must work 'not on the colours which belong to a determinate object, but on a *quale*, whether plane or pervading the whole of space, which subsists for itself with no determinate vehicle'. The colours of the spectrum roughly fulfil these conditions. But these coloured areas (…) are in reality one of the possible structures of colours, and already the colour of a piece of paper or a surface colour (…) no longer obeys the same laws. The differential thresholds are lower in the case of surface colours than in coloured areas. Coloured areas, moreover, are always parallel to the frontal plane, whereas surface colours may show any orientation. Finally, coloured areas are always more or less flat, and cannot, without losing their distinctive quality as such, assume a particular form and appear curved or spread out over a surface.

However, Molineux Man loves looking at the sky and its drifting clouds at a fine shiny day. He can understand that Katz means these are examples of film colours and that film colours therefore are not exclusively scientific objects.

Furthermore, Molineux Man gets able to judge materials by their visual texture. See in this connection section 1.4.3.

> The surface of an object can be smooth or wrinkled, and according as it is the one or the other the surface colour, too, will be either smooth or wrinkled. Surface colour follows all wrinkles of the surface of the object, and presents, too, its finest structure and texture. (Katz, 1935, p. 11-12)

In his book *The World of Touch*, Katz extends his description of structure and texture. Texture might be coarse, that is, thickly grained and stranded, or it might consist of tiny differences in very small areas.

> These elements are so small that a greater number of them probably could be discovered within only a square millimetre. There is an astonishing variety among these elements. We might even say that regularity within irregularity of elements is the law of texture. There are materials in which the smallest formal elements are combined into structures of higher order, and these, in turn, into structures of an even higher order, which then give the material its characteristic texture. (Katz, 1989, pp. 56-57)

In addition to determining textures, Molineux Man learns to discern different objects by sight and their reflections behind the surface of both non-coloured and coloured mirrors. (Katz, 1935, pp. 22-23)

Some colours he finds to be the lustre on the surface of objects. He develops an ability to tell metal lustre from silk lustre, for example. He can tell the difference between lustre, glitter and glow. (Katz, pp. 23-25)

He judges degrees of luminosity and sees the difference between luminous and non-luminous colours. He is able to differentiate light spots from shadow spots, when they move and when they remain in one place. Katz explains shadow:

> Conjoined shadows are of importance primarily inasmuch they are responsible for the plastic appearance of objects; the conjoined shadow is the real modeller of the object. A ball can be illuminated and set up before a background in such a way that its cast shadow is not visible without at the same time having any of its plastic character sacrificed. The conjoined shadow, as the very name suggests, clings so closely to the surface of its object that it is practically impossible to see it as distinct from the genuine colour of the object. An air-shadow causes the empty space in which it is seen to appear darker, and it appears as medium filling this space, whereas the spaces before it and behind it are seen as distinctly brighter. The situation here is similar to that which we observed in connection with differently lighted spaces lying one behind another. When we turn to cast shadow, we find that in general the deeper the cast shadow the more it eats its way into the colour of the object, and the weaker it is the more readily it tends to assume the character of a "shadow membrane". (Bühler) When it is in motion it seems to belong to the surface of the object. (…) I might add that according to my own observation a shadow which has begun to move becomes darker, but at the same time induces a smaller change in the colour of the surface across which it is moving. When a shadow moves it moves not *in* the surface of the object but *across* it. (Katz, 1935, p. 48)

One of the colour categories he develops is of illumination colours. Here, light itself is perceived as coloured. Katz takes this category to be non-inferential, that is, the observer does not need to see the light source in order to infer which coloured light fills a room, nor does he need to infer the type of illumination after observing the illuminated objects in a room. That is, Molineux Man thinks of coloured lights as something that fill out parts of space. Such observations leads us to the conclusion that there is a non-derived, non-inferred primary impression of the illumination of the

visual field, which from the point of view of experience is genetically prior to the experience of the individual colours of the objects which fill the visual field. (Katz, 1935, p. 41)

One category Katz does not explore is volume colours that are not transparent. This might be because thickness is not perceived by direct observation, that is, if you extract some of the contents of a tube of oil colour, you might believe it is the same colour right through, even though it presents itself only by its surface. However, let us define this category opaque volume colours, something with which Molyneux Man is familiar having been to the paint shop and bought buckets and buckets of them so he can paint every room in his big house in different colours.

Call this STAGE THREE.

Which leads us back to his friends. The first to come are Chevreul and Goethe. They show Molyneux Man two oil colours. One is called light cadmium yellow and the other light cyan blue, both named by the firm Holland Colours which produced them. After pressing the liquid pigments out onto a palette, the two gentlemen show him how mixing yellow and cyan produces a green colour. And Molyneux Man seems finally to understand the meaning of the sentence *Green is a heterogeneous colour*. It is, at first, obvious to him that the sentence is true, because he cannot doubt yellow and cyan pigments continue to exist in the green because the amount of green stuff is the sum of the yellow and cyan stuff. And, he is told; mixtures of other pigments could neither result in yellow nor cyan. He is sure he can trust in his friends and does not need to experience it first-hand.

However, the very next day Gerritsen and the RGB representative knock at his door, and in they come carrying three light projectors. They install the equipment in front of a white painted wall onto which they project two equally large spots of light and with the same circular figure. One is yellow the other cyan. They ask Molyneux Man to tell them what colour would appear if the two spots were mixed, i.e. both spots covering the same area on the wall. Molyneux Man predicts the result will be green, because he is biased by his observation of pigment blend. However, the result of mixing the two spots turns out to be white (and appears whiter than the white painted wall). He asks for an explanation.

The three gentlemen want to give him a theoretical explanation, but first they want to demonstrate some other facts. They shine three spots onto the wall, one red, one green and one blue. The latter is not like the cyan; it is more of a cobalt blue, with reference to the Holland pigment colours. When they mix the green and red, yellow appears. When they mix blue and green, cyan appears. Which goes to show that yellow and cyan are both heterogeneous colours, insists the RGB representative:

> The fundamental fact on which colour measurement is based is that almost all colours can be produced by combinations of three differently coloured lights. In Plate 6, coloured beams from three lanterns fall together on a translucent screen. Smoke was blown into the beams to show their paths, and the screen is cut to the shape of the projected, overlapping, round spots, so that the beams can be seen approaching the screen. Where the red and green beams fall together, on the smoke as well as on the screen, the appearance is yellow. Where the blue and green fall together, the combination is bluish green. Where the red and the blue fall together the result is purple. Where all three beams fall together, at the centre of the screen, the combinations of red, green, and blue is white. By varying the amounts of light in the three

> beams, all intermediate colours can be produced. (Committee on Colorimetry, 1953, pp. 38-39)

Molineux Man carries out his own demonstrations. He arranges the primary green light, so that it can be seen beside the pigmentary green made of cyan and yellow. And then he makes two apertures in a white disc in order to isolate the colours from their surroundings, and when seen through the apertures he cannot judge any difference between them. He does the same with yellow, which is a composite of the green and the red lights and compares it with Hollande cadmium yellow which is pigment primary, and the colours are identical. That is, he sees no difference between lights and pigments.

This makes Molineux Man frustrated: How can the same colour be both primary and secondary? Is it homogeneous and heterogeneous at the same time?

Hardin (1984, p. 492) wants to help him out of his confusions and explains the differences between pigment and light mixtures on the one hand and the psychological divide between visibly simple colours and visibly composite colours on the other hand.

> Now most colours are visibly composite in hue like orange, rather than visibly simple in hue, like green. In fact, there exist only four hues which have none of their neighbours as constituents: these are called *unique* hues. There exist a unique red, a unique green, a unique yellow and a unique blue. Hues like orange or turquoise are known as *binary* hues. The unique hues are sometimes called 'psychological primaries,' but the use of 'primary' here invites to confusion with so-called 'subtractive' (pigmentary mixing) and 'additive' (light mixing) primaries.

This makes him consider Hardin's divide between unique and binary hues. And he tries to forget about how the hues he considers are made. This is Hering's demand, which Hardin seems to follow, and which is a way of using the substantival mode in judging colours: "But in all these colour designations we are concerned only with what is actually seen in the colour, not with the light mixture or the pigment by which this colour was produced and which the colour may *bring to mind*." (Hering, 1964, p. 46) See in this connection sections 1.5.6 and 1.5.7.

But Molineux Man does not manage. He cannot forget his conceptions of the colours that are reduced by the apertures, see in this connection section 1.4.4. The use of an aperture still makes him think there are colours behind the disc which are either coloured lights or pigments.

His naïve realistic conceptions with reference to colours have become part of his mental equipment, and Molineux Man is so happy with his achievements. He partakes in normal life both in communicating and in acting. He sees out in the world and judges things and their situations and goes on with his life much easier than before.

He understands the world of colours in adjectival terms. The additive mix concerns coloured lights and the subtractive concerns coloured materials. He sees them ""out there" in space", just as Katz puts it. (Katz, 1935, pp. 36-37) In other words, the colour names function as adjectives which characterize lights and materials, respectively. That is, the mixtures referred to are about objects situated in space, not about colours abstracted from them.

In moments though, he feels gratitude to science and eye-brain surgery. He was made to see; his vision came not miraculously. He remembers Newton's words from section 2.12.1, last part, namely that lights are not coloured. And he recalls his first stage of development which was based on using the substantival mode. First after some time in learning from experience, he was ready to develop his space perception and use the adjectival mode.

Sometimes he therefore can believe that colours really are two-dimensional and homogeneous like it is argued in section 3.1 and 12.1 respectively. But except for such moments he stays put with his naïve realistic conceptions.

Chapter I
An explanation of the Formal System of Colours and its main implications

Introduction

In this chapter I systematize my findings into a formal system of colours. That is, I make a divide between basic suppositions and basic definitions on the one hand, and on the other hand some implications that I mean can be drawn from them.

In section 1, I present the basic suppositions (BS) which I have already justified, and refer to sections in General Introduction (GI) where these justifications are given. There is an exception for BS V, which I justify immediately after it is presented.

In section 2, I present basic definitions (BD). For some of them I give brief explanations. In this connection the word "explanation" should be understood in the meaning making something clear, expanding the issue or enlightening the issue by examples, that is, illustrations that must be contemplated. Most of the definitions are justified in this way.

In section 3, I list some main implications. I also furnish arguments for the implications (IMP) gathered from the basic suppositions and the basic definitions.

The Formal System is not meant to be a deductive system like Euclid's geometry based on axioms, postulates and definitions, all of which are rationally evident (maybe except for sufficient and necessary for proving theorems.

The basic suppositions are far from being self-evident. This is why I need to give them substantial justifications in GI. Furthermore, they are based on induction from observations, and these observations are guided by the substantival mode, which someone might find directly impossible to rely on.

In order to accept the basic definitions as true generalizations one must rely on the same substantival mode. This mode concerns characterization of the colours by their relations. The colours are not taken to be properties of objects, that would be to use the adjectival mode. Throughout sections 2 and 3 in GI I try to justify the use of the substantival mode, see especially sections 2.1 and 2.10.

Now, not all of the basic definitions are needed to justify the implications. And indeed, I also present more implications than I am, at the outset, supposed to do in this thesis. Consider them therefore as spin off effects.

In GI, sections 2.12.1 and 3.1, I have argued that colours are homogeneous and two-dimensional, respectively. These two implications are integral parts in the set of implications, and the first to be presented.

However, the reason why I add extra definitions and implications, is that I, besides being a colour philosopher and lecturer in philosophy, am a painter of fine arts. I need

these definitions and implications in order to produce pictures. And, when I finally figured out how to deal with the problems and came to my results, I see no reason why I should not share them with others.

The basic propositions IV and V, both concern identity between colours, are not needed for justifying the implications put forwards in this chapter. But I use them in Chapters IV and VII. And in GI I have given BS IV substantial justification.

1 Basic suppositions

BS I: There is concomitance between colours and their extensions.
Justification: GI, section 2.12.1

BS II: Colours can only relate beside each other
Justification: GI, section 3.1.1

BS III: Only colours can limit colours
Justification: GI, section 3.1.2

BS IV: Two or more colours can be identical, notwithstanding difference in figure, size and position.
Justification: GI, section 2.11.4

BS V: Two or more different colours cannot all be identical with one and the same colour.

It may seem likely that some people would see a difference between two colours, but, because of the slight difference, find both to be identical with a third colour. However, according to BS V, their judgement would in case be wrong.

BS V does not apparently follow from BS IV. Having said that, BS V, can be deduced from the principle of non-contradiction. If A is identical with B and B is identical with C, then it would be a contradiction to state that A and C are not identical. If A = B and B = C, then you can substitute C for B, and the result in the first assertion would be A = C. BS V is, on these logical grounds, not to be doubted.

2 Basic Definitions

BD I
See in this connection explanations in GI, section 2.10.

A (Leonardo) line is the place where one or more colours end, and one or more others begin.
Explanation:
a) If the line is a relation between just two colours then the line is an end of the one

and a beginning of the other.
b) If a sliding scale and another given colour relate in a line, then the line is an end of the sliding scale and a beginning of the other colour.
c) If two sliding scales relate in a line, then the line is an end of the one sliding scale and a beginning of the other.
Leonardo claimed such a line to be mathematical, and I believe that nothing has better claim to be the empirical counterpart of Euclid's third definition in the Elements, Book I, namely, "A line is length without breadth". However, this is not to say that the definition conforms to all Euclid's definitions, and I restrict the use of it only to colour relations.

Picture 1

BD II
A sliding scale is a continuous juxtaposition of different colours.
Explanation:
BD II contradicts the line definition, that is, either a colour relation contains lines or it contains no lines. This dichotomy is just as strong as the dichotomy between the straight and the curved in geometry; there is no third possibility. This means you can describe a combination of colour in the negative, i.e. a combination without lines, and then it must be a sliding scale.

Picture 2

BD III
A colour position is a relation between two or more colours.
Explanation:
There are both loose and fixed positions.
Where there exists a line or where lines from different directions meet, the positions

are fixed.
If member of a sliding scale, the colour is a loose position.
Different positions, fixed or not, are directional.
If only one colour exists at one time, there can be neither fixed nor loose positions.

BD IV
A colour totality is the colours that exist at any given time.
Explanation:
It can be one colour, it can be one sliding scale, it can be a combination of lines and sliding scales, it can consist of figures in combination with ended lines (see BD IX) and sliding scales. It is possible it can be frozen, that is, not changing, but usually changes are conveyed perpetually.

BD V
Essential colour change is one from existence to non-existence or vice versa.
Explanation:
A totality may consist of red as infield and white as outfield. Were the red to disappear, or, if a blue colour appears, it would be an essential change.

BD VI
Unessential colour change is change in size, figure and/or relative position.
Explanation:
The same red (or any hue) can first be bigger, and then smaller (and vice versa), and this change in extension is not an essential change of the colour.
The same red may relate to its outfield as a circle and next as a square; it is the same colour that has undergone a figurative change.
The same red can be positioned first to the left, then to the right, or in any direction relative to an arbitrarily chosen, but constant reference.
According to BS IV on colour identity, the same colour has undergone the explained unessential changes.

BD VII
A continuous line is a line without end or ends, and can be either finite or infinite.
Explanation:
A line is continuous and finite if it is the end of a figure. See BD VIII.
A line that is not a figure might still be without ends, and this means the line is continuous and infinite. Infinite lines must, though, be considered only a logical possibility, not observable.

BD VIII
A figure (spot/patch) is either one colour or a sliding scale, which relates to another

colour, or some other colours, in a Leonardo line in all directions. See Pictures 1 and 2.

Explanation:

BD VIII is not entirely in agreement neither with George Berkeley's claim that a figure is the termination of magnitude (NTV, §124), nor with Euclid's 14th definition in *Elements*, Book I, "A figure is that which is contained by any boundary or boundaries" because, the figure in question, under these definitions, is arbitrary. According to Euclid you can for example inscribe a square in a circle and still maintain that the circle is there. However, according to BD VIII, this is not possible, because the square deforms the circle by changing it into four segments and those are four figures according to BD VIII.

Remark that if red is infield and white outfield, and white is delimited by blue into a finite continuous line, then the white has become a continuous figure according to BD VIII. The red delimits the white from within, and the blue delimits the white from without.

I give a further explanation and justification for this definition of figure in GI, section 2.10.

BD IX

The end of a line is a sliding scale.

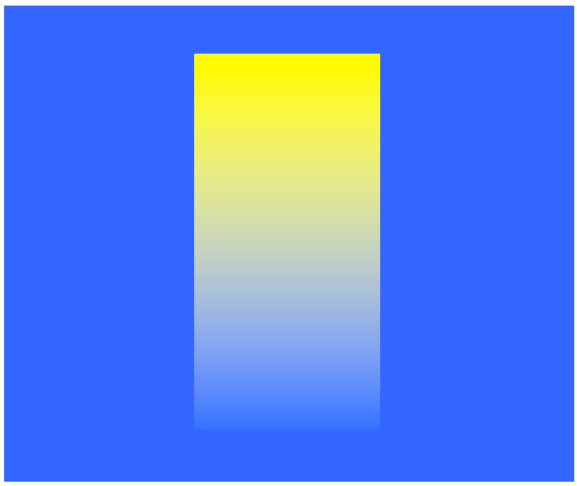
Explanation:

This definition does not conform to Euclid's third definition in Elements, Book I, namely "The extremities of a line are points".

Given a certain line relation with no points, let the infield slide into the outfield in one direction. The line will dissolve into a sliding scale on each side. Picture 3 is an example. Focus on the upper side of the sliding scale.

An ended line is discontinuous. See BD VIII, definition of continuous line.

Picture 3



BD X

A discontinuous figure is one in which the infield contains a line that has an end or

ends. The sliding scale from yellow to blue in Picture 3 is a discontinuous figure. Focus on yellow in order to get aware of the two opposite sides sliding into blue.

BD XI
A point is the meeting of Leonardo lines.
Explanation:
Consider blue relating to white in a square line, i.e. a finite line. Two colours make the relation and only one line. If a point should appear, it is evident that at least one third colour must be added to the picture, either from within or from without, unto the square line. In the figure to the right the meeting between blue and khaki gives two points.

Picture 4

Any line can have numerous points, depending on its length, but it cannot at the same time have an infinite number of points, because between two points there must be a colour or colours.

BD XII
A semi-shape is resemblance of a figure but is still a part of a sliding scale.
Explanation:
A semi-shape can be for example more or less circular; let us say reds slides into white equally in all directions and extent. While there are no lines between the reds and white, the shape is different from other shapes. One could also imagine, let us say, a figure like the rectangle in picture 3 above. This constellation too would be a semi-shape according to the definition.

The co-existence of lines and sliding scales is a well-known feature of the fine arts and in principle it is the dichotomy clear/obscure. Obscure should in principle be understood as a sliding scale, and not as dark, no matter how usual is the last interpretation. Some artists are famous for line pictures, for example the Dutch painter Piet Mondrian (1872 – 1944) and some for virtually line-less pictures, for example the British painter Joseph M. W. Turner (1775 – 1851). However, a combination of sliding scales and lines is most common, “The naked Maja”, a painting of the Spanish artist Francisco Goya (1746-1828), is an excellent example.

3 Main implications

IMP I
Colours are homogeneous.

Argument:

BS I: There is concomitance between colours and their extensions.

Take any uniform infield as example. It is concomitant with its own extension, according to BS I. If a uniform infield should be heterogeneous, it must consist of at least two colours all over. But this means its extension is the double of its own extension. This is absurd, that is, it contradicts BI I. Therefore, since BS I is taken to be true, it follows all colours are homogeneous.

This argument has the form of Reductio ad absurdum. See GI, section 2.12.1 for a wider explanation and for justification of BS I.

IMP II

Colours are two-dimensional.

Argument:

"Length" and "Breadth" are terms that usually denote two-dimensionality. The term "Depth" usually denotes the third dimension of three-dimensionality.

My argument takes departure in the following basic suppositions:

BS I: There is concomitance between colours and their extensions.

BS II: Colours can only relate beside each other

BS III: Only colours can limit colours

BS II excludes that colours can exist in front of or at the back of each other.

BS III excludes that colours can have a front side and a backside because then space itself would limit them, but space is not a colour, and BS III says only colours can limit colours.

Hence, colours cannot be three-dimensional.

BS I says: There is concomitance between colours and their extensions.

In which way are colours extended?

Colours constitute lines as one kind of extension, namely length. Therefore, each colour in a line relation must be another kind of extension, namely breadth. It follows, colours are two-dimensional.

IMP III

There is no distance between neighbouring colours.

Argument:

From BS III, which says that only colours can limit colours, it follows that a distance between two colours cannot be without a colour. There is therefore no distance between neighbouring colours. This conclusion also conforms to BD I which says A (Leonardo) line is the place where one or more colours end, and one or more others begin. They relate in the same place.

IMP IV

Distance between colours must itself be one or several colours.

Argument:

If any two colours are separated, there must be a third colour or other colours in between, because, BS III says only colours can limit colours. And insofar as there is no distance between neighbouring colours, see IMP III, it follows that the between colour or colours must comprise the distance between any two or more colours.

IMP V

Black, white and grey are homogeneous and two-dimensional.

Arguments:

First: according to BS III, only colours can limit colours. Black, white and grey can all limit red, blue, green, etc, and therefore black, white and grey are all colours. Second: According to the same arguments as in IMP I, it follows black, white and grey are homogeneous. Black, white and grey are two-dimensional according to the same argument as in IMP II.

IMP VI

A colour totality is infinite.

BD IV: A colour totality is the colours that exist at any given time.
Explanation:
It can be one colour, it can be one sliding scale, it can be a combination of lines and sliding scales, it can consist of figures in combination with ended lines and sliding scales. It is possible it can be frozen, that is, not changing, but usually changes are conveyed perpetually.

Argument:

If a totality consists of only one colour, this colour must be endless or infinite, because, according to BS III only colours can limit colours. See in this connection GI, section 2.10.4, fourth theme.
If a totality consists of an infield-outfield relation, the outfield is either one infinitely extending colour from the infield or it is a range of neighbouring colours in extending from the centre. Anyway, the last colour cannot be limited, because it is the last, which means there exists no other colour to delimit it from without. It follows that all totalities are infinite.
However, while the number of colour combinations is infinite, some combinations may perhaps be confusing with respect to the latter argument. If, for example, we consider the logical possibility that a totality consists of only a two-colour relation that contains an infinite line, it can have no centre. In spite of this, the conclusion remains sound, because the line can be considered as the centre and the colours that relates in the line extend endlessly also in opposite directions. See BD VII, Explanation. See also Chapter VII, section 2, for an expanded discussion.

IMP VII

A figure (spot/patch) must be a relation between at least two colours.

Argument:

A colour totality is infinite, according to implication VI. If it consists of only one colour, no lines exist, because it takes at least two colours to make a line. See BD I. And, since a figure is a finite line relation, which logically necessitates at least one colour being the infield and another being the outfield, a figure must be a relation between at least two colours.

IMP VIII

A continuous line is an exact measurement of length.
Argument:

Let a continuous finite line be a relation between red as infield and white as outfield. Because, according to IMP III, there is no distance between the red and the white the length is the same for the two colours, the outer length of the red and the inner length of the white must therefore be exactly the same.

If two or more colours encircle red, the (outer) length of the red is identical with the sum of the lengths of the encircling colours.
The same applies to infinite lines; if only two colours form the line, they measure each other. If an infinite number of colour areas form the line, the areas respectively sum up each other, and the length of the two main areas is the same, namely the sum of their respective colours, which is infinite.
See explanation in BD VII, of finite and infinite continuous lines. See also BD XI, Explanation, which says that the ends of a line are sliding scales and therefore not determinate, and it follows that only in finite and infinite lines the colours are exact measurements of length.

IMP IX

No more than two separate finite lines can make a figure.

Argument:

Let red be the last infield, and let white be the outfield of red, and let blue be the outfield of white. White has become a middle field. See BD VIII. White is delimited by blue from without and by red from within in two separate, finite lines. If white were limited in any other way than this, the only possibilities are that either blue or red meet in some place, or a different colour connects the blue and the red in some place. In both instances the outer and inner lengths of white will connect into only one continuous, finite line. Therefore, no more than two separate finite lines can make a figure.

Chapter II

Naïve realism vs. realism – causal determinations of colours with relation to the Formal System

Introduction

In this chapter, I let naïve realism confront realism without taking colour perception into consideration. This is different from Dancy, for example, who links perception theories directly to ontology, using some of the same terms. (Dancy, 1998, Chapter 10.) When reading the following then, one has to take caution and not expect theory of perception to be involved.

If you take a closer look at the psychophysics of today, you may notice the explanatory kind of approach. One prevalent feature is to link colours to their causal relations. It says, in other words, that colours are determined by their physical and/or physiological causes. Modern physics, for example, defines colours as the effects of electromagnetic radiation of certain wavelengths, while modern neurophysiology defines colours as effects of certain neuronal and molecular processes in the retina and/or the visual cortex and related areas of the brain. These two causal definitions are often used supplementary to each other. And not a word needs to be said about colour perception in the sense of how we perceive a world by means of colours.

In principle at least, you can link every colour, be it chromatic or achromatic, other than red to brain processes y, z, etc. This is analogous to what computers do. The practical reason for linking colours to some causes is to produce and reproduce colours using technology.

Some philosophers seek to identify colours with their material causes. Hilbert can serve as an example. I "will argue", he writes "that colour is identical with the characteristic ways objects have of reflecting light." (Hilbert, 1987, pp. 16-17)

In his article *Colour*, which is a general view on recent colour philosophy, Maund says,

> The attempt to locate the essence of colour among the microstructural features of coloured bodies seems unpromising. One of the major problems is 'the problem of multiple realizations'. Given the range of bodies that have colours – surfaces, volumes, light-sources, illuminations, luminescent bodies, films, expanses – the intrinsic physical features that provide the causes for the way colours appear show a bewildering variety. (Maund, 2006, p. 13)

The categories Maund mentions are naïve realistic. See in this connection GI, section 3.2, in where I explain most of Katz's naïve realistic categories. When someone look at a light-source he or she sees its colour but it is not reflected light, it is direct. Hilbert's identification seems therefore not to cope with all kinds of colours. However, he may talk of physical objects that are insensible, but also in this respect

his project strands. See in this connection section 5 below about Hardin's rejection of identification. The reason he gives is that colours are not always caused by radiant energy. Remember, the Committee on Colorimetri (1953, p. 102) says

> Although radiant energy is the normal visual stimulus, it is far from the only means of initiating visual impressions of colour. Colour responses can be produced by mechanical pressure on the ocular structures, chemical or physical irritation of the sensory fibres, electrical currents, powerful magnetic fields, certain drugs, certain diseases, and direct stimulation of the primary visual areas of the brain. Such results show that conscious colour response is a less restricted conception than colour, for the latter has been defined with respect to light excitation alone.

Though naïve realistic conceptions and psychophysical realistic conceptions must go hand in hand it is important not to confuse the one with the other.

In this chapter I treat naïve realism in colour science under the rubric of causal explanatory theory, and I refer to the colour theories of Aristotle, Goethe and Chevreul. These theories are advanced in relation to views among ordinary people, and especially the theories of Goethe and Chevreul have been applied throughout the world in visual art and education, as indeed the American colour theorist Faber Birren points out. Birren is an authority on colour systematics and theories of colour harmony and does not hesitate to stress the importance of both Goethe and Chevreul. (Birren, 1981, p. 38)

The presentation of both naïve realism and realism is chronological, that is, I start with Aristotle, continue with renaissance realism, turn to naïve realism of the nineteenth century referring to Goethe and Chevreul, and end with eliminativism, which is, according to my view, nothing but a recapitulation of classical realism in the tradition following from Descartes and Newton.

Throughout the presentation I refer to the Formal System of Colours and make comparisons. See Chapter 1.

1 Naïve realism in the Aristotelian sense

The Aristotelian naïve realistic tradition in colour theory holds that colours are objective, which means they are inherent in materials, i.e. they inhere in matter.

Aristotle holds this naïve realistic position, but draws the following conclusion: "We never see a colour in absolute purity: it is always blended, (…)." (On Colours 793b14 – 794a16)[28] There is therefore a crucial difference between the seen colours and the object colours, because the seen colours are always blends and the object colours might be pure.

Aristotle believes colours are accidental, i.e. different objects (substances) may have the same colours, which means there are no necessary connections between any particular colour and any particular material. Maund's explanation of the multiple

[28] It is commonly agreed that Aristotle himself did not write the text *On Colours*.

realization problem echoes in a way Aristotle on this point. See quotation from Maund in the introduction, above.

According to Aristotle the main kinds of colour objects are, first, the light sources, such as, for example fire; second, the colour materials, which can be lit and also reflect light; and, third, the medium between these objects, namely air, water or earth, an example of the latter being glass. These media are, when dense, the whitest of things. When not dense a medium is more or less transparent and slips light rays through, which is a necessary condition for seeing objects. The medium has a hazy colour even when it is "of a very rear consistency". (Ibid.)

Aristotle maintains that we never see a colour in its purity, because the eye is a sense organ that receives not the materials themselves, only their colours, and these are always in a mix. So, when you look directly at a light source, its colour passes, in the form of light rays, through the rarefied air, and the colour the eye receives is a mixture of the colours of the two. A lit object receives coloured light from a light source, which in turn mixes with the colour of the object, and this two-component mix is reflected from the object and mixes with the colour of the medium, before the mixture finally reaches the eye.

For Aristotle, the seen colours are not properties of objects because the visual sense receives

> into itself the sensible form of things without the matter. This must be conceived of as taking place in the way in which a piece of wax takes on the impress of a signet-ring without the iron or gold; we say that what produces the impression is a signet of bronze or gold, but its particular metallic constitution makes no difference: in a similar way the sense is affected by what is coloured or flavoured or sounding, but it is indifferent what in each case the substance is; what alone matters is what quality it has. (On the Soul, 424a, Bk. II: Ch. 12, 15-25)

Hence, objective colours and their transmitters, namely the coloured light rays, are both causes of the seen colours, but the coloured rays are direct causes. In other words, Aristotle gives us a causal explanatory theory of the seen colours that can be applied by modern psychophysics.

Whether certain rays hit the eyes of a living animal is accidental. And if it were not, the rays would continue to exist in the medium as long as the light conditions and the relations between the lit objects are the same. This is in a way a dispositional theory of seen colours.

Aristotle draws attention to a kind of phenomenon nowadays known as optical blends.

> The reason is that the pores of the wool are tinged by the dye that enters them. The intervals of solid hair do not take the colour, and if they are white, then in juxtaposition to the colour they make the dye look brighter, but if they are black, they make it look dark and dull. For the same reason a more vivid brown is obtained on black wool than on white, the brown dye blending with the rays of black and so looking purer. For the intervals between the pores are too small to be separately seen, just as tin is invisible when blended with bronze; and there are other parallel cases. (On Colours, 794a17-794b10.)

From the last sentence it seems Aristotle included pigment blends. The thought seems to be that colour pigments, when divided into very small parts and are mixed the rays reflected from the blend result in a seen colour that is different from the materials that

constitute the blend. Most people are familiar with this kind of mixture though they may not be familiar with causal explanations in terms of optical blends.

Blends are very important in Berkeley's Argument from Microscopes, which gainsays daily life notions of the objectivity of colours. The different colours we can discern in an object at close range seem to mix or fuse as we move into the distance. However, through the microscope we see other colours than we see close up, and the crucial problem is to decide under which circumstances one sees the real colours of an object.

If you cannot decide, there are few reasons to hold that colours belong to objects. The silent premise seems to be that if colours are not objective, they must be subjective, in conformity to Cartesian dualism. In the first dialogue between Philonius and Hylas, the microscope argument finds Philonius concluding beyond any doubt that colours are subjective. (Berkeley, (3), p. 147, 1975.)

This is a refutation of Aristotelian naïve realism in colour philosophy. By his conclusion Berkeley cancels out the Aristotelian conception of an outer world in which objects are coloured.

Back on the stage are only the seen colours. This agrees both with Descartes and Newton, and also with modern psychophysics and pure physiology, as I have explained it in GI, section 1. If it were not for Berkeley's idealism, his famous denial that a physical world exists, he could have joined the psychophysical party.

Note also my discussion of subjectivity in GI, section 1.5.3 in where I take Berkeley to mean that colours are ideas and therefore objects of thought. That is, they are not part of the soul. This I also quote Berkeley on in the following section.

Berkeley's view conforms with the Formal System, see Chapter I. Take as example IMP 1 and 2 stating respectively that colours are homogeneous and two-dimensional. The common name colours denotes the qualities which by thought are determined homogeneous and two-dimensional.

2 Realism and epiphenomenalism

Realism in colour philosophy holds that all colours are effects in us. This notion implies, just as Berkeley's notion, a refutation of the Aristotelian colour categories: there are no coloured light sources, there are no coloured objects, there are no coloured media and there are no coloured light rays.

However, in some versions realism also includes the view that causes are physical and only physical. And as long as colours are subjective, and therefore not physical, colour mixing is impossible, because, by colour mixing one means a causal process whereby, for example, two colours mix to create a third colour. Neither can a colour be a cause in the sense of producing afterimages. The view includes the contention that a colour or some colours can under no circumstances be a cause of a colour or some colours.

This view is a specific instance of epiphenomenalism. It means, colours are considered to be effects only, i.e. they are produced within a causal chain starting from the physical via the physiological.

Epiphenomenalism on colours agrees with the Formal System, but only in so far as the conclusion is, no colour or colours can be a cause of other colours. Both implications on colour's homogeneity and heterogeneity support this kind of epiphenomenalism. See Chapter I, section 3.

It is noteworthy to quote also Berkeley (4) § 25, p. 84) in this connection. For him colours are nothing but ideas and those are inactive: "So that one idea or object of thought cannot produce, or make any alternation in the other." And in § 139, p. 121, he continues: "I answer, all the unthinking objects of the mind agree, in that they are entirely passive, and their existence consists only in being perceived: whereas a soul or spirit is an active being, whose existence consists not in being perceived, but in perceiving ideas and thinking."

But this is to say that colours and colour relations makes us think. In this way they are causes to spiritual activity. But as Berkeley insists, this activity is itself not colours.

Hering says that the physical does not end with the colours, which, in relation to epiphenomenalism, means colours as mere happenings along the way. Colours are happenings that last just as long as their relevant causes are active, i.e., they appear like a flash and disappear without a trace. The physical causal chain is independent and unaffected.

> Without intensively examining the enigmatic "body and mind" relation, still I ought to mention that these "psycho-physical" processes are not to be regarded as the final component of the neural activities associated with stimulation of the retina. One should not assume that the somatic events come to an end with them, and that from there on a mental event begins, which for its part could then occasion somatic, for instance, motor, processes. From the standpoint of physiology, an "immaterial" member cannot be imagined as inserted in the chain of "material" brain processes. For this reason one should not designate those psychophysical processes as the "terminal" ones and say that they are "converted into sensations." For one physical process can be transformed into another physical one, but not into a mental one. An unbroken series of somatic processes combines the change effected in the retina by an intense light, for example, with the muscular contractions by which the protecting hand is placed in front of the dazzled eye; the fact that a mental event, a sensing and willing, inheres in all this need not mislead the physiologist into making this assumption.

I bring in Hering just to illustrate the point that the physical chain continues. From one point of view Hering cannot be said to be an epiphenomenalist, because he rather thinks of colours as causes to colours. See in this connection GI, section 1.5.6. But from another point of view he could be, because of his psychological approach to colours. See in this connection GI, section 1.5.8.

Newton (1642–1727) is the most known of his contemporaries in reaching a consistent causal explanation of colours, and his theory is compatible with epiphenomenalism on colours. Newton describes his theory in the following way.

> The homogeneal Light and Rays which appear red, or rather make Objects appear so, I call Rubrifick or Red-making; those which makes Objects appear yellow, green, blue and violet, I call Yellow-making, Green-making, Blue-making, Violet-making, and so with the rest. And if any time I speak of light and rays as coloured or endued with colours, I would be understood

> to speak, not philosophically and properly, but grossly and according to such conceptions as vulgar people in seeing all these experiments would be apt to frame. For the rays, to speak properly, are not coloured. In them there are nothing else than a certain power and disposition to stir up a sensation of this or that colour. For a Sound in a Bell or musical String, or other sounding Body, is nothing but a trembling Motion, and in the Air nothing but that motion propagated from that Object, and in the Sensorium 'tis a sense of that Motion under the form of Sound; so Colours in the Object is nothing but a Disposition to reflect this or that sort of Rays more copiously than the rest; in the Rays they are nothing but their Disposition to propagate this or that Motion into the Sensorium, and in the Sensorium they are Sensations under the Forms of Colours. (URL, Gutenberg, Pg 125)

In this quotation Newton defends a dispositional theory of colour. Locke has his version of such a theory.

Locke draws his famous distinction between primary and secondary qualities of real, that is, physical objects. According to Locke the primary qualities are solidity, extension, figure, number and motion or rest, which are inseparable from the objects.

The secondary qualities are powers in the objects, first, powers to affect other things like when the sun melts wax, second, powers to affect our sense organs. The powers are secondary qualities in the meaning they are dispositions in objects and dependent on the primary qualities; they do no causal work until appropriate conditions are established (Locke, 1971, Book II, Chapter VIII, § 22)

For example, the sun sends out radiant energy, but this energy cannot affect my eyes until it so to say meet with them and the picture of the sun is instantiated. The rays are only dispositions in the secondary qualities to produce colours.

Mackie comments on Locke's distinction:

> It is clear that Locke adopted the distinction as part of the 'corpuscularian philosophy' of Boyle and other scientists of the time whose work Locke knew and admired. It had long been known that sound is a vibration in the air, and Hooke, Huygens, and Newton were trying out wave and corpuscular theories of light. In the development of any such theory it is simply superfluous to postulate that there are, in material objects, in the air or in the light, qualities which are at all like sounds as we hear sounds or colours as we see colours. (Mackie, 1990, pp. 17-18)

Locke (Locke, 1971, Book II, Chapter VIII, § 12) explains that objects affect the sense organs by impulse, and because many objects affect us from a distance the impulse must be conveyed through space by some chain reaction between imperceptible small bodies, and these finally hit our body, i.e. an appropriate sense organ, whereby the impulse is relayed by our nerves to the brain which is the seat of sensation.

One group of these sensations is ideas that resemble neither the primary nor the secondary qualities (= the dispositional qualities) of objects, and such ideas are colours, sounds, tastes, feelings and smells. They are considered mere happenings or side effects caused by the dispositional powers in objects, side effects that have no causal power in their own, in which sense they are therefore epiphenomenal.

The other group of sensations is ideas that resemble the primary qualities of the objects, i.e., they are quantitative.

> A piece of *manna* of a sensible bulk is able to produce in us the idea of a round or a square figure; and by being removed from one place to another, the *idea* of motion. This *idea* of motion represents it as it really is in the *manna* moving; a circle or square are the same, whether in *idea* or existence, in the mind or in the *manna*; and this both *motion and figure, are really in the manna,* whether we take notice of them or no: this everybody is ready to agree to. (Ibid. § 18.)

Locke considers, so it seems to me, all sensations to have the same ontological status, namely to be epiphenomena.

However, the quantitative sensations play an epistemological role in achieving knowledge of the real world, because they represent the physical objects in being copies of their primary qualities.

This may mean Locke ascribes any idea of extension only to the primary qualities. And, because the ideas we have of them represent the primary qualities and nothing else, it seems to follow that colours cannot be extended, because colours as ideas are excluded from the ideas of extension.

However, nothing seems to be gained in psychophysics by insisting that colours are zero-dimensional. And, as also seems the case in practical scientific work, no psychophysicist pays attention to the option anyway. See in this connection discussion of the subjectivity thesis in GI, section 1.5.3.

In relation to Locke there is this terminological problem involved in using the word *quality* both by itself and in connection with, respectively, *primary* and *secondary*. Mackie makes a point out of it, criticizing Berkeley. (Mackie, 1990, pp. 12-13.)

Mackie's concern is that both Berkeley and others use the term *secondary quality* to denote ideas of colours, sounds, etc., while at the same time using the term *primary quality* to denote ideas of extension, motion, rest and figure.

But after all, the meaning of the term, which conforms to Berkeley, has become quite common in philosophical literature, as Mackie points out.

It seems true that Berkeley, for example in the first dialogue between Philonius and Hylas, uses Locke's terms without making clear Locke's original ontological implications of the distinction. Berkeley lets Hylas explain.

> For the clearer understanding of this, you must know sensible qualities, are by philosophers divided into primary and secondary. The former are extension, figure, solidity, gravity, motion, and rest. And these they hold exist really in bodies. The latter are those above enumerated; or briefly, all sensible qualities beside the primary, which they assert are only so many sensations or ideas existing nowhere but in the mind. (Berkeley, (2), 1975, p. 148.)

One key to elucidation may be to reconsider Locke's use of the word *quality*. It is this use that is irregular in light of later tradition. However, in accordance with Mackie's explanation, *quality* is most probably synonymous with *property*: "the primary qualities are the intrinsic properties of material things". (Mackie, 1990, p. 12)

You could therefore substitute *property* for *quality* and say that according to Locke objects have two kinds of property: a) properties like three-dimensionality and solidity and these are primary, with respect to b) the dispositional properties of

objects, which are powers. The latter are secondary properties of objects because they rely on the primary properties.

This means that the word *quality* can be reserved for all those entities we use to call colours, sounds, feelings, smells and tastes. This is how the word is used in this present thesis.

3 Goethe's challenge to colour philosophy

The philosophical importance of the discovery of what Goethe calls physiological colours, findings that colour science delivered first in the last decades of the 1700s and of which Goethe presented a clear overview, cannot be denied.

To acknowledge the existence of these subjective colours implies admitting traditional naïve realistic conceptions of colours, i.e. Aristotelian colour theory, is not complete.

In an ontological sense Aristotelian naïve realism holds that colours are properties of outer physical objects. As such, they cannot exist alone, but only in the objects, that is, objectively, independent of human or animal vision.

But in fact, afterimages exist only subjectively, depending on the physiological structure and processes in a sense organ (eye-nerve-brain). Speaking metaphorically, Goethe says that physiological colours belong to the eye. (Goethe, 2002, § 3.)

But the subjective colours represent a challenge also to realism in the form of Newton's theory of light. Remember, Newton explained the existence of colours according to the different elementary light rays. However, most physiological colours may occur and certainly exist independent of the eye's exposure to light. See quotation from the Committee on Colorimetry in the introduction to this section.

The afterimage phenomenon is a prototypical example of physiological colours, because afterimages exist independently of light impressions, that is, they continue to exist when light no longer impacts the eye. For a broader discussion and description of Goethe's physiological colours, see Chapter VI.

Goethe presents the different kinds of physiological colours in the first of three main sections of his colour theory and orders them according to a diminishing degree of subjectivity.

In the next two main sections of his colour theory Goethe systematizes first physical and thereafter chemical colours. One of his main ideas is to order kinds of colour in such a way that it becomes clear how degree of subjectivity decreases while degree of objectivity increases throughout the range of physical colours, ending with the chemical colours.

For example, section two presents physical colours arranged in dioptrical, catoptrical, paroptical and epoptical colours. The last class, Goethe tells us, finally links the physical with the chemical in that the colours might be said to inhere in the matter. If, for example, a piece of polished steel is heated, "it will, at a certain degree of warmth,

be overspread with yellow. If taken suddenly away from the fire, this yellow remains". (§ 472)

This means that Goethe denies that there is a dichotomy between subjective and objective colours, what he wants is to show how nature makes a synthesis out of the kinds.

Physiological colours mix with both physical and chemical colours. For example, shadow colours are subjective, but entirely dependent on ambient light conditions. One of the most beautiful passages in Goethe's colour theory describes these phenomena, i.e. how subjective colours take part in colouring our environments.

> In travelling over the Harz in winter, I happen to descend from the Brocken towards evening; the wide slopes extending above and below me, the heath, every insulated tree and projecting rock, and all masses of both, were covered with snow on hoar frost. The sun was sinking towards the Oder pounds. During the day, owing to the yellowish hue of the snow, shadows tending to violet had already been observable; these might now be pronounced to be decidedly blue, as the illumined parts exhibited a yellow deepening to orange.
>
> But as the sun at last was about to set, and its rays, greatly mitigated by the thicker vapours, began to diffuse a most beautiful red colour over the whole scene around me, the shadow colour changed to a green, in lightness to be compared to a sea-green, in beauty to the green of the emerald. The appearance became more and more vivid: one might have imagined oneself in a fairy world, for every object had clothed itself in the two vivid and so beautifully harmonising colours, till at last, as the sun went down, the magnificent spectacle was lost in a grey twilight, and by degrees in a clear moon-and-starlight night. (§ 75.)

Ott and Proskauer have made recent contributions to the study of shadow colours, following the naïve realistic tradition of Goethe in colour science. (Ott § Proskauer, 1979.)

Colour philosophy in recent time is in great part concerned with discussing whether colours are either subjective or objective. Arstila, 2005, is one example. It seems that the thought that colours might be both subjective and objective is rejected without further reflection. Jackson mentions the possibility parenthetically "I am assuming that there is no third possibility, intermediate between being mental and being physical." (Jackson, 1977, p. 119.) He does not justify his assumption by philosophical arguments.

The modern naïve realistic tradition in colour science has been lasting for more than 200 years and is still a vivid spiritual force. Why so many philosophers seem to ignore this fact is a mystery to me. Those who adhere to subjectivism criticize the objectivists for not contributing to prevailing science. While objectivists try to rescue naïve realism from complete brake down. And the third possibility is not taken into consideration at all.

Shadow colour is a certain instance of simultaneous colour contrasts, a phenomenal category, which is widely recognized and explored into the finest details, and not only by Goethe. Chevreul, too, independently of Goethe, made a great contribution to this research field, and his findings were published in his 1839 book, The Principles of Harmony and Contrast of Colours. (Birren, 1981)

An example of one of his principles is the law of simultaneous colour contrast which occurs when subjective colours mix with physical or chemical colours, that is, make

blends with them. In the naïve realistic conception, you cannot understand the meaning of the term ‘simultaneous contrast’ without imagining two or more kinds of colour that interfere with each other, one of them by definition subjective or as Goethe calls them; physiologic.

Take a painting as an example. The picture is made out of chemical colours, that is, different pigment colours attached to each other and to the canvas with help of a binding medium. These colours may in themselves be the result of mixing. For example, a green area is made from the mixing of blue and yellow pigments.

Now, the painted canvas is illuminated by a light source, which has its own colour, and it really makes a difference to the picture if the colour of this light source is changed. All of which means, that the pigments and the light are already a mixture in the picture.

The law of simultaneous contrast tells that any distinct or limited colour area, gets affected by its neighbouring colours when you stare at them and this effect is reciprocal, so that both areas tend to be as different from each other as possible. See in this connection Chapter VII for a wider explanation.

However, these particular effects are due to subjective colours, which, according to the theory, mix with the existing mixtures between the chemical and physical colours. The picture as it is seen then, is a mixture of colours belonging to all three categories, namely the physiological, the physical and the chemical.

This conclusion leads directly to new problems in colour philosophy, related to the naïve realistic conception. What is seen is a mixture. The seen colours, therefore, cannot be identified with any of the kinds of the constitutive colours in particular. However, because they cannot be identified with either, the mixture of them must form a new kind.

This is analogue to pigment colour mixing theory, which everyone in some way or another is familiar with from their childhood on. One usually believes that if two different colours mix, a third colour appears, like when yellow pigments blend with blue pigments and green appears.

However, when talking about colour categories in terms of Goethe’s colour theory, it is not the special hues or achromatic colours that are in question but the colour kinds: the physiological, physical and chemical colours. If the colours subsumed under each of these colour kinds can mix, they surely must create a new kind of colour, but not necessarily a different colour.

Consider this example in connection with the latter possibility: let the paint on a canvas be yellow, let the light that shines on it also be the same yellow, and let the afterimage you have already established also be of the same yellow, in your first look at the canvas. There are then three kinds of yellow, mixed with each other, and they form this new kind you observe, namely yellow.

Such a conception of colours flies right in the face of the implications deduced from the Formal System. However, this mixing conception can be rejected by virtue of the same argument as in IMP I. If the yellow seen in the previous example really is a

compound of three kinds of yellow, it should in some way be three times its own extension. But this is absurd.

However, I have shown that such absurdity also follows from Hering's conception. He does not use the categories Goethe relies on, but his colour theory is based, or so it seems, see in this connection GI, sections 1.5.6 and 1.5.8, and finally 2.12.1, on an ontological claim that colours are heterogeneous.

In both sections 1.5.6 and 2.12.1 I quote him implying that for example orange consists of four colours; red, yellow, black and white: "A chromatic colour can generally be regarded as comprising four primary components, two chromatic and two achromatic (white and black); a *single* chromatic primary component characterizes only those colours that have a primary colour hue." (Hering, 1964, p. 64.)

On page 228 in the same book, he deals with uniocular and binocular colours, and they are achromatic. He says, "If two uniocular colours are of the same quality, then only a mixture of precisely the same quality can emerge from their combination." Suppose that the two uniocular colours consist of black and white in a certain ratio. Should not the binocular colour then be a mixture of four colours where two and two are identical?

And consider if two identical chromatic uniocular colours like orange which is not primary mix, would it not be eight colours in the binocular result?

I let these questions stay unanswered. It is the mixing theory or the heterogeneity thesis that makes me pose them. I retreat to the Formal System in order to get some relief. And really, I hope the terminology also in psychophysics can be changed.

4 Eliminativism

Psychophysics may have learned from Goethe and Chevreul that specific light inputs on the retina are not always regularly connected with specific colours.

> A surface with a certain spectral reflectance can take on virtually any colour, depending less on the illumination and the reflected spectral distribution than on the surround conditions. This was well known in the last century (i.e. the 19th century, my remark) and has more recently been emphasised by Edwin Land. The colour is therefore not "caused" by the spectral composition of an isolated patch, although we have a strong tendency to make this assumption. (Valberg, 1998, p. 108)

This passage echoes the artist Delacroix (1798–1863) who declared, "Give me mud and I will make the skin of a Venus out of it, if you will allow me to surround it as I please." (Birren, 1981, p. 28)

But Delacroix expressed himself in naïve realistic terms. Mud is supposed to be coloured or to have a colour, and the surrounding colours are also colours of some material or other. In the naïve realistic view, the reason the mud looks different is in the surrounding colours themselves, not in any reflections of invisible radiant lights. When the appearance of the mud is changed, it has not acquired a different colour property, its colour is in reality still the same. However, it is now mixed with the

physiologic colours, creating one or several different colours, which can be seen. Colours are supposed to be the cause of other colours.

Naïve realism rescues the belief some colours belong to outer physical objects. In contrast, Valberg tilts towards the realistic idea in his explanation that all colours are effects in us.

Eliminativism à la Hardin starts by rejecting the idea that colours belong to external objects. (Hardin, 1988, Chapter II: *The Ontology of Colour*.) This means common sense colours and naïve realistic objective colours are eliminated. But while a true predication, …. *is coloured*, or, …. *is yellow*, seems to be what objectivists in general seek, Hardin asks if detecting necessary connections between physical inputs on the retina and particular colours can actually save this kind of predication.

One of Hardin's main arguments against this possibility is that, for example (a particular) yellow (=Yx), in fact may be said to be an effect of 575 nanometre (nm) photons hitting the retina under the right conditions. But this only means that the 575 nm photons are sufficient to produce Yx.

Because it is only sufficient, one cannot infer from the existence of Yx that this particular photon is the cause. The reason being, according to Hardin, "There are indefinitely many such hue-matching stimuli (though not single-wavelength ones) which will have this effect on our standard observer, and most of them do not include 575 nm photons." (Hardin, 1988, p. 63.)

In his 1984 article Hardin gives a wider explanation, see in this connection GI, section 2.11.3.

> Unique green, for example, is experienced by most subjects when they are stimulated by monochromatic light of 503 nm. But unique green is equally well evoked by a mixture of 490 nm and 540 nm or, indeed, by indefinitely many other wavelength pairs, none of which need contain 503 nm. Nor is there any relationship between unique hues and single wavelengths, or between binary hues and pairs of wavelengths. There is no wavelength relationship that corresponds to the opponent relationships either. An object may reflect equal amounts of 503 nm (which perceptually evokes unique green) and 650 nm light (which evokes a very slightly yellowish red) without producing a perception of greenish red. Instead, it is white or grey barely tinged with yellow which is seen. (Hardin, 1984, p. 495)

According to Hardin, some philosophers retreat to a possibility of establishing disjunctive causes. The idea is that if different physical causes A, B, C, etc. each and every one produces Yx, one can still postulate a necessary connection between Yx and the outer world because of the disjunctive cause A or B or C … etc. While none of the members of the disjunction are necessary in and of themselves, however, the thought is that the whole disjunction is necessary.

But also, this connection Hardin eliminates. (1988, pp. 91-92.) His reasons are obvious and certainly not new. As Chevreul pointed out long ago, colours occur from other causes, for example by pressing the eye in the dark. This means that Yx can be caused by neuronal causes only, and therefore there are no necessary connections between physical light inputs and Yx. This conclusion may be generalized to all colours. In §§ 120 and 121 (Birren, 1981), Chevreul puts it this way.

> Buffon was the first who described, under the appellation of accidental colours, several phenomena of vision, all of which he considered to have this analogy, that they result from too great vibration, or from fatigue of the eye; wherein they differ from the colours with which bodies appear to us usually coloured, whether these bodies decompose light by acting upon it by reflection, by refraction, or by inflection. Accidental colours may arise from various causes; for example, they are perceivable under the following circumstances: 1. When the eye is pressed in the dark. 2. In consequence of a blow on the eye. 3. When the eyes are closed after having looked at the sun for a moment. 4. When the eyes are fixed upon a small square piece of coloured paper, placed upon a white ground; then the square, if red, will appear bordered with a faint green; if it is yellow, by a blue; if it is green, by a purplish white; if it is blue, by a reddish white; and if it is black, by a vivid white. 5. If, after having observed these phenomena for a considerable time, we turn our eyes to the white ground in such a manner as no longer to see the small square of coloured paper, we shall then perceive a square of an extent equal to the other, and of the same colour as that which bordered the little square in the preceding experiment. (Birren, 1981, pp. 67 - 68.)

Hardin adds to this that light inputs are only linkages in a causal chain. They affect the retina, but from that point on, the ensuing processes have no resemblance with light at all.

> Remember that the eye is a very coarse harmonic analyzer because it contains only three types of colour receptors, their response curves are broad and overlap markedly, and each one will generate a signal whenever it captures a photon anywhere within its response range. Once a photon is absorbed, the wavelength information that it bears is lost. All the nervous system "knows" is whether or to what degree each of the three receptor types has been excited. Any two events that produce the same response pattern will be seen the same way. (Ibid, pp. 62-63.)

Colours are not, Hardin concludes, in any reasonable way, connected to objects in the outer world.

From the retinal responses, neuronal processes transform in a chain reaction all the way to the visual cortex, where the immediate causes of colours are found. I take this to mean colours are subjective, because their causes are subjective. This needs not imply that Hardin consider colours are properties of mind, see discussion in GI, section 1.5.3.

Hardin continues:

> Because perceptions of colour differences and perceptions of boundaries are closely intertwined neural processes, we see colours and shapes together. Roughly speaking, as colour goes, so go visual shape. Consequently, there are no visual shapes in the ultimate sense, just as there are no colours. (Ibid. p. 111)

By this move it seems that Hardin plainly eliminates also the colours. However, in light of Hardin's strenuous efforts to defend his view that some hues are unique and others are binary, his contention that there are no colours can obviously not be taken in a literal sense. His expression *the ultimate sense* can perhaps lead to this interpretation: 'there are no objective colour shapes just as there are no objective colours'.

In GI, section 2.11.3, last two pages, I conclude that Hardin's eliminativism does not include epiphenomenalism.

CHAPTER III
Comments on central notions in colour systematics

Introduction

In chapter III, I first discuss Hardin's definition of unique colours, thereafter I repeat my critique on the lacking conceptual criteria for dividing colours into chromatic and achromatic. Then I present and discuss some theories of opponent colours within pigment colour systems. Further, I address some difficulties within colour systematics which arise from the detection of so-called forbidden colours. In the next sections I address the Swedish Natural Colour System and explain my reasons for not accepting that the use of the term natural is sufficiently counted for.

1 Defining colours by colours

In colour systematics it is common to divide colours into two kinds, i.e. homogeneous and heterogeneous colours, and this can be understood as an attempt to define some colours on the basis of other colours. But this strategy provides for circularity. I do not deny that systems, even if they are dependent on circular definitions, can be useful, because failures in the theory on which they are constructed, do not need to make the construction useless.

In order to explain what I mean by a circular definition of colour, I want to cite Aristotle, who wrote, "the field of each sense is according to the accepted view determined as the range between a single pair of contraries, white and black for sight". (On the Soul, Book II: Ch. 11, 422b-423a.)

In this quotation Aristotle concentrates on the field of each sense. With respect to colours, it is not the process of sensing, i.e., the material causes of colours, but the colours themselves, that are in question. I read Aristotle as trying to define the colours.

However, the epistemological value of the Aristotelian definition vanishes because of circularity: The intermediates are defined by the extremes and the extremes are defined by the intermediates.

Furthermore, every colour – apart from black and white – is defined as an intermediate. But it seems to be no justification for pointing out black and white to be the single pair of contraries according to which all other colours are determined. If blue and yellow or even orange and brown were taken as contraries, black and white could be members of a range of colours between them.

To say black and white are contraries amounts to nothing more than to say they are very different. But this is not a definition of them. See in this connection GI, section 2.4, on Johnson's term betweenness.

The first thing to note about Hardin and Valberg is that they too define the main part of the hues according to some single pairs of contraries. However, because the pairs are multiple, the circularity in their definition may not be that obvious.

Unique hues for Valberg and Hardin are four, namely yellow-blue-green-red. In Hardin's opinion, these hues have no colour in common with other hues, something binary have. (Hardin, 1998, pp. 127-132.) A binary hue can therefore comprise unique colours to a greater or lesser extent, but the opposite is not the case.

This idea is to me highly questionable. In Hardin's terms, orange, for instance, should have one hue in common with yellow, namely yellow, but yellow has nothing in common with orange.

However, to say of orange that it is a combination or a mix between red and yellow, is not a circular definition.

In order to characterize the unique hues, the expression *neither-nor* is frequently used. Consider what Valberg says: "Unique yellow is characterized by being "neither reddish nor greenish". It is thus determined by means of the two closest unique hues on the hue circle. Unique blue satisfies the same definition." (Valberg, 1998, p. 110) But already this should wake suspicion on circularity, because of identical definiens.

All unique hues, according to Valberg, are defined negatively with reference to each other.

But by defining something negatively in this way, you achieve no new information. If x is defined as *not y* and y at the same time is defined as *not x*, then of course you can substitute *not y* for x and *not x* for y. For example, if x = not y, and you substitute not x for y, then you get x = not not x, which is a double negative, that is, a positive, giving x = x, which tells us nothing new about x.

Hardin defend the theory of unique hues in much the same way as Valberg does:

> But hues do have certain characteristics necessarily. This is a central truth, no less true for having been so frequently overlooked. If we reflect upon what it is to be red, we readily see that it is *possible* for there to be a red that is unique, i.e. neither yellowish, nor bluish. It is equally apparent that it is *impossible* for there to be a unique orange, one that is neither reddish nor yellowish. (Hardin, 1988, p. 66)

Hardin appears to advance two arguments for classifying some colours as unique and others binary, one, we readily see it, and two, it is apparent. However, what he sees so readily about red, is exactly what Valberg contends, that red is a colour that is neither yellowish nor bluish.

I do, however, not take this to be a vicious circular definition, but I wish to underscore that it in reality is naming. Whereas the definitions of binary colours is not naming, but a contention they are heterogeneous. See, GI, section 1.5.7, for a comment on the method used by Hardin and Hering, which is judgement rationality.

2 Chromatic and achromatic colours

Valberg draws a distinction between black and white on the one hand and red, green, blue and yellow on the other. (Valberg, 1998, p. 110) He names black and white achromatic colours and the hues chromatic colours. I just want here to expand on my notion that these words are not defined.

But they have literal meanings. The word chroma is from Greek and it means colour. If likewise, the word chromatic means coloured, and achromatic means not coloured, then black and white must, it follows, be not-coloured colours.

And by saying the hues are chromatic colours, it follows red-green-blue-yellow are not unique, but coloured colours, which is contrary to Valberg's initial notion.

The distinction between chromatic and achromatic colours is widely applied by both colour philosophers and scientists. Maybe the use of the distinction amounts to nothing more than a matter of speech, based on tradition and not on explicit ontological considerations. This would be an excuse for using it.

In GI, section 2.3.1 on naming I use Hering as example, I say that though the words chromatic and achromatic allude to categories, the difference between them is not justified by definitions. Hering treats of them as categories as if they belong to a taxonomy but he gives no conceptual justifications for doing so.

According to Johnson, colours have no connotation in a taxonomical sense, see GI, section 2.6.1, and I agree. It follows from this point of view that chromatic and achromatic are only common names each denoting a lot of colours. These colours are given these names by being pointed out.

3 Opponent hues in pigment colour systems vs. psychological opponent colours

Both Valberg and Hardin contend that the members of each pair yellow-blue, red-green and white-black are opponent colours. An idea of opponent colours has been a central notion of colour systematics for many years and is generally accepted nowadays too. (Arstila, 2005, p. 97) However, different systems differ in which colours are taken to be opponents. I shall therefore make a brief detour to review some of the landmark events in the history of colour systematics.

In his famous 1839 treatise, Chevreul (1786 – 1889) described a system of colours based on pigment mixing. Mixing two of what he called the three primary or basic colours, red, blue and yellow, would create, he reported, three secondary colours. (Birren, 1981, p. 80) According to Chevreul, violet is made of red and blue pigments, green is a blend of yellow and blue pigments, and finally orange of yellow and red pigments.

Intriguingly, some people still believe, (unlike the adherents of the yellow-blue-red-green theory), only red, yellow and blue to be pure colours, with violet, green and orange making up the compounds. Take, for example, the Norwegian translation of *Kunst der Farbe* (Itten, 1994), a work frequently found on the curriculum of colour appreciation courses in aesthetic or artistic programmes. Indeed, its author Itten's system is based on pigment mixing, as is Chevreul's.

Chevreul had the advantage of allowing himself to be a naïve realist. According to a naïve realist, mixing a certain amount of yellow pigment with a certain amount of blue pigment yields green. To Chevreul, it was therefore logical to maintain that green in reality is a mixture of yellow and blue pigments. Likewise, he believed, violet is

binary because it contains both blue and red pigments, and orange is secondary and derived from red and yellow pigments.

Chevreul also observed how equal proportions of the three primary pigment colours made black. According to his naïve realistic theory black should subsequently be defined as a tertiary colour, being a compound of red, yellow and blue. But he did not make this implication.

However, two of the colours may predominate in such a mixture, causing the third colour to vanish. He concludes, "Thus, if a small proportion of Blue is added to Red and Yellow, a little Black is produced, which goes to reduce or *break* the orange." (Birren, 1981, p. 79) Thus, blue and orange are complementary colours, which means they are opponents.

On the other hand, the divide into three primaries seems not to be of good practical value. Birren tells the story like this:

> Perhaps red, yellow, blue were fundamental to Chevreul's theories for the simple reason that in combination - with dyestuffs as well as pigments – they formed other hues. He states in § 156 that equal parts of the three primaries yielded pure secondaries, and that equal parts of all three primaries yielded black. This is not altogether true. It is difficult with any choice of red, yellow, blue to produce vivid yellow-green, ultramarine blue or purple. Wilhelm Ostwald set five colours as a minimum for pigment mixtures – a vermilion red, a purplish red (magenta), a clear yellow, a turquoise or peacock blue, and an ultramarine blue. In process printing the primaries are magenta, yellow and turquoise (cyan), but these have limitations. Chevreul´s primaries as can be best determined from his writings and from the plates in his book are a scarlet red, a clear yellow, and a blue between turquoise and ultramarine. (Birren, 1981, p. 80)

In ordinary pigment colour systems, the primary and secondary colours are placed round the white-grey-black axis. Let me quote Birren comparing the achievements of Runge in relation to Lambert, both pioneers in three-dimensional system building.

> Colour solids represent an attempt to chart the world of colour variations in three dimensions. One of the first was that of J. H. Lambert who, in 1772, devised a colour pyramid based on red, yellow and blue primaries. Lambert was a physicist and philosopher and appreciated that mixtures were "subtractions" and tended towards black. A base triangle, with red, yellow, and blue on its angles, shaded towards a black centre. Subsequent triangles, each smaller in dimension, rose vertically toward a white apex.
>
> In 1810, Phillip Otto Runge, a distinguished German painter, conceived of a colour sphere (Die Farbenkugel) in which pure colours ran about an equator, while tints scaled upward towards a white top pole, shades scaled downward towards a bottom black pole, and greyish tones scaled inward towards the grey axis. (Birren, 1981, p. 85)

The greyish tones that run diametrically from Runge's equator periphery towards the central axis are supposed to be mixtures of complementary (opponent) colours that reduce or break each other into graded blends, in which only the dominant is recognizable, until neutral grey is reached. (Illustration in Gerritsen, 1972, p. 22)

So according to Chevreul and Runge, if violet – to take a random example – is reduced gradually in blends with yellow, the result will be only grey shades of violet. It can never result in a yellowish violet tone ever. Turned around, when yellow is reduced with violet, only grey shades of yellow obtain.

However, Runge's conception of complementary colour pairs leaves us with a tremendous number of opponent colours, because not only are pairs of primary and secondary colours opponents, pairs of secondary colours are too, for example a red-orange and a bluish-green. This can be confirmed by Gerritsen's illustration. (1972, p. 22)

I discuss the psychological approach in colour determination in GI, 1.5.7. The clue is only to see what is in a colour and what is not. Check the quotation from Hardin in section 1 above. It is not about experienced colour mixing but about intuition. Hospers (1961, p. 153) classifies this kind of method as judgement rationalism.

This seeing results in a determination of four unique hues of which two pairs are opponents, that is, red-green and yellow-blue, which is a reduction in number compared to pigment colour systems such as described above.

Another difference is that none of these opponent hues are considered compounds. That is, according to Hering, they have a darkness component, which means they are compounds, but they are not compounds of any other hues. See in this connection GI, section 1.5.1.

Hering (1964, p. 41) is very clear on this point: "Every chromatic colour of given chromatic quality, which in agreement with Helmholtz I call its hue, can be more or less whitish, greyish or blackish, that is, can be veiled or masked by white, grey, or black to different degrees."

However, there is a likeness in that unique pairs cannot meet except through a range of less and less saturation. For example, red must dissolve into one grey in the middle axis and so must green, for them to hang together in a linear scale. This agrees with other constructions of colour space, see also section 5 below. In the following quotation Hering uses the term veiling instead of saturation degrees.

> The four series of intermediate hues that we mentioned are like the black-white colour series in which we can similarly go from black to white through a continuous series of intermediate colours, of which all those on one side appear more or less related to black and those on the other side to white. But between red and green, or between yellow and blue, there is no comparable series of colours. By steadily increasing its veiling with an achromatic colour, for instance with a grey, a clear red can be transformed into this grey, and, furthermore, by continuously decreasing the veiling a grey can be transformed into a clear green, and the same thing holds for yellow and blue; but these transitions do not form a colour series in which each member contains something of the chromatic quality of the two limiting members, red and green or yellow and blue. For starting from the strong red colour, we see its redness continuously fade without showing any comparable increase in greenness, but rather the redness must first have faded entirely into grey before greenness can begin beyond this grey. (Hering, 1964, pp. 49-50)

4 Forbidden colours

Hering writes this on forbidden colours:

> It seems highly striking from the start that between red and green, for example, there is not a series of intermediate chromatic colours as there is between red and blue, that there are consequently no colours that appear simultaneously reddish and greenish, in the way that orange is simultaneously reddish and yellowish, or grey simultaneously whitish and blackish.

> We should conclude from this that in the inner eye a physiological process whose psychological correlate would be simultaneously both red and green or yellow and blue is either not possible at all or is possible only under quite special, unusual circumstances. (Hering, 1964, p. 50)

Crane and Piantanida (1983, p. 1078) report they found such circumstances: "Among the stimuli presented to our observes was a vertical pair of red and green stripes whose common boundary was stabilized and whose outer edges were formed by unstabilized black occluders." They tell this experiment is one of the so-called filling-in colour experiments, but shows different results from those that are described earlier. See in this connection Chapter VII, section 1.

> To date, more than a dozen observers of both sexes and a wide variety of ages, with normal or corrected visual acuity, have viewed this unusual stimulus. The observers reported three different appearances, and among them was one a composition of red and green. Although most reported that regardless of where they attended in the field, the colour was simultaneously both red and green, some observers indicated that although they were aware that what they were viewing was a colour (that is, the field was not achromatic), they were unable to name or describe the colour. One of these observers was an artist with a great colour vocabulary. (Crane and Piantanida, 1983, p. 1079)

They also presented, but then for fewer observers, yellow and blue stripes under the same conditions, and "when the blue and yellow stripes disappeared, observers reported seeing the field as simultaneously blue and yellow, regardless of where in the field they turned their attention."

On the same page Crane and Piantanida discern between two kinds of process.

> Thus, filling-in seems to be more of a lateral; one that we might think of as resulting from corticocortical rather than from retinocortical connections. If so, our result suggest that the percepts of reddish green and yellowish blue, although not reported under conditions of retinocortical colour perception (that is, chromatic processing in the primary visual pathway as described, for example, by opponent-processing models) apparently are possible in corticocortical colour vision processes.

Billock, Gleason and Tsou (2001, 2398)) performed another kind of experiment, but which confirms Crane and Piantanida's observation results. Some observers saw the colours as if they were transparent and "could be seen, one through the other." Others reported they saw a sliding scale from green to red. On the following page they tell that "Interestingly, after our experiments, two subjects noted independently that reddish-green and yellowish blue could now be imagined."

I have no competence in judging or criticizing the experimental conditions and instruments used. And so, I cannot carry out the experiments and make a control. However, I trust the observation reports, just as does Arstila (2005, pp. 95-97).

To me it therefore seems curious that Nida-Rümelin and Suarez (2009, pp. 362-363) lay so much stress in refusing the reports on forbidden colours. It seems none of them has carried out the experiments. One of their arguments is the following.

> According to the realist view about phenomenal composition that we defend a person can seriously judge that he or she has an experience of a hue that is phenomenally composed for her at that moment in a particular way and yet thereby be wrong about the phenomenal character of his or her own experience. For someone who accepts this view that explicitly endorses fallibilism about phenomenal judgements it is quite natural to consider the possibility

> that those subjects who described the colour perceived in the laboratory as being composed of red and green for them on this occasion were misdescribing their own experience.

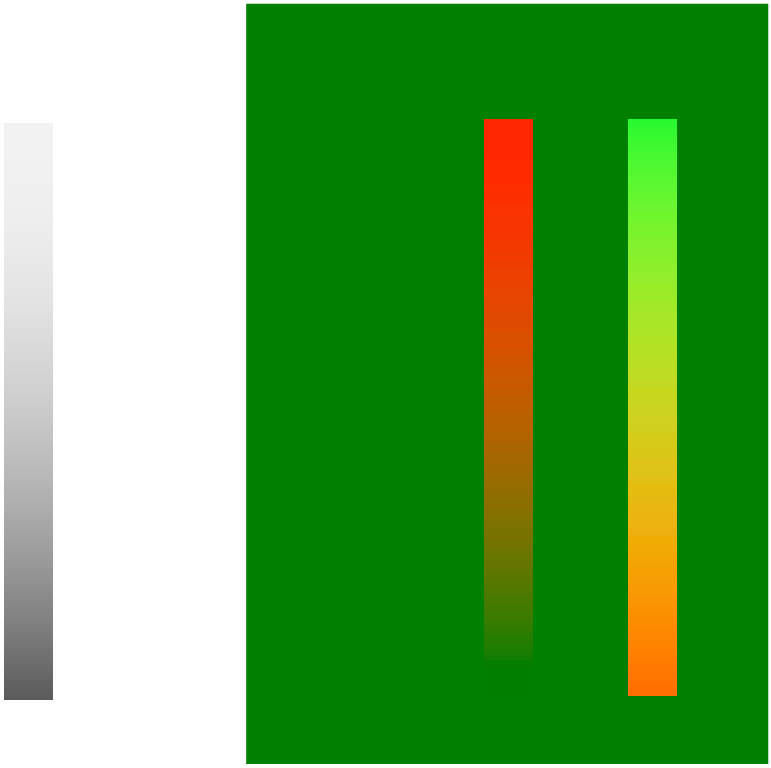
However, they consider this possibility "highly speculative" but then they continue.

> The error at issue – according to the present speculation – is a confusion of phenomenological descriptions: *apparent simultaneous presence of red and green on a surface* is mistakenly described as a genuine phenomenal composition of red and green. According to this speculative proposal there is a possible experience that is in fact produced under the unusual circumstances at issue that can adequately be described as a case where red and green are simultaneously present on a surface (for the perceiver on that occasion) but where red and green do not phenomenally mix into a new kind of hue as they do in genuine cases of phenomenal composition.

I will not discuss this speculation, I present it only in order to show that the actual experiments of Crane and Piantanida is mistrusted by someone.

As a counter argument to Nida-Rümelin and Suarez I present below two sliding scales that combine red with green and green with orange. I have used a standard colouring program in my computer when designing the picture below. If you compare with the sliding scale of greys on the left you will, may be, see no likeness. If so, the picture shows that red and green can hang together in a sliding scale. I have also produced a sliding scale from yellow to blue, see Chapter I, section 2, BD X.

Picture 5



5 Colour space: three-dimensionality vs. two-dimensionality

The scientifically confirmed observations of red-greens (and other forbidden colours) leads to another threatening conclusion, according to Hardin: “Thus, if the experiment is valid, no resemblance ordering of all experienced hues is possible in a three-dimensional colour space.” Hardin refers to Crane and Piantanida’s 1983 experiments.

The ordering according to three dimensions is intended to ensure adherence to the systematic principle whereby one particular colour shall have only one place, which means that in a proper system no colours shall be repeated. When ordered in a solid one believes that the middle axis, black–grey–white, relates to all the other colours and so the criterion of no colour repetition is satisfied.

The Committee on Colorimetry (1953, p. 56) writes.

> If these charts were piled on top of each other with the lowest brightness at the bottom and the highest brightness at the top, with the achromatic samples directly above each other, and with corresponding hues in the same direction, we would then have a three-dimensional solid in which any colour whatsoever occupies a unique position. The characteristics of any colour can be described in terms of the coordinates of the point representing it, namely, by giving its position on the linear brightness and saturation scales and its angular position on the hue scale.

The Formal System of Colours brakes with this naïve realistic thinking. It follows from the system that colours cannot relate in a three-dimensional construction, stretching out in length, breadth and depth, because colours are two dimensional.

Besides, the suggested three-dimensional ordering has no practical application when it comes to observing colour relations in colour systems. Colours can only be observed beside each other; no colour is ever directly observed to cover another colour. In practice therefore, all systematic presentations of colour relations have to repeat some colours.

However, Hardin's reference to a three-dimensional space in this connection might amount to nothing more than a manner of speech. For example, Clark takes *dimension* to mean *differentiative property* by which he means that a dimension is not necessarily understood as one coordinate in a three-dimensional space of length, breadth and depth, but only as a mark of differentiation. In this respect there can obviously be many more dimensions than three. (Clark, 1993, p. 144 and p. 153.)

This may do little to soothe Hardin's worry, because his psychological theory of opponent colours has been shown to be unreliable anyway. Crane and Piantanida's observations should lead to a revision of colour systematics. The old school of pigment system holds that the connections between opposite primaries and opposite secondaries, goes only through grey. But evidence from the discoverers of forbidden colours shows that other connections too are possible, as do my picture, see section 4.

6 A psychological point of view

Both Hardin and Valberg seem to believe most people have a common inclination to conceive of hues as either unique or binary, with unique hues most commonly perceived as the four unique hues in NCS. However, this is a psychological contention because it concerns social facts. Valberg makes even a stronger claim. "No colour is seen as both yellow and blue at the same time, in the way that orange can be said to be perceptually composed of yellow and red. The same reasoning applies to the unique red-green pair." (Valberg, Proceedings, 1998, p. 111)

Therefore, the discussion in this section is not concerned with ontological determinations of colours, but only with the psychological claim that most people perceive colours in agreement with the experimental results of colour determinations in the NCS. See in this connection GI, section 1.5.5.

7 The Natural Colour System – NCS

NCS does not base its colour determinations on physics or chemistry or physiology, but on psychology. Grethe Smedal, who has applied NCS throughout her career in design and as a lecturer on colour, emphasizes, the system was developed in agreement with reports on colour determination from a huge number of supposedly neutral or unbiased observers. (Smedal, 1996, p. 34.)

This useful snippet of information sheds light on what is supposed to be natural in the Natural Colour System, namely a collective way of describing and judging colours but without any information on how these colours were physically or physiologically produced.

So far, so good – I do not deny the method is psychological. The final result is that hues are arranged as binaries between the opponent pairs yellow-blue, red-green and all of which are determined as unique hues, all of which are related to black-white.

In the psychometric method used for developing NCS subjects are shown pre-prepared coloured cards, each differing regularly from its neighbours. A total of 446 cards were shown to about 50 observers over an eight-year period. Most of the observers were unbiased and had no prior knowledge of NCS gradation terminology. However, they were introduced to it, because their final mission was to arrange the colours in series according to this pre-ordained difference.

I have this information from a book about NCS, where Hård, who is one of the founders, describes the idea of the system, how it was developed and its application area. (Hård, 1996, pp. 74-76.)

However, in some groups the cards were arranged according to their likeness with the unique hues, which were shown.

The most peculiar aspect of this method is that, in some other groups, the unique hues could not be seen by the subjects.

Hård describes the procedure leading to the conclusion the unique hues, besides black-white, are ideal. Two groups, A and B, were organised, each consisting of 14 observers. Each observer was asked to describe 28 colours, and suggest which of the six constituent colours they looked alike, and their relative quantities in per cent. The aggregate percentage should never exceed 100.

The difference between the groups was that A was given paper reproductions of the unique hues to compare, while B only had recourse to

> a mental image concerning the unique colours, that is, those colour impressions that bears no likeness with each other and cannot be described according to no other colour than itself (a so-called ostensive definition). (Hård, 1996, p. 68, in my translation.)

> The mutual arrangement between the samples grounded on the calculated middle value was (…) almost identical between the two groups. Between experiment A, with determination according to reference samples, and experiment B, with determination according to the inner ideas about these "pure" colours, the correlation was huge, something that the correlation coefficient rA:B = 0,985, earns to show. (Hård, 1996, p. 69, my translation.)

Hård will have us believe that the high correlation rate resulted from a natural ability to judge colours after the paradigm of the six unique hues. They are so to say archetypical or ideal, in his opinion.

In none of the psychometric experiments carried out by NCS, did an observer judge a colour to be both yellow and blue at the same time, nor green and red at the same time. (Hård, 1996, p. 79.)

I shall discuss neither the reliability of these experiment, nor the validity of what Hård makes out of them concerning the universality of NCS and ability of the ideal colours to correct any normal person's colour determinations. I shall restrict myself to discuss what these ideal colours in fact can be.

Grethe Smedal says,

> When we compare colours, using the six unambiguous colour ideas that function as an "inner reference system", we can describe the colours as being more or less alike one, two, three or four, of these six colour ideas. That is, a colour like for example "soft violet" may be described as more or less reddish and bluish (more or less resembling our ideas of red and blue), and more or less greyish (more or less resembling our ideas of white and black). (Smedal, 1996, p. 36, my translation.)

This thought that the unique colours are ideas according to which other colours are determined finds no support in psychophysical theory, because, according to psychophysics, all colours are on an equal footing being effects in us.

However, at first glance it seems to agree with Hume, who divided the mind into two distinct kinds of perceptions, namely impressions and ideas. But if the ideal unique hues are ideas in Hume's meaning, they will be weak and faint copies of some original impressions and as such not very helpful in determining other colour impressions that are, according to Hume's theory, strong and vivid. See in this connection GI, section 2.9.

According to physicalism, which is a doctrine within the philosophy of mind, a colour must have a physical cause, which means in this case the sufficient physiologic neural processes in the brain. No colour can be produced by thought. (Kim, 1998, pp. 10 – 11) If ideal colours are colours, then, the physicalist doctrine requires them to be produced by the brain, which means they must be seen just like other colours.

8 Some objections

I cannot see why one should accept NCS on these grounds as a natural system which certainly must imply that other systems are artificial and non-natural. I suspect the observations made by the test persons actually prove nothing concerning NCS in particular, but I do indeed take them to confirm a general point, which is that people are able to judge degrees of differences and likenesses in relation to any chosen colour standard whatsoever.

Albers shows it is possible to determine relations when the standards are selected arbitrarily. Instead of letting students mix paint to make scales, Albers preferred readymade cards. At the time, the arrangement had no connection at all with any of the systems in use, i.e., either Munsell's or Ostwald's. Albers's method used random pieces of coloured paper he had picked up from anywhere and everywhere.

> Sources easily accessible for many kinds of colour paper are waste strips found at printers and bookbinders; collections of samples from packing papers, of wrapping and bag papers, just cut outs from magazines, from advertisements and illustrations, from posters, wallpapers, paint samples, and from catalogues with colour reproductions of various materials will do. Often a collective search for papers and a subsequent exchange of them among class members will provide a rich but inexpensive colour paper "palette". (Albers, 1971 p. 6)

It is indeed no indications in Albers book that all his students through the years used the six unique hues as a standard. If they did, I think he himself, the leading teacher, would have noticed. In this connection it is interesting to see that Harding, although he holds the distinction between his unique and binary hues to be fundamental in

perception, contends that his central truth have been frequently overlooked (Hardin, 1988, p. 66.)

Furthermore, if NCS was a natural system, it should follow most people would find it difficult to envisage any other system. But people do not seem to encounter such difficulties, either theoretically, or in practice.

The use of computers today shows normal persons can substitute one system for another, following in each case the specific rules of colour determination and comparison. Remember, applications of the RGB system, is for colours produced on for example computer screens. This is what you need if you want to produce or manipulate computer images.

In contrast, a subtractive system like the Pantone Colour Selector with its CMYK colours is made for printing pictures and decorations and for controlling the printing results.

On the other hand, the NCS colour chart was devised mainly as a colour selection tool for house and furniture paint.

These are three very different uses, but a normal person should be able to cope with every system, if for no other reason than these systems are meant to help normal persons.

It follows that if *natural* is to be a criterion for identifying the true system from among the mentioned ones, the ease-of-use factor will not help us find which of them is the most natural.

As I remarked above, the only natural thing under the circumstances, seems to be the human ability to perceive differences and likenesses according to a certain template. However, the template itself can be arbitrary, like determining the length of the metre, as happened in Paris in 1889. But as soon as a standard becomes the norm, the descriptive comparison work can be carried out.

9 Different templates – same idea

According to NCS, the natural template is the four unique hues, together with white-black. This template differs of course from that of other systems, but remark, in principle there is no difference: some colours are said to be perceived as homogeneous, and others heterogeneous.

In the CMYK system Cyan-Magenta-Yellow-blacK are determined as primaries, or what is the same, 100 per cent colours. All the colours in between are conceived of as different compounds of those four. A peculiarity of the system is its ability to define a hue as for example a 300 per cent colour, that is, the sum of 100 per cent each of cyan, magenta and yellow. You can add percentages of black too. White, on the other hand, is not included in the percentages. Indeed, white lacks a percentage definition altogether, which is down to the idea of subtraction. White is the colour on which the other ones are printed. See in this connection Pantone: *Process Colour Selector*, Euroscale, uncoated version, Pantone, Inc. 1983.

By subtraction, any change in white is considered a step "downwards" in direction of black. (Gerritsen, 1975, p. 74)

In (variants of) the RGB system, that is, the optical system, lights of Red-Green-Blue are considered primaries, and in certain light intensities they sum up to white in its brightest form. Black takes no part, i.e. it is considered a privation of light. (Gerritsen, 1975, p. 75)

Generally speaking, the mode of determining according to a template is principally the same.

10 Searching for the unique hues

The forgoing considerations provide objections to the alleged shared perceptions of NCS's unique colours on sociological grounds. In this section I show that there is some disagreements among authorities on which are unique.

But first, I want to refer the reader to what Albers has to say. The following is from his book on colours; I believe it summarizes his experience of students throughout a long teaching career:

> If one says "Red" (the name of a colour) and there are 50 people listening, it can be expected that there will be 50 reds in their minds. And one can be sure that all these reds will be very different. (Albers, 1971, p. 3)

Likewise, what the NCS unique hues actually look like, even after a study of the reproductions, remains decidedly unclear.

One would perhaps hardly expect to find any significant variation between professional's samples of the unique hues. But that is precisely what one does find. Indeed, it is very difficult to find an agreeable match. For example, if you visit the net address of NCS's unique hues (URL) the website samples do not match the opponent pairs of red-green and yellow-blue that Smedal presents in her book. (Smedal, 1996, p. 158) One is therefore left in the dark as to what the unique ones actually look like.

I have a 1963 Norwegian colour atlas, a translation from the Danish original. If I translate the Norwegian title literally, it would read in English *The Colours in Colours*. (Revold, 1963) This book contains an observable colour system and a lot of names of colours, including the usual English names. Some of the names evoke the animal kingdom, for example camel brown or canary yellow, some are accompanied by intensifiers like vivid yellow or deep black, and some are relational names like greyish turquoise or yellowish green.

The authors of the atlas deploy four so-called primary colours, yellow, red, blue and green. They even have a primary black, but not, apparently a primary white.

But the unique hues in Smedal's book are very different from the primary colours in the atlas, and if the latter are supposed to represent normal use of colour names, Smedal's NCS colours deserve special interest, because they deviate so severely. However, maybe Smedal's unique hues are the norm. If so, the atlas must be

misleading. The problem is to decide which is which. There are two systems claiming to represent what is normal, and two different sets of observable standards. To decide the issue, we need an independent benchmark, one that is not simply a third range of colours. However, if it is not available, we have to do without.

The following list pairs the unique hues in Smedal's circle, yellow, blue, red and green with the nearest colours found in the atlas:

> Unique Smedal-yellow lies somewhere between orange yellow and yolk yellow
>
> Unique Smedal-red matches brownish red
>
> Unique Smedal-green matches deep green
>
> Unique Smedal-blue matches deep blue.

Remark that so-called deep colours in the atlas are further in relative terms from the primary, being a few steps closer to primary black.

Hård has an NCS colour circle too. (Hård 1995, p. 138) Two of his unique hues do not deviate as much from the atlas as Smedal's. However,

> Unique Hård-yellow lies between yellowish orange and yolk yellow in the atlas
>
> Unique Hård-red matches dark red

According to the atlas, dark red is a general term for "strong and at the same time dark, red colours that lie within a larger area; brown red." It is stressed that the match in the atlas is typical dark red. (Revold, 1963, p. 191)

The unique Hård-blue matches the primary blue of the atlas, which may not be as coincidental as first appears. Unique Hård-green too is quite close to primary green in the atlas, and matches green, which differs from primary green by being a shade closer to black.

The Norwegian paint manufacturer Jotun uses the NCS code system to define pigment colours, and samples of Jotun NCS colours are to be found in more or less every store with a paint mixer. However, following a 1995 makeover, none of the unique hues are displayed on the colour chart. It means, according to basic scientific principles, no one can, by direct observation, control whether the relational determinations are agreeable.

Of course, it speaks in NCS's favour if people believe the system is natural. But while every other colour determination depends on the unique hues, and not even the distributors and theoreticians can agree even tentatively on what is the most accurate reproduction of the alleged unique hues, NCS provides no means by which anyone can control the contention by colour matching.

Hardin commends NCS for its simplicity and easy-to-grasp terminology. However, when he turns to the identification of unique hues, he becomes vague and imprecise: "The exception is elementary red. We recall that unique red is to be found in the spectrum only at low light levels. At moderate levels, all spectral reds are slightly yellowish." (Hardin, 1988, note 4, p. 201)

Plate 1 of Hardin's book is of a linear illustration of the visible spectrum, starting with the 400 nm wavelength at the left and progressing to 700 nm on the right. The numbers refer to wavelengths measured in nanometres of light hitting the retina.

According to Gerritsen, red is caused by light of 700 nm, yellow is an effect of 600 nm, green appears when the light rays reach 550 nm and blue appears at 450 nm. (Gerritsen, 1975, p. 29)

If we now compare Hardin's unique hues with those of *The Colours in Colour*, we get the following:

> Unique Hardin-yellow (approximately 600 nm) matches orange
>
> Unique Hardin-green (approximately 550 nm) matches green (!) and
>
> Unique Hardin-blue (approximately 450 nm) matches blue (!)

Hardin's unique green and blue are both close to the atlas's primary green and primary blue, being only a smidgen closer to black.

None of the reds in Hardin's illustration match the primary red of the atlas. However, if we attribute unique Hardin-red with a 700 nm wavelength, it does match one of the atlas colours, which it calls violet brown.

In all the NCS illustrations I have referred to, the reds are more like the atlas brown than its primary red.

Brown is not a unique hue, according to NCS. But research by Berlin and Kay into colour terms of natural languages, found brown to be a separate colour category in the most advanced cultures. Owing to the fact that both Hård, 1996, p. 19, and Hardin refer to Berlin and Kay's investigation, I shall quote Hardin on the general tendencies:

> All languages contain terms for white and black.
> If a language contains three terms, then it contains a term for red.
> If a language contains four terms, then it contains a term for either green or yellow (but not both).
> If a language contains five terms, then it contains a term for both green and yellow.
> If a language contains six terms then it contains a term for blue.
> If a language contains seven terms, then it contains a term for brown.
> If a language contains eight or more terms, then it contains a term for purple, pink, orange, grey, or some combinations of these. (Hardin: 1998, pp. 165 – 16.)

Both Hård and Hardin take this scheme to show that NCS's unique hues are in fact the first six basic colour terms to enter into language, providing to their mind crucial support to the validity of psychological theory of unique colours. This is, however problematic, in light of Rosch's study of the Dani. See my presentation and discussion in GI, section 2.6.4.

I cannot say that from these presented observations the conclusion follows that there are no agreement on unique hues. All I say is that these persons referred to do not agree among each other in which colour are the unique ones. See in this connection GI, section 1.5.5, in which Seim refers to a recent test that shows high agreement.

11 As-if mixtures, quantification vs. matching, and the idea of an intermediate

All the systems I have discussed or mentioned so far, NCS, RGB and CMYK, not to mention Chevreul's, Runge's and Itten's, present a few colour standards that allow us, in theory, so is the common contention, to determine all other colours.

Peculiar to the three systems NCS, RGB and CMYK, is their dependence on an as-if mode in characterizing the particular colours. The terminology includes concepts of blends of certain standard colours, in spite of the fact that none of the systems are based on colour mixing in the naïve realistic sense.

The difference between NCS and the CMYK system, says Svedmyr, is that the latter is silent about what a colour is psychologically. It only tells us how it is produced. (Hård, 1996, p. 140) However, this must be a misunderstanding. The difference in figures, that is the particular definitions in each system, does not that people understand the CMYK definitions only in operational terms, and NCS definitions as perceptively essential. Both systems deploy a quantitative percentage terminology, the only difference being how they make the determinations. That is, both systems determine colours as if they are compounds.

I can give an example of the as-if mode of colour determination of the NCS system. A certain tone of orange is said to be 20 per cent Yellow with the addition of 30 per cent Red, 10 per cent black and 40 per cent white. The togetherness of Red and Yellow is called the chromatic value of the blend. In my translation, Grete Smedal describes procedures.

> The outlook of a colour, in addition to its specific tone, is determined by its whiteness (w), its blackness (s) and chromatic value (c). Together these three properties determine the nuance of a colour, which is always 100 (s + c + w). (Smedal, 1996, p. 50)

Chapter IV
Sorites series

Introduction

In chapter IV, I discuss the problem of sorites series, which concerns degrees of likeness between colours. I refute the idea that two colours can be different while at the same time matching or being identical with a third colour.

1 Sliding scales vs. sorites series

It is this difference between sliding scales and sorites series that the former contains no lines while the latter is a juxtaposition of patches with no inner variation.

Albers made the following important observation concerning sliding scales:

> When these clouds, often lined up in horizontal groups, appear gleaming white in their upper part in full sunlight, separated from and rising against a distant deep blue, then underneath they show grey tones as shaded white. These shades merge, or even hinge, with the same but here very close blue. Why very close? This grey is of the same light intensity as the neighbouring blue below. Thus, the boundaries between grey and blue vanish, and we do not see where clouds end and where the sky begins. With such clouds, this is best observed with the sun at our backs. (Albers, 1971, p. 64)

Imagine you are looking on a blue sky on a bright and chilly day in autumn, in a country in the northern latitudes, like, for instance, Norway. Let us say the sun is behind you and therefore not part of the scene. Let us also suppose that your view stretches from the highest point in the sky to a distant horizon. The zenith is almost cobalt blue, the hue of the horizon closer to cyan. Those are very different colours and would, probably relate in a (Leonardo) line when put together, however, now they are connected by some intermediates, which do not relate in lines.

How, one might ask, can colours be homogenous, yet still not sufficiently distinct to allow us to observe where the one ends and the other begins.

To this question the Formal System of Colours can give no answer. This is because the system is based on observation of colour relations, of which sliding scales are one kind. The facts are observed and from the descriptions and all generalizations it follows colours are homogeneous.

Therefore, it would be a mistake to maintain that lines do exist anyway, but we are not able to see them.

Another mistake would be to explain sliding scales as mixtures of colour dots. Someone might point to a picture and say that the sliding scale we see now, must really be constituted by hues which form definite borders, because the nearer we get

to the canvas, the easier it becomes to see that the picture is built up of patches. This is a naïve realistic explanation.

Pointillism is a painting technique used among others by two famous French artists Georges-Pierre Seurat (1859-91) and Paul Signac (1863-1935). In an effort to achieve very fine gradations of colours they painted monochrome dots side by side in a more or less varied colour outfield, or they put different coloured dots so closely together, they limited each other, like a mosaic. According to received wisdom, the dots merge at a certain distance from the viewer, creating new colour relations like sliding scales, and even monochromatic areas.

Television screens and lap top screens provide pictures that are often explained as the blend of pixels, that is, picture elements, which can be observed using magnifying glass. This explanation is wholly naïve realistic, though may of course pass outside a formal realm. However, from a formal point of view, one must take care not to identify sliding scales with monochrome spots, as some people do when they say these pictures on the television screen are nothing but a lot of colour dots.

The concept of a pattern of colours with no inner variation, i.e., uniform infields, is contrary to the concept of a sliding scale, which is to say the two kinds of colour relation are incompatible. See BD II and BD VIII,

So, let it be granted: some colours do not constitute lines in juxtaposition. They are, then, constituents of a sliding scale.

2 Colour relations and mathematics

In modern visual colour systems particular colours are furnished with numbers, and, it seems, the difference degree between colours can be expressed in numbers. This may lead one to believe that the human ability to discover a blank in a colour series is due to mathematical determination. However, what I want argue is that difference degrees between colours are not something we can grasp in mathematical terms.

By taking a passage from Hume's *Treatise on Human Nature*, I will show that while Hume's concept of *all colours being present* involves a concept of minimal differences, it does not predicate equality in difference degrees. And while such equality cannot be known, the idea that difference degrees are mathematical must be dismissed, and with it the logical foundation of sorites series and neutral colours.

Hume's blank is a missing colour.

> Suppose therefore a person to have enjoyed his sight for thirty years and to have become perfectly well acquainted with colours of all kinds, excepting one particular shade of blue, for instance, which it never has been his fortune to meet with. Let all the different shades of that colour, except that single one, be plac'd before him, descending gradually from the deepest to the lightest; 'tis plain, that he will perceive a blank, where that shade is wanting, and will be sensible that there is a greater distance in that place betwixt the contiguous colours, than in any other. Now I ask, whether it is impossible for him, from his own imagination, to supply this deficiency, and raise up to himself the idea of that particular shade, tho' it had never been conveyed to him by his senses? I believe there are few but will be of opinion that he can; and this may serve as a proof, that the simple ideas are not always derived from the correspondent impressions; tho' the instance is so particular and singular, that 'tis scarce worth our

> observing, and does not merit that for it alone we should alter our general maxim. (Hume, 1969, pp. 53–54)

Seemingly, Hume presupposes the number of different colours is limited and rather scarce. He believes namely that a person may become acquainted with colours of all kinds and that he or she remembers them as well. According to modern colour science the number of discernible colours is in the order of about nine to ten million (Gerritsen, 1975, p. 68 & Hardin, 1988, p. 88). Therefore, Hume's assumption of the capacity of human memory is likely to be false.

Hume's shades seem to depart from his particular blue in a linearly scaled fashion, ending in white in one direction and black in the other. This seems a reasonable supposition because he used the adjectives light and deep to describe the shades, and both terms are commonly determined relative to white and black.

Hume does not tell us exactly as far as I can see how he fancies his scale organized, i.e. if the shades are spots in a common outfield or if they are contiguous, i.e., members of a sliding scale. However, he is clear about the difference between every pair of shades being the smallest possible, because he imagines all shades of the blue to be present (except for the one). If he thought of them as contiguous, he would probably have remarked on his blue scale as a sliding scale, not a relation between spots. As is commonly known, sliding scales can be obtained when the difference between the members is small enough. It seems most likely then, that Hume had in mind a relation between colour infields in a common outfield.

If we imagine this outfield to be white and that the blues relate to white in squares, the shade 'almost white' may be placed furthest to the left and the shade 'almost black' furthest to the right.

As should be clear from this outline, however, a linear scale has two endings and no colour is repeated. The colours relate in the order those who are most alike are closest to each other. It follows that if two colours match, i.e. are judged as completely similar, only one of them is allowed into the series. This secures the non-transitivity of likeness relations: A is different from B, B is different from C, and A is more different from C than from B. See in this connection GI, section 2.4, about Johnon's term betweenness.

From the idea of *all colours being present* it follows there is a minimal difference between each pair in the scale, but nothing else. Regularity in difference degrees does not follow. Hume may have assumed this, but nothing in the quotation is fit to justify the assumption.

3 The fancy of perceivable arithmetic difference degrees

In other words, if you have three colours A, B and C, and, in accordance with Hume's supposition, the difference between each pair is minimal it follows that the difference between A and B is less than the difference between A and C.

My conviction is you cannot, without contradiction, conceive of the difference degrees in mathematical terms. However, the conception is, as far as I can see, quite

common. I have already mentioned NCS and I believe one of the originators of this system, Ostwald, is an obvious representative of mathematical determination. For example, Ostwald says, "where brightness differences form a geometrical progression, only then do we experience corresponding grey colours as being visually equidistant" (Ostwald, 1969, p. 26). He states some correspondence between measured light intensities and experienced regularity in difference relations. But Ostwald does not explain or discuss how this equidistance can possibly be known. He just takes it as an observational fact that equidistant arrangements obtain.

An arithmetic series implies equidistance and is characterized by the property whereby any member subtracted from its succeeding neighbour gives the same number. The following series of natural figures is therefore arithmetic: 1-2-3-4-5-6-7-8-9-10 and the difference degree is 1. If colours relate in this way, our ability to detect the missing link in Hume's scale must therefore be a matter of (mathematical) logic: 1-2-3-4-6-7-8-9-10.

But if difference degrees between colours could be determined mathematically, it would also be possible to judge if a series is arithmetic or if some of its colours relate in another way, e.g. geometrically or according to a Fibonacci series, and, what is more, one should be able to judge divergences in decimals. But human beings have no means to decide when only the colours are present because there are no figures linked to them. And if you furnish each colour in a series with a number, the numbers can only function as names, not as figures from which you can deduce mathematical conclusions on difference degrees.

Another point is that if the colours in a series relate arithmetically one should, analogous to a series of natural figures, be able to subtract one colour from its succeeding neighbour wherever one wishes and the difference should be a colour, and this colour should be the same wherever the operation is carried out. So, if you have a regular series from red to green, one green subtracted from its green neighbour should result in the same colour as when a red is subtracted from its red neighbour. In my opinion this implication only serves to show the absurdity of understanding difference degrees between colours in mathematical terms.

4 All colours present

Hume's idea of *all colours present* seems to presuppose that the colours are all perceivably different. But the idea that difference degrees can be reduced to numbers seems to violate this presumption.

Given an arithmetic series of figures, you should be able to introduce a middle figure between every pair without harming the arithmetical nature of the series. However, if you apply the same principle to colours and presuppose they are equivalent in difference, and you introduce a middle colour between every neighbouring pair, the scale should likewise remain an arithmetical one. Obviously, this is what Ostwald had in mind when he wrote the following in *The Colour Primer*:

> Between two different greys it is always possible to insert a third grey, which is lighter than one and darker than the other. In this manner the steps can be made even smaller, until they

> finally become imperceptible. (…) It probably follows that the complete grey series consists of an infinite number of steps. (Ostwald, 1969, pp. 20-21)

The premises of this argument are highly dubious, however, and for several reasons. First, Ostwald does not justify his first premise, but obviously takes it to be true a priori. But his contention is supported by Johnson. In GI, 2.4.1 I wrote this about Johnson:

Again, Johnson insists on degrees of difference between determinates, but without mentioning identity as a limiting case in such serial orders. Instead, he suggests infinite discernibility among determinates, that is, in Johnson's conception, betweenness may be established in an endless array. He says, "It follows from this account of continuity that, between any two determinates which may be said to have a finite adjectival difference, may be interpolated an indefinite number of determinatives having a finite difference, and this number becomes infinite as the differences become infinitesimal." (Johnson, 1921, p. 183) I address Johnson's suggestion in Chapter IV.

If the premises are changed as follows: 1) between any two different colours there can exist an intermediate; and 2) there is a perceptual threshold beyond which there can exist different colours, Ostwald's main conclusion seems to follow. But his conclusion is clearly false, because the idea of an infinite number of colours between two perceptible different endings contradicts the assumption that these endings can exist: If the middle area is infinite there is, precisely, nowhere for the endings to go. And because the conclusion is false, at least one of the premises must also be false.

I think the same kind of argument can be used to show that both premises are false. If there exists an intermediate between every pair of different colours, there will obviously be no place for any colours to go, because between every chosen pair there will be an infinite array of intermediates. And this shows the absurdity both of premise 1) and 2).

It is important to note that argument my rejection of both premises depends on the Formal System's BS I, which says there is concomitance between colour and extension.

5 Sorites series

The core idea of a sorites series is, according to Nes, this: A matches B, B matches C, but A and C are perceived to be different. Nes has no objections to the thought that sorites series exist and may be observed. (Nes, 2008, p.128)

I speculate if the belief in so-called sorites series is grounded on the false assumption that colours can relate arithmetically in difference degrees.

Anyway, according to logical rules B must be different from A and C, because BS V (see Chapter I, section 1) says that two different colours cannot be identical to one and the same colour. If such a relation obtains, it follows colour B must be beyond the perceptual threshold in relation to A and C.

However, if you allow for one colour to be beyond the perceptual threshold, it follows that infinitely many colours can be beyond the threshold and still be related to A and C in the way described, while all being different from each other.

This leads to the absurd idea that A and C are infinitely different and so is every other colour pair. That is, the two matching colours, A and B, are just as different from each other than any two non-matching colours because infinite difference cannot be a matter of degree.

6 Observation

Armstrong seems to assume that sorites series are quite common and easy to observe. (Armstrong, 1968, pp. 218-219.) Nor does Goodman express doubts in presupposing that several colours can all match and yet be different from each other on a linear scale, the order of which he supposes can be detected by procedures according to other non-matching observations. (Goodman, 1977, p. 217)

Hardin, writing in *Colour for Philosophers*, puts forward this critical point. There is no common criterion, he claims, for deciding whether a perceptual indifferent middle obtains, and we should therefore, he seems to suggest, not allow notions of perceptual indifferent colours to enter into an argument.

Hardin's objections take the following form.

> It is plain that Armstrong takes indistinguishability to be an all-or-nothing affair. In passages such as this, the notion of a criterion or test of perceptual indistinguishability never makes an appearance, yet we know that this makes a real difference. (Hardin, 1988. p. 179)

I too miss a decision-making criterion, that is, a description of the conditions under which sorites series can be realized and observed.

Sorites relation seems to be intended to be between separate colours i.e., infields in a common outfield (or for that matter, in different outfields). In order to observe these infields, one may have to move one's eyes from one colour to the other, and during these movements one's comparative faculty will be based on memory. But in this case memory might easily lead one to make false assumptions.

Clark mentions this difficulty. In order to test matching, he says, presentations must be simultaneous.

> It is difficult to judge whether three visual items match without fixating them successively. Even if one could make the comparisons of x to y and y to z fixating each item only once, the final comparison (of x to z) calls for a second glimpse. But a second glimpse is impossible if x is a singular, datable presentation. (Clark, 1993, p. 57.)

Be that as it may, contrast colours will always appear and do away with the initial colour symphony. In fact, as was noticed by both Goethe and Chevreul, the simultaneous contrast starts to work very quickly. Observation of matching and non-matching colours must therefore be performed within quite a short period of time.

It seems to me, then, that philosophical approval of sorites series is hardly convincing. Most probably the thought that sorites series are obtainable is founded on the assumption that colour differences are arithmetical, which means the possibility of sorites series is inferred, not directly observed.

One cannot, however, put aside observation reports just because one suspects them of containing mistakes. Clark mentions this as an objection to Jackson, who points out that the idea of sorites series, is contradictious. However, Clark does not justify his approval of sorites series by reference to psychological tests; all he furnishes is a thought experiment. (Clark, 1003, pp. 56-58.)

In the absence of trustable observational reports, it seems that Jackson's objection is quite appropriate. (Jackson, 1977, p. 114.) Jackson presupposes that one and the same person observes the relations at one and the same time. In brief, Jackson says that if A is perceived to be different from C, while C is not perceived as different from B, it follows A and B must consequently be perceptually different, and same holds the other way around.

Let me try to explain. Say you cannot decide which is which of B and C and you call both by the same name X. Then, if the three colours are separate infields in a common outfield, the relation will be A – XX. But you cannot group the two Xs together in separation from A without there being a reason, and the only reason available must be that A is perceptually different from both. But this contradicts the presumption, namely that A is not perceptually different from one of the Xs.

By extension, from the contention that a sorites series like A – B – C is possible, it follows that a sorites relation like B – C – D, where C is the indifferent colour, is also possible. But when put together with A, we will obtain A – B – C – D. Here B should be indifferent in relation to A and C, but not to D. Likewise, C is indifferent in relation to B and D, but not to A. To me it is clearly contradictory to state that B and C are indifferent and not indifferent at the same time.

Clark offers an authoritative argument in favour of sorites series in pointing to Hume, who contended, "tis possible, by the continual gradation of shades, to run a colour insensibly into what is most remote from it." And Clark continues:

> The 'insensible gradation' is that neighbours match. So the matching of x and y, and of y and z, fails to establish the matching of x and z. Non-transitivity is not confined to colour perception: it is found in any sensory modality in which some non-zero differences elude detection. (Clark, 1993, p. 57.)

However, I think Clark misunderstands Hume. Hume does not approve of insensible difference, in fact; in the same paragraph from where Clark selects his quoted sentence, Hume argues against the contention it is possible by showing it leads to an absurdity. Hume's blank is an exception, see quotation in section 2.1 above, and rests on his conviction that indiscernibility is not the case.

Here follows the sentences that precede Hume's story of the blank and in which Clark's sentence is found.

> I believe it will readily be allow'd, that the several distinct ideas of colours, which enter by the eyes, or those of sounds, which are convey'd by the hearing, are really different from each other, tho' at the same time resembling. Now, if this be true of different colours, it must be no

> less so of different shades of the same colour, that each of them produces a distinct idea, independent on the rest. For if this shou'd be deny'd, 'tis possible, by the continual gradation of shades, to run a colour insensibly into what is most remote from it; and if you will not allow any of the means to be different, you cannot without absurdity deny the extremes to be the same. (Hume, 1969, p. 53, Book I, Section 1)

Given my analysis of Hume's linear scale in Section 2.1 above, non-transitivity is secured in linear scales of which all members are perceptually different. Sorites relations are not needed to secure non-transitivity. In fact, they tend to blur it. What Hume can be taken to mean is that by observing only minimal differences between colours, you will, if you continually pass from one colour to its neighbour in one direction, obviously end up with a colour that is very different from the starting point.

7 The idea of neutral colours

Some philosophers seem to believe that some colours can balance perfectly between two others, i.e. they are neutral. See, for example, Nes, 2008, pp. 134 - 135, who believes there is an orange colour that perfectly balances yellow and red. These philosophers believe, it seems, that the connection between colours in a series can only be established first by finding the neutral balancing point between two very different colours and then, by repeating the procedure, finally reaching the complete series. One starts with A and C, finds N_{AC} (N = neutral), which is B, and then between A and B one finds N_{AB}, and the same for B and C, N_{BC}, and so on. But this is to beg the question, insofar as one has already presupposed the availability of a neutral balancing colour between A and C.

But even assuming that difference degrees between colours are equal, it does not necessarily follow that between any two very different colours there is a discernible neutral balancing point. A series between two very different colours A and C might be established by descending from one by adding the least different colour each time: A – A_{C1} – A_{C2}, etc. Then, of course, it would be a matter of experience whether a middle colour was found or not. That is, the number of intermediates may contingently turn out to be 100, and then no middle colour would be obtained. It may, however, also be 101, but no one can know that a priori.

On the other hand, we can follow the same procedure, but now without implying equality in difference degrees. Let us say we start with both A and C simultaneously, and place the minimal different colour nearest to A and the minimal different colour nearest to C, and so on, until they finally meet. If there is a blank that can be filled with a different colour in the middle, the series contains an uneven number of colours. But, because you cannot decide if there is equality in difference degrees, there is no reason to judge the middle colour to be neutral.

8 The many in the one – a philosophical speculation

In the last century, classical qualitative atomism gave psychologists and philosophers of mind an incitement to apply their energy to finding out how consciousness works in order to make a structure out of an atomic manifold. Gestalt theory is one

celebrated result. The human mind has the ability to fashion spots into larger wholes. The ability, gestalt theory maintains, is governed by principles expressed by the gestalt laws.

Ascertaining the existence of sliding scales was not the issue. Not surprising really, since sliding scales are not unities constructed by the mind.

A sliding scale is thing unto itself, and that unity is destroyed if it is split into parts. It is impossible to conceive of a sliding scale if only relations between infields with no inner variation are given.

When we are aware of sliding scales, our concentration is taken from one position to another, from area to area, some of which might be very different. In daily life we look up at the blue sky, which is, though it is one sky, not of one hue, but many. Or we see the smooth differences in a circular spot, and we judge those differences to be one, namely the outside of a sphere. The same applies to the wall in our drawing room at night, lit by the lamp and populated by shapes throughout. It is an undeniable unity, though we conceive of many colours in it.

It may therefore be that from the perception of sliding scales we come to realize the principle of the many in the one.

Something the obscure Heraclitus (540 – 480 B.C.) wrote (URL) is possibly not that obscure after all if it is taken as asserting continuity in change of colours. “Hesiod is a teacher of the masses. They suppose him to have possessed the greatest knowledge, who indeed did not know day and night. For they are one.”

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Chapter V
Two-dimensionality - an exclusive property of colours?

In this chapter I expand on my contention in GI, section 3.1.2 about touch vs. colours. There I quote Berkeley who, in New Theory of Vision, (NTV) supposes that touch includes spatiality. In NTV112 he writes:

> For by the distance between any two points nothing more is meant than the number of intermediate points: if the given points are visible the distance between them is marked out by the number of intermediate points: if they are tangible, the distance between them is a line consisting of tangible points; but if they are one tangible and the other visible, the distance between them doth neither consist of points perceivable by sight nor by touch, i.e. it is utterly inconceivable.

My answer to this, in GI, section 3.1.2, is: I think rather there is no tactile point at all. Touch is about hard-soft, rough-smooth, hot-cold, wet-dry. If there should exist a tactile point it must concern one of these impressions, say, a particular hard that is very small. But what should it be? A pinprick? But the feeling of a pinprick has no size, it is some sort of pain, weak or strong. And a line cannot consist of, say, ten pinpricks in a row, because the pains exist only in time, one after the other.

Whether colours and feelings of touch have common extensional properties is the problem occupying Berkeley, and he answers in the negative. In NTV49, Berkeley is very clear they have nothing in common, however they are both dimensional. Colours are two-dimensional (NTV2), whereas tangible things are three-dimensional, according to Berkeley.

At least, in NTV he seems to think that touch is the proper sense of three-dimensionality. In NTV111 he tells "For all visible things are equally in the mind, and take up no part of external space: and consequently, are equidistant from any tangible thing which exist without the mind."

In a related discussion Atherton remarks that

> His argument is rather that the content of what we see, lights and colour, is lacking in usable spatial information but that this is not true for the content of what we apprehend through touch. Reaching out and touching is a way of experiencing the distance and situation of things, and for this reason distance and situation are among those things whose nature is an immediate object of touch. Similarly, we learn about size and shape tangibly but not visually, because the tangible experience of size and shape are stable and responsive to measurement, whereas there are no stable visual experiences of a shape or a size of some object. (Atherton 1990, p. 222.)

Berkeley sees a connection between touch and colours, that is, he contends that from experience we learn to predict which tactual experiences that are to come. In NTV158 he says colours suggest tangible experiences.

> From all which we may conclude that planes are no more the immediate object of sight than are solids. What we strictly see are not solids, nor yet planes variously coloured: they are only diversity of colours. And some of these suggest to the mind solids, and others plane figures, just as they have been experienced to be connected with the one or other: so that we see planes in the same way as we see solids, both being equally suggested by the immediate objects of

> sight, which accordingly are themselves denominated planes and solids. But though they are called by the same name with the things marked by them, they are nevertheless of a nature entirely different, as hath been demonstrated.

This is why Berkeley does not try to argue anything in favour of colour's two-dimensionality by referring to touch, like for example Goethe seems to do.

Goethe's argument from paintings is based on a comparison of colours with touch. We perceive the colours as if they were embedded in three-dimensional space, but the surface of the painting has only two dimensions, and so must the colours, by logical extension, because they constitute the surface.

> In our prefatory observations we assumed the reader to be acquainted with what was known respecting to light; here we assume the same with regard to the eye. We observed that all nature manifests itself by means of colours to the sense of sight. We now assert, extraordinary as it may in some degree appear, that the eye sees no form, in as much as light, shade, and colour together constitute that which to our vision distinguishes object from object, and the parts of an object from each other. From these three, light, shade, and colour, we construct the visible world, and thus, at the same time, make painting possible, an art which has the power of producing on a flat surface a much more perfect visible world than the actual one can be. (Goethe, 2002, pp. lii – liii.)

But the very painting is already, in Berkeley's understanding, an object in space, and should therefore not be used to prove that colours are only two-dimensional.

Berkeley criticizes such arguments in NTV157.

> I must confess men are tempted to think that flat or plane figures are immediate objects of sight, though they acknowledge solids are not. And this opinion is grounded on what is observed in painting, wherein (it seems) the ideas immediately imprinted on the mind are only of planes variously coloured, which by a sudden act of the judgment are changed into solids. But with a little attention we shall find the planes here mentioned as the immediate objects of sight are not visible but tangible planes. For when we say that pictures are planes, we mean thereby that they appear to the touch smooth and uniform. But then this smoothness and uniformity, or, in other words, this plainness of the picture, is not perceived immediately by vision: for it appeareth to the eye various and multiform.

But now, if you touch such a picture by your forefinger and move it along the plane, the observation can be of a constant feeling of pressure in your finger tip, and this is what I think Berkeley here denotes smooth and uniform.

Katz discusses touch perception of uninterrupted plains and it seems that he directly opposes Berkeley in these matters.

> One could suppose that the experience of the uninterrupted tactual surface actually derives from the representation of visual continuity, with which it is very closely connected, and that there is no genuine tactual continuity at all. This supposition will become an assured fact when one succeeds in proving that no spatial properties at all adhere initially to the sense of touch. (Katz, 1989, p. 60.)

In GI, section 1.4.3 I explain Katz's category surface colours. See also GI, section 3, especially 3.2 in where I explain his other categories. These are all visual, and indicates that Katz means people's experience of a three-dimensional world has to do only with colours.

According to Hering, colours are perceived as existing independent of the perceiver's visual system and therefore outside the body. (Hering, 1964, pp. 4-6) Katz supports Hering in this connection. "Colour phenomena are always characterized by objectification; they are always seen "out there" in space." (Katz, 1935, pp. 36-37)

According to Katz, feelings as joint, tendon, touch, resistance, warmth etc., are all time-sequenced experiences.

> The congenitally blind, according to this, can never come to have a *surface touch* in the strict sense of the term (…); for such persons, the properties of surface structure develop only in an *historical* sequence. (…). After all, we referred empathically to the particular temporal mode of appearance of the vibration sensations, which transform the persisting visually provided properties of surface structure into an historically developing sequence. Goldstein and Gelb left open the question as to whether the impressions of hard and soft are exclusively tactual qualities, or are influenced by visual images of the spatial deformation of the skin. I rather think that the tactual and kinetic qualities, with their special temporal organization, determine these impressions, as well as the impression of elasticity. (Katz, 1989, pp. 228-229)

Let me illustrate by my own observations: If I stick half of my finger into the water and move it around, I will observe for example wet, smooth and soft simultaneously, and if I move my finger at a leisurely, unvarying speed, these feelings of touch will remain constant until I pull my finger out.

It follows that if I draw circles or triangles, or whatever figure I like, moving my finger in the water, I do distinguish these figures from each other only by the movements of my arm.

This example shows that only the feelings I usually associate with a contraction or relaxation of the muscles, lead to judgements of dimensionality, because touch is the same during the movements. Contraction is associated with a sense of constraint and relaxation, the latter being a sensation of relief. That is, constraint and relief are usually explained in terms of the contraction and relaxation of muscles.

These feelings of constraint and relief are in themselves neither two-dimensional nor three-dimensional. They are inner bodily feelings and can be compared with pain and its alleviation. They may exist at the same time, as when I stretch my arm or hold my hands together, but they form no joint positional system between themselves, and they exist may simultaneously as do other feelings. For example, when I feel a constraint in my arm, I cannot discern its position in relation to the temperature, i.e. the feeling of warmth or cold in my arm. They are only joined in time.

Most of the judgements or perceptions of form or figure based on these feelings of constraint and relief also rely on temporality. Talk of spatial position in relation to time would be a failure, because there cannot be any distance, in the meaning length or breadth or depth, between now and then.

However convenient it is, and however often one judges or perceives two- or three-dimensional extension by feelings, there seems to be no good philosophical reasons for thinking that feelings are in different positions in relation to each other.

This gives reason to conclude that colour combinations are the only combinations that provide an inner positional relation. Besides figures, we can judge directions and positions between colours without reference to anything else.

It is not necessary for determining colour positions to associate to determinates under other determinables; I am free to describe and determine figures, in-between relations and directional relations completely without reference to anything else.

Katz is psychologist, and his three-dimensional colour space concerns ordinary people's perceptions. It needs not be that he himself consider colours as three-dimensional.

On the other hand, in NTV, Berkeley did not bring the other determinables (this is Johnson's term, not Berkeley's) – sounds, tastes and odours – into consideration. Maybe he considered all determinates under these determinables as obviously non-dimensional, and therefore Berkeley did not pay attention to them.

Neither do I, and exactly for this reason: they are obviously not dimensional.

Chapter VI
Colour identity and ontology

Introduction

BS IV says two or more colours can be identical, notwithstanding difference in figure, size and position. See Chapter I, section I.

As I contend in GI, section 2.11.4, identity between colours cannot be proved, but assuming that the principle of colour identity is true, makes it much easier to reason theoretically about special themes on colours than assuming the opposite. For example, most colour systems are based on the premise that the same colours, and therefore the same colour relations can be established from time to time.

In this chapter my main contention is that identity between colours must be an ontological identity. If, for example, two colours are believed to be the same blue, we should assume them to be of the same ontological kind.

My formal system has no difficulty with this, as IMP I and II says, all colours are homogeneous and two-dimensional, and if you judge two colours to be the same blue, no ontological differences are presupposed.

However, both in daily life and in philosophy and science on colour it seems sometimes questionable whether two or more colours can be of the same kind, even if they are judged to be identical. Descartes (URL), in his first Meditation, § 5, pointed to the fact that colours are the same in dreams and in waking, but people continue to discriminate between dreamt colours and real colours, as if a certain red is not of the same kind when dreamt and experienced awake. Colours in dreams are not supposed to be properties of physical objects, while real colours are.

A distinction between real an unreal colours appears in different contexts. For example, Katz distinguishes between perceptual and non-perceptual colours, as if the latter category, which comprises eidetic and hallucinatory colours, is of another ontological kind than the so-called perceptual colours. (Katz, 1935, pp. 34-35.) The distinction between perceptual and non-perceptual is a dichotomy: either it is true that a colour is perceptual or it is true that the same colour is non-perceptual. But with respect to the particular colour, there can be no difference in ontological sense, which means the dichotomy between perceptual and non-perceptual has nothing to do with the colours per se.

There is also a distinction in science between afterimages and other colours. The examples I discuss in the following are collected from scientific descriptions of different kinds of afterimages.

In Section 1, I present the argument from identity in connection with so-called positive afterimages.

In Section 2, I trace the naïve realistic tradition in its characterization of negative afterimages as transparent colours. Chevreul's diverse kinds of colour contrast are

explained and I show how the colour mixing terminology leads to inconsistency. Finally, the distinction between real and unreal colours is rejected.

In Section 3, I relate the Formal System of Colours and point out that naïve realistic descriptions of colour changes only complicates the explanandum in psychophysics on colours.

1 The argument from identity

In everyday life it is quite common to say of two different objects, blue ink and a blue textile for instance, that they share the same colour, though the objects are not the same. It is as if one extracts or detaches or abstracts the colour from the different materials.

Colour science from the 18th century has been drawn to colour phenomena like positive and negative afterimages. These phenomena are conceived of as colours, however, the praxis of abstracting or detaching colours is not applicable on positive afterimages.

The fundamental philosophical premise in connection with the argument from identity is the fact that our concept of positive afterimages ruins the logical possibility of extracting or abstracting a colour from them, because those afterimages are understood to be non-physical, but also two-dimensional.

Let me refer to Goethe's use of language in his description of a positive afterimage in § 40 of his *Colour Theory*. When an afterimage is classified as positive it is because it at first shows up in the same or identical colour as the colour impression that precedes it, while negative afterimages under some specific conditions are said to be of the complementary kind.

In order to catch up with an experience of a positive afterimage I think it would be instructive to follow Goethe's instructions to certain practical limits. The phenomenon is easy to establish and anyone can compare his description against the obvious facts. (One can also obtain a positive after image of the same sort using a strong flashlight in a dark room.)

> Let a room be made as dark as possible; let there be a circular opening in the window shutter about three inches in diameter, which may be closed or not at pleasure. The sun being suffered to shine through this on a white surface, let the spectator from some little distance fix his eyes on the bright circle thus admitted. The hole being then closed let him look towards the darkest part of the room; a circular image will now be seen to float before him. The middle of this circle will appear bright, colourless, or somewhat yellow, but the border will at the same moment appear red.
> After a time this red, increasing towards the centre, covers the whole circle, and at last the bright central point. No sooner, however, is the whole circle red than the edge begins to be blue, and the blue gradually encroaches inwards on the red. When the whole is blue the edge becomes dark and colourless. This darker edge again slowly encroaches on the blue till the whole circle appears colourless. The image then becomes gradually fainter, and at the same time diminishes in size. Here again we see how the retina recovers itself by a succession of vibrations after the powerful external impression it received. (Goethe, 2002, § 40.)

Now, I consider the first appearance, which Goethe seems to identify in with the colour shone on the paper.

Goethe is certainly describing the afterimage in terms of two-dimensionality. Goethe holds afterimages to be purely subjective, and this means, according to him, they pertain entirely to the eye. But as such they can have no three-dimensional coordinates; they cannot extend in three-dimensional space. When Goethe localizes the afterimages to the eyes, it does not mean that the eyes can be filled with colours like water can fill an empty bottle. The afterimages are of a dreamlike nature seemingly situated in the room, outside our body.

However, my general point is that a positive afterimage is determined to be two-dimensional. It has no front, because it has no behind; if you try to walk around it you only carry it with you. The colour itself (or the shifting colours) is the object and no one can extract or abstract a certain colour from such an afterimage because it would plainly be contradictory. If you try to separate the colour (or colours) from the afterimage you would have to do away with the afterimage at the same time.

This point is fundamental to the argument from identity, which now must be considered.

First. Agree with the following. Colour identity means essential identity, and an afterimage is a colour which can be identical to another colour. Because an afterimage is essentially two-dimensional, the identical colour must also be two-dimensional. Thus, if an afterimage is identical with the colour preceding it, as with the colour of a candle flame, both colours are two-dimensional.

Second. It is illogical to argue the other way around, contending that the colour of the flame is the colour of an object, and so the colour of the afterimage must be, because of identity. The fault being that this inference relies on ignoring the premise already agreed to, namely afterimages are not object properties.

I insist, however, this argument from identity does not replace IMP II, because IMP II is robust proof of colours' two dimensionality. The argument from identity is weaker than IMP IV, because BS IV has a weak inductive base. See GI, section 2.11.4. Therefore, all I say is the argument from identity should encourage us to remedy the inconsistent colour terminology still prevailing in some parts of the colour philosophy and colour science establishment.

2 Negative afterimages conceived of as transparent

In the foregoing section I focused on Goethe's description of the colour changes in a positive afterimage and noted that he did not treat of the afterimages as three-dimensional. It must be remarked, however, that Goethe's paragraph 42 can still be interpreted as if afterimages can exist in space somehow, because he instructs the reader to look into the darkest part of the room to find the afterimage floating before us.

However inconsistent this must be, Goethe's positive afterimages are opaque, they are not determined as transparent. This is opposite to his and other's conception of negative afterimages.

2.1 Simultaneous colour contrast

There is a marked tendency among scientists to describe negative afterimages as if they existed in physical, i.e. three-dimensional space, something I find very invidious. Chevreul's theory of colour contrasts is the most glaring example.

The term *colour contrast* was, I believe, first used systematically by Chevreul and has maintained a place for itself in colour theory ever since. This may perhaps conceal the origin of contrast phenomena in the development of negative afterimages, that is, complementary afterimages and their variations.

The phenomenon Chevreul called simultaneous contrast is something anyone can observe systematically. One notices an increasing change in colour for a certain duration, that is, normally after 20 to 30 seconds, and the extent of the change reaches what may be considered the maximum level of contrast with strict reference to some juxtaposed colours.

Imagine a colour, say orange, suddenly appearing within a green area. Both colours will gradually change, the orange infield becoming redder and the green outfield becoming bluer. These changes are slight and the observer must concentrate. The changes are most pronounced near the line the colours relate in and tend to disappear with increasing distance from the line.

Chevreul understood such changes in terms of colour mixing, so much is clear. From the symmetrical development of afterimages, Chevreul found a recipe, which predicts which changes will occur. Commenting on this, Birren says the law-like changes differ in mode from other so-called colour mixing rules. I think it would be helpful to let Birren himself enlighten us on this point.

> He remarks that "the modifications of contiguous colours are precisely such as would result from the addition to each of them of the colour which is complementary to its neighbour." The word precisely is not too well chosen here. In § 21, using the combination of orange and green, he observes that the blue compliment of orange, added to green, would make the green appear bluer. Conversely, the red complement of green, added to orange would make the orange appear redder. Yet these effects (which are due to afterimage phenomena) do not precisely follow laws of *pigment* mixture, nor do they precisely follow laws of *light* mixture. Afterimages, or the complements of a colour, are visual opposites, and visual colour mixtures differ from colour effects encountered in the mixing of pigments or the mixing of coloured lights. For example, a chrome yellow pigment added to an ultramarine blue pigment will form a dull green. Two such colours mixed in lights will form a dull white. But if the chrome yellow and ultramarine blue are combined on the discs of a colour wheel and spun rapidly - forcing the eye to mix the colours – the result will be a neutral grey. Such visual mixtures are called medial and seem to be a combination of pigment and light mixtures as the eye mixes the reflected light of the coloured discs.
> However, in viewing a given colour, a "complementary" impression of it will arise, and this "complement" will influence the appearance of a contiguous colour in ways fairly well described by Chevreul. (Birren; 1981, p. 52.)

But not only did Chevreul detect the change of neighbouring colours because of their respective complements, he also detected a change in brightness value. The darkest colour turns darker and the lightest colour turns lighter, or in colour mixing terms, the light colour turns whiter, and the dark colour turns blacker. To Chevreul, the simultaneous contrast must logically consist of two kinds of colour change, one due to the complements of the juxtaposed colours, and one due to the brightness difference in relation to the very same juxtaposed colours.

If we take both kinds of contrasts into consideration, we can understand Chevreul's Law of Simultaneous Contrast of Colours thus: *In the case where the eye sees at the same time two contiguous colours, they will appear as dissimilar as possible, both in their optical composition and in the height of their tone*. (Birren, 1981, p. 50.)

This law is an excellent example of an empirical law and because of its simplicity one can derive predictions from it, helping one decide which colour to put into this or that colour surrounding in order to obtain the desired composition. However, there are exceptions to the law, and the surroundings may be too complex to allow for precise predictions. I believe this is why, for example, the clear pictorial demonstrations Albers made, like the 1960 painting *Evident*, are quite simple in composition. (Albers, 1963.)

The simultaneous contrast is one of three contrast phenomena Chevreul explored, the other two being successive contrast and mixed contrast. All three are due to the development of afterimages.

The name *mixed contrast* refers directly to colour mixing, as if the afterimage blends with the colour it is supposed to fall upon. If you look at orange in white surrounding and a blue afterimage results, the theory says that you can turn to a yellow colour, while the afterimage still is visible, and the afterimage will turn green. And this is then the rule. The colour of the afterimage, which is blue on white, will change according to the colours on which it is projected. One thinks therefore of the afterimage as a transparent colour, through which one may look at a coloured background. This is exactly to describe afterimages and their changes in terms of three-dimensionality.

2.2 Neutrality and contrast effects

In Chapter IV, Section 2.6, I introduced and objected to an idea of colours being neutral in their balancing perfectly between two (or more) other colours. With respect to colour contrast phenomena, another idea of neutrality obtains. This idea relates to black, white and grey, considering them to be colours, but of a peculiar sort, namely as neutral in the meaning not able to influence or affect other colours, rendering them as they really are. Byrne and Hilbert promote this idea.

> The distinction between *related* and *unrelated* colours is frequently employed in the empirical study of colour vision. Unrelated colours are colours that are seen in isolation from other colours, typically against a black or other neutral background. Related colours, by contrast, are colours seen against a background of other colours. (Byrne § Hilbert, 2003, p. 18.)

Accordingly, Chevreul classifies some specific contrasts of colour without reference either to colour mixing, or to colour surrounds. This is, in my opinion, because Chevreul believed white to be a neutral colour. This notion makes it plausible that in white surroundings all afterimages appear as they really are. Especially when it comes to successive contrast, Chevreul seemed to rely uncritically dependent on the white is neutral. In his own words.

> The successive contrast of colours includes all the phenomena which are observed when the eyes, having looked at one or more coloured object for a certain length of time, perceive, upon turning them away, images of these objects having the colour complementary to that which belongs to each of them. (Birren, 1981, p. 64, § 79.)

The meaning of the expression "turning the eyes away" is in this connection, by implication, looking at something white.

Goethe held white to be a neutral colour as well, and his studies of the law-like behaviour of afterimages led him to believe that the complementary colours reveal their true nature only when they are projected onto a white colour area. In paragraphs 805 and 806 he writes,

> When the eye sees a colour it is immediately excited, and it is its nature, spontaneously and of necessity, at once to produce another, which with the original colour comprehends the whole chromatic scale. A single colour excites, by a specific sensation, the tendency to universality. To experience this completeness, to satisfy itself, the eye seeks for a colourless space next every hue in order to produce the complementary hue upon it. (Goethe, 2002, p. 317.)

Goethe uses the expression *a colourless space* as if there is nothing problematic about it, as if his readers of his theory will understand the true meaning. But this is a reference to white and, in my opinion, a belief that white in these instances does not mix with the afterimages. But this is inconsistent with both his theory and Chevreul's. If afterimages generally mix with a colour ground, white should be no exception.

I see no other explanation for this inconsistency than a wish, conscious or not, to save the theory of complementary colours from collapse. In other phenomena both theoreticians treat of white as a colour, which makes juxtaposed colours darker, and therefore do not consider white to be neutral in that instance. But if one cannot treat of white as neutral in successive contrasts, one will end up with the implication that no afterimage is a pure complementary to the initial colour, it must always be mixed with what one considers to be the underlying colour or colours.

If we include projections on black and grey, no one will ever see the negative afterimage as it really is, because, in relation to white, it will be whiter, and in relation to grey, it will be greyer, and in relation to black, it will be blacker, and any other colour on which the afterimage is supposed to be projected will make a difference. In these instances, pure afterimages cannot therefore be observed.

Someone might think there is a solution to this in the instances where an afterimage seems to be exactly the same as the projection ground such as if the afterimage and the projection ground are both red, the afterimage will be identical with the ground. But in this instance no afterimage will be seen, and no conclusions can confidently be drawn. This is in fact the principal difficulty with evidence of the possible identity between colours, as I have written in GI, section 2.11.4.

The implication to be drawn seems to be that a complementary colour is only thought of, it is a theoretical construction.

2.3 Real and unreal colours

In the foregoing section I have shown that negative afterimages are treated of as if they can mix, that is, the afterimage is believed to be transparent. When projected upon a colour ground a third colour is created. Afterimages are therefore understood as if they had physical properties and existed in three-dimensional space.

This is contrary to reason and can only be excused as an ad hoc strategy in certain disciplines. What reason might tell us, however, is that since this strategy is possible to carry out, all colours are probably essentially like the afterimages, namely two-dimensional. Because the theoreticians are inclined to describe negative afterimages in terms of three-dimensionality in the face of reason's insistence on their two-dimensionality, it would be easier to think of all colours as of the same essence as afterimages and the spatial determinations to be false, whenever they occur. This would, eventually, comply with the argument from identity, but also, of course, with IMP II, Chapter I, section 3.

However, some philosophers still try to defend a view of the world compatible with naïve realistic colour ontology, which forces them to treat of contrast effects as if they were illusions. This is maybe because they hold the naïve realistic view to claim all colours to be three-dimensional: Colours are properties of external objects. This universal proposition puts paid to ideas of afterimages as colours. But to adhere to this latter possibility is not a strategy of reason, it is, as I see it, a strategy of deliberate ignorance.

I quote Byrne and Hilbert on negative afterimages.

> (…) But we should say something about the afterimage example. Afterimages are simply illusions, as Smart pointed out many years ago. When one has an experience of a red circular afterimage, the content of the experience is – to a first approximation – that there is a red circular patch at a certain location. But this proposition is simply false. There is no circular patch – not even in some mental realm. (Byrne § Hilbert, 2002, § 1.3.1)

Byrne and Hilbert refer to Smart 1959. Although Smart does not use the term *illusion*, he does come very close to doing so. Smart refers to afterimages as "something is going on", that is, a sort of nothing that is only conceivable in terms of so-called real colours.

> When a person says, "I see a yellowish-orange afterimage," he is saying something like this: "*There is something going on which is like what is going on when* I have my eyes open, am awake, and there is an orange illuminated in good light in front of me, that is, when I really see an orange." (Smart, 1959, p. 149)

Smart refers to a person. It can be any person, and so his contention is about all persons. He gives no justification, and should at least have offered some statistical data either from psychological or linguistic research, to justify his claim. If what he claims is about naïve realistic persons, it should be restricted to such individuals. But since there is no justification, his proposition leads nowhere.

What upsets me is Byrne and Hilbert's apparent belief in their ability to do away with colours by classifying them as illusions. They seem to forget that an illusion is an untrue belief about something that is observed here and now. But since the simply deny a plain truth, namely that after images exist, it seems to be them that suffer from illusion.

The same sort of mistake as is carried through in several presentations of contrast phenomena, for example when the so-called Bezhold effect (URL) is explained as an optical illusion: At this net address it is explained that the same red colour looks darker when it is combined with black surround and lighter when combined with white. However, the initial red is not observed: there is no third red in the picture, only two different reds for everyone to see. And those cannot be illusions.

The challenge for those who take some colours to be illusions is to explain how the distinction between real and unreal colours can be justified. The argument from identity shakes the very foundation of that distinction, urging philosophers of colours to make up their minds and address the inconsistency caused by distinguishing between real and unreal colours.

3 From a formal point of view

According to the Formal System of Colours, it would be convenient if scientists and professionals on colour endeavoured to describe colours and colour changes according to the basic suppositions and definitions.

One should apply a suitable colour system in the determination of hues or tones, allowing relations like lines, figures and sliding scales to be addressed relative to different hues insofar as matches can be made.

When it comes to afterimages, negative or positive, what seems to be crucial is to describe the time relations in the development of the screen of colours in accordance with the implication of colours' two-dimensional nature.

A description that satisfies the constraints related to the Formal System will be one that most effectively facilitates a concise representation of the initial phenomenon. And a description that satisfies the formal constraints seems therefore to be the one that best suits psychophysics/neurophysiology in the area of colour.

However, Clark describes a contrast phenomenon in purely naïve realistic terms à la Goethe: "Skiers who remove yellow ski goggles after a morning of skiing may notice that the snow looks quite blue for a moment." (Clark, 1993, p. 25.) And he asks how this effect, i.e., how the blue disappears, which he classifies as colour adaptation, can be explained. My point is that using a naïve realistic terminology only complicates the explanandum. White snow that looks blue is not to be explained. His problem concerns a part of a screen of slightly shifting colour from blue to white. Which part this is should be determined according to the kinds of colour relation manifested, i.e., its colour surrounds.

Colour physiology is bound to treat colours as directly caused by neuronal processes in the brain and each change in colour appearance must therefore be traced back to

these physical causes. There can be no double causal processes, is the implication of this methodological principle. An afterimage cannot first be caused by neuronal processes only at a later stage to be the cause of another colour change by mixing. In Clark's example: there is no white that is coloured with a blue tint. Only if one uses a completely formal terminology to describe the colour development, will one get a clear understanding of what the explanandum in question is.

Chapter VII
Colour totality and infinity

Introduction

This is BD IV: A colour totality is the colours that exist at any given time.
Explanation:
It can be one colour, it can be one sliding scale, it can be a combination of lines and sliding scales, it can consist of figures in combination with ended lines (see BD IX) and sliding scales. It is possible it can be frozen, that is, not changing, but usually changes are conveyed perpetually.

In section 1, I discuss IMP IV, on distance between colours:

Distance between colours must itself be one or several colours.

Argument: If any two colours are separated, there must be a third colour or other colours in between, because, BS III says only colours can limit colours. And insofar as there is no distance between neighbouring colours, see IMP II, it follows that the between colour or colours must comprise the distance between any two or more colours.

IMP IV says it must be a colour or some colours between two or more others, but could it not be a blank? This is the problem I discuss in section 1.

In section 2, I discuss if the totality of colours can end in a blank. This option is contrary to IMP VI, which says a colour totality is infinite.

Argument: If a totality consists of only one colour, this colour must be endless or infinite, because, according to BS III only colours can limit colours. See in this connection GI, section 2.10.4, fourth theme.
If a totality consists of an infield-outfield relation, the outfield is either one infinitely extending colour from the infield or it is a range of neighbouring colours in extending from the centre. Anyway, the last colour cannot be limited, because it is the last, which means there exists no other colour to delimit it from without. It follows that all totalities are infinite.
However, while the number of colour combinations is infinite, some combinations may perhaps be confusing with respect to the latter argument. If, for example, we consider the logical possibility that a totality consists of only a two-colour relation that contains an infinite line, it can have no centre. In spite of this, the conclusion remains sound, because the line can be considered as the centre and the colours that relates in the line extend endlessly also in opposite directions. See BD VII, Explanation.

1 Within a colour totality

Some philosophers seemingly contend there can be blanks limiting colours.

Hospers (p. 415) says: “A microscope enables us to make more discriminations than does the unaided eye. Hence in this case too we say, “Blood looks red; but turn a microscope on it and you see that it’s partly red, partly white, partly clear, and so on.””

What does he mean by “clear”? It cannot be that he considers white, black and grey as non-colours, because on page 409 he says that,

> Psychologically speaking, black and white, of course, are just as much colours as red and blue; they are just as much objects of immediate and direct awareness; only after a study of physics do we learn that where there is no object to reflect light, or the object absorbs all the light-waves, then we see black.

Can the clear parts be lustre and glitter? In that case they are colours according to Katz’s categories. See in this connection GI, section 3.2.

Berkeley in NTV, asks in § 130 for empirical evidence. In this paragraph he is mainly concerned with arguing against those who mean extension and colours can be separated. See in this connection GI, section 2.8. However, one sentence in the paragraph seems to be an apply for empirical evidence in relation to the question if it can be a blank within a colour pattern. “(…) I leave it to anyone that shall calmly attend to his own clear and distinct ideas to decide whether he has any idea immediately and properly intromitted by sight save only light and colours.” (Berkeley, 1975, p. 9, § 130)

The Committee on Colorimetry gives an outline of filling in colours. It seems that, from a psychophysical point of view, there is reason to expect some sort of blank, but this is prevented by some brain processes.

> There is a hole in the retina about 1 mm in diameter, through which the optic nerve passes. This hole contains no light-sensitive cells of the sort found in the retina itself, and, therefore, it is to be expected that the eye should be blind in the corresponding area of the visual field. (…) Experiment shows a region of very low sensitivity about 6.5 degrees in this neighbourhood , which is called the blind spot. This area of relative blindness in the normal eye is often not noticed because the other eye is sensitive to that portion of the visual field, although blind in a similar area on the other side of the fixation point. Even when one eye is closed, the blind spot is not noticed unless a small object happens to be entirely within the blind region. Since such an object will simply not be seen, the blindness is not noticed unless attention is specifically directed to the disappearance of the object. (Committee on Colorimetry, 1953, p. 84)

The filling in mechanism provides a colour anyway.

> There are three reasons why the spots and bands rarely are noticed to infer with visual perception: (1) the object of attention is normally fixated and imaged upon the fovea where it is fully visible; (2) in usual binocular vision, seeing portions of the retinas fill in for each other and so eliminate the blind areas; and (3) in monocular vision, the blind areas themselves tend to fill in perceptually. Thus, if a blue patch, surrounded by a uniform yellow field, is imaged upon the blind spot, monocular observation reveals only the unbroken yellow field: there is no blank patch or gap. In general, the blind spot is perceptually blind to any contrasting object, which is imagined entirely within the spot, but not to a uniform expanse or background. It is important to recognize that the blind spot is not blind in the sense that nothing is seen there. (Committee on Colorimetry, 1953, p. 104)

It seems to me that filling-in colours supports Berkeley’s disbelief in any contention there can exist blanks.

This does not mean that colours always exist for a person. But only that when they exist they do not contain a blank or gap among themselves. Smythies tells this story.

> A second example is the phenomenal difference between the blindness induced by retinal lesions and that by cortical lesions. In the former a visual field is preserved even if it is always black. In the latter the visual field is lost. This can be experienced by normal subjects in stabilized-retinal-image experiments. The subjects find the experience terrifying; as one said, "I could not see anything, not even blackness". A similar situation obtains in the somatic sensory field. After amputation most patients preserve the somatic sensory field for that part (i.e., a phantom limb) which can be removed by a subsequent parietal cortical ablation. (Smythies, 1966, p. 371)

Smythies' analogy to a phantom limb indicates it is not a question of a blanc in the meaning discussed above, but only of nonexistence. This is maybe comparable to listening. Sometimes there are sounds and sometimes there is complete silence.

2 From without a colour totality

One may ask why I not use the term visual field instead of colour totality. The reason is that I want to avoid connection to causal explanation. However, in this section I give examples of definitions of visual field connected to causes during my discussion. Other conceptions of visual field which are not causal I have explained in GI, section 2.10.3.

Smythies lists up some causal definitions of visual field. He wants his colleges to use the term visual field in one precise meaning within neurology, psychology and visual science. He makes a complaint this is not the case. The term visual field is used about many different causal components.

> The term '(external) stimulus field or 'field of view' refers to physical objects and light sources in the external world that impinge on the retina. It forms the *input* to the computational mechanism of the brain mediated by what we might call the '(internal) stimulus field', which refers to the earliest retinal sensory registration of external stimuli. The term 'visual field' refers to the spatial array of visual sensations available to observation in introspective psychological experiments. These (…) form the *output* of the representational mechanism in the brain. These are powerfully affected by 'top-down' influences modified by prior experiences, expectation, etc via the many re-entry circuits available. (…) Also, the brain contains a large number of 'maps' each of which processes different aspects of information derived from the stimulus field. Last, there is the 'visual field' neurologists measure when they are determining whether the patient has a visual defect such as hemianopia or scotoma. Since all these are all indiscriminately labelled the 'visual field' a degree of confusion obtains. (Smythies, 1966, p. 369)

This quotation contains one definition that could look somewhat like my definition of colour totality, namely, "The term 'visual field' refers to the spatial array of visual sensations available to observation in introspective psychological experiments." However, this use is restricted to psychological experiments, and according to Smythies these involve causal explanations, and even identification of conscious experiences with brain events. See in this connection my discussion in GI, section 2.11.4. Smythies explains, on the following page, in brief the causal connections.

> When a person sees something, a proper scientific account of what is going on needs to include the following (if one assumes for the moment that the psychoneural Identity Theory is correct): (1) the objects seen ((external) stimulus field); (2) the resulting earliest retinal events

> ((internal) stimulus field; (3) the brain events that are identical with our conscious experiences (visual field); (4) the brain events that we are not aware of but which act by influencing (3) (for example in the lateral geniculate nucleus)); and (5) the 'visual field to confrontation' as mapped by our neurologists; this however is merely a clinically useful conflation of (1) and (3).

Gerritsen too operate with the concept a field of vision. A field, he says, depends on the angel of physical light that slips in through the pupils. According to Gerritsen, the field of vision (processed with two eyes) has a form like a reclining ellipse, both the upper and lower periphery are in the middle somewhat pressed against the centre. (Gerritsen, 1975, pp. 51-52)

What is outside the periphery is not questioned. Gerritsen's printed illustration shows of course a colour outside the line of the periphery, namely the white paper, but this only implies that there is no rational problem with the illustration. The problem arises when we ask what the illustration models; is this deformed ellipse supposed to correspond to the psychological visual field, that is what Smythies describe as the spatial array of visual sensations available to observation in introspective psychological experiments?

Another possibility seems more plausible. Gerritsen's description of the visual field concerns the colours caused by the input of electromagnetic radiation on the retina. Light falls on the retina, he suggests, in vertical direction (from above and from below) at a range of approximately 120 degrees, and in horizontal directions (from right and left side) across a range of approximately 200 degrees. It follows that the drawing of the so-called visual field is a geometric reconstruction of these light relations.

Hering gives an implicit definition of visual field. However, also this implies causal connections.

> We can call *the totality of real objects* imaged at a given moment on the retina of the right or left eye. These two visible fields form the momentary visible field in this way: there is a larger central part common to both, and to this binocular area a small region is added, both on the right and on the left, which is visible to only one eye. (Hering, 1964, p. 226)

A definition of visual field which is closer to my definition of colour totality I found in MedlinePlus (URL): "Visual field refers to the total area in which objects can be seen in the side (peripheral vision) as you focus your eyes on a central point." This definition is used in medicine and authorized by U.S. National Library of Medicine.

However, the definition contains the term total area. This may indicate some sort of limitation which my definition of colour totality does not indicate.

The question now is if the colour totality is limited or not. Philosophically speaking, if only colours can limit colours, it follows there is no limitation.

In GI, section 2.10.4, forth theme, I discuss both Aristotle and Hume. They give examples of colour totality in where only one colour is involved.

Hume, however, contends darkness is "without parts, without composition, invariable and indivisible". (Hume, 1969, p. 104, Book I, Sect. V) He does not directly say darkness is infinite or unlimited, but he does not say it is limited either. Neither does

Aristotle in his example of white. And what should the limit be? However, I can encourage persons to have a look for themselves: Go into a room completely closed in all direction, turn off the light, and observe. Ganzfeld observations are also an option. Again; see GI, section 2.1.4, fourth theme.

Hering describes another observation situation. He talks about closing the eyes in a complete darkened room, and observe the colours that can be seen, for example after images. This is not in accordance with Hume's darkness, but none of the descriptions excludes the possibility of the other.

> We see these intrinsic colours, ordinarily achromatic, whenever we attend to them, whether a variety of forms, like afterimages or other endogenous colour images have attracted our attention, or whether we deliberately attend to what is in the visual field. A person with his eyes closed usually pays no attention to all these phenomena, not even when light reaches the retina through the lids. Yet if one keeps his eyes open in a completely darkened room and intentionally looks around, he begins to notice for the first time how much his visual field can contain even though external objects are completely invisible. (Hering, 1964, p. 226)

But now, Hering comes to the crucial point. The visual field is limited, he says, and it is limited by nothing.

> Also the fact that, on the average, the colours of the peripheral visual field enter much less into consciousness, or, more correctly stated, enter less into conscious memory, than those of the central field is not because they are less "intensive," meaning less bright, visual sensation than the latter, for in the daytime the average brightness of colours even near the peripheral limit of the visual field is not less, and they are not blacker, than in the centre of the visual field. Moreover, the limits of the visual field cannot be determined by the fact that here the "intensity" of light sensations falls to its zero point which allegedly correspond to the deepest black; for at the limit of the visual field and beyond it black is not seen but rather nothing at all is seen. (Hering, 1964, p. 116)

Maybe Hering takes the whole discussion to be uninteresting. There could be better things to do than to concentrate on finding an outer limit to a visual field.

However, Hering's last sentence in this quotation is a sort of construction that Carnap (1959, p. 70) warns against, "it is simply based on the mistake of employing the word "nothing" as a noun." But "nothing" is not a name, as Carnap insists, the term has only a logical function, which is to deny the existence of something. This implies that Hering's statement denies that there is an outer limit to his visual field.

Also, when the Committee on Colorimetry says about the blind spot that "it is to be expected that the eye should be blind in the corresponding area of the visual field", it could be that someone makes the same grammatical mistake as Hering and expects to see nothing.

In GI, section 2.10.2 I explain that it is customary to use patch as substantive and say for example this patch is red. However, a patch is not a blank that gets coloured, it is colours that relate in patches, that is, as infields and outfields.

My conclusion is therefore that both problems discussed in section 1 and 2, should be answered in the negative; there is no blank within a colour totality and a colour totality is not limited from the outside.

Post Script

I will not present a summary in this post script. This I have already done, at least for General Introduction, in Chapter I.

Instead I will try to look forward and in brief tell how I would use crucial notions in this thesis if I was to write a textbook on colours for students in fine arts. When I put in a number like this; (23), in a sentence or after a sentence, it is a reference to a page in this thesis.

Colours are homogeneous (152)
I use this conclusion and all my relevant arguments for it (118), included that from epiphenomenalism (159), and dismiss by that Goethe's theory on completeness and harmony (Goethe, 2002, p.360), which is based on a conviction that some colours are homogeneous and others are heterogeneous. In § 805 Goethe says, "When the eye sees a colour it is immediately excited, and it is its nature, spontaneously and of necessity, at once to produce another, which with the original colour comprehends the whole chromatic scale."

Goethe's talk here is about negative after images. (200) And he grounds his contentions in terms of heterogeneity, that is, what he calls completeness is three colours whereof two are a compound. If the first colour is yellow, then the complement is violet, which, according to Goethe is a compound of red and blue.

In § 810, he says; "Yellow demands red-blue, blue demands red-yellow, red demands green and contrariwise." Note that Goethe means green is a compound of yellow and blue. For Goethe, each of these colour pairs is the totality of all colours, and "If, again, the entire scale is presented to the eye externally, the impression is gladdening." (§ 808) I say the impression might be gladdening for many people, but not for the reasons Goethe provides.

In § 805, Goethe talks of after images as if there are no exceptions to the symmetry. However, he should have mentioned positive after images (212), which do not follow the rule. The Committee on Colorimetry (1953, p. 115) tells that negative after images are the "most common kind of after image", but adds that "Thus after images are complex resultants which vary in hue, saturation, brightness, size, shape, pattern, texture, focus, latency, duration, and developmental sequence."

It is therefore other arguments too against Goethe's generalization.

However, the conclusion that colours are homogeneous, can also be used against Itten and Kandinsky's theory on form (figure) colourism. (66) The argument they serve concerning the figures of orange, green and violet, is wholly based on colour mixing, that is, the contention that these colours are heterogeneous.

Colours are two-dimensional (152)
This is maybe not that easy to convince art students about. After all, the practise of painting pictures demands a naïve realistic approach.

However, a deconstruction of Katz's colour categories (135) seems to be appropriate and needed. In imitations of motives, one has to start with the first colour on a canvas.

This is analogous to Molineux Man opening his eyes for the first time. Perception of space develops until the picture is finished.

And afterwards, when it hangs on the wall, it may be understood that colours can only relate beside each other. (147, BS II) Someone will perhaps object that the first stroke of the brush lies under the finishing ones, but this no one can see. Or, one may say that some strokes are transparent (139), which means one can see through them unto the colour behind. But this is either a sliding scale or it is a part with no inner variation and therefore only different from the first. (148)

Both imitations and abstract paintings need to be seen on the wall, and why not call attention to the fact that the end of the frame, constitute a Leonardo line with relation to the wall. And since the wall is a colour that also ends, it may be convenient to mention BS III, which says that only colours can limit colours. (147) And then the student will perhaps be aware that there is no end to the colour totality (206) and hopefully understand that his or hers picture is a part only and consider if that part really is to the purpose of the interior settings.

Pigment colour systems
I will call attention to the fact that the students may ignore pigment colour systems (171) which bind their understanding to colour solids (176).

A painter has his or hers own system ready on the pallet. It may be few colours, it may be many. Of course, if the intention is to mix all colours by some few colours I remind of Birren's words (172) that you, in addition to white and black, need more hues than yellow, red and blue in order to create them. A conviction that these hues are sufficient for the task is, according to Birren (172), not true.

However, I continue and say that the ready picture is also a colour system. This can be analysed according to Johnson's betweenness relation. Some colours are between the others and some may not be between any other. Remember, Johnson gives an example of the latter: yellow, red and green do not relate in a betweenness relation (58), and this apparently goes for blue, black and white also.

Betweenness (56) and not betweenness is about the colours without mentioning their figures or extensions, nor their relative positions. Neither is it directly about lines and sliding scales. The same goes for identity which is not a betweenness relation; BS IV (147) says that two or more colours can be identical, notwithstanding difference in figure, size and position. This relation may be part of the composition. However, sliding scales, are instances of betweenness.

Maybe students in fine arts also use other colour determinations like the ones in psychophysics, namely, brightness (which is a claimed property also of the black-grey white axis), hue and saturation. (17) But these terms are technical and should be applied only in the practical creation process, for example when using airbrush while controlling it by aid of a colour system on a computer.

Determinables and their determinates
Johnson says determinates under different determinables are not comparable because they are absolute different and, it follows, they cannot be properties of each other. (61) Berkeley says the same about colours vs. touch. (134) But I suggest (197) that also he means that determinate under colours are completely different from determinates under other determinables.

In accordance with Johnson, I therefore advise my readers of the textbook not to characterize colours as warm or cold. This is opposite other writers on colours. I think it is needed to present an overview. Here follow some brief considerations.

Goethe (2002) generalizes about particulars but he does not characterize colours as warm or cold. In § 768 he says that "We find from experience, again, that yellow excites a warm and agreeable impression." And in § 782, he says "Blue gives us an impression of cold, and thus, again, reminds us of shade." This is not, in my opinion, determinations of inherent properties in the colours, but a contention of how we (may) react upon seeing them. These reactions are, according to Goethe, not only inner feelings, but also associations.

However, Itten (1995, p. 45), says, in my translation, that "blue-green and reddish-orange, which is the cold and the warm pole, are always cold and warm". Itten ascribes, in other words, cold and warm as inherent properties of the poles.

Also, Kandinsky (1977, p. 36) uses an expression that supposes warmth and cold to inhere in colours: "Generally speaking, warmth and cold in colour means an approach respectively to yellow and blue."

Hardin (1987, p. 288), talks about analogies. "The most common analogical characterization of the different labels red and yellow as the "warm" hues and green and blue as the "cold" hues." However, on the next page, he sees a deeper analogy between the hues and warm and cold than simply "environmental associations". "Further reflections on the character of the resemblances and differences persuades one that they are, as it were, intrinsic to the perceived colours, and that "warm" and "cold" express, rather, a deeper *analogy*."

Unvin (2011, p. 3) adheres to Hardin, and suggests, in order to support Hardin, some neuronal connections.

> Thirdly, and much more controversially, red and yellow look intrinsically 'warm' (…) whereas green and blue look intrinsically 'cool'. This may be purely cultural, or due to familiar physical associations, but perhaps not. It might be that there are actual physiological connections between opponent channels and those neurons implicated in the sensations of warmth, and likewise between opponent channel inhibition and those neurons implicated in the sensation of coolness.

Since the divide between warm and cold hues are accepted by colour theorists and colour philosophers, I would write in a textbook that, if a student really feels warmth and cold when looking at these hues, he or she is allowed to. If he or she does not feel it, that is allowed too. But this allowance implicates that I not take warmth and cold to be intrinsic properties of these hues. I must state further grounds for this view, but that is dependent on whether I ever start writing a textbook on colours.

Bibliography

Albers, Josef: *Interaction of Colour*, Yale University Press, New Haven and London, 1971.

Alter, Torin: Knowledge Argument against Physicalism, Internet Encyclopedia of Philosophy, 14. November, 2005, http://www.iep.utm.edu/know-arg/

Aristotle: *On the Soul*, in McKeon, Richard, "Introduction to Aristotle", The Modern Library – New York, 1947.

Aristotle: *Metaphysics*, in McKeon, Richard, "Introduction to Aristotle", The Modern Library – New York, 1947.

Aristotle: *On Colours*.

Aristotle: *Categories*.

Aristotle: *De Memoria et Reminiscentia*, in Aristotle On Memory, Gerald Duckworth & Company Limited, 1972. Translated by Richard Sorabji.

Armstrong, D. M.: *Perception without belief,* in "A Materialist Theory of the Mind", London, Routledge & Keagan Paul, 1968, pp. 216-226.

Armstrong, D. M.: *Berkeley's Theory of Vision, A Critical Examination of Bishop Berkeley's Essay Towards a New Theory of Vision*, Melbourne University Press, 1960.

Arstila, Valtteri: The Paradox of Colours, Reports from the department of Philosophy, Vol. 15, University of Turku, Finland, 2005.

Atherton, Margaret: *Berkeley's theory of vision*, in "The Cambridge Companion to Berkeley", Cambridge University Press, 2005.

Atherton, Margaret: *Berkeley's Revolution in Vision*, Cornell University Press, Ithaca and London, 1990.

Atherton, Margaret: *How Berkeley Can Maintain That Snow Is White*, Philosophy and Phenomenological Research, Vol. LXVII, No. 1, July 2003.

Beck, Jacob and Schneider, Keith A.: *Attention and Mental Primer*, in Mind and Language, Vol. 32, No. 4 September 2017, pp. 463-494, John Wiley & Sons Ltd, 2017.

Berkeley, George (1): *An Essay Towards a New Theory of Vision*, in Berkeley - Philosophical Works – including the works on vision, Dent, London, Melbourne and Toronto, Rowman and Littlefield, Totowa, N.J., 1975.

Berkeley, George (2): *The First Dialogue*, in "Three Dialogues Between Hylas an Philonous", in Berkeley - Philosophical Works – including the works on vision, Dent, London, Melbourne and Toronto, Rowman and Littlefield, Totowa, N.J., 1975.

Berkeley, George (3): *The Theory of Vision Vindicated and Explained*, in "Philosophical Works – including the works on vision, Dent, London, Melbourne and Toronto, Rowman and Littlefield, Totowa, N.J., 1975.

Berkeley, George: (4): *Principles of Human Knowledge*, in Berkeley - Philosophical Works – including the works on vision, Dent, London, Melbourne and Toronto, Rowman and Littlefield, Totowa, N.J., 1975.

Berkeley, George (5): *De Motu*, in Philosophical Works – including the works on vision, Dent, London, Melbourne and Toronto, Rowman and Littlefield, Totowa, N.J., 1975.

Bezold effect: https://en.wikipedia.org/wiki/Bezold_effect

Billock, Vincent A., and Gleason, Gerald A., and Tsou, Brian H.: *Perception of forbidden colors in retinally stabilized equiluminant images: an indication of softwired cortical color opponency?* Optical Society of America, Vol. 18, No. 10/October 2001.

Birren, Faber: *The Principles of Harmony and Contrast of Colours*, by M. E. Chevreul, Van Nostrand Reinhold Company, 1981: Part I, + Introduction and notes by Faber Birren.

Birren, Faber (1): *Principles of colour*, Van Nostrand Reinhold Company, 1969.

Birren, Faber (2): A Basic Treatise on the Colour System of Albert Munsell: A Grammar of Colour, Van Nostrand Reinhold Company, 1969.

Boogart, A.: Traité des Coleurs servant à la peinture à l'eau, from 1692, presentations from the book at http://www.thisiscolossal.com/2014/05/color-book/

Briggs, David; *The Dimensions of Colour*, 2013, URL http://www.huevaluechroma.com/073.php

Byrne, Alex and Hilbert, David R.: *Color Realism and Color Science*, Behavioural and Brain Sciences (2003) 26, copyright Cambridge University Press 2002. http://mit.edu/abyrne/www/ColorRealism.html

Carnap, Rudolf: *The Basis*, in "The Logical Structure of the World – Pseudoproblems in Philosophy", London – Routledge and Kegan Paul, 1967, pp. 98-136.

Carnap, Rudolf (2): *The Elimination of Metaphysics Through Logical Analysis of Language,* in Logical Positivism, edited by A. J. Ayer, THE FREE PRESS, a division of Macmillan Publishing Co., INC., New York, 1959.

Carnap, Rudolf: *Philosophy and Logical Syntax*, found by Google: Canvas@Harvard, originally published in Psyche Miniatures, General Series No. 70, Kegan Paul, Trench, Trubner & Co., Ltd., London, 1935. I paginate according to the Google copy.

Carnap, Rudolf: *The Old and the New Logic*, URL: files 7. Webedy.com, originally entitled "Die alte und die neue Logik", Erkenntnis. Vol. 1, 1930-31.

Carnap, Rudolf: *Empiricism, Semantics, and Ontology*, URL: ditext.com, also found in the supplement to Meaning and Necessity: A study in semantics and Modal Logic, enlarged edition, University of Chicago Press, 1956.

Carnap, Rudolf: *Logical Foundations of the Unity of Science*, URL: The hanged man.com, Reprinted from International Encyclopedia of Unified Science: Volume I, University of Chicago Press, 1955.

Chalmers, David: *The Puzzle of Conscious Experience,* Scientific American, December 1995.

Chuard, Philippe: Indiscriminable shades and demonstrative concepts, Australasian Journal of Philosophy, 85:2, 277-306. Downloaded from http://ds.doi.org/10.1080

CIELAB, 1976, URL http://dba.med.sc.edu/price/irf/Adobe_tg/models/cielab.html

Clark, Austen: *Sensory Qualities*, Clarendon Press – Oxford, 1993.

Cohen, Jonathan, *Two Recent Anthologies on Colour*, Philosophical Psychology, 14(1): 118 – 122, 2001.

Committee on Colorimetry – Optical Society of America; *The Science of Colour*, New York: Thomas Y. Crowell Company, 1953.

Conee, Earl: *Phenomenal knowledge*, Australasian Journal of Philosophy, 72:2, 136-150, 1994 – downloaded by University of Oslo, 15. December 2016, at 08.33.

Crane, Hewitt, D. and Piantanida, Thomas P.: On seeing Reddish Green and Yellowish Blue, Science, New Series, Vol. 221, No. 4615 (Sep. 9, 1983) pp. 1078-1080. Downloaded from URL: http://www.jstor.org/stable/1691544

Dalin, Aasa: *Some Critical Remarks on the Natural Colour System, NCS*, in "Proceedings: Colour between Art and Science", Oslo International Colour Conference, 1998.

Dancy, Jonathan: *Introduction to Contemporary Epistemology*, Blackwell, 1998.

Dancy, Jonathan and Sosa, Ernest: *Knowledge by acquaintance/by description,* in A Companion to Epistemology, Blackwell, 2000, pp. 237-240.

Descartes, René; *Meditations on first philosophy*, http://selfpace.uconn.edu/class/percep/DescartesMeditations.pdf

Euclid: Greek Mathematics: I, *Euclid, Definitions*, pp. 437-441, Harvard University Press, 1991. Translation by Ivor Thomas.

Fields, Keota: *Berkeley - Ideas, Immaterialism, and Objective Precence*, Lexington Books, 2011.

Forrest, Peter: *The Identity of Indiscernibles*, 2010, URL: https://plato.stanford.edu/archievs/win2016/entries/identity-indiscernible/

Fuller, Stuart and Carrasco, Marisa: *Exogenous attention and color perception: Performance and appearance of saturation and hue*, Department of Psychology, New York University, New York, NY, USA, 2006 – URL: www.elsevier.com/locate

Galaaen, Øistein Schmidt: *The Disturbing Matter of Downward Causation – A Study of the Exclusion Argument and its Causal-Explanatory Presuppositions*, Faculty of Humanities, University of Oslo, 2007.

Ganzfeld: https://psi-encyclopedia.spr.ac.uk/articles/ganzfeld first quotation, collected 07. 03. 2019

Gerritsen, Frans: *Farbe – optische Erscheinung, physikalisches Phänomen und künstlerisches Ausdrucksmittel*, Otto Maier Verlag Ravensburg, 1975.

Giere, Ronald N.: Scientific Perspectivism, The University of Chicago Press: Chicago and London, 2006.

Goethe, Johan Wolfgang von: *Theory of Colours*, The M.I.T. Press, Cambridge, Massachusetts, and London, England, 2002.

Goto, Ichihara Yasuyo: *The suitable colour palette on CRT for individual human colour vision sensitivity*, in "Proceedings: Colour between Art and Science", Oslo International Colour Conference, 1998.

Grayling, A. C.: *Berkeley's argument for immaterialism*, in "The Cambridge Companion to Berkeley", Cambridge University Press, 2005.

Hardin, C. L.: *Color for Philosophers – Unweaving the Rainbow*, Hacket Publishing Company, Indianapolis/Cambridge, 1988.

Hardin, C. L.: Are 'Scientific' objects coloured?, in Mind (1984) Vol. XCIII. 491-500.

Hardin, C. L.: Qualia and Materialism: Closing the Explanatory Gap, Philosophy and phenomenological Research, Vol. 48, No. 2 (dec., 1987), pp. 281-298. Downloaded from http://www.jstor.org/stable/2107629

Heraklit: https://books.google.no/books

Hering, Ewald; *Outlines of a Theory of the Light Sense*, Harvard University Press, Cambridge, Massachusetts, 1964, Chapters I and II.

Hilbert, David R.: *Colour and Colour Perception – A Study in Anthropocentric realism,* Centre for the Study of Language and Information, Leland Standford Junior University, 1987.

Hume, David: *A Treatise of Human Nature*, Part I, in Penguin Books, 1969.

Hume, David (2): *An abstract of a book lately published, entitled, A treatise of Human Nature*, http://ota.ox.ac.uk/text/3448.txt

Hård, Anders: *Färgsystemet NCS – tanke tillkomst – tillämpning*; Statens Råd for Byggnadsforskning, Stockholm 1996.

Ingarten, Roman: Innføring I Edmund Husserls Fenomenologi, Johan Grundt Tanum Forlag – Oslo 1970.

Itten, Johannes: *Farvekunstens elementer*, Borgen, 1994.

Jackson, Frank: *Perception – A representative theory*, Cambridge University Press, 1977.

Jackson, Frank: *Epiphenomenal Qualia*, The Philosophical Quarterly, Vol. 32, No. 127. 1982, pp. 127-136 – URL: http://www.jstor.org

Jackson, Frank: *What Mary Didn't Know*, The Journal of Philosophy, Vol. 83, No. 5 (May, 1986), pp. 291-295.

Jammer, Max: *Concepts of Space; The history of the theories of space in physics,* Harper Touchbooks – The science library, Harper and brothers, New York, 1960.

Jesseph, Douglas M: Berkeley's philosophy of mathematics, in "The Cambridge Companion to Berkeley", Cambridge University Press, 2005.

Johnson, W. E.: *Logic Part I*, Cambridge University Press, London: Fetter Lane, E.C.4 – 1921.

Kandinsky, Vasilij: *From Point to Line to Plane*, Dover Publications, Inc., New York, 1979.

Kandinsky, Vasilij: Concerning the spiritual in art, Dover Publications, Inc., New York, 1977.

Katz, David: *Introduction*, in "The World of Colour", Routledge and Keagen Paul Ltd. 1935.

Katz, David: *Chapter II, Types of Tactual Phenomena*, in "The World of Touch", Lawrence Erlbaum Ass, Publ., 1989.

Kim, Jaegwon: *Philosophy of Mind*, Westview Press, 1998.

Kuhn, Thomas S: *The Structure of Scientific Revolutions*, International Encyclopedia of Unified Science, The University of Chicago Press, Chicago 1962.

Landesman, Charles: *Colour and Consciousness – An Essay in Metaphysics*, Temple University Press, Philadelphia, 1989.

Leeuwen van, Cees: *Perception*, in "A Companion to Cognitive Science", Blackwell Publishers, 1999.

Lenning, Einar: Färgernas system och harmoni, Bröderna Lagerströms Förlag / Stockholm, 1954.

Lewis, David: *What Experience Teaches*, URL reproduced from David Lewis, Papers in Metaphysics and Epistemology, Cambridge, Cambridge University Press, 1999. Downloaded from URL: https://www.repository.cam.ac.uk/bitstream/handle/1810/247198/Lewis-Experience.pdf?sequence=2 which means paging is different from the original.

Lewis, David: Percepts and Color Mosaics in Visual Experience, The Philosophical Review, Vol. 75, No. 3 (Jul., 1996), pp. 357-368. Download from URL: http://www.jstor.org/stable/2183146

Locke, John: *Book II,* in "An essay concerning human understanding", Dent: London – EVERY MANS LIBRARY – Dutton: New York, 1971.

Lund, Lars-Gunnar – Montgomery, Henry – Waern Yvonne: *Kognitiv Psykologi*, Ad Notam Gyldendal, 1996.

Mackie, D. L.: *Primary and Secondary Qualities*, in "Problems from Locke", Clarendon Press – Oxford, 1990, Chapter I.

Maund, Barry: *Colour*, Stanford Encyclopedia of Philosophy, First published Mon Dec 1, 1997; substantive revision Mon Sep 18, 2006.

MedlinePlus: https://medlineplus.gov/ency/article/003879.htm collected 24.04.2019.

Merleau-Ponty, Maurice: *Phenomenology of Perception*, Routledge and Kegan Paul, 1981.

Miescher, K. – Richter, K. – Valberg, A: *Colour and colour vision*, extract in Norwegian from Farbe – Design, number 23/24, pp. 2-23, 1982.

Nagle, Thomas: *What Is It Like to Be a Bat?* Originally in The Philosophical Review, Vol. 83, No. 4 (Oct., 1974), pp. 435-450. Published by Duke Univerity Press on behalf of Philosophical Review. Downloaded from http://www.jstor.org/stable/2183914

NCS: https://www.ncscolour.no, looked up 01.05.2019.

Nida-Rümelin, Martine: *Qualia: The knowledge argument*, in Stanford Encyclopedia of Philosophy, substantive revision Mon Nov 2009. (http://plato.standford.edu/entries/qualia-knowledge/)

Nida-Rümelin, Martine and Suarez, Juan: *Reddish Green: A Challenge for Modal Claims about Phenomenal Structure*, Philosophy and Phenomenological Research, Vol. 78, No 2, pp. 346-391. Downloaded from http://www.jstor.org/stable/40380429

Nes, Anders: *Essay 2: Conceptualism, Recognitional Concepts, and Indiscriminability, & Essay 3: Conceptualism, Self-Conscious Thought, and Systematicity*, in "Experience, Intentionality, and Concepts - Essays in the Philosophy of Perception", Faculty of Humanities, University of Oslo, 2008.

Newton, Isaac: Optics, Pg 64-75 & Pg 122-125, URL: http://www.gutenberg.org/files/33504/33504-h/33504-h.htm

Ostwald, Wilhelm: *The Color Primer*, Van Nostrand Reinhold Company, 1969.

Ott, Gerhard and Proskauer Heinrich O., *Das Rätsel des Farbigen Schattens, Versuch Einer Lösung*, Zbinden Verlag Basel, 1979.

Pantone: *Process Colour Selector*, Euroscale, uncoated version, Pantone, Inc. 1983.

Revold, Reidar: *Fargene i Farger*, H. Aschehoug & Co., W. Nygaard, Oslo 1963.

Price, H. H.: *Perception*, Methuen & Co. LTD, 1964.

Rescher, Nikolas: *Common Sense: A New Look at an Old Philosophical Tradition*, The Aquinas Lecture, 2005, MARQUETTE UNIVERSITY PRESS.

Rosch, E. H.; *Natural Categories*, Cognitive Psychology (1973), 4, 328-350.)

Rosch, E. H.: *Principles of Categorization*, University of California, Morgan Kaufmann Publishers, Inc, 1988.

Russell, Bertrand; *The Problems of Philosophy*, URL: Free Ebooks, Project Gutenberg, 2015.

Popper, Karl. R.: *The problem of the empirical basis*, in The Logic of Scientific Discovery, Hutchinson, 1980.

Sanford, David H.: *Determinates vs. Determinables*, in Stanford Encyclopedia of Philosophy, 2006 (http://plato.stanford.edu/entries/determinate-determinables/#1.)

Schlick (1), Moritz: *Positivism and Realism*, A.J. Ayer ed. "Logical Positivism", The Free Press, a Division of Macmillan Publishing Co. Inc., New York 1959.

Schlick (2), Moritz: *The Foundation of Knowledge*, in A.J. Ayer ed. "Logical Positivism", The Free Press, a Division of Macmillan Publishing Co. Inc., New York 1959.

Seim, Torstein: *CIE Div 1, R1-47 Hue angles of Elementary Colours,* 2009, URL http://files.cie.co.at/526.pdf

Smedal, Grethe: *Farge overalt*, Tell Forlag, 1996.

Smythies, John: *A note on the concept of the visual field in neurology, psychology, and visual science*, Perception, 1966, Volume 25, pages 369-371.

Strand, Anders: *The Metaphysics of Mental Causation – The Exclusion Problem Revisited, Reconsidered and Resolved*, Faculty of Humanities, University of Oslo, 2008.

Tse, Peter U.: *Volontary attention modulates the brightness of overlapping transparent surfaces,* Department of Psychological and Brain Sciences, Dartmouth

College, H. B. 6207, PBS, Moore Hall, Hannover, NH 03755, USA, Vision research 45, pp. 1095-1098, 2005. Downloaded from URL: www.sciencedirect.com

Tye, Michael: *The Subjective Qualities of Experience*, Source: Mind, New Series, Vol. 95, No. 337, 1986 – URL: http://www.jstor.org.stable/2254286

Unvin, Nicolas: *Why do Colours Look the Way They Do?* Cambridge Core, Volume 86, Issue 3, 2011 – URL: Https://www.cambridge - downloaded 09.01.17

Valberg, Arne: *The enigma of unique hues. On colour perception and neurophysiology,* in "Proceedings: Colour between Art and Science", Oslo International Colour Conference, 1998.

da Vinci, Leonardo: *A Treatise on Painting*, reprint from London, George Bell § Sons1897, translated from Italian by Rigaud, John Francis, with a Life of Leonardo and an Account of his works by Brown, John William, Kessinger Publishing.

Watzl, Sebastian: *Attentional Organization and the Unity of Consciousness*, Journal of Consciousness Studies, 21, No. 7-8, 2014, pp. 56-87.

Westphal, Johnathan: *Whiteness*, in (Red.) Amrine, F, Zucker, F. J. & Wheeler, H. "Goethe and the Sciences: A Reappraisal", D. Reidel 1987.

Wittgenstein, Ludwig: *Remarks on Colour*, Basil Blackwell Oxford, 1977.

Winkler, Kenneth P.: *Berkeley and the doctrine of signs*, in "The Cambridge Companion to Berkeley", Cambridge University Press, 2005.

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