How Can We Distinguish Perception from Cognition?

The Perceptual Adaptation Hypothesis

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Abstract

How can we determine which aspects of a given experience are represented perceptually, as opposed to cognitively? I explore perceptual adaptation as an empirically based method for distinguishing perception from cognition. I focus on vision. The basic idea is that, if a represented property shows adaptation, then it is perceptually represented. I explore why, and under which conditions this is true. In short, if a given property shows adaptation, then we must rule out that the effect (1) can be explained by a cognitive shift in category boundary, and (2) that it is a result of adaptation to other (low-level) visual features of the stimuli, before we can conclude that the property is perceptually represented. I discuss methods for excluding these possible explanations. I also discuss whether we should expect all perceptually represented properties to show adaptation. As evidence suggests that this is plausible, I conclude that the adaptation methodology has the potential to determinably distinguish perception from cognition.

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Introduction

On the face of it, the difference between perception and cognition might seem obvious. They simply play different roles in our mental life. Perception is what puts us in contact with our present surroundings, while cognition is what makes us able to form beliefs, make decisions, and so on. Despite the seemingly obvious difference, drawing a strict line between perception and cognition has proven difficult. Some even doubt whether there is a real distinction at all. Consider the overall experience you are presently in. Can you distinguish what you strictly speaking perceive, on the one hand, from what you cognitively judge on the basis of what you perceive, on the other? The question is how we can determine, in a given experience, what is contributed by perception, on the one hand, and cognition, on the other.

In this thesis, I investigate perceptual adaptation as an empirically based method for making the distinction. I focus on vision. Perceptual adaptation refers to perceptual systems' adjustments as a response to change in stimuli. The visual system adapts to a variety of different aspects of its inputs, including form, colour and brightness, but there has also been found adaptation for more complex stimuli features, such as faces and causality. Adaptation can produce dramatic aftereffects. A well-known adaptation aftereffect is a phenomenon called the waterfall illusion. If you keep your eyes fixated on a waterfall for some time, you will adapt to the rapid downward motion of the water. If you then move your eyes to a stationary scene, for example a hillside, it will for the first couple of seconds look like it is moving upwards.

That adaptation, and the aftereffects adaptation produce, can help us distinguish perception from cognition, has been suggested from various holds, but perhaps most directly by Ned Block (2014). The philosophical discussions of the phenomena are all quite brief, however. A clear account of how (and why) adaptation can be used to distinguish perception from cognition is missing in the philosophical literature. While adaptation has been extensively studied in psychology, the studies tend to focus on specific cases of adaptation. Moreover, the main focus of these studies is often not on the boundary between perception and cognition. Therefore, I wish to undergo a detailed investigation of the phenomenon of adaptation. Based on the limited philosophical discussion, and the studies on specific cases of adaptation from the psychological literature, I will try to get clear on why adaptation is suited to distinguish perception from cognition, and to develop a general account of how it can successfully do so.

Chapter 1 is meant to provide theoretical background, and to set the stage for the upcoming investigation. The chapter considers the differences between perception and cognition. A large part of the chapter focuses on the alleged evidence that perception is systematically influenced by cognition – a potential threat to there being a clear distinction. Towards the end of the chapter, I turn to the question of how we should distinguish perception from cognition. In chapter 2, I begin the investigation of perceptual adaptation. I formulate a hypothesis which, in short, says that if a represented property shows adaptation, then it is perceptually (as opposed to cognitively) represented. I attempt to get clear on what adaptation is, and why being susceptible to adaptation is evidence of perception. The upshot of the discussion is that the hypothesis is plausible, but that there are two alternative explanations of adaptation effects that is not yet ruled out. The first alternative explanation, which is the focus of chapter 3, is that adaptation is a cognitive effect. If cognitive states also adapt, then adaptation would not be evidence of perception. I argue that we do not have reason to think that adaptation occur in cognition, and discuss strategies for making sure that an alleged adaptation aftereffect is in fact an instance of genuine perceptual adaptation (as opposed to cognitive shift in category boundary). In chapter 4, I discuss the second alternative explanation: that adaptation only operates on low-level features. If we find adaptation for a (high-level) property, we must be sure that what vision adapts to is in fact that specific property, and not just other (low-level) features of the presented stimulus. I discuss strategies, and evidential sources, for ruling out this explanation. In chapter 5, I consider whether we should expect all perceptually represented properties to show adaptation, and whether the hypothesis will be testable for all potentially perceptually represented properties. In chapter 6, I conclude the thesis by suggesting possible applications of the adaptation methodology.

1 What is the distinction between perception and cognition?

The distinction between perception and cognition has traditionally been presupposed in both the philosophy of mind and in psychology. The distinction is also deeply woven into our common-sense conception of the mind. However, a growing body of evidence purportedly shows that all kinds of cognitive states, including beliefs, purposes, and emotions systematically interact in intricate ways in generating perceptual representations. The alleged interaction between perceptual and cognitive processes challenges the assumption that there is a clear dividing line between perception and cognition, and might lead to us to doubt whether the categories reflect a real distinction in the mind at all. Others (Firestone & Scholl, 2016a; Fodor, 1983), however, reject the so-called cognitive penetration of perception, and insist that perception and cognition are fundamentally distinct. The aim of this chapter is to give the reader some theoretical background, and to show how the main topic of this thesis – how to distinguish perception from cognition – fits in a broader picture. Particularly, I think the cognitive penetration debate is a good illustration of how determining what counts as perception, on the one hand, as opposed to cognition, on the other, is not an easy task.

I begin by briefly describing what I take to be the common understanding of perception and cognition. Then, I turn to Fodor's modular conception of the mind. On this view, perception is clearly distinct from cognition. Then I discuss the evidence that purportedly show widespread cognitive influences on perception – evidence that directly conflicts with the modular conception of the mind. As we shall see, there are various reasons for doubting this evidence. Towards the end of the chapter, I shift focus from *whether* there is a distinction, to *how* to make the distinction.

1.1 The common conception of perception and cognition

Pre-theoretically at least, it seems that we have a fairly good understanding of what perception and cognition is, and on the face of it, they seem like quite different phenomena. We usually take perception to be something like openness to, or awareness of, the external world. Perceptual experience presents us with what we take to be mind-independent objects and their sensible properties. We also take it that the objects and properties we perceive are what caused the experience we have, by stimulation of our senses. Traditionally, our senses are thought to include sight, smell, tastes, hearing, and touch. For example, when I have a visual experience as of a dog running in circles on the lawn chasing its own tail, I take what I see – the dog, its fur, its tail, the lawn, its greenness, and so on – to be things in the world independent of my experience of them. I also take these things to be presently before me, and I believe that they caused my experience by certain wavelengths of light reflecting from the objects hitting my eyes. (Crane & French, 2017)

Sometimes, what we perceive does not correspond to the outside world. I can, for example, see something which in fact is grey, as blue, or I can see an object, say a tree, as having a different size than it actually has. Some illusions might have more harmful behavioural consequences than others, like seeing a wolf as a dog, or seeing a lake as covered with ice when it is actually just unusually still. Illusion is a matter of seeing something as having properties that it does not have. There is also the possibility of hallucination – having perceptual experiences as of things that are not present at all. Hallucinations are commonly associated with drug intake and mental illness. People with schizophrenia, for example, often report hearing voices, or seeing things that are not there. When illusions and hallucination occur, we usually take it that perception has made an error; that the perceptual capacity has failed in properly performing its task. (Crane & French, 2017)

The fact that we take perception to be something which puts us in somewhat direct contact with our immediate external environments, and that we think that something has gone wrong when our perceptual experience does not correspond to the outside world, serves to illustrate how we ordinarily think of perception as something which, when working properly, presents the world to us *with the goal of presenting it the way that it actually is*.

Cognition is meant to capture, roughly, the capacity of thought. Thinking is unlike perceiving in that it does not essentially involve, and is not limited to, the “here” and the “now”. I can think of things that happened years ago, even before I was born, I can wish for future things, I can imagine things that have never, or will never, exist, and so on. Cognition centrally involves reasoning, evaluation, knowledge, belief, memory, decision making and problem solving. Very roughly speaking, one could say that, as usually understood, while perception is the process of acquiring new information; cognition makes use of already existing information in its operations.

Since perception and cognition are taken to be, at least by and large, conscious mental states, there is a sense in which we can say that we, as conscious beings, have a direct understanding (or conception) of what perception and cognition is. A lot of what's going in our heads is of course unconscious. But when it comes to our conscious mental states, we can say that *it is something it is like* to undergo them. The "what-it-is-like"-aspect of mental states – the subjective perspective of experience – is called *phenomenal character*. There is a distinct phenomenal character associated with different types of perceptual states. What it is like to visually perceive something is very different from what it is like to hear something, for example. Whether cognitive states also exhibit phenomenology is more controversial. Is there a distinct way it is like to believe that zebras have stripes, or to calculate 56+87 in one's head? We do have, of course, beliefs, desires, memories, and so on, which are not presently conscious and so obviously do not have a phenomenal character. However, it might seem implausible that *no* cognitive state has phenomenology. It might seem strange, for example, to insist that it is nothing it is like for me to be in the conscious cognitive sate that I presently am (the state of me cognitively trying to come up with a good formulation of the thoughts I wish to express), especially since a condition for it being conscious seems to be that it is something it is like for me to undergo it. (Smith, 2016)

If there is something like cognitive phenomenology, it is obviously very different from the phenomenology of perception. The experience of seeing the splashes of waves on a sandy beach, the blueness of the ocean, while the setting sun slowly falls into the horizon and colours the sky orange, is rich, clear and vivid (Hume, 1739). The phenomenology of thought would seem obscure in comparison, which can be demonstrated by asking someone to describe what it is like to undergo the thought processes they do. It's not easy. The experiential differences between perception and thought arguably strengthen the deep and intuitive understanding we have of the two as distinct.

There is something that perceptual and cognitive states both seem to have in common, however, and that is that they are about things; they have a subject matter. I see *that* such and such, I think *that* such and such, and so on. They seem to be mental states that are directed toward something beyond themselves. The power of mental states to be about things, or to represent, is called *intentionality*. Intentional states have content, or meaning. They carry information. My belief that Oslo is the capital of Norway has the content 'Oslo is the capital of Norway'. It represents Oslo, and it represents it in a certain way, namely as the capital of Norway. Most will agree that cognitive states, such as beliefs and judgments, are intentional states. I will also assume, although this is a bit more controversial, that perceptual states are intentional also. So, analogous to beliefs, I will assume that perception has content. The content of a perceptual experience is what that perceptual experience "tells" me – the information conveyed by that particular perceptual state. (Siegel, 2016)

So, on the common conception, we take perception and cognition to be different both in what they do, and what it is like to do it. The purpose of perception is to convey correct information about our immediate surroundings. Cognition, on the other hand, involves forming beliefs, making decisions and solving problems, on the basis of already existing information. The role of cognition is therefore much more general than that of perception. Moreover, there is a distinct phenomenology associated with each perceptual modality, while the phenomenology of cognitive states is much more obscure (if they have any).

1.2 The modularity of mind

In *The modularity of mind* (1983), Jerry Fodor presents the idea that the mind divides into functionally distinct systems, some of which exhibit *modularity*. Although Fodor's theory is considerably more complex and technical, I think his overall picture harmonize well with our common understanding of the mind. The modular conception of the mind is committed to a clear distinction between perception and cognition. The view has dominated the studies on perception for the last decades, but despite its success in uncovering the operations of the visual system, the view is threatened by extensive evidence that cognitive states routinely interact with perception.

In his influential book, Fodor distinguishes between *input systems* and what he calls *central systems*. The input systems are the systems underlying perception, while the central systems underlie cognition[1]. The function of the input systems is to process information resulting from proximal stimulation of the sensory organs as to make it accessible to the central systems (p. 42). In other words, the inputs systems function to represent the world as to make it accessible to thought. (p. 40)

Fodor's main argument is that the input systems, in contrast to the central systems, are *modular*. For the input systems to be modular, in Fodor's sense, involves having a number of theoretically interesting properties in common. In having these properties in common the

[1] Fodor also thinks there are input systems underlying basic forms of language processing. I will not focus on this issue.

input systems pick out a natural kind, where ‘natural kind’ is understood as “…a class of phenomena that have many scientifically interesting properties in common over and above whatever properties define the class” (Fodor, 1983, p. 46).

So, what are the properties that the input systems share, in virtue of which they are modular? First of all, input systems are *domain specific* (p. 47). This means that they are restricted in what they can take as their input. Simply put, the visual system only processes information resulting from retinal stimulation, while the auditory system only processes information resulting from stimulation of the eardrum, and so on. In other words, vision is limited to visual input and audition is limited to auditory input.[2]

Further, the inputs systems are *fast* (p. 61) and have *mandatory operations* (p. 52). For example, we cannot decide not to process the visual information coming through our eyes, or the auditory information coming through our ears. We have no conscious control over the operations. Of course, you can try not to focus on, or to ignore, elements of your perceptual experiences, for example if there is an annoying sound in an otherwise quiet room and you’re trying to read. But most certainly this is a matter of attending away from, and not a matter of turning off, perception. This is also reflected in that the input systems are, according to Fodor, *inaccessible* (p. 55) from the central systems. The central systems do not have access to the operations carried out by the input systems, prior to their delivering of their outputs. We do not, for example, have access to the two-dimensional image formed on our retina when we see, and we cannot consciously intervene with the input processes, and, for example, choose to hear an uttered sentence in a language we know, not as language, but as mere noise.

Moreover, the input systems have *shallow outputs* (p. 87). Very roughly, this means that there are constraints on what the outputs of the input systems can be. If vision is modular, then the visual system can arguably not deliver non-visual outputs, for example. It cannot represent sounds, or smells. However, the visual system is, according to Fodor, restricted also in which visual features it can represent. For example, while there is little doubt that the

[2] Fodor thinks that there are domain specific input systems within the different perceptual systems. With regards to the visual system for example, there might be one system responsible for processing color information, another for information about motion, and so on. (p. 47) Presumably, however, if the input systems underlying vision all qualify as modular, it seems plausible, and in accordance with Fodor’s theory, that the visual system as a whole will qualify as a modular input system as well.

output of the visual system contains such things as colour, shape, texture, and so on, its output can most likely not contain highly theoretical things such as 'proton'.[3]

According to Fodor, input systems also have a *fixed neural architecture* (p. 98), their *ontogeny exhibits a characteristic pace and sequencing* (p. 100), and they exhibit *characteristic and specific breakdown patterns* (p. 99). The input systems are innate in us, and even though they are individuated by function and not by location, the input systems are associated with specific neural structures in the brain. There is evidence that the processes develop more or less uniformly among individuals. For example, infants seem to develop colour vision and their capacity for object recognition at the same stage and order in their development. This suggests that the development of our perceptual capacities is ontogenetically determined and not a result of intentional learning. Moreover, there is general agreement that there are patterns in how input systems fail to function, when they do. For example, otherwise cognitively functioning subjects can lose, or lack, the ability to visually individuate objects, to see colour, or to see motion. One might think that it is odd that such narrow and specific aspects of mental life can be impaired, while the rest functions perfectly well. But on Fodor's view, this seems rather natural. If there are highly specific and closed off systems underlying our perceptual capacities, and these systems can to a certain extent be neurally localized in our brains, then one would expect that damage to any of these systems would have effect only on the output of that system.

Finally, and most importantly, the input systems are *informationally encapsulated* (p. 64). A system is informationally encapsulated insofar as it cannot access information outside the system in performing its operations. The function of the visual system, for example, is, on Fodor's view, to process the information resulting from stimulation of the retina as to generate a representation of the outside world. In performing its task, the visual system is informationally encapsulated to the extent that, in generating visual outputs, the system is guided only by information internal to the system, where that is the information resulting from the retinal stimulation together with "assumptions" about such information that is innately built into the system itself.

[3] As we shall see, the central issue of this thesis is how to determine what the outputs of perception are. I will leave this issue aside for now, however, and focus on Fodor's general theory.

A well-known example that serves to illustrate how vision is thought to be informationally encapsulated is the Müller-Lyer illusion. Even when a subject explicitly *knows* that the two arrows are same length, the illusion that they are different remains. This is arguably because the visual system does not have access to the subject's beliefs, which is external to the system, in forming the visual representation. If vision is informationally encapsulated, then no such information, including beliefs, expectations, desires, and so on, can affect the outputs of the visual system.

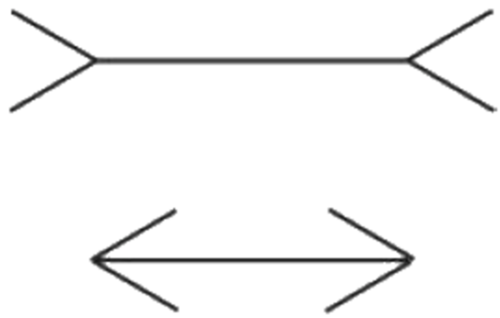

Figure 1. The Müller-Lyer illusion

According to Fodor, informational encapsulation is the essence of the modularity of the input systems (p. 71). It is in virtue of being encapsulated systems not depending on other processes of the brain, that the input systems have many of the properties they have. For example, the domain specificity of the systems is a natural consequence of encapsulation; in being informationally encapsulated a system is restricted in what information it has access to. It is also what makes the systems able to operate as fast as they do; they would be a lot slower if they had to perform complex operations over an unrestricted amount of information. That the input systems are informationally encapsulated also seems to explain the mandatoriness of their operations, since the central systems cannot intervene. Moreover, the inaccessibility from the central systems, as might have become clear, is more or less just one aspect of informational encapsulation. That encapsulation is essential to modularity is important to note, since it implies that the modularity of the perceptual systems stand and fall on whether (or to what extent) their processes are informationally encapsulated. As we shall see, the claim has repeatedly been challenged.

When it comes to the central systems – the systems responsible for cognition and conscious thought – these processes are, as opposed to the input systems, unencapsulated and thereby not modular (p. 103). The central systems receive information from the various input systems, and so naturally, they must have access to information from more than one domain. According to Fodor, “the typical function of central systems is the fixation of belief (…) by nondemonstrative inference” (p. 104). When we undergo a given experience, for example, the central systems consider the outputs delivered from the input systems, compares it with already stored information, and on basis of this information comes up with the best available hypothesis about what the world is like. When I look at the Müller-Lyer illusion, for example, the output of the visual system tells me that one of the arrows is longer than the other. But as I have encountered this illusion before, and even remember one instance of measuring the arrows, I know that they are in fact the same length. Taking this into account, I therefore reject the hypothesis that the arrows are different, and conclude that they are the same length, despite what my eyes are telling me.

According to Fodor, the nondemonstrative fixation of belief has two central properties; it is what he calls *isotropic* and *Quineian* (p. 105). By being isotropic, Fodor means, roughly, that all accessible information is, in principle, relevant in determining what else to believe. By being Quineian, Fodor means that the degree of confirmation we assign to a hypothesis is sensitive to the belief system as a whole. These properties are intimately connected, but they are not identical. Being isotropic reflects how a given belief might affect, or be affected by, other beliefs in a system of beliefs, while being Quineian reflects how a belief is sensitive to the belief system as a whole.

Being isotropic and Quineian clearly conflicts with encapsulation, since for a system to have these properties requires it to have (at least potentially) unlimited access to information residing anywhere in the central systems as a whole. If the process of me forming a belief, which according to Fodor is the main function of our cognitive capacities, is sensitive to what I already know, and the degree to which I come to believe it is sensitive to my belief system as a whole, then this process must have access to all this information. And of course, if the process has this kind of access it cannot be an encapsulated process. Furthermore, since encapsulation is, as Fodor claims, more or less the essence of modularity (partly in being responsible for modular systems having most of the properties they have), the unencapsulation of central systems also makes them non-modular.

On Fodor’s picture, one could say that the mind overall is something like a general-purpose computer. It has different input systems, each specified in processing different types of external stimuli, generating specific representational outputs which are delivered to the central systems. The central systems have access to the outputs of the input systems as well as information stored in the central systems (memories, beliefs, knowledge etc.). Being limited in what kind of information they process, and what kind of outputs they generate, the operations of the input systems are fast and specific. The central systems are much more general in their operations. They have the capacity to process large amounts of very different types of information, and to perform complex calculations for various different purposes. In return, this makes the central systems considerably slower than the input systems. The most important point for the present discussion is that on the modular view of the mind, perception and cognition are fundamentally distinct mental processes, with a definite boarder between them.

1.3 Cognitive influences on perception: is there a real distinction?

Judging from what has been presented so far, perception and cognition seems like distinct processes. However, an increasing body of evidence is suggesting otherwise, giving rise to a radically different conception of perception; one which seemingly blurs the distinction between perception and cognition.

In recent years, various studies in cognitive science have suggested that beliefs, purposes, emotions, and other psychological (as well as physiological) states, can influence perception. Such influences on perception are often called *cognitive penetration* or *top-down effects*. The idea is that higher-level cognitive states can penetrate low-level perceptual processes so as to dramatically alter their content. The cognitive penetrability of perception directly opposes informational encapsulation and thereby also challenges the modularity of mind. If the perceptual systems are continuously penetrated by cognition, then they cannot, by definition, be informationally encapsulated.

The idea traces back to the 1950s, and the “New Look” movement in psychology. Pioneers were Jerome Bruner and Cecile Goodman who in 1947 published a study where children were asked to estimate the perceived size of coins and pieces of cardboard. The study showed that children perceived coins as larger than pieces of cardboard of the same size, and that poor children perceived coins as larger than wealthy children (Bruner & Goodman, 1947). Their conclusion was that values and needs can affect perceived size. These results triggered a number of different studies with similar results, suggesting that all kinds of mental states, expectations, and so on, determine how we perceive the world. During the 1960s, the "New Look" movement eventually faded out, due, in part, to problems with replicating the studies. However, in recent years countless of new studies have been published with conclusion in the "New Look" spirit (Firestone & Scholl, 2016a).

For example[4], researchers have reported that desirable objects look closer, and also larger, than undesirable objects. One study showed that thirsty subjects judged a water bottle seen from a given distance as closer than non-thirsty subjects (Balcetis & Dunning, 2010). Another study reported that muffins were perceived as larger by dieting subjects than by non-dieting subjects (van Koningsbruggen, Stroebe & Aarts, 2011). It has even been reported that women's breasts look larger to men who have been primed with sexual images (den Daas, Häfner & de Wit, 2013). Such motivational effects on perception have led some theorists to conclude that, instead of seeing the world as it really is, people rather "see what they want to see" (Dunning & Balcetis, 2013, p. 33). This kind of "wishful seeing" is thought to (at least sometimes) have adaptive consequences; when objects look closer and larger, they are easier to spot and approach.

Other studies allegedly show that our emotional states affect what we see. For example, there has been published evidence that reflecting over unethical actions makes the world look darker (Banerjee, Chatterjee & Sinha, 2012; Meier, Robinson, Crawford & Ahlvers, 2007), that smiling faces look brighter than non-smiling faces (Song, Vonasch, Meier & Bargh, 2012), and that heights seem higher to those who fear them (Stefanucci & Proffitt, 2009). Since emotions often reflect our needs, it is thought that such "emotional colouring" of what we see might have some advantages (Banerjee et al., 2012).

There is also evidence that the categories and language we use determine our perceptions. For example, studies suggest that categorizing faces as 'white' or 'black' makes them look lighter or darker, respectively, even when the faces have the same average luminance (Levin & Banaji, 2006). It has also been reported that expectations about categories alters perceived instances of those categories. For example, knowing that bananas are yellow, and that carrots are orange, supposedly makes greyscale images of the objects appear luminated in their typical colour (Hansen, Olkkonen, Walter & Gegenfurtner, 2006). Additionally, there is

[4] The following examples are mentioned in Firestone and Scholl's 2016a Paper. They are just some examples out of many. Firestone and Scholl have collected over 170 studies only since 1995 showing similar cognitive effects on perception. The studies are listed on the following web site: http://perception.yale.edu/Brian/refGuides/TopDown.html

evidence that “activating” linguistic categories enhance visual processing of stimuli corresponding to the category. For example, verbally hearing the word ‘kangaroo’ supposedly makes it easier to visually detect kangaroos (Witzel, Valkova, Hansen & Gegenfurtner, 2011).

There are also reports that abilities, purposes and even physical states influence perception. A classic example is that of Bahlla & Proffitt (1999) who claims to have shown that wearing a heavy backpack makes hills look steeper. Other studies have shown that so does being fatigued or physically unfit (Bhalla & Proffitt, 1999; Cole, Balcetis & Zhang, 2013; Sugovic & Witt, 2013). Drinking Coca-Cola or other sugary drinks, on the other hand, supposedly makes hills look shallower (Schnall, Zadra & Proffitt, 2010). It has also been reported that batters who hit well perceive softballs as bigger (Witt & Proffitt, 2005) and that skilled golfers perceive golf holes as larger (Witt, Linkenauger, Bakdash & Proffitt, 2008). These researchers often emphasize that perception primarily exist to guide action. On their view, a central function of the visual system is to help us in action planning, by modifying the perceived environments to make it easier for us to make the right decisions (Proffitt 2006; 2008; Proffitt & Linkenauger, 2013; Witt, 2011). For example, if we wear a heavy backpack, or are worn out, the visual system makes hills look steeper to protect us from choosing to climb up hills we might not manage to climb, or to make us look for less energy consuming alternatives. If we have been drinking sugary drinks or are feeling in shape physically, however, hills look shallower, because we have the energy levels and ability to climb them. In this way, we do not have to evaluate neutral visual outputs and compare one by one the associated costs and benefits of different actions; perception has already made the beneficial actions literally *look* more attractive according to what we want to achieve, and correspondingly decision-making requires less thought.

As indicated above, this evidence seems to blur the distinction between perception and cognition. If perception systematically interacts with all kinds of mental states, then the conception of perception as a functionally distinct process seems to lose some of its appeal. The evidence of top-down effects directly opposes the view that perceptual processes are informationally encapsulated, and thus challenges the modularity of perceptual systems. It might be possible to maintain the distinction between perception and cognition even after rejecting the modularity of perception (after all, the cognitive penetrability of perception, defined as influences of cognitive states on perceptual states, at least in some sense presuppose that there is a distinction). However, it seems that without (at least something like) modularity, we seem to lose some of the independent grasp of perception that we first seemed to have.

If the interaction between perception and cognition is as extensive as the evidence suggests, then this arguably should make us re-evaluate to what extent we are warranted in thinking that the labels ‘perception’ and ‘cognition’ actually correspond to a real distinction in the mind. This is indeed what many theorists have done. For example, as Miskovic, Kuntzelman, Chikazoe & Anderson writes: “It is quite possible – indeed it seems likely – that static distinctions between perception, cognition, and emotion reflect much more about historical intellectual biases in the field of cognitive science than about the true operations of the brain/mind” (Miskovic et al., 2016, p. 42).

Moreover, as mentioned above, the modular conception of the mind has dominated the research on perception the last decades. Most of our current models for explaining the operations of the visual system is based on this account, and does consequently not involve such things a desire, belief, language, purposes and so on. If what these researchers report is right, then a revolution in our conception of the mind is called for.

The evidence of cognitive effects on perception could potentially have substantial epistemic consequences as well, in that it challenges the idea of theory-neutral observation. Both in everyday life, and in science, we commonly base and justify our beliefs and knowledge by reference to what is seen, or otherwise observed. But if perception is not the capacity of receiving neutral information about the external world then this raises doubts about the extent to which perceptual observation can provide adequate justification for knowledge.

1.3.1 Firestone and Scholl’s reply: “the distinction is real, the cognitive influences are not!”

Is the evidence for massive top down penetration convincing? Despite the enormous amount of evidence, Chaz Firestone and Brian Scholl (2016a) reject that perception is subject to top-down effects. They identify six empirically based “pitfalls”, which they argue undermine each and every study on cognitive effects so far reported (p. 7). Each pitfall points to methodological flaws of the research. The pitfalls provide alternative explanation of the effects. The pitfalls suggest that, instead of being effects on perception itself, each alleged top-down effect can be explained as being an effect either on post-perceptual cognitive processes, or pre-perceptual attentional processes. In some instances, the effects can even be explained by low-level differences between the presented stimuli itself. Moreover, Firestone and Scholl not only show that the top-down studies *could* be susceptible to these pitfalls, for each pitfall, they provide empirical examples of reported effects that actually *are* explained by the given pitfall. I will now briefly describe each pitfall.[5]

Pitfall 1: An overly confirmatory research strategy

The first pitfall is based on general principles about confirmation and disconfirmation in empirical research. "Not only should you observe an effect when your theory calls for it, but also you should *not* observe an effect when your theory demands its absence" (Firestone & Scholl, 2016a, P. 7). Firestone and Scholl's worry is that most of the studies on top-down effects only involve tests that could potentially confirm their hypothesis, neglecting the tests that could potentially disconfirm it. Surely, this last sort of testing is just as important as the first; discovering every black raven supports the hypothesis that all ravens are black, but the hypothesis cannot be confirmed until you have excluded that there also are white ravens.

Firestone and Scholl (2014) conducted a study that investigated such disconfirmative predictions of top-down effects. The study was inspired by Banerjee et al.'s (2012) study which showed that reflecting on unethical actions makes the world look darker. In the original study, the participants were asked to rate the brightness of the room on a numerical scale after reflecting on either ethical or unethical actions. Firestone and Scholl succeeded in replicating the effect; the room was judged as darker by the subjects who reflected on unethical actions. However, their study involved a crucial, but ingenious, twist. Instead of asking the participants to rate the brightness of the room using a numerical scale, they made the participants use a scale of actual greyscale patches in doing their ratings. The alert reader might notice that this change completely reverses the prediction of the study: if reflecting on

[5] Before turning to the pitfalls, I must point out a remarkable thing about the reported top-down effects (which instantly should provoke some suspicion). This remarkable thing is that the effects do not seem to impact our phenomenology. You can try this yourself. For example, you can try putting two objects of the same size in front of you, one in which you desire and one in which you don't. Does the desirable object look closer and larger? Alternatively, you can try to reflect on unethical actions, for example physical abuse, and see whether your surroundings visually seem darker, or you can check whether the hill before you become steeper when you put on a heavy backpack. If the alleged effects are real, then the fact that you will not experience any phenomenological difference seems very odd. As Firestone puts it, "[i]f the perceptual world is always warping before our eyes, then why don't we notice it?" (Firestone, 2013, p.464)

unethical actions actually makes the world look darker, then the greyscale patches should look correspondingly darker too. In other words, the effect should be "nulled" out by this type of measuring. The fact that Firestone and Scholl succeeded in obtaining the effect when there should have been none indicates that the effect could not be an effect on what the subjects actually perceived (pitfall 2 might illuminate what the effect really reflects).

This type of fallacy applies to any reported top-down effect which should equally affect the means measurement itself and what's being measured. And as Firestone and Scholl (2016a) contend: "The studies that fails to test such predictions are too numerous to count; essentially, nearly every study falls into this category" (p. 8).

Pitfall 2: Perception versus judgment

Most of the experiments conducted on top-down effects on perception are based on participant report, verbally or otherwise. The worry with report-based studies on perception is that they can fail to distinguish between perception – what is actually seen – on the one hand, and perceptual judgment – judgments based on what is seen – on the other.

Firestone and Scholl (2016a) points to evidence favouring the alternative explanation that many of the reported top-down effects are effects on judgment rather than perception. For example, Witt et al. (2004) reported that the effort associated with a given action (in this case throwing a ball) can affect distance perception. In their original study, participants were asked to throw either a heavy ball or a light ball at targets, and then judge the distance to the targets (Witt, Proffitt & Epstein, 2004). The participants who threw the heavy ball judged the targets as farther away than those who threw the light ball, which formed the basis for their conclusion. However, Woods, Philbeck & Danoff (2009) followed up on this experiment. In their modified version, the participants were separated into three different groups, where each group was given different sets of instructions, varying in what factors the participants were asked to take into account in making their distance judgments. The first group, after throwing either a heavy or a light ball, was asked to estimate the distance based on *objective (physical) distance*. The second group was asked to make their estimations based on *apparent (perceived) distance*. Finally, the third group was asked to focus on *nonvisual factors*, where this is meant as something like "felt" distance, in making their estimations. Woods et al. (2009) were only able to replicate the effort-effects reported by Witt et al. (2004) in the third group, where nonvisual factors formed the participants' basis for judgment.

Although it seems obvious that distance must be a perceptual property, it seems plausible that how we *judge* distance could be influenced by factors beyond what we actually see. In this way, it is likely that associating different actions, and the effort it takes to preform them, with the environments we find ourselves in can change our *impressions* of this environment, however, it is not obvious that this change is a change in what is actually *seen*. This supposition is further strengthened by the fact that similar effects have been found also for non-visual judgments. For example, Alter & Balcetis (2011) found that forming positive attitudes towards New York City made subjects judge the city as closer to their current location (Princeton). Taking this into account, it seems likely that many of the reported effects on perception could be due to the participants taking into account more than purely perceptual factors in making their judgments. However, as Firestone and Scholl (2016a) points out, "it is striking just how few discussions of top-down effects on perception even mention judgmental effects as possible alternative explanations" (p. 10).

<u>Pitfall 3: Demand and response bias</u>

The third pitfall is only slightly different from the second. Whereas the second pitfall made it plausible that many reported top-down effects were in fact effects on the participants' (sincere) judgment, the third pitfall raises the worry that many of the alleged effects are first and foremost effects on their *response*.

The accusation is that many of the experiments on cognitive effects on perception are vulnerable to *demand characteristics*: that the participants form an impression of the study's purpose and consciously or subconsciously alter their behaviour accordingly. A usual way in which experiments can be biased in this way is if the experimenter implicitly (but not purposely) communicates the purpose of the experiment in their interaction with the participants. Durgin, Baird, Greenburg, Russell, Shaughnessy & Waymouth (2009) conducted a study testing for demand characteristic effects with a modified version of the study on effects of wearing a heavy backpack on slant estimation of hills (although, in this experiment, Durgin et al. used a two meter long wooden ramp instead of a real hill). First, they succeeded in replicating the effect: the group wearing a heavy backpack estimated the wooden ramp as steeper than those who did not. But this experiment also had ha third group of subjects, who in addition to wearing a backpack, was told, falsely, that the backpack contained equipment for monitoring their ankle muscles. The subjects also had a wire leading from their ankle to the backpack, to make the story more convincing. The hypothesis was that the subjects who wore a backpack without being provided any explanation for it would see the connection between the backpack and how it was supposed to affect their impression of the hill (or, in this case the wooden ramp), and thereby complied (consciously or not) with the experimenter's expectations in giving their response. If, on the other hand, the subjects were offered an alternative explanation about why they wore the backpack, Durgin et al. (2009) hypothesized, this would deceive the participants about the purpose of the experiment, so that its real purpose would not bias their response. This was exactly what they found. The slant estimations of the third group, with the alternative explanation for the backpack, matched, not the group who wore unexplained backpacks, but the group who did *not* wear backpacks. In other words, the alleged perceptual effects of wearing a heavy backpack vanished when subjects were given an alternative explanation for why they wore it. Durgin et al.'s conclusion - that demand characteristics can be responsible for the reported effects of wearing backpacks (and possibly also for other reported effects on perception) - is supported by the fact that almost every subject who wore the backpack without explanation, in a post-experimental questionnaire assessing their beliefs about the purpose of the experiment, explicitly reported seeing a connection between the backpack and perceived slant of the ramp.

Several other studies also support this conclusion. For example, explicitly informing participants about demand characteristics have shown to eliminate the backpack effects (Durgin, Klein, Spiegel, Strawser & Williams, 2012). The effect of wearing a heavy backpack has also shown to decrease when participants were accompanied by a friend (Schnall, Harber, Stefanucci & Profitt, 2008). Although the conductors of this study concluded that social support influence perception, an arguably more plausible explanation would be that the social support reduced the pressure to go along with what the experiment (implicitly) expected of them (Firestone, 2013).

Pitfall 4: Low-level differences

The fourth pitfall raises the worry that some reported top-down effects could be explained by differences in low-level properties of the test stimuli. For example, Levin & Banaji (2006) found that faces categorized as 'black' are perceived as darker than 'white' faces, even when the faces have the same average luminance. What's exciting about this particular effect is that it, in contrast to nearly every other reported top-down effect, can actually be demonstrated. Consider figure 2; the two faces are matched in mean luminance, however, the 'black' face clearly looks darker then the 'white'. The fact that we can clearly *see* the effect makes it considerably more persuasive. However, can we be sure that it is our racial categories that causes this effect? Firestone and Scholl's worry is that how light or dark an object looks might be determined by low-level factors above mean luminance (like, for example, their pattern of illumination and shadow). If you take a closer look at the faces, you can see that they do not seem to stand in the same light conditions. Thus, it seems possible that the (low-level) differences in illumination and shadow could explain why the lightness of the faces look different.

Figure 2. A 'black' and a 'white' face matched in mean luminance From Firestone and Scholl (2016a)

Firestone and Scholl (2015a) tested this alternative explanation using a blurred version of the faces (demonstrated in figure 3). The faces still have the same mean luminance, however, one can arguably no longer tell what race the faces have. The results of their study showed that even the subjects who judged the faces to have the same race still judged the left face to be darker than the right. If a subject thinks the faces have the same race, then it is hard to imagine how facial categories could affect the perceived lightness of the faces. This pitfall mainly concerns the studies where the stimuli itself varies across experimental conditions

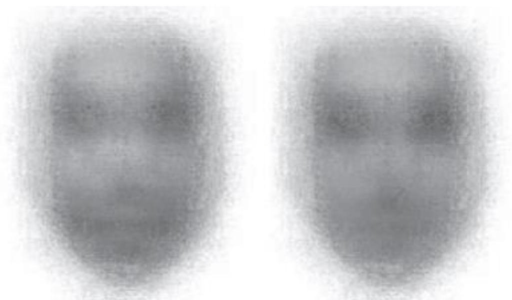

Figure 3. Blurred version of the faces in Figure 2. From Firestone and Scholl (2016a)

Pitfall 5: Peripheral attentional effects

The fifth pitfall concerns attention. Firestone and Scholl (2016a) argue that shifts in attention, for example in the locations or features we are focusing on, can account for many top-down effects. Attention is of course closely linked to perception, and can partly account for what we see (or notice) and what we miss. Additionally, attending to an object is generally thought to enhance our perception of it, enabling us to see it clearer and in more detail (compared to unattended objects). And crucially, we can (at least to a certain extent) intentionally control what we attend to. However, Firestone and Scholl's contention is that attentional effects are completely independent of your reasons for attending in a given direction. Desires or purposes, for example, might make us attend more to a given object, which can enhance our perception of it (making it clearer which thereby perhaps makes it look larger, closer, lighter, etc.), but the perceptual effect of attending to it does not depend in any way on the content of our purposes and desires. Most studies fail to consider what they take to be purposes, desires, and so on, directly altering what we see, could in fact be indirect effects of attention.

Pitfall 6: Memory and recognition

The final pitfall concerns the studies that report top-down effects that centrally involves recognition. For example, Gantman and Van Bavel (2014) purportedly showed that words related to morality are easier to see than words that are not. In this study, subjects were presented with flashes of either words or non-words, and asked to report whether what they saw were real words or not. The subjects were considerably better at identifying morally relevant words (like 'justice', 'victim', 'hate') than other real words not related to morality (like 'pilot', 'house', 'confuse'). They call this the *moral pop-out effect*, based on the idea that morally relevant stimuli more easily "pops" into our visual awareness, probably because, in satisfying many of our "core motives", morality has a priority in perceptual processing (Gantman & Van Bavel, 2014).

As indicated, studies like this seem to be more directly tied to *recognition* than to that of purely *seeing*. Firestone and Scholl's worry is that "…by its nature, recognition necessarily involves not only visual processing per se, but also memory: To recognize something, the mind must determine whether a given visual stimulus matches some stored representation in memory" (Firestone & Scholl, 2016a, p. 15). Thus, it seems that any study involving effects on recognition could be an effect on memory access rather than a top-down effect on perception itself. A notable detail with the moral pop-out experiment is that the moral words are not only related to morality, they are also related to each other (in virtue of being morally relevant). In contrast the morally irrelevant words have no such relation. This opens for the possibility that, instead of being a perceptual effect specific to morality, it could be a general instance of semantic priming. It is well-known that word recognition can be enhanced by initially priming subjects with related words. But crucially, this is not regarded as an effect on perceptual processing, but rather an effect of activating certain parts of memory. If the alleged moral pop-out experiment really just is a regular priming effect on memory, then we should expect to see the same result with any group of related words, and not just with words related to morality. This is exactly what Firestone and Scholl (2015b) found. They replicated the study, and found the same effect, first with words related to clothing, then with words related to transportation. Firestone and Scholl (2016a) conclude that any study that involves visual recognition, but fails to separate perception and memory, is susceptible to this pitfall.

1.4 Shifting the focus towards how to make the distinction

The pitfalls cast serious doubt on the evidence of top-down effects. Although I think this discussion does not end in favour of the top-down theorist, the primary reason for presenting the debate was not to disprove top-down effects. I think the debate is a nice illustration of what's potentially at stake. I also think it helps give the reader an idea of what a mind where perception and cognition is distinct, as opposed to a mind where perception and cognition conflates, might look like. Additionally, as what the two sides of the debate ultimately argue about is whether a large group of effects occur at the level of perception, or whether they can be explained by other mental processes, I think it nicely illustrates how isolating perception from other cognitive processes can be quite complicated. Despite being intimately connected, however, whether perception is cognitively penetrable, and whether there is a dividing line between perception and cognition, are ultimately two different questions.

Although the distinction between perception and cognition (at least partly) depends on whether or not they interfere, I think the top-down debate illustrates how this also goes the other way around; in order to determine whether (or to what extent) cognition influence perception, we need to get clear on what counts as perceptual. The top-down theorist might not expect there to be a way of making this delineation, however, I do not think the outcome of this debate in any way shows that this is something that can be taken for granted. From here on out my focus will not be on whether there are cognitive top-down effects on perception, but on whether there is a principled way of distinguishing the two.

After all, there are reasons to think that perception is different from cognition that does not ultimately depend on whether perception is penetrable or not. One of the most apparent reasons, which has been emphasized both by Firestone and Scholl (2016b) and Pylyshyn (1999), amongst others, is that perception and thoughts can, and often do, conflict. As mentioned above, the Müller-Lyer illusion maintains even when you explicitly know that the lines have the same length. What you know cannot correct what you see. Although the conflict between perception and thought often is used as an illustration of the cognitive impenetrability of perception, it does not exclude the possibility that cognition can influence perception in other ways. However, such conflicts strongly suggest that what you see and what you think is not a result of the same underlying process. Moreover, perception and cognition seem to be governed by quite different principles; a point which becomes apparent when you consider a phenomenon called *amodal completion* (illustrated in figure 4). In figure 4 A you see three geometrical shapes. The one in the middle is partially covered by two black squares. While it seems obvious to reason that the middle shape is of the same octagonal shape as the two others, it nonetheless *looks* as though it has a different, unfamiliar, shape. And similarly with figure 4 B. Though it seems obvious to infer that what's hiding behind the grey rectangle is the head of a lion and the back part of a moose, it visually looks like an unrealistically long animal.

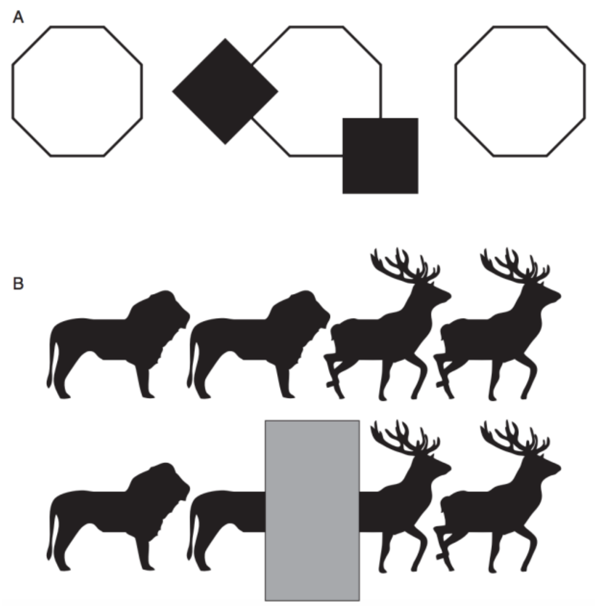

Figure 4. Illustration of amodal completion. From Firestone and Scholl (2016b)

Perception seems to have a way of "filling in" the covered parts of the figures that does not follow rules associated with rational thinking, such as, for example semantic coherence (using the broader context to interpret the covered parts), or to favour the most likely scenario (given the evidence available). Moreover, the phenomenon is insensitive to learning. Speaking loosely, one could say that perception follows its own logic (pylyshyn, 1999).

Knowledge about the "logic" of perception can be used to create demonstrative illusions. Consider for example the *devil's tuning fork,* or the *impossible triangle*. These are two-dimensional images of figures which could not exist in three-dimensional space. Despite this fact, perception construct them as three-dimensional by drawing on individual pieces of depth cues from different parts of the images (which put together are not coherent). Since a central principle of thinking is to favour coherency, if seeing was governed by the same processes, we would plausibly expect the visual system not to construct these figures as three-dimensional, since it is obvious that they do not make sense as such. However, as the devil's tuning fork and the impossible triangle demonstrate, construction of perceptual representations is to a large extent determined by "assumptions" about specific features of the visual input, as opposed to rational principles about coherency or physical possibility (Holt et al., 2015).

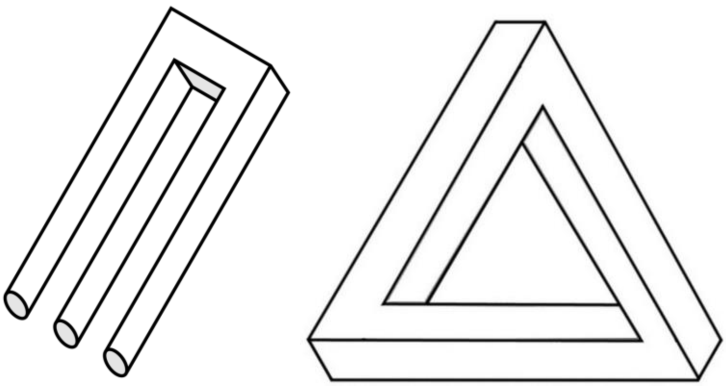

Figure 5. The devil's tuning fork and the impossible triangle.

According to Firestone and Scholl, such considerations "…forces us to acknowledge a *distinction* between seeing and thinking even before offering any *definition* of those processes" (Firestone & Scholl, 2016b, p. 54). I agree. However, that there is a distinction between perception and cognition does not automatically imply that there is a principled way of drawing a strict line between the two. The distinction could be a blurry one. Another possibility is that there are several distinctions; that what counts as perception and what counts as cognition depends (in part) on our interests. In what follows, I wish to take, as an initial assumption, that there is in fact a clear boundary between perception and cognition. My focus will be on how to make the distinction. If the method I pursue turned out not to be successful, then this might come in favour of one of the other alternatives.

1.4.1 Pure perception and perception in a broad sense

As pointed out in the beginning the chapter, we have an intuitive understanding of the difference between seeing and thinking. However, it can be useful to distinguish 'pure perception' from perception in this intuitive, or broad, sense. The intuitive conception of perception involves a broader understanding of the concept, and includes more than that which is purely perceptually represented. It is this notion of perception I make use of when I say that I could *see* that a meal tasted delicious, that I *saw* that someone's coat was expensive, or that I *observed* that an act was unfair. An objects taste, price, or the moral properties of an event, are arguably not something that can be visually represented (mainly because there are no specific visual features corresponding to it). Arguably, we can only *judge* something to have such properties (based on what we see *and* know). The broad conception of perception reflects the overall experience; it is a hybrid state that does not distinguish between perceptual and cognitive representations. Crudely put, it is mix of what you *see* and what you *think* when you see it.

Pure perception, on the other hand, is meant to capture the information conveyed by the perceptual system alone – the *pure* outputs of perception. This is a question of what you, strictly speaking, *see*, or in other words, which representational aspects of your experience are produced by the visual system. The claim that there is a clear distinction between perception and cognition corresponds to the claim that there is a fact of the matter what, in a given experience, is represented purely perceptually. However, discovering which properties the perceptual system represents is not an easy task.

It is commonly agreed that vision represents shape, position, size, motion, texture, luminance and colour – so-called low level properties. It is disputed, however, whether such properties exhaust the outputs of visual processing. Some philosophers defend a more liberal account of perception, according to which perception is capable of representing various much more complex properties, so-called high-level properties, like being a tiger or a pine tree (kind properties), being a specific person (identity properties), someone being happy or sad (emotional properties), or being the cause or effect of something (causal properties) (Siegel, 2016).

Even though we intuitively see all these things, how can we know whether these representations are being produced in the visual system, or whether they are products of (often automatic) cognitive judgments?

Consider looking at an angry face. The face has certain low-level characteristics (colour, shape, luminance, and so on). You "see" that it is a face, and that it expresses anger. But can you know whether the representation of 'faceness' and 'angriness' is something which is attributed by perception rather than cognition?

There are two alternative interpretations of this experience. Alternative 1: the properties 'being a face' and 'being angry' are represented by the visual system. On this interpretation, the visual system has the capacity to specifically detect and represent faceness and angriness. Alternative 2: Faceness and angriness are represented only cognitively. On this interpretation, the visual system represents only the specific shape, size, colour, and so on, of the object. Based on this information the cognitive system (perhaps quite fast and automatically) attributes the properties 'is a face', 'is angry', to the visually represented object.

1.4.2 Which strategy should we pursue?

So how do we choose between these alternatives? How can we distinguish what, in a given experience, is contributed by perception and what is contributed by cognition?

One strategy could be conceptual analysis. Conceptual analysis involves clarifying the meaning of a concept by breaking it down into its constituent, and preferably better understood, parts. A well-known example is the analysis of knowledge as justified, true belief. If a concept is successfully analysed, then all and only the things that are knowledge, are also justified, true, beliefs. Thus, conceptual analysis involves formulating the necessary and jointly sufficient conditions for being an instance of the concept, which then serves as the concept's definition. So, one strategy would be to try to define the necessary and jointly sufficient conditions for being perception and cognition, respectively, making sure that the extension of the concepts don't overlap (Beaney, 2016).

In order to find out whether a concept is successfully analysed, we must test it against a range of possible scenarios where the original concepts ('perception' and 'cognition') apply, and see whether the definition also applies. If the extension of our analysed concepts fully overlap, that is, if there is no scenario where either only the original concept, or the analysed concept, applies, then the analysis is successful. Thus, conceptual analysis ultimately depends on intuitions about the meaning of the concepts involved.

But recall that, according to Fodor (1983), in presenting an account of the structure of the mind where perception and cognition is distinct, thinks that the concepts correspond to natural kinds. That is, he believes that the categories 'perception' and 'cognition' reflects real categories of the mind, independent of how we categorize it. Firestone and Scholl (2016a) also share the view that perception and cognition are natural kinds. So does Block (2014) and Burge (2010), who will be relevant in our discussion. To use the traditional metaphor, discovering natural kinds is a matter of "carving nature at its joints". In order to discover the joints of nature, however, it seems that we are forced to turn our focus outwards, on nature. It is unclear how giving conceptual definitions based on intuition would help us here. What we want is to discover a distinction in the world, not define what the intuitive meaning of a concept is.

Another approach would be to try to settle the matter on the basis of phenomenology. An influential method for distinguishing perceptual from cognitive representations has been the method of phenomenal contrast, of which Susanna Siegel (2006; 2010) is commonly regarded as the main advocate. The method of phenomenal contrast offers a way of testing whether a given property is perceptually represented. In practice, it is mainly used to argue that given high-level properties are in fact perceptually represented (Siegel for example, uses this methodology to argue that we can represent certain kind properties).

The basic idea is that there is a non-arbitrary relation between the content of a visual experience and its phenomenology, so if two visual experiences differ with respect to which properties they represent, they will also differ in phenomenology. The strategy is to compare two mental states which, by intuition, differs phenomenologically despite resulting from similar sensory input, and argue that the best explanation of the phenomenological difference is that one experience has the high-level property in question as part of its perceptual content, while the other does not.

The classical example involves the property of 'being a pine tree'. Suppose that you are not initially familiar with pine trees, but are hired to cut down pine trees in a forest of various different trees. As you perform the task, your ability to distinguish pine trees from other trees improve, and after some time you are able to recognize pine trees immediately. As, Siegel puts it "[t]hey become visually salient to you" (Siegel 2006, p. 491).

Compare the experience of looking at pine trees before you were hired for the job, and were unfamiliar with pine trees, with the experience of looking at pine trees after you have completed the job. Intuitively, the experiences differ in phenomenology. The proponent of liberal accounts of the contents of perception will then argue that the best explanation of the phenomenological difference derives from a difference in content. Your initial experience of looking at pine trees does not involve a perceptual representation of pine trees as pine trees, while after becoming familiar with pine trees you have gained the capacity to perceptually represent pine trees, so the property 'is a pine tree' is part of the perceptual content of the second experience.[6]

However, given that we accept the intuition that there is a phenomenological difference between the two experiences, there are still several alternative explanations of the phenomenal contrast between them. One is that the phenomenal difference is a matter of difference in cognitive phenomenology; that your knowledge about pine trees, or cognitive judgment that certain objects are pine trees, changes what it is like to experience pine trees, but that the perceptual content is unchanged. Another explanation is that familiarity with pine trees guides your attention towards certain low-level features of pine trees which improves your ability to distinguish and identify pine trees. This ability might even change your perceptual content with respect to these low-level features (or only the overall phenomenology), without the experience involving perceptually representing the pine tree as a pine tree.

The problem is that there seems to be no general a priori considerations that can rule out any of these explanations. No amount of introspection about what it is like to undergo the two experiences can give us access to the representational origin of the experience. Based on the phenomenology alone, all the above alternatives seem equally plausible. In other words, I think considerations about what it is like to undergo an experience will not in itself give us

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[6] Correspondingly, if you wish to argue that a given property is *not* perceptually represented, you can compare two experiences, one experience that, if perception had the capacity to represent the property in question would have the property as part of the perceptual content, with a similar experience that clearly would not, and show that they do *not* differ phenomenologically (in the relevant way), and thereby that that they have the same content, both lacking the property in question.

access to which part of the experience originate from perceptual, as opposed to cognitive, processes. I agree with Block (2014) and Burge (2014) that these things cannot be determined from the armchair alone. As Burge complains:

> One cannot distinguish cognition from perception in any warranted way from the armchair. The processes for forming attributives on the basis of perception are too fast, inaccessible to consciousness, and complex to allow phenomenological or other armchair methods to distinguish perception from cognition. (Burge, 2014, p. 583) [7]

Due to the limits of this thesis, I do not wish to go into a debate about the various proposed methods for distinguishing perception from cognition. I wish to go in a different direction, and investigate an empirical method for distinguishing perception from cognition. I wanted to mention the two above methods, however, because I think the simple reasons for rejecting these methods equally serves as reasons *for* the method I wish to pursue. I wish to investigate a method based on a psychological phenomenon called *perceptual adaptation*. The idea that adaptation can help us distinguish perception from cognition has been defended from various corners (Di Bona, forthcoming; Fish, 2013; Firestone & Scholl, 2016b; Rolfs & Dumbacher, 2016), but perhaps most directly by Block (2010; 2014). Block's main defence of the method appear in a paper of just under twelve pages (Block, 2014). Together with Burge's (2014) eleven-page reply to Block (where he, despite expressing some worries, admits that the phenomenon of perceptual adaptation is certainly evidentially relevant for distinguishing perception from cognition), this constitutes the most thorough discussion of the method in the philosophical literature so far. The discussions of this method have generally been quite scarce, in other words, and as the method seems quite promising, I think a more thorough investigation is called for.

[7] An 'attributive' is the representation of a property, or attribute.

2 The Perceptual Adaptation Hypothesis

Perceptual adaptation is not a new discovery. The phenomenon is described by Aristotle: "…when persons turn away from looking at objects in motion, e.g. rivers, and especially those which flow very rapidly, they find that the visual stimulations still present themselves, for the things really at rest are then seen moving" (Aristotle, 1955, p. 731). What Aristotle had discovered is an adaptation aftereffect, now known as *the waterfall illusion*. If you keep your eyes fixated on the rapid downward moving waterfall for some time, and then move your eyes to a stationary scene, for example a hillside, it will for the first couple of seconds look like it is moving upwards.

That adaptation, and the aftereffects adaptation produce, can help us distinguish perception from cognition, has been suggested from various holds (Block, 2010; 2014, Di Bona, forthcoming; Fish, 2013; Firestone & Scholl, 2016b; Rolfs & Dumbacher, 2016). The discussions are all quite brief, however. A clear account of how (and why) adaptation can be used to distinguish perception from cognition is missing in the philosophical literature. While adaptation has been extensively studied in psychology, these studies tend to focus on specific cases of adaptation. Moreover, the main focus of these studies is often not on the boundary between perception and cognition. Therefore, I wish to undergo a detailed investigation of the phenomenon of adaptation. Based on the limited philosophical discussion, and the studies on specific cases of adaptation from the psychological literature, I will try to get clear on why adaptation is suited to distinguish perception from cognition, and to develop a general account of how it can successfully do so.

The present chapter is the beginning of this investigation. I start by forming The Crude Perceptual Adaptation Hypothesis (and a stronger version of it), which is meant as a first approximation to an account of how adaptation can help us determine the representational nature of a given property. Then, I turn to what adaptation is, and why perceptual systems adapt. Finally, I return to the hypothesis, and I try to use what has been uncovered about adaptation to defend it. The upshot of the discussion will be that the hypothesis is plausible, but that there are two alternative explanations of adaptation effects which is not yet ruled out (these alternative explanations will be the subject of the next two chapters).

2.1 The Crude Perceptual Adaptation Hypothesis

The idea that adaptation can help us distinguish perceptual from cognitive representations initially appears in a footnote in Block's 2010 paper:

> Philosophers have been interested in the question of whether vision represents only properties like shape, size, contrast, colour and texture […] or whether vision also represents 'high level' properties such as facial expression, causation or number […]. There is however, a powerful line of evidence that philosophers engaged in this debate have not noticed so far as I know: whether perception of a property shows adaptation […]. (Block, 2010, p. 58)

In his 2014 paper, the method is further discussed. The paper is very dense, however, and the argumentation must sometimes be read between the lines. Block's main argument is that we can use perceptual adaptation to help us distinguish perception from cognition. The paper specifically argues that vision represents emotional expressions of faces (and perhaps also other facial features). However, Block notes that he is more concerned "…with the methodology of answering the questions rather than the actual answers" (p. 563), indicating that the methodology used to arrive at his answer should be applicable in general to determine the perceptual (or cognitive) nature of representations.

The claim that vision represents emotional expressions is based on evidence that emotional expressions show adaptation aftereffects. Consider the following example taken from Butler, Oruc, Fox & Barton (2008) study which illustrates a rather surprising aftereffect. Figure 6. illustrates three different facial expressions. The leftmost face express anger, while the rightmost face express fear. The middle picture is a hybrid composed of elements of the angry and the fearful face, and is supposed to be ambiguous. Stare at the angry face for a minute or so (the effect may be increased by covering up the other faces), and then turn to the middle picture. What you will find is that the ambiguous face now appears to express fear. After a couple of seconds, you will see the aftereffect fade, and that the face returns to its ambiguous expression. Try doing the same, but now start with the fearful face. As you probably suspected, the aftereffect will now make the ambiguous face in the middle picture appear to express anger.

Figure 6. Adaptation to facial expression. Illustration from Butler et al.'s (2008) study, in Block (2014).

This is an example of an adaptation aftereffect. Block claims that "[t]his phenomenon grounds a prima facie case that we have visual attributives for facial expressions" (Block, 2014, p. 564). The quote from the footnote above is followed by a similar claim. In the footnote he states that the fact that facial expressions exhibit adaptation is "…[a] very strong argument for supposing that vision represents facial expression…". Considering his overall interest, we should understand these claims as saying that we have a prima facie reason (or a very strong argument) to consider *any* represented property which exhibit adaptation as being represented by the visual system. Most of Block's paper focuses on evidence that adaptation is a *perceptual* effect. He is less concerned with providing a clear account of what adaptation is, and what makes it suited to uncover the boundaries of perceptual processing. I will therefore, in the following section, go into a bit of detail about what the phenomenon of perceptual adaptation is. But first, I will simplify Block's claims and formulate a conditional I will call *The Crude Perceptual Adaptation Hypothesis*, which will be a point of departure for the following discussion. The hypothesis reads as follows:

The Crude Perceptual Adaptation Hypothesis (CPAH): *If a represented property is susceptible to adaptation, then it is perceptually represented.*

I will also formulate a stronger version of the hypothesis in terms of a bi-conditional:

$\text{CPAH}^{\text{STRONG}}$: *A represented property is perceptually represented if and only if it is susceptible to adaptation.*

While CPAH predicts that every represented property which is susceptible to adaptation is perceptually represented, the strong version of the hypothesis additionally predicts that every property which is perceptually represented is susceptible to adaptation. In contrast to

CPAH^{STRONG}, CPAH does not exclude the possibility that there are perceptually represented properties that are not susceptible to adaptation. In this respect, CPAH only has the power to include represented properties in the perceptual domain, while the CPAH^{STRONG} can also exclude represented properties from the perceptual domain. That is, according to CPAH^{STRONG}, if a represented property is *not* subject to adaptation, it is *not* perceptually represented. For adaptation to be able to distinguish perception from cognition completely, something like CPAH^{STRONG} should be true. In what follows, I will focus on CPAH. That is, I will attempt to get clear on whether, and if so, why, observing that representation of a property is susceptible to adaptation makes us warranted in inferring that the property is perceptually represented. As part of the reasoning behind the methodology is based on the realization that adaptation is deeply tied to perceptual processing *in general*, the argumentation behind CPAH will generally also support CPAH^{STRONG}. However, I will save the discussion of whether we should expect every perceptually represented property to be subject to adaptation to chapter 5.

For reasons that will later become clear, the hypothesis is too crude to be true, and will need revision. I think starting out with a clear hypothesis nevertheless will be helpful in the upcoming discussion. Although the hypothesis is partly based on Block's claims, I do not suppose that that neither the hypothesis, nor the arguments I propose in support of it, is what Block has in mind. Although I focus on *vision*, I formulate the hypothesis in terms of *perception*, keeping open the possibility that it might be extendable to other sensory modalities as well.

2.2 Adaptation

Perceptual adaptation refers to the perceptual system's adjustment as a response to change in stimuli. The visual system adapts to a variety of different aspects of its inputs (Webster, 2015). Sometimes, adaptation produce dramatic aftereffects. The waterfall illusion is a well-known example of such an effect. If you keep your eyes fixated on a waterfall for some time, you will adapt to the rapid downward motion of the water. If you then move your eyes to a stationary scene, for example a hillside, it will for the first couple of seconds look like it is moving upwards. What explains this effect is that prolonged exposure to the downward moving waterfall reduces firing in the neurons responsible for detecting downward motion. This raises the threshold for the visual system detecting downward motion and thereby biases the system towards upward motion. Thus, when you turn your head toward the stationary scene, it appears to move upwards (Block, 2014, Clifford, 2005, p. 47-82).

Another example of adaptation is *the tilt aftereffect* (Gibson & Radner, 1937), demonstrated in figure 7. Focus on the lines in square (a) which is tilted counterclockwise, for a minute or so, and then change your focus to (b). The first few seconds the lines in (b), which is vertical, will appear to be tilted clockwise.

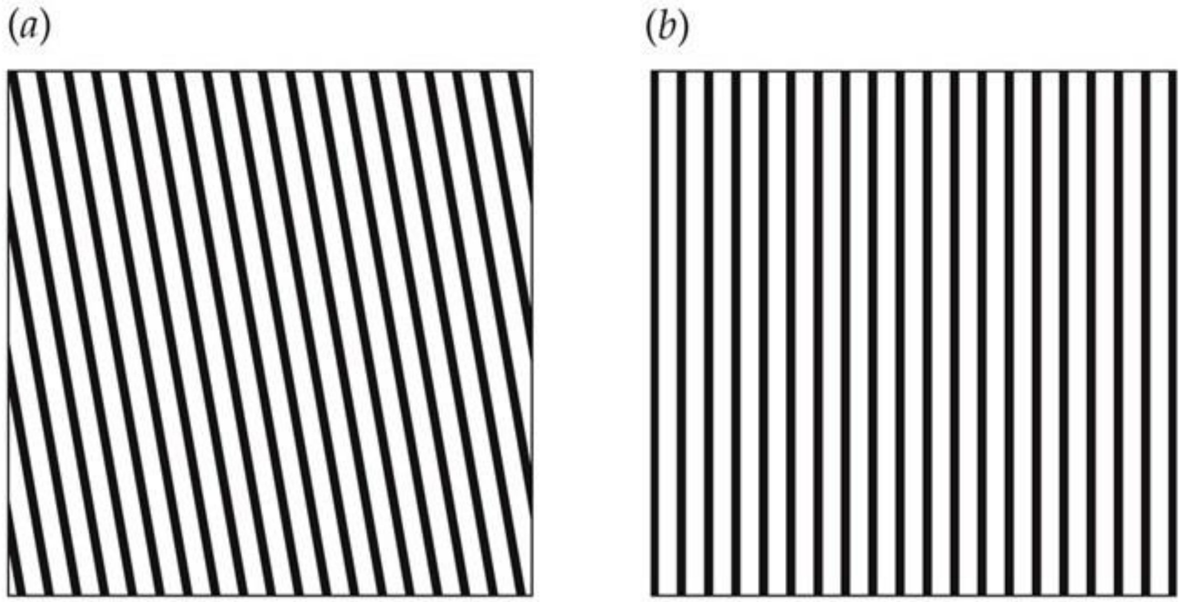

Figure 7. The tilt aftereffect

The tilt aftereffect shows the same kind of effect as the waterfall illusion, except with orientation instead of motion. By fixating at (a), you adapt to the orientation of the lines, and the sensitivity to that specific orientation is reduced. When you then turn to the vertical lines in (b), you are biased in the opposite direction (Gibson & Radner, 1937).

Adaptation aftereffects are produced by continuous fixation at a given stimulus, the adaptor, followed by exposure to a new stimulus, the test stimulus. The adaptor is what you are adapting to, and what's causing the aftereffect when you are subsequently viewing the test stimulus. In the waterfall illusion, the waterfall is the adaptor, and the stationary scene is the test stimulus. Similarly, in the tilt aftereffect, the tilted lines are the adaptor, while the straight lines are the test stimuli. In general, adaptation aftereffects have same characteristics as these examples: Adapting to a stimulus shifts perception of subsequently viewed stimulus towards opposite (or different) features of what you have adapted to. Adaptation to facial expressions also shows this pattern. As you stare at the angry (or fearful) face, you adapt to anger (fear).

When you shift your eyes to the face which is ambiguous between anger and fear, its appearance is shifted away from the facial expression you are adapted to, and towards the other expression.

Sometimes, adaptation also results in a more neutral appearance of the stimulus you are adapting to. This is what happens when you are riding on the freeway, and although you hold the same speed, you appear to move slower after a period of time. Similarly, if you continuously stare at a strong shade of green, it will gradually look more neutral, that is, less saturated (closer to grey). Both effects may occur for the same stimuli. For example, staring at a green patch both makes the current stimulus (the green patch) look more neutral, while simultaneously biasing the perception of other stimuli away from green. When you turn your eyes from the green patch to a white patch, it will appear red (Webster, 2003).

Aftereffects are produced after seconds to minutes of adaptation. Studies have found a power-law relationship between adaptation periods and aftereffects, where the strength and duration of an aftereffect gradually increases with the duration of adaptation. Aftereffects typically fade after a couple of seconds. (Greenlee, Georgeson, Magnussen & Harris, 1991; Leopold, Rhodes, Müller & Jeffery, 2005)

An important point about adaptation is that is selective. Staring at the downward motion of the waterfall only affects perceived motion, while staring at tilted lines only affect perceived orientation. Prolonged exposure to tilted lines will not affect the appearance of colours, or contrast, for example. In other words, adaptation effects are contingent on a sufficient similarity between the adaptor and the test stimulus.

Perceptual adaptation is physically realized by changes in neural responses in sensory receptors and neural units responsible for processing visual information (Palumbo, D'Ascenzo & Tommasi, 2017). At one level, we can speak of adaptation of individual neurons and population of neurons, so-called *neural adaptation*. This refers to change in electrical and chemical signals as a response to stimulation. At another level, we can speak of adaptation as changes in representation of the external environment as a response to (the same) stimulation. I will focus on adaptation at the level of perception. When I speak of adaptation, I mean the adjustments in the processing of perceptual information (physically realized by changes in neural responses) that can cause representational changes with the typical characteristics as described above.

2.2.1 Why does vision adapt?

On the face of it, adaptation seems maladaptive since it gives rise to inaccurate representations of the environment. Traditionally, adaptation effects were considered to be deviations from normal functioning. It was, for example, thought that lack of sensitivity resulted from neural fatigue; that neurons get tired out by being exposed to the same stimuli over time, and as a result reduces their response. Gibson (1979), who first discovered the tilt aftereffect, later disregarded adaptation as irrelevant for understanding vision. He argued that adaptation only arises in artificial viewing contexts, such as laboratory experiments. After all, continuously fixating your eyes at lines of various orientations is a task rarely encountered in everyday life. However, it is now acknowledged that adaptation is not a deviation, but rather something in which perceptual systems always engage in. That is, the visual system continuously adjusts its response to incoming stimuli. Most of the time, the process of adaptation pass unnoticed without producing aftereffects. It is the aftereffects, however, which reveal the adaptation. Adaptation is increasingly being recognized as essential to the operations of the visual system, and is thought to occur at all levels of visual processing (Webster, 2015).

If adaptation is not a kind of defect, but rather an essential part of vision's normal operations, what is its function? Or in other words, what sorts of benefits does the visual system gain by adaptation? If we consider light adaptation, the answer seems obvious. If you walk into a dimmed room after spending some time outside in the sun, the first few second you will be blinded by darkness. And similarly the other way around; if you move from a dark room out into the sun, the intense light will literally blind your eyes. If our eyes did not have the ability to continuously adjust their sensitivity to the large variety of light conditions which we encounter every day, we would be blind most of the time. The purpose of adapting to such things as orientation, motion, and faces, is a bit less intuitive. (Webster, 2015)

How vision copes with variations in the environment is shaped by how the world varies in these respects. The visual world is by no means static; thus, it seems unlikely that vision would function best with entirely fixed operations. Adaptation in general is considered to help the visual system process information optimally and efficient. Neurons are limited in the range of intensities they can fire in; however, they must potentially code a wide range of stimulus levels. By centring around the mean level of a given stimulus, A neuron's ability to adjust its responses can optimize the range of information it can carry, as well as enhance its discriminative power (Webster, 2011; 2015).

That neurons become less responsive to current stimuli is thought to promote efficiency in other ways as well. Focusing responses on how new stimuli differs from what the visual system is currently exposed to potentially enhances the efficiency of coding, while simultaneously saving metabolic resources. At the level of perception, this characteristic of adaptation might also play a role in determining what captures our attention, by filtering out uninteresting variations and making novel features more salient. Naturally, being alert on sudden changes in the environment is important for survival (Webster, 2011; 2015).

There is also evidence that adaptation contributes to *perceptual constancy* (Webster, 2011; Webster & Macleod; 2011; Webster, Werner & Field, 2005). Perceptual constancy is the perceptual system's ability to represent an object or a property as being the same under a wide variety of proximal stimulation. Shape constancy, for example, is the ability to represent an object as having the same shape under different viewing conditions. You see a coin, for example, as having the same circular shape from (at least almost) any view point, even though the different viewpoints will give rise to radically different retinal images. Size constancy is the ability to represent objects as having constant size under different conditions. The same tree seen from five and fifty meters' distance will yield very different retinal images. However, you see it as having a constant size. There are also constancies for such things as distance, motion and colour. Note that perceptual constancy is not a trivial achievement. The reason for this is that the initial proximal stimulation underdetermines the environmental causes; the same two-dimensional retinal image could have been caused by many different three-dimensional environmental scenes, thus the same proximal stimulation is compatible with various representational states. A ball coming towards you in the air, and a ball floating still in the air increasing in size, for example, could yield the exact same proximal stimulation. Similarly, a red wall, and a white wall illuminated by red light, could give rise to the same retinal image. Yet, the visual system is quite successful in forming representations of the "right" environments. In general, the objects we encounter in everyday life seem to have constant properties (to the extent that they actually have constant properties, of course). The building I live in appears to have the same brick red colour on both sunny and on cloudy days, in the middle of the day when the light is white, and in the evening when the light is more red. Even when part of the building is covered in shade, both the shaded part and the part illuminated by sunlight appears to have the same colour. Across the various light conditions, it is the illumination which seems to vary, not the actual colour of the building. *Colour constancy* refers to the visual systems ability to recover the “true colour” of an object under such drastically different light conditions. It is thought that adaptation contributes to such constancies by filtering out ‘superfluous’ variations in the incoming information. Such information could for example be the variance in colour temperature from sunrise to sunset. The colour temperature is lower as the sun sets, causing a redder light. By reducing sensitivity to redness, adaptation can contribute to colour constancy (Webster, 2011; Webster et al., 2005; Webster & Macleod; 2011).

While colour representation is perhaps the case where adaptation most directly contribute to constancy, it is thought that adaptation, in similar ways, can promote constancy in representation of other properties as well, by reducing sensitivity to extraneous aspects of stimuli. For example, adaptation might promote a form of “face constancy”. We are generally highly competent in identifying, and noticing subtle changes in faces. It has been suggested that adaptation might make unique characteristics of a face more visible by filtering out more global characteristics of faces. While in the case of colour constancy, the constancy is a matter of “seeing beyond” such things as perspective and illumination, the face constancy additionally seems to be a matter of “seeing beyond” characteristics common to all faces (that is, face characteristics that are not helpful in identifying a face as ‘that particular face’) (Webster, 2011; Webster et al., 2005; Webster & Macleod; 2011).

In some situations, adaptation is also thought to promote constancy by compensating for deficiencies or changes in the observer. For example, as we age, the lens of our eyes gradually become more and more yellow. However, the world does not increasingly look yellow to us. Adaptation is thought to be able to correct for such types of errors in the system itself. It has also been suggested that adaptation can promote “interobserver constancy”; the ability of individuals to form similar representations of the external world, despite internal differences (Webster, Werner & Field, 2005).

It has been suggested that all of these functional benefits could be achieved by a shared adjustment: normalization of neural responses (Webster, 2011; 2015). There is evidence that in many cases, the visual system code and represent a given property relative to how it deviates from a norm. The norms are special states (both on the neural and perceptual level) commonly associated with neutrality. The norm is ‘grey’ for representation of colour, ‘horizontal’ and ‘vertical’ for orientation, and ‘static’ for motion. The idea is that the function of adaptation is the continuous recalibration of such norms – so-called renormalization. Staring at a moving waterfall over time makes the visual system redefine the “neutral point” for motion (staticity) in the direction of the velocity of the waterfall. Thus, when you move your eyes to a stationary scene, the norm for representing motion has changed, and the scene appears to move in the opposite direction as the visual system renormalizes. Considering how wearing sunshades affect the perception of colour may provide a familiar example of such renormalization processes. When you put on a pair of shades with warm coloured glasses, for example, what initially seemed neutral (grey and white) suddenly appear yellow- and red-ish (the whole world in fact appears warmer in colour). But after a couple of minutes, the world gradually looks normal. According to the account of norm-based coding, what has happened is that the visual system, by readjusting its responses to the light signals, has set new standards for representing the norm; neutral greyness. So naturally, when you take the shades off, what is in fact grey now seems blue and green, since the norm for neutrality is shifted towards the other side of the spectrum.

One consideration supporting norm-based coding is that adaptation to the norm (the “neutral point”) does not produce aftereffects. Adaptation to grey, for example, does not produce colour aftereffects (Webster & Leonard, 2008). Similarly, while adaptation to a distorted face causes facial aftereffects on undistorted faces, adaptation to an undistorted face does not produce aftereffects on distorted faces (Webster & Macleod, 2011; Webster & MacLin, 1999). This indicates that when exposed to the norm, instead of recalibrating, the visual system simply maintains the current norm. This is further supported by neural evidence that adaptation to norms corresponds to a balanced response rate (Webster & Leonard, 2008).

In other cases, there is evidence that normalization is a matter of adjusting to the average level of the stimulus (for example colour contrast or spatial frequency), rather than operating with a neutral norm. In these cases, the norms are the average level of the current stimulus (Webster, 2011; 2015).

Adaptation undoubtedly plays an important role in perceptual processing. As noted in the previous chapter, the main goal of perception is to yield accurate representations of the world. Adaptation promotes this general goal in helping the visual system cope with the great variations in the perceptible world. In this respect, one could say that adaptation helps in “fitting the mind to the world” (Clifford & Rhodes, 2005).

Moreover, the functions of adaptation are intimately connected to characteristics distinctively associated with perception. As noted in the first chapter, a distinct feature of perception is that it provides something like a continuous stream of representations of our immediate environment. Adaptation continuously readjusts to fit the current environmental conditions. This aspect of adaptation seems closely tied to perception's inescapable dependence on the "here" and "now".

Perceptual constancies are also distinctly perceptual phenomena. In his highly influential Book, Origins of Objectivity (2010), Burge argues that perceptual constancies are identifying marks of perception as a natural psychological kind. That is, according to Burge, "their presence in a sensory system is necessary and sufficient for the system's being a perceptual system" (p. 413).[8] According to Burge, in order for perceptual states to represent (either accurately or inaccurately) environmental entities and their properties beyond the individual, perceptual processes must constitute what he calls *objectification*. Objectification involves systematically distinguishing proximal stimulation (which is internal to the individual) from external entities and properties, independent of perspective and context. Naturally, constancies are expressions of this objectification. Recall that perceptual constancies are the ability to represent things as being the same under radically different proximal stimulation (resulting from variations in viewing angle, illumination, location, motion and so on). In other words, what makes perception what it ultimately is – contentful states with conditions for being accurate or inaccurate representations (as opposed to a mere information registration) – is, according to Burge, Perception's ability to represent things as being the same under various contextual and perspectival conditions.

In pointing out constancies as the mark of perception, Burge (2010) is not mainly focused on what distinguishes perceptual states from cognitive states, however. Burge is concerned with the distinction between perceptual states and mere sensory information-registration, that is, states that merely function to register sensory information, without, strictly speaking, involving representation. Thus, while our present concern is the upper border of perception, we could say that Burge has, by pointing to perceptual constancies, identified the lower border of perception. Anyway, the main reason for bringing this up here was to emphasize that adaptation is tied to phenomena that are distinctively associated with perception.

[8] This is not meant as an independent conceptual criterion, but rather as an empirical claim.

2.3 “If it adapts, it’s there” – returning to the hypothesis

The idea that adaptation can reveal that a feature is visually represented is inspired by the ways adaptation has been utilized in perceptual psychology. In the majority of studies on adaptation, adaptation aftereffects have been used as a tool rather than being the subject of study itself. In these studies, adaptation is used to reveal the underlying mechanisms of the visual system and the strategies it uses to process information. (Webster, 2011; 2015)

Adaptation aftereffects have frequently been called “the psychologist’s microelectrode” (Frisby, 1979, Mollon, 1974). Microelectrodes can be used to measure neural signals in the brain. By microelectrode recordings the physiologist can find that some neurons are responsive to a specific type of stimulus. The perceptual aftereffects caused by adaptation correspond well with the response changes found in with microelectrode (and fMRI) recordings. Thus, the idea is that the psychologist can use adaptation aftereffects to make the same kind of discovery as the physiologist can with a microelectrode. By prolonged exposure to a particular stimulus, we can alter responses of a particular neuron, or a population of neurons. Then, by observing the perceptual effects of these response changes, we can infer the function of these neurons.

Consider the tilt aftereffect. Before you have adapted to the tilted lines, the vertical lines appear vertical. But after you have adapted to the tilted lines, the vertical lines appear tilted (in the opposite direction). So, the same stimulus gives rise to different perceptual representations. But adapting to the tilted lines does not alter your experience in any other way; the appearance of colour, motion, contrast and so on, remains unchanged. Moreover, the occurrence of the aftereffect depends on a similarity between the adaptor (the tilted lines) and the test stimulus (the straight lines). The fact that exposure to a stimulus with a specific type of feature can alter subsequent representations with respect to only that specific feature, indicate that there is something in the visual system (a population of neurons) which is selectively responsive to that specific feature. In this example, the specific feature in question is orientation.

This is therefore the first point; *adaptation aftereffects can reveal selective processing of a property type.* When prolonged exposure to a complex stimulus instantiating a given property shows alterations in subsequent representations of that property type specifically, this shows that the visual system is able to detect and selectively “pick out” the instance that property type from the complex stimulus and adjust in accordance to it, which thereby implicates that the property type in question is selectively processed and represented as an instance of that property type.

In psychology, adaptation has proved powerful in revealing how the visual system process incoming information, and particularly which features are selectively processed (Webster, 2015). The success of adaptation in uncovering visual processes has led to the slogan “if it adapts, it’s there” (Mollon, 1974; Webster, 2015). The slogan reflects the idea that if a represented property adapts, then it is subject to visual processing. In this way, the slogan corresponds to CPAH.

2.3.1 Justifying the inference from adaptation to perception

Traditionally, adaptation was studied only on low-level properties. However, recent studies have found adaptation for various high-level properties including faces (Webster & Macleod, 2011), bodies (Winkler & Rhodes, 2005; Palumbo, Laeng & Tommasi, 2013), properties of environmental scenes (Clifford & Rhodes, 2005, Greene and Olivia, 2010), causation (Rolfs, Dumbacher & Cavangah, 2013), and number (Burr & Ross, 2008). Adaptation to different facial features is undoubtedly the most studied high-level adaptation effects. In the beginning of the chapter I described adaptation to expression of anger and fear. Similar effects have been found for other facial expressions as well, such as happy/sad and surprised/disgusted (Fox & Barton, 2007). But facial expressions are not the only facial features which exhibit adaptation. There has also been found adaptation for aspect ratio of faces, ethnicity, identity and gender (Webster & Macleod, 2011). For example, adapting to a female face makes a face ambiguous between male and female look more male, and vice versa (Webster, Kaping, Mizokami & Duhamel, 2004). So according to CPAH, the fact that these features exhibit adaptation imply that causality, synchrony, multitude, facial expressions, ethnicity, identity, and gender, are visually represented.

Several authors (Burr & Ross, 2008; Fish, 2013; Di Bona, forthcoming; Helton, 2016), whether they support it or not, seems to regard the general argument for the adaptation methodology to be as follows: Since all low-level properties, which everyone agrees are perceptually represented, are susceptible to adaptation, then if we find adaptation also for other properties, this is evidence that these properties are perceptually represented as well.

Fish, for example, using Burr & Ross' (2008) study on adaptation to numerosity as an example, writes that:

> Their reasoning behind this methodology was that all agreed primary visual properties […] are susceptible to adaptation. So if we can show that another property is also susceptible to adaptation, we have an argument that *this* property appears in phenomenal character too.[9] (Fish, 2013, p. 52)

Similarly, Di Bona (forthcoming) summarizes the general argument for the adaptation methodology as follows:

> The existence of adaptation effects on a property is commonly taken to be significant evidence that this property is part of the content of perception […]. The logic behind this idea is that in vision, for example, all the uncontroversially perceivable properties agreed upon – such as luminance, contrast or motion – are susceptible to adaptation […]; so if other properties are susceptible to adaptation, this is at least suggestive that they may be part of the content of perception as well. (Di Bona, forthcoming, p. 4)

In and of itself, this does not sound like a very good argument, however. If I go out and gather ten left-handed people, and all happen to be male, this is not a very good reason to assume that the next left-handed person I find will also be male. But the argument would have similar structure; since every left-handed person so far have been male, then if I find other left-handed people, I have evidence that they are also male. In this example, being left-handed is meant to be the evidential basis for being male, in similar way as being susceptible to adaptation is for being perceptually represented.

What we have is a phenomenon which is said to expose perceptual mechanisms. But what reasons do we have to suppose that the mechanisms exposed by adaptation are always *perceptual*? The worry is that susceptibility to adaptation could be an accidental feature of low-level representations, in the same way as being left-handed arguably is an accidental property of (some) males. There is no appropriate relation between handedness and maleness that makes us warranted in inferring from one to the other. Similarly, if it is a mere accident that low-level properties show adaptation, then the fact that all agreed low-level perceptual

[9] Here, to 'appear in phenomenal character' should be understood as part of *visual* experience.

properties show adaptation does not give us reason to infer anything about other represented properties that are susceptible to adaptation.

There is little doubt that low-level adaptation is perceptual. Low-level adaptation alters representations that we agree are perceptual, and physically, adaptation to these properties literally begin in the senses; adaptation to luminance, colour, and contrast, for examples, begins in the photoreceptors of the retina (Webster, 2015). The real issue is whether high-level adaptation also is perceptual.

In principle, adaptation could be a general psychological phenomenon, not specifically connected to perceptual processing. It could be the case that adaptation operates on both cognitive and perceptual representations. And if this *is* the case, then we are not authorized in drawing inferences from adaptation to perception.

That low-level perceptual representations are susceptible to adaptation is evidence that *some* adaptational processes are perceptual. We need further evidence, however, to make plausible the claim that adaptation is a general characteristic of perceptual, as opposed to cognitive, processes. In other words, for the argument to work, we must provide evidence that there is a non-accidental connection between being susceptible to adaptation and being perceptually represented – that it is not an accident that the representations we know are perceptual show adaptation.

The most obvious source of evidence spring out of functional considerations about adaptation. As emphasized in the previous section, adaptation undoubtedly plays an important role in perceptual processing. Adaptation contributes to optimal and efficient processing of information in accordance with the visual system's goal: to yield accurate representations of a drastically varying world. Part of adaptation's contribution involves continuous adjustment to the current environment. Moreover, adaptation contributes to perceptual constancy. According to Burge (2010), constancies are necessary and sufficient for perception. If Burge is right, and if adaptation is necessary for constancies, then adaptation is also necessary for perception.

At any rate, both perceptual constancies and the inescapable dependence on current environmental conditions (mediated through proximal stimulation) are characteristics distinctively associated with perception (as opposed to cognition). They are at least partly responsible for perception being what it is. By adjusting to the current environment, and by contributing to perceptual constancies, adaptation contributes to perception upholding its function.

The pervasiveness of adaptation, and functional importance it has in perceptual processing, has, according to Webster, led many to "…now consider it evident that adaptation is an essential part of natural viewing" (Webster, 2015, p. 555) and to realize that "…the processes of adaptation are themselves essential to how vision works" (Webster, 2015, p. 547). 'Essential' in this context should not be understood in a metaphysical sense. The claim is not that adaptation is the essence of perception, in the sense that it is the fundamental property which ultimately makes perception what it is. Nor is the claim that every perceptual system in every possible world exhibits adaptation. The claim is rather that perceptual systems, in our world, has evolved to cope with the variations they encounter in our world. The way perceptual systems cope with these variations is by means of adaptation. And so, as a contingent fact, for perceptual systems to be able to work properly, that is, to be able to generate stable representations of a varying world, it is essential that perceptual systems adjust their responses to match the incoming stimuli.

Still, to be warranted in inferring from adaptation to perception, we must exclude that adaptation also occur in cognition. This will be the focus of the next chapter. For now, I will just note that the role adaptation plays in perception is connected to characteristics of perception that is distinctly associated with perception. Put crudely, the role of perception is to represent the current environment, and adaptation contributes by continuously adjusting to it. It seems that adaptation does not have a corresponding role to play in cognition. Cognition plays a much more general role than perception and is concerned with matters far beyond the current environment.

In addition to the fact that adaptation has an important role to play in perception which it does not seem to have in cognition, a further consideration supporting that also high-level adaptation is perceptual is the striking similarity between high-level adaptation and low-level adaption. First of all, high-level adaptation follow the same patterns as low-level adaptation in that it, as we have seen in the examples above, bias the perceiver towards the opposite feature of the perceived stimulus. Some cases of high-level adaptation also have the tendency to "neutralize" the stimulus you are adapting to. For example, looking at a distorted face (for example a face which is stretched horizontally) over time makes the face appear less distorted (Webster & Macleod, 2011). Low-level and high-level aftereffects also follow the same dynamic pattern. As noted earlier, there is a power-law relationship between adaptation time and the duration and strength of the aftereffect. This power-law relationship seems to hold equally for both low-level and high-level adaptation (Leopold et al. 2005). In addition, studies indicate norm-based coding also for perception of high-level features such as face perception, according to which the visual system represents faces relative to how they deviate from an average or a prototype face (Webster & Maclead, 2011). These observed similarities between high-level and low-level adaptation indicates that they stem from the same underlying system.

To sum up, it is not an accident that all properties that we know are perceptually represented, are also susceptible to adaptation; adaptation plays an important, if not essential, role in perceptual processing. Adaptation does not have corresponding role to play in cognitive processes. Thus, adaptation seems like a characteristic of perceptual processing. Further, the similarity between low-level and high-level adaptation is so striking that it seems reasonable to suppose that they are operations of the same underlying system. Thus, if adaptation to low-level properties are perceptual, of which there is no real question, then we should regard adaptation to high-level properties to be perceptual too.

I do *not* agree that the general argument for the adaptation hypothesis to is that, since all agreed perceptually represented properties show adaptation, other properties which show adaptation is perceptually represented as well. I consider the general reasoning behind the adaptation hypothesis to be as follows. For various reasons, summarized above (the fact that all agreed perceptually represented show adaptation, being only one of them), adaptation is to be regarded as an important characteristic of perceptual, as opposed to cognitive, processing. The aftereffects resulting from adaptation can reveal that a property type is selectively processed. Thus, if we find adaptation for a given property, this indicates that the property is perceptually represented.

The first point of this discussion (emphasized in the previous section) – that adaptation can reveal selective processing of a property type – is key to the adaptation hypothesis. Perception has several important characteristics. For example, it has a distinct phenomenology. As Burge emphasizes, it engages in perceptual constancies. Although this is disputed, some (including Fodor (1983), Block (2014), Burge, Firestone and Scholl (2016a)) regard informational encapsulation as characteristic of perception. Some might wonder why, among the various characteristics of perception, adaptation is the characteristic to look for in trying to separate it from cognition. The answer is that adaptation, through its aftereffects, offers a way to test whether a given property type is selectively processed. I have already argued that phenomenology is a poor guide to the origin of a given representation. But also when it comes to other perceptual characteristics, like for example perceptual constancies, it is unclear how we could test, for a particular high-level property, whether it is subject to perceptual constancies or not. Although there might be other perceptual characteristics that are just as, or perhaps even more, central to perceptual processing, adaptation is the characteristic which offers a concrete way to test whether a given property is perceptually represented, and thus seems best suited to locate the upper border of perception, and its distinguishing line to cognition.

2.4 As things stand

Let's return to the example from the beginning of the chapter. We saw that adapting to an angry face makes an ambiguous face look fearful, and vice versa. That adaptation to a facial expression alters the representation of subsequently facial expressions indicates that the visual system has selective processes for the detection and representation of facial expressions. When you continuously stare at an angry face over time, the visual system readjusts, and becomes less sensitive to anger. Thus, when you turn to the face which is ambiguous between anger and fear, the visual system is more sensitive to fearfulness, and so the resulting output represents the face as fearful. This is the explanation that drives CPAH. From what we have seen in this chapter, the explanation seems plausible.

However, as things stand, there are two alternative interpretations of what this aftereffect is an expression of, that must be ruled out before the present explanation could be confirmed.

One possible interpretation, already mentioned above, is that the effect is not a perceptual effect, but rather an effect on cognitive judgment. For example, it is possible that the facial expression we are exposed to can alter our criterions for cognitively labelling other facial expressions. It is possible, for example, that after staring at an angry face over time, it takes more for you to think that the next person is angry. At any rate, if adaptation also occurs in the cognitive domain, that is, if thoughts (including perceptual judgments) also adapt, then adaptation seems worthless for distinguishing perception from cognition.

Another possible interpretation is that the effect is perceptual, but not a product of high-level adaptation. On this interpretation, the change in appearance is due to low-level adaptation:

When you stare at the angry face, the visual system adapts to its low-level features – its shape, contours, lines and so on. Thus, when you turn to the ambiguous face, the visual system is less sensitive to the low-level features it shares with the angry face, and thus the resulting representation is more like the fearful face. Nowhere in the process, however, is the face processed by the visual system as either angry or fearful (or as a face, for that matter). That the ambiguous face looks fearful after adapting to angriness and vice versa is something you *judge* based on the low-level changes.

This is how I will proceed: In the next chapter, I will discuss whether adaptation could be a cognitive effect, and how we can rule out the cognitive interpretation of adaptation effects. In chapter 4, I will discuss methods for ruling out the low-level interpretation (what I call *the low-level worry*). Although I think we, in principle, have reason to rule out the cognitive interpretation on general grounds, there are practical reasons why we should exclude this interpretation in each individual case of adaptation. As we will see, the low-level worry must also be faced in each individual case of adaptation. This means that the adaptation methodology requires extensive testing. However, if we find adaptation for a given property, and are able to rule out both the cognitive interpretation and the low-level interpretation of the effect, then I think we can safely conclude that the property in question is perceptually represented.

Thus, if we can revise the hypothesis so that it only covers genuine cases of adaptation, and show that there are available strategies for testing it, then I think we have identified a secure way of determining that a property is perceptually represented. And to the extent that the strong version of the hypothesis is viable, we have identified a method for determining *whether* a property is perceptually represented, that is, a method for distinguishing perception from cognition.

3 Is there adaptation in cognition?

The focus of this chapter is whether high-level adaptation aftereffects could be effects on cognition rather than perception. A possible interpretation of high-level adaptation is that when prolonged exposure to a high-level stimulus (for example a facial expression) causes an aftereffect, the aftereffect is an effect on judgment rather than on perception. That is, prolonged exposure to the adaptor shifts your criteria for applying certain categories (like 'angry' and 'fearful') to what you see, but perception itself is unaffected. If this is the case, then high-level adaptation has little to say about perception and its upper border to cognition. The plausibility of the adaptation hypothesis depends on whether perception is the only type of process that involves adaptation.

I will start by discussing a study that, according to Block, shows that adaptation is wholly perceptual. Then, I turn to an objection by Grace Helton (2016). She argues that adaptation is common also in thought. I Reply to Helton's objection and discuss general reasons why we should not expect adaptation in cognition. Then I mention some additional sources of evidence that can help us determine, in particular cases, whether an alleged adaptation effect is in fact a result of genuine perceptual adaptation. Finally, I present a revised version of the perceptual adaptation hypothesis.

3.1 Block's example of a study where adaptation is determinably perceptual

Block (2014) presents a study which shows that in at least one case, adaptation is wholly perceptual. The drawback is that this study only involves low-level adaptation. Hence, it is restricted what this study makes us warranted in concluding about adaptation to high-level properties. The study is still relevant however, because the experiments are designed in a way that makes adaptation independent of perceptual judgments. Thus, it stands as an example of how one might determine whether a given adaptation effect is perceptual.

The study attempted to disentangle adaptation and priming. Priming in general has the opposite effect as adaptation; it is what happens when exposure to one stimulus biases you towards similar stimulus. In the waterfall illusion, prolonged exposure to rapid downward motion biases the perceiver towards motion in the opposite direction. But exposure to motion can also have the opposite effect; when subjects stare at a downward moving stimulus only very briefly before being presented with a stationary stimulus, they report that the stationary stimulus is also moving downwards (Schwiedrzik, Ruff, Lazar, Singer & Melloni, 2013).

In their study, Schwiedrzik et al. (2013) designed an experiment which allowed them to study both priming and adaptation effects simultaneously on the perception of tilt. The subjects were presented with grids like the ones you see in Figure 8. below. Which direction you perceive the grids as tilting depends on the distances between the dots. If the distance is smaller between the dots in the direction stipulated as 0° than in other directions, like in the leftmost grid, you are more likely to see the grid as oriented in that direction. Similarly, if the distance is comparably smaller between the dots in the 90° direction, like in the rightmost grid, you are more likely to see the grid as oriented 90°. If the distance between the dots is the same in every direction, as in the middle grid, then no direction will be favoured.

First subjects were presented with a grid oriented either clockwise or counterclockwise (like the left or the right grid) for four seconds, and then asked to indicate the direction of tilt. Then they were presented with a grid with ambiguous orientation (like the middle grid) and asked to indicate that grid's direction of tilt also.

The experimental design allows us to see how exposure to the first grid affects how you see the second (ambiguous) grid. If the subjects see the second grid as tilted in the same direction as the grid they were first exposed to, this indicates priming. If the second grid is perceived as tilted in the opposite direction of the first, this indicates adaptation.

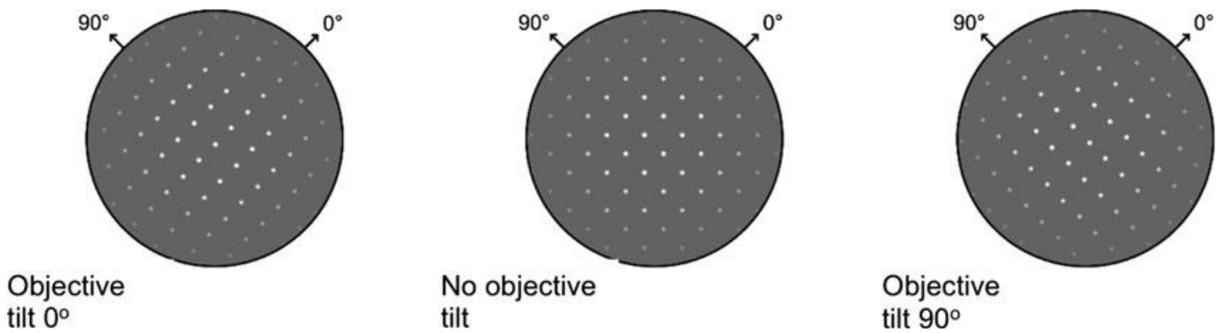

Figure 8. Adaptation to grids of different orientations. Illustration of Scwheidrzik et al.'s (2013) study, in Block (2014).

As expected, when the subjects were exposed to the first grid, the more distinctly it *actually* was tilted clockwise (or counterclockwise), that is, the smaller the distance were between the dots in that direction, the more likely the subjects were to report that the grid was tilted clockwise (or counterclockwise). Secondly, the subjects were more likely to classify the second grid as tilted clockwise if they had classified the first grid as tilted clockwise (and vice versa). The result indicates priming: The subjects were biased towards judging the second (ambiguous) grid as tilted in the same direction as they judged the first.

Now to the crucial point: The more distinctly the first grid was *actually* tilted clockwise, the more likely the subjects were to report that the second grid was tilted counterclockwise. This is an effect of adaptation, similar to the effects found in the classic tilt aftereffect studies. The important point is that this finding pertained irrespective of whether the subject *judged* the first grid to be clockwise or not. That is, what predicted the adaptation effect was not "…what the subjects thought they saw…", but rather "…the actual objective tilt of the first grid as registered in the visual system" (Block, 2014, p. 569). Block's point is that, since adaptation did not depend on the (cognitive) perceptual judgments of the perceiver, but rather on the actual orientation of the grids, adaptation cannot, at least in this case, be a cognitive effect.

If adaptation is perceptual, we would expect the processes to be independent of what the perceiver's thinks and judges. At any rate, if adaptation is wholly independent of the perceiver's thoughts and judgments, as this study suggests, then how could it be a cognitive effect?

The adaptation aftereffect in this study is analogous to the Müller-Lyer Illusion. The illusion occurs even when you know that the arrows are the same length. So, the illusion is independent of what you think and judge. In a similar way, this study shows that adaptation to tilt occurs independent of what the subjects thinks and judges, and can therefore not be a cognitive process.

Burge thinks that this argument is a slip, however. His claim is that "[m]any post-perceptual, cognitive effects do not depend on judgment or other propositional attitudes (Burge, 2014, p. 579, footnote 6). The objection is that an adaptation effect could be cognitive even if it is independent of thoughts and judgments. Helton poses similar worries: "…there is some evidence that non-conscious thoughts can influence conscious thoughts. So, it is at least feasible that non-conscious thoughts about contextual features (…) might contribute to the shifting of standards for those features…" (Helton, 2016, p. 858). What Burge and Helton seems to suggest is that, when presented with the first grid, the subjects could have an unconscious thought that 'the grid is tilted clockwise', which affected their judgment of the second grid, increasing the probability that they judged it to be tilted counterclockwise.

I do not doubt that there are things going on in cognition that are independent of thought and judgment. I am not convinced that this is what's going on in this case, however. Recall that the adaptation effect also occurred for subjects who judged the first grid to be tilted counterclockwise. How likely is it that the subjects had an unconscious thought which corresponded to the actual tilt of the grid, but directly conflicted with their perceptual judgment of it, and at the same time had the capacity to affect the perceptual judgment of the next grid? Moreover, the cognitive explanation of the adaptation effect in this example seems to suggest that cognitive processes have two conflicting operations at work simultaneously. At one level, there are unconscious perceptual judgments causing adaptation effects, while at another level, there are conscious perceptual judgments about the same stimuli causing priming effects.

I think these considerations favour Block's conclusion about the adaptation effects; that since they were independent of the subject's judgments, they had to be perceptual. This conclusion is also supported by functional magnetic resonance imaging (fMRI) of the participants in the study. While priming effects involved a widespread network of brain areas, adaptation effects only showed activation in early parts of the visual cortex, V2 and V3, which are associated with early visual processing (Schwiedrzik, Ruff et al, 2013). Crucially, adaptation did *not* involve activity in the frontal and parietal brain areas that are associated with thought and cognition (Block, 2014). This evidence should at least be relevant for Burge (2014), who agrees with Block (2014) that localization in the brain can serve as partial evidence with regards to determining the perceptual/cognitive nature of adaptation effects.

3.2 "Adaptation in thought is common!" Grace Helton's objection

If perceptual judgments are subject to adaptation, then we should expect to see adaptation with regards to thoughts in general. This is also pointed out by Block. He writes that "[*o*]*ther things equal*, if there were conceptual adaptation one would expect conceptual-without-perceptual adaptation" (Block, 2014, p. 567). Here, concepts should be understood as constituents of thought (that is, cognitive elements). Block thinks there are reasons to doubt that adaptation ever occurs in thought, however: "the point of perception is to register news, and adaptation contributes to that by filtering out old news; old news, however, is important to cognition, so one would not expect adaptation in cognitive systems" (Block, 2014, p. 567).

Helton (2016) is not convinced by this reasoning. She argues that there are examples of adaptation in thought. She construes the following example:

> You are looking through lists of houses for sale, which include each house's size. You first spend a long period carefully reading through a list of very large mansions. While going over this list, you think, without explicit inference or felt effort, 'what large houses!' Then, very suddenly, you happen to move to a list of medium-sized houses. You immediately think, without explicit inference or felt effort, 'what small houses!' (Helton, 2016, p. 858)

Helton regards this as a case of adaptation, similar to the cases of adaptation discussed above: Looking through the list of very large mansions causes a readjustment of the standards for evaluating house sizes. Applying the usual adaptation vocabulary, we could say that you become less sensitive to a house being 'very large'. Judgments of houses you are subsequently exposed to is thereby biased in the opposite direction, so when you come across a house you would otherwise regard as medium-sized you now consider it small.

Although this is a hypothetical example, it seems rather plausible that exposure to houses of a certain size could cause such effects on subsequent judgments of house sizes. Moreover, it is very easy to imagine similar examples that you might even recall having experienced yourself. Similar effects do not seem unusual in shopping situations, for example. Imagine that you are out looking for a new coat. After looking at very expensive coats, you find a coat on sale, and think ("without explicit inference or felt effort") that the sales price is a very good price, and you even end up buying it. When you return home, you regret your purchase, however, because when you compare the sales price with what you initially thought you would spend on a coat, the coat on sale still far exceeds this price. As we can easily construe similar cases for any gradable feature, Helton suggests that adaptation in the cognitive domain is "…not just possible, but common" (Helton, 2016, p.858).

Helton is right that the effect is common. She does not point this out herself, but her example is actually an example of a well-known cognitive bias in the psychological literature, usually referred to as *contrast effects*. There are many examples of this type of bias. For example, studies have found that when subjects are first presented with highly qualified job applicants, they judge moderately qualified job applicants as less qualified (Hakel et al., 1970; Wexley et al., 1972). Another study reported that, when asked to suggest the appropriate sentences for different crimes, subjects suggested milder sentences then otherwise if the judgment was preceded by a narrative of a particularly harsh crime (Pepitone & DiNubile, 1976). Holmes and Berkowitz (1961) found contrast effects in personality judgment. In this study, participants were first presented with audio recordings of a psychologist interviewing a student either in a hostile or a friendly manner. They were then presented with audio recordings of a student talking about himself in a neutral manner, and asked to judge his personality based on different adjectives. The participants who were first presented with the hostile psychologist judged the neutral student to have a favourable personality. The participants who first heard the friendly psychologist, on the other hand, judged the student less favourably. There has also been found contrast effects in speed dating settings. Bhargava and Fisman (2012) arranged organized speed dating sessions where the participants were asked to rate the partner after each date, and answer either ‘yes’ or ‘no’ on romantic interest. The results showed that for male participants, if the prior date partner were rated high on attractiveness, this reduced the likelihood that they would answer ‘yes’ on romantic interest for the subsequent date partner.

Contrast effects have the same characteristics as adaptation effects; exposure to one type of stimulus biases your impression of subsequent stimuli in the opposite direction. The effect can be put in terms of renormalization. To use Helton’s example, let’s say that the size of houses is judged along a scale from ‘very large’ to ‘very small’. In the middle of the scale you have medium sized houses, serving as the norm. The norm adjusts in accordance with currently (or recently) considered instances. Thus, when you look through the list of very large mansions, the norm shifts towards those houses. And with the norm shifted in the direction of the of the very large mansions, houses which initially would seem medium-sized now seem small.

Contrast effects in thought pose a serious threat to the adaptation hypothesis. If adaptation is a common phenomenon in cognition, then the fact that a represented property exhibits adaptation effects can tell us nothing about the representational nature of that property.

Adaptation for facial expressions, for example, might as well originate from post-perceptual processes, and so adaptation does not give us reason to favour any explanation over another.

3.2.1 A reply to Helton

Although adaptation and contrast effects share the same surface characteristics, I argue that closer investigation makes the phenomena seem more different than like. Specifically, I will point out three crucial differences which I believe illustrate that contrast effects in thought are not instances of adaptation.

First, in Helton's (2016) example, even though the thoughts occur "without explicit inference or felt effort" (p.858) you are not powerless to avoid the effect. It seems rather plausible that, if I inform you about the contrast effect before you start looking through the lists of houses, or just explicitly tell you that looking at large houses might bias you towards judging medium sized houses as small, the effect would not occur, or at least be reduced. Although knowing about cognitive biases does not make us immune to them in general, it seems reasonable to think that you will be able to succeed if you, in facing a particular task, focus on avoiding one specific cognitive bias. Moreover, the effect is contingent on whether you have already made firm category boundaries. If you, before you start looking at houses, decide the size range which corresponds to being 'large', 'medium' and 'small', the effect would not occur. In contrast, no matter how sternly I warn you about what the effects of gazing at tilted lines (or angry faces) will have on the appearance of vertical lines (or ambiguous faces), there is nothing you can do to prevent it from happening. The processes of adaptation are mandatory and automatic, triggered by presentation of the relevant stimuli. They cannot consciously be turned on or off, or interacted with.

Second, adaptation effects have a characteristic build up and decay. As mentioned above, both low-level and high-level adaptation aftereffects show similar patterns in duration and strength, relative to the duration of the adapting stimuli. While it might be plausible that the extent to which your judgment of house sizes is biased depends in part on how long you are looking at the list of large mansions, that there will be a similar power-law relationship between exposure time and the strength and duration of the contrast effect seems highly doubtful. It seems very unlikely, for example, that there would be a systematic difference in strength and duration of the effect of looking at the list for 15 and 30 seconds. This is because the dynamics of thought, due to its complexity, rarely follow strict laws.[10] Adaptation aftereffects typically last for only a couple of seconds. Contrast effects, however, are generally thought to be able to persist long after exposure to the stimuli which caused it (Skovronski & Carlston, 1989). Moreover, adaptation aftereffects show a gradual decay. When you adapt to tilted lines, a waterfall, or a face, the aftereffect will be distinct and clear at first, before it gradually fades literally before your eyes, after only a couple of seconds. In contrast, when you turn to the medium sized houses and think 'what small houses!', the judgment will arguably not gradually fade into the thought 'what medium sized houses!' as the cognitive system "readjusts". You might keep thinking that the house is small, or perhaps you re-evaluate its size in light of different factors. The general point is that the dynamics of thought do not seem to follow the lawful readjustment patterns that adaptation would suggest.

Third, contrast effects do not seem to be selective to the same extent as adaptation. Recall that adaptation to colour only affects the appearance of colour (on a specific spectrum, for example, green to red), adaptation to tilted lines only affect the appearance of specific orientations. If the test stimulus is not sufficiently similar to the adaptor, if prolonged exposure to tilted lines, for example, is followed by presentation of a circle, no aftereffect will occur. In comparison, it seems that contrast effects can transfer between categories. For example, a study showed that subjects judged recycling to be less important if the evaluation followed questions about abortion laws and capital punishment, than if it followed questions about leash laws for pets or required trash can lids (Sherman, Ahlm, Berman & Lynn, 1978). In this example, exposure to the categories 'abortion laws' and 'capital punishment' effected judgments of the fairly different category 'recycling'. These issues may belong to the overall category 'social and political issues', however, this category seems very broad and indeed much broader than anything we have seen in the conventional cases of adaptation. Similar examples of category transfer have been reported, for example by Schwarz and Bless (1992), who studied how mentioning specific politicians affected subjects' evaluation of their political party, and how mentioning political scandals affected the subjects' judgments of the trustworthiness in politicians in general.

I think these considerations illustrate a serious disanalogy between adaptation and contrast effects, to the effect that they should not be considered as expressions of the same phenomena. Moreover, contrast effects already have an alternative, and well documented,

[10] That the complexity of thought makes it hard to discover strict lawful relationships within the cognitive domain is also emphasized by Fodor (1983) in his discussion of central systems.

explanation (Sherif, Sherif, & Nebergall, 1965). In making judgments, we often make cognitive short-cuts, instead of evaluating every piece of information at hand. One such short-cut is called *anchoring*. An anchor is a standard which judgments are made in comparison to. What your anchor is with respect to a given judgment is often decided by accessibility: in making a judgment about something, we tend to compare it to the easiest accessible comparable piece of information. Motivational factors, frequency of category occurrence, salience in memory, and the relation between categories can affect the accessibility of a category (Herr, Sherman & Russell, 1982). However, what's easily accessible is to a large extent a question of what you have recently been exposed to, and hence your anchor will often depend on recently reviewed information. It is therefore easy to manipulate anchors by introducing different types of information. In Helton's example, the mansions become your anchor, so when you consider the medium sized houses, they seem small in comparison. When the anchor causes your judgments to shift away from the anchor, it is called a contrast effect. Anchoring can also have the opposite effect; that judgments are biased towards the anchor. This is called an *assimilation effect*. Especially two factors are important for predicting whether an anchor will cause assimilation or contrast effects – the extremity of the anchor, and the ambiguity of the judged stimuli. If the anchor is extreme in one direction (like very big mansions), then the anchor is likely to cause contrast effects. If the stimulus being judged is unambiguous, then moderate anchors should also cause contrast effects. In contrast, assimilation effects are likely to occur if the anchor is moderate and the stimulus being judged is ambiguous (Herr, Sherman & Russell, 1982).

We have seen that the characteristics and dynamics of adaptation do not match the dynamics of contrast effects. There are also more general reasons that adaptation does not seem to make sense in thought. One such reason is emphasized by Block (2014), in the quote above. To repeat, he pointed out that adaptation contributes to the purpose of perception – to register news – by filtering out old news, but since cognition is equally concerned with old news, we would not expect adaptation in thought. As pointed out in the first chapter, cognition involves reasoning, decision making, problem solving – processes that centrally involves comparing and applying old information, like past experiences, knowledge, strategies, principles, and so on, with the current task. Thus, it is unclear what benefits cognition would gain from filtering out old information.

However, the existence of anchoring effects seems to show that, because news often is more accessible than old information, news is in fact sometimes favoured in thought. This makes

Block's point slightly imprecise. We must therefore go a bit more into detail about how adaptation contributes to the purpose of perception, to see why the same function would not contribute to the purpose of cognition.

Adaptation is selective change in sensitivity, as a result of renormalization of responses to incoming stimuli. This is thought to serve various beneficial roles, among other things, to ensure optimal and efficient processing as well as contributing to perceptual constancy. The visual system needs to continuously adjust its responses to cope with the variations in the incoming stimuli. This is directly tied to the visual system's task: to produce a continuous representation of the current environment (the current "here" and "now"). Cognition, however, is not restricted to the "here" and the "now". Cognition is also concerned with the past, the future, the abstract, and so on.

While perception is concerned with generating accurate representations of the current environment, the role of cognition is much more general, both with regards to the tasks it performs, and to the contents of which it is concerned. We miss, and regret, things in the past, we plan, and hope, for the future, we construe abstract theories about relations in the world, we solve mathematical problems, make decisions, form beliefs, and so on. Some concepts (understood as cognitive elements) could possibly benefit from continuous adjustment. Others would perhaps benefit from being robust and resilient to change. However, being nearly unrestricted in generality, it is hard to see how it could be beneficial for cognition to be governed by a lawful renormalization pattern. Moreover, there is generally not one fixed purpose for each one concept; we often use the same concept in a variety of different ways. Hence, it even seems unlikely that the same concept would benefit from adjusting in one particular way.

Continuous renormalization makes sense for perception; it contributes to the formation of stable representations of the immediate environment on the basis of varying proximal stimulation. Cognition, on the other hand, does not have a corresponding source of stimuli which it would make sense to adjust in accordance to. Considering both the generality of the tasks cognition perform, and the generality of the content of cognitive states, it does not make sense for cognitive processes to follow lawful readjustment patterns. I think this also holds for processes that produce relatively automatic cognitive judgments that occur "without explicit inference or felt effort". General considerations about the role of cognition makes it unintelligible why cognition would be susceptible to adaptation.

Although contrast effects and adaptation are similar on the surface, closer examination reveal that contrast effects lack several of the central characteristics of adaptation – characteristics that contribute to adaptation being what it is. Contrast effects simply do not seem to fit into the framework of adaptation.

3.3 Further evidential sources

From the discussion above, I conclude that we do not have reason to think that adaptation occur in thought. The most plausible candidates for being instances adaptation in cognition, contrast effects, turned out to be quite different from adaptation. I have described various general differences from which they can be distinguished. Contrast effects can transfer between categories, they can be avoided, and there is no strict regularity in the strength of the effect and how long they persist. Additionally, the same cause can even have the opposite effect; assimilation. Adaptation, on the other hand, is selective, automatic, and the processes follow lawful and specific adjustment patterns.

While we have general reasons to refute that adaptation occur in the cognitive domain, we have also seen that contrast effects can sometimes, on the surface, be quite similar to adaptation effects. It is therefore important to be careful not to confuse the two effects. Experiments are often based on subjects reporting what they see, which involves a particular risk of confusing effects on judgment and effects on perception (as the top-down debate discussed in chapter 1 illustrates). I will therefore note some further evidential sources that can be used, in specific cases, to make sure that a given effect in fact is a genuine case of adaptation.

One strategy is to design an experiment that enables us to measure adaptation independently of perceptual judgments. Schwiedrzik et al.'s (2013) study, described in the beginning the chapter, is one example of this.

Localization in the brain can serve as supporting evidence with regards to these issues. If an effect can be localized in a brain area associated with perceptual processing (like the visual cortex), this will support the claim that the effect is perceptual. Such evidence is limited, however. The reason for this is that, even if a process can be localized in a visual brain area, we cannot exclude that the brain area in question depends for its operations on other brain areas that serve cognitive processes. It is also hard to conclusively exclude that brain areas involving visual processing do not also serve post-perceptual processes. Although localization cannot by itself settle the issue, it can serve as supplementary evidence for the perceptual nature of a given effect. (Block, 2014; Burge, 2014)

Another evidential consideration that can be relevant in determining whether a given effect is a case of genuine perceptual adaptation, is whether the aftereffect depends on the *retinal location* of the presented stimuli. If the occurrence of an aftereffect is contingent on whether the test stimulus is presented in the same retinal location as the adaptor stimulus, independent of external location, then the aftereffect is arguably determinably perceptual. While the formation of perceptual states depends on proximal retinal stimulation, cognitive states do not. In the next chapter, I will describe a study (Rolfs et al., 2013) that uses evidence that the causation aftereffects are dependent on retinal mapping to argue that the effect is perceptual and not cognitive. As they argue:

> Cognitive boundary shifts are common and may even be contingent on location in the world – what looks like steam over a pot will look like steam over a chimney. Never, however, will cognitive boundary shifts be specific to a particular location on our retina, independent of location in the world. (Rolfs et al., 2013, p 253)

While retinal dependence can be powerful evidence that a given aftereffect is perceptual, the lack of retinal dependence is not necessarily evidence to the contrary, however. This is because retinal dependence gradually diminishes at higher levels of the visual hierarchy. And since many high-level properties naturally will be processed in the higher levels of the visual hierarchy, we cannot expect all high-level properties to be retinally dependent. For example, Leopold et al. (2001) found that face aftereffects showed partial transfer between retinal location, size, and orientation, of the stimulus. They used this finding to argue that face aftereffects are due to face specific adaptation at higher levels of the visual hierarchy, as opposed to a combination of low-level adaptation to orientation, spatial frequency and colour. Thus, retinal dependence can show that a given representation is perceptual, but the lack of retinal dependence, however, does not, in itself, show that a given representation is cognitive.

However, if an effect is perceptual, but independent of retinal location, then we should expect the entire visual field to be equally susceptible to the effect, since perceptual effects ultimately depends on proximal stimulation. Thus, if a given effect is independent of retinal location, but depends on location in the world, this suggests that the effect is cognitive. If for example, the occurrence of an aftereffect depends on where in the room the stimulus is presented, but is independent of which angle you see the stimulus from or where in the room you fixate your eyes, then the effect is likely to be cognitive, and a result of a cognitive association you have to that specific location (Rolfs et al., 2013).

3.4 The Perceptual Adaptation Hypothesis, first revision

Based on the discussions so far, I will end the chapter with a first revision of the perceptual adaptation hypothesis, to make sure that it does not apply to contrast effects:

The Perceptual Adaptation Hypothesis, first revision (PAH1): *If a represented property is susceptible to selective and automatic adaptation with a lawful and specific readjustment pattern, then the property is perceptually represented.*

And correspondingly, the stronger version:

PAH1^{STRONG}: *A represented property is perceptually represented if and only if it is susceptible to selective and automatic adaptation with a lawful and specific readjustment pattern.*

The "selectivity" requirement means that the adaptation must be restricted to tokens of the property type in question. The "automaticity" requirement is meant to capture that the process must be automatic, mandatory and inaccessible from conscious thought (you cannot consciously intervene with the processes). The "lawful and specific readjustment" requirement captures the dynamics of adaptation, specifically the build-up and decay of the aftereffects, briefly described earlier, stated more precisely by Leopold et al. (2005).

Opponents might reply that the revision of the hypothesis is ad hoc; that we have no legitimate reason to "shape" adaptation to fit our interests. However, it is important to keep in mind that we are not trying to formulate a conceptual definition of perception. What we are trying to do is to *discover* the boundary between perception and cognition as it is manifested in the nature of the mind. We have not shaped adaptation to fit our interests; we have considered evidence about the dynamics of adaptation and contrast effects and discovered that they are not instances of the same phenomenon.

Although the upshot of the preceding discussion is that it seems doubtful that adaptation occur in thought, and thereby that high-level adaptation could be a cognitive effect, there is a related alternative which might be more worrisome. Even if the alterations adaptation causes are perceptual, the possibility still remains that they are ultimately all low-level. That is, it is possible that when you continuously stare at a high-level stimulus, the visual system adapts only to its low-level properties, causing changes in the visual appearance of subsequently viewed stimuli, but only at lower levels. For the perceptual adaptation hypothesis to succeed, we must be sure that what we take as high-level adaptation is not just a product of low-level adaptation. The upcoming chapter will discuss methods for excluding this possibility.

4 Is all adaptation low-level?

The topic of this chapter is how to rule out that what seems like a high-level adaptation aftereffect is actually just a result of low-level adaptation. The worry is that, when adapting to a facial expression, for example, the visual system adapts only to the low-level properties of the face – its shape, size, lines, contours, and so on –, which alters the visual appearance of the face. As a result of the low-level changes, subsequently viewed faces literally *look* different, causing you to (automatically) judge its facial expression to be different. But the visual system has not selectively adapted to the face *as a face*, the adaptation processes have only operated on its low-level properties. If this is the case, then although adaptation can alter the appearance of faces, these effects does not show that vision represents faces, because the representation of the face *as a face* are produced only outside the visual system.

Note how this worry differs from that of the previous chapter. In the previous chapter, we discussed whether the processes of adaptation themselves could be cognitive, or whether such processes also were present in cognitive systems. The present worry is not whether the processes of adaptation themselves could be cognitive, but whether the high-level representational changes caused by adaptation could be cognitive, as a result of visual adaptation to low-level features. The accusation of the previous chapter was that adaptation for a given (high-level) property does not show that the property in question is perceptually represented because adaptation also occur in cognition. The present accusation is that changes in the representation of a given high-level property, as a result of adaptation, does not show that the property in question is perceptually represented, because adaptation could adjust only to low-level features of the high-level property, and never selectively to the high-level property itself. From the beginning, there were reasons to expect adaptation only to occur in perceptual processing. Further considerations made it even more unlikely that adaptation is also a cognitive phenomenon. Thus, the present worry might seem even more serious than the previous.

This is also Burge's (2014) main worry. He seems to be less worried about whether adaptation processes themselves are perceptual. In his reply to Block (2014), Burge focus is on whether we can know that adaptation operates on higher levels of vision. As he puts it:

> There is extensive evidence that adaptation is a sensory – as distinguished from cognitive – process. But whenever a higher-level attributive exhibits adaptation,

> there is the question whether the adaptation operates on its low-level, perceptual applicational basis, even while the higher-level attributive itself is formed only post-perceptually. In other words, even if a higher-level attributive is *not* formed in a perceptual system, but nevertheless has a perceptual applicational basis in low-level perceptual attributions, perceptually based applications of that non-perceptual higher-level attributive will still exhibit adaptation. (Burge, 2014, p. 580)

Burge is, on the face of it, more hesitant about the adaptation methodology than Block: "[Block] thinks that facial and facial-expression attributives are prima facie perceptual because they are subject to adaptation effects. I think the matter [is] less straightforward" (Burge, 2014, p. 579). However, Burge admits that "…Block is probably right that face-related attributives are perceptual. He is certainly right that adaptation is evidentially relevant" (Burge, 2014, p. 583). However, Burge thinks that no one criterial test can determine whether a property is visually represented, and that we need to use evidence from various sources. As Block is also aware that we need evidence to rule out both the cognitive interpretation, and the low-level interpretation, of high-level aftereffects, it is a bit unclear what Burge's disagreement with Block ultimately amounts to.

How can we meet the low-level worry? High-level stimuli are always constituted by certain low-level features. For a face to look like a face, for example, it must have certain shape, size, structure, and so on. An object cannot look like face if it does not meet any of the low-level criteria associated with faceness. Usually, high-level properties are attributed on the basis of low-level properties. This is also the case for cognitive representations. If faces are represented only cognitively, the basis for judging 'that is a face', when a face is seen, will still be the low-level visual features of that object. Changes in low-level features of a stimulus can therefore potentially alter which high-level properties we attribute to it, even if the attribution is cognitive. Since, whenever you adapt to a high-level stimulus (like a face), you will also adapt to the low-level features of that high-level stimulus, the possibility that the effect can be explained by adaptation to low-level features will always be present. We must therefore be able to rule out the low-level interpretation whenever we stand against what we take to be adaptation to a high-level property. What we need seems to be methodological strategies for distinguishing adaptation to high-level features of a stimulus from adaptation to low-level features of that same stimulus.

I will begin by discussing a study, pointed out by Block (2014), as evidence that adaptation to faces cannot be accounted for purely by low-level adaptation. The study is an example of how we can disentangle high-level from low-level adaptation. Then I will describe other types of evidence that can also be brought to bear on the present problem. Then, I will describe a study which is pointed out by several authors, including Burge (2014), as a prime example of a study that combines sources of evidence to exclude both the cognitive interpretation, and the low-level level worry, in arguing that causality is perceptually represented. I end the chapter by making a final revision of the adaptation hypothesis.

4.1 One strategy for distinguishing levels of adaptation

Block (2014) points out a study by Susilo, Mckone and Edwards (2010) which is designed to distinguish aftereffects deriving from low-level, shape general, adaptation from aftereffects deriving from high-level, face specific, adaptation. The experimental design is based on two ideas. First, there is evidence that the visual system's processing of inverted faces is qualitatively different from its processing of upright faces. Specifically, it has been suggested that the processing of inverted faces is object general (low-level), as opposed to face specific (high-level) (Susilo et al. 2010). Thus, if adaptation to upright faces reflect face-specific processing, then adaptation to upright faces should not be qualitatively identical to adaptation to inverted faces. The second idea is to examine transfer of adaptation between faces (high-level) and sufficiently similar non-face stimuli (low-level), on the assumption that adaptation which transfer between such stimulus types will derive from low-level adaptation.

As mentioned in chapter 2, we find adaptation in the aspect ratio of faces. For example, adaptation to eye height causes the usual adaptation aftereffect. Adapting to an elongated face (a face with eye height shifted upwards) makes the eye height of following faces appear lower. The eyes-nose-mouth region of a face forms a T-shape. Shifting the eye height of a face corresponds to moving the horizontal line of that T-shape up and down. Because of the similarity between 'T's and the shape formed by the eyes-nose-mouth region of faces, we should expect that, to the extent adaptation to faces are low-level, the eye height aftereffect should transfer between faces and T-shapes.[11]

[11] Note that this would not be an instance of adaptation being non-selective. The adaptation effect would not truly be a transfer between the property type 'T-shape' and the property type 'face'. The whole point is that the low-level shape properties of the T-shape, and the eyes-

The study compared transfer of adaptation between upright faces and T-shapes, with adaptation to inverted faces and inverted T-shapes. The subjects were asked to fixate on the adaptor, which was either a face, or a T-shape, of one of three elongations for 4 seconds, before they were presented with either a test face, or a test T-shape, and asked whether the test stimulus was 'too high' or 'too low'.

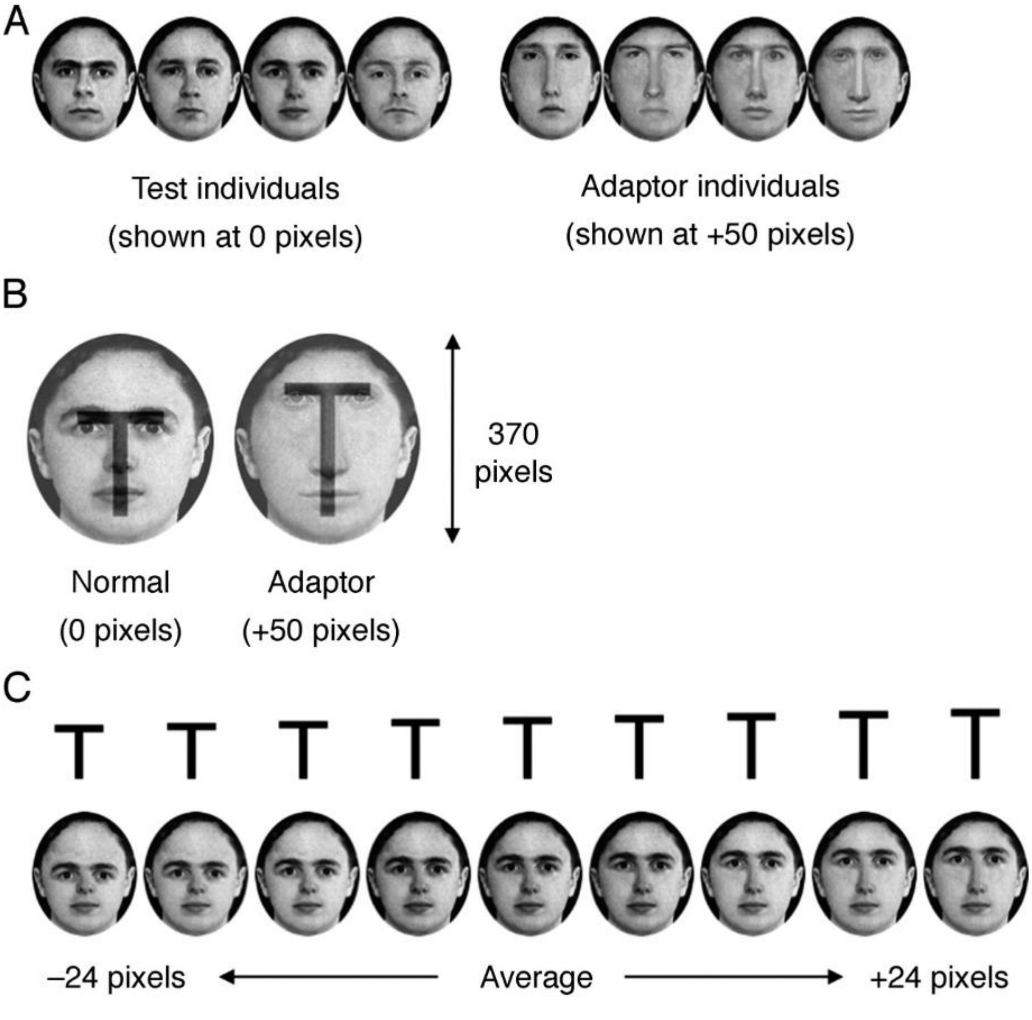

Figure 9. Adaptation to faces and T-shapes. From Susilo et al. (2010).

There were made three predictions: If an aftereffect originates purely from adaptation to low-level (shape general) properties, then we should find complete transfer between faces and T-shapes. That is, if 'F' stands for face, then F-F = F-T = T-T = T-F. If, on the other hand, an aftereffect originates purely from adaptation to (high-level) face-specific properties, then we should find *no* transfer from faces to T-shapes (that is, F-F > F-T and F-T = 0). If an

nose-mouth region of the face, would be sufficiently similar for selective low-level shape adaptation to work on both stimuli.

aftereffect originates from adaptation to a combination of low-level (shape general) and (high-level) face specific properties, then we should find partial transfer between faces and T-shapes (that is, F-F > F-T and F-T > 0 and T-F > 0). (Susilo et al. 2010, p. 8)

Susilo et al. found almost complete transfer (92%) between inverted faces and inverted T-shapes, suggesting that inverted face aftereffects result almost entirely from low-level adaptation. With regards to upright faces, on the other hand, they found a significantly smaller amount of transfer. Susilo at al. calculated that only 45% of the adaptation effect could be accounted for by shape general adaptation. 55% of the aftereffect were specific to faces, suggesting that a substantial part of the visual processing of faces derive from face-specific processes.

In Burge's (2014) reply to Block, he points out that it is very unlikely that we will find aftereffects that originates purely from adaptation to high-level properties. As noted above, the visual representation of high-level properties depends to a large extent on the occurrence of certain low-level properties. Low-level properties are usually the applicational basis for high-level properties. The visual system can arguably only recognize something as a face by consideration of low-level features. Thus, we should expect all high-level adaptation aftereffects, even when genuinely high-level, to result in part from low-level adaptation.

Burge (2014) is still not convinced by this study, however. He is not surprised that the geometrical patterns that are more specific to faces played a bigger role in adaptation than those more specific to T-shapes. His point is that, although faces and T-shapes share some low-level features, there are additional low-level similarities shared between faces which also contributes to the adaptation effect. Thus, it is unsurprising, according to Burge, that the face aftereffect shows a larger transfer from one face to another than from a face to a T-shape, and vice versa.

While this, in itself, seems like a reasonable observation, I am not convinced by this point. What Burge seems to overlook here is the fact that, for inverted faces, Susilo et al. (2010) found an almost complete transfer. If the lack of transfer between upright faces and T-shapes can be accounted for by other low-level features of faces, why did we not find the same lack of transfer between inverted faces and inverted T-shapes? It seems reasonable to think that, to the extent that other low-level features, beyond the pattern common to faces and 'T's, contribute to the eye-height aftereffect in faces, this would be equally observable in the inverted face condition. Thus, I think the lack of transfer in the upright face condition favours the explanation that facial aftereffects for upright faces derive partly from face-specific adaptation. I therefore think this is an example of a methodological way of disentangling low-level and high-level contributions in adaptation aftereffects, which can help us determine whether a given high-level aftereffect really shows that a given high-level property is visually represented.

4.2 Other strategies, sources of evidence, and relevant considerations

The above strategy involves comparing adaptation to a high-level stimulus with adaptation to a stimulus that shares some of the low-level features of the high-level stimulus, but not the high-level property under study. Another related strategy is to keep the high-level property constant, while varying the low-level properties, on the assumption that, if adaptation is selective for the high-level property, then the aftereffect should persist through variations of low-level properties, as long as the high-level property is present. Fox & Barton (2007), for example, tested adaptation to facial expression across faces of different identity and gender. They found that adaptation to a certain facial expression (like anger), produced aftereffects on subsequently viewed faces irrespective of gender and identity. Other face aftereffects have been found to persist through variations in size, spatial frequency content, contrast, and colour (Yamashita, Hardy, Karen, Webster, 2005). Faces, no matter how different, will ultimately have many low-level properties in common, however. This is because looking like a face ultimately amounts to meeting some low-level criteria of faceness. Thus, it seems that, although adapting to one face can yield aftereffects on a different face, the possibility could remain that the aftereffect is due to adaptation to the low-level properties shared by those faces. Since the occurrence of most high-level properties depend on the occurrence and structure of certain low-level properties in this way, this strategy faces some obstacles.

Burge (2014) points out that timing considerations can be brought to bear on the levels of which a given adaptation effect occurs. It has been shown that early visual processing needs longer time to adapt than later stages. While we find adaptation in visual processing in primary visual cortex (V1) after minimum 500 milliseconds of stimulus exposure, later, and more advanced, stages of visual processing show adaptation after 150 milliseconds, and sometimes even less (Suzuki, 2005). While processing in V1 centres on local features of a stimulus, these later stages centre on more global features of the stimulus. Thus, it seems possible to use what we know about timing to isolate different levels of adaptation.

I have already mentioned that localization in the brain, and retinal dependence, are relevant in determining whether an effect is perceptual or cognitive. Naturally, these types of evidence are also relevant in distinguishing levels of adaptation within the visual system. Where in the brain a given adaptation process can be localized could help determine at what stage of the visual hierarchy that adaptation process occur. Further, if an aftereffect depends on retinal location, then the effect must derive from a brain area that process information in an eye-centred reference frame. Although retinal dependence is mainly associated with early stages of visual processing, some brain areas associated with later stages of visual processing, like the mediotemporal area (V5) and the superior temporal sulcus, show retina mapped processing (Rolfs et al., 2013).

Another interesting point Burge (2014) mentions concerns the role of attention. With experience and practice, we acquire expertise in different fields. If you study birds over time, you can become an expert in identifying bird species on the basis of appearance. And similarly, if you are a piano collector you might become an expert in piano types. By acquiring expertise with respect to certain kinds of objects, your capacity to identify and distinguish among such objects can improve. And arguably, the experience of the expert will differ from that of the non-expert, when looking at the same object. It would be a misinterpretation, however, Burge claims, to assume that the bird expert and the piano expert, respectively, has acquired the capacity to perceptually represent different bird species and piano types (according to Burge, there is no evidence supporting this interpretation). By acquisition of expertise, what the expert learns is to "…attend to, group, distinguish and remember…" (Burge, 2014, p. 582) certain low-level features of these objects in ways that anyone who is not an expert will not. The bird expert, for example, might learn to attend to, and thereby notice, various, perhaps subtle, features of a bird's shape, colour, and so on, which might also affect how these features are grouped by the visual system. Burge calls this *expertise guided attention*. By causing attention to, and thereby becoming aware of, subtle low-level features of certain objects, expertise guided action can improve the perceptual applicational basis of such things as bird species and piano types. The application of a given bird species or piano type to a perceived object, however, is not perceptual, according to Burge.[12]

The reason this is relevant for the present discussion is that, although this has not been comprehensively tested, Burge believes that we would find adaptational differences between experts and non-experts within the expert's field of expertise. We could imagine, for example, an experiment where subjects are first asked to stare at a bird of a certain species, let's say a magpie, before being presented with a bird which is ambiguous between a magpie and a sparrow. Since expertise guided attention improves the perceiver's ability to notice and differentiate details, it seems plausible that, for a bird expert, adapting to the magpie will make the ambiguous bird appear less like a magpie (and thereby more like a sparrow), while the non-expert would show no such effect. On the face of it, this might seem like a high-level adaptation effect which reveals that the bird-expert has acquired a capacity to perceptually represent magpies and sparrows, whereas the non-expert, who remained unaffected by adaptation to the magpie, has not. What Burge seems to suggest however, is that in such cases, the adaptational differences can be explained in terms of attention. The bird expert, who has an improved capacity to attend to low-level features of birds, will notice differences resulting from adaptation to the low-level features of the magpie, while the non-expert will not.

Although I am suspicious, I will not take a stand on whether we can learn to perceptually represent bird species and piano types. But Burge's point regarding expertise guided attention seems reasonable. If we overlook the role of attention with regards to these issues, we might be led to ascribe a perceptual nature to clearly non-perceptual high-level representations. The lesson to take from this is that, if we find what we take to be selective adaptation to a high-level property, especially if representation of that property is likely to be a learned representation, we should be able to exclude that the effect is not due to expertise-guided attention to low-level features of that high-level property, before concluding that what we have found is actually a high-level adaptation aftereffect. The strategy for addressing this worry will coincide with the strategy for addressing the low-level worry in general, however, I think it is important to be aware that expertise guided attention could be a source of misinterpretation.

[12] Price (2009) and Connolly (2014) use the same line of argumentation to reject Siegel's conclusion, from the method of phenomenal contrast, that we perceive kind properties.

4.3 An exemplary example

Especially one study has been pointed to, by several authors, as exemplary to how we can use adaptation to determinably show that a given property is perceptually represented. This is Rolfs et al.'s study on Visual Adaptation of the Perception of Causality (2013), which has already been mentioned in earlier chapters. Burge describes the study as "[a] fine example of combining different types of evidence – including evidence from adaptation and retinal dependence – to argue that attributives for *causation* are perceptual" (Burge, 2014, p. 581). Firestone and Scholl calls it "…our new favorite example…" (Firestone & Scholl, 2016b, p. 55) of ways to empirically demonstrate that a given property is perceptually processed, whereas Scholl and Gao contend that Rolfs et al.'s findings "…seems impossible to explain without implicating visual processing" (Scholl & Gao, 2013, p. 206). I will briefly describe this study.

We inevitably experience certain events as causes and effects of other events. When you observe someone running towards a ball and kicking their foot at it, and this event is followed by the ball flying through the air, it would be hard to avoid experiencing the first event as causing the other, that is, to see the kick as causing the ball to fly through the air. One possible explanation is that we automatically, but cognitively, infer the causal connection between the two events based on what we see. The other is that the representation of causation is produced by the visual system; that events are visually processed as causal events. To find out whether the representation of something as the cause of another are produced within the visual system, Rolfs et al. (2013) carried out a series of adaptation experiments.

In their experiments, subjects were presented with test events of two grey discs on a black background. In each test event, the first disc moves towards the second disc in a straight line. The second disc is initially stationary. When the first disc overlaps with the second disc to a certain amount, the first disc stops, and the second disc takes off in the same direction and with the same speed as the first disc. Whether you see the event as causal depends on the amount of overlap between the two discs when the first stops and the second takes off. If there is little overlap, you will see the first disc as hitting the second disc, causing it to move. If there is large overlap, however, you will see the first disc as merely passing over (or under) the second disc, which appears to remain stationary throughout the test event. Rolfs et al.

calls the first, causal interpretation, a *launch*, and the second, non-causal interpretation, a *pass*.

Their first experiment resembles the classical adaptation test. To obtain a baseline, the subjects were first presented with a series of test events with variations in disc overlap. After each event, the subjects reported whether the event was a launch or a pass. From these data, Rolfs et al. calculated, for each individual subject, the amount of overlap between the discs where he or she were equally likely to judge the event as a launch or a pass, that is, the *point of subjective equality* (PSE). After obtaining the PSE, the subjects were presented with the adaptor stimuli, which was a series of 320 clearly causal launch events. After the adaptation period, the subjects were presented with a second series of test events, and once again asked to judge, after each event, whether they saw a launch or a pass. With the aim of maintaining adaptation throughout the test period, the subjects were shown a series of 16 clearly causal launch events between each test event.

The results showed that the PSE of each subject was reduced after adapting to the clearly causal launch events; the amount of overlap where he or she was equally likely to judge the event as a launch or a pass had become smaller. In other words, the events that were ambiguous between a launch and a pass (the degree of overlap corresponding to the subjects PSE) before adaptation, were in most instances judged as a pass (that is, non-causal) after adaptation. Correspondingly, events that were initially reported as a launch (that is, causal), appeared ambiguous after adaptation. The change in PSE is clear evidence of adaptation; prolonged exposure to causal events biases subsequently viewed events in the opposite direction, making them appear non-causal. The reduction in PSE was larger with regards to the test events which was shown in the same location (relative to the fixation point) as the adaptor stimuli. This also indicates that the observed adaptation aftereffect is also spatially specific.

The first experiment indicates that representations of causation are susceptible to adaptation. The purpose of the second experiment was to test whether the effect could be explained by other visual features of the adaptor (and test) stimuli. The second experiment was set up as the first, but the adaptor stimuli was replaced by a series of ‘slip events’. These slip events were designed to match the adaptor stimuli in as many ways a possible. In the slip event, the first disc moves towards the second disc in a straight line. The second disc is initially stationary. Instead of stopping when it hits the second disc, the first disc stops right after it has passed completely through it. At the moment the first disc stops, the second starts to move in the same direction and with the same speed as the first. The slip events have the same properties as the launch events with regards to disc size, colour, speed, direction, duration and so on. Crucially, however, slip events do not appear causal. The motion of the discs appears as two independent events.

The results showed that adapting to the slip events had little or no effect on the subjects' PSE of the test events. If the adaptation effect observed in the first experiment was due to any property of the adaptor stimuli besides causation, then we should have found similar effects in the second experiment, since the adaptor stimuli of experiment one and two was similar in every respect (except with regards to causality). From this Rolfs et al. concluded that the adaptation effect found in the first experiment could not be explained by other visible features of the adaptor stimuli.[13]

In the third and final experiment, Rolfs et al. tested whether the adaptation effect observed in the first experiment were specific to retinal location. In the first experiment, the effect of adaptation was significantly larger if the test events were shown in the same location as the adaptor events. This result is silent on whether the effect depends on location in the world or location on the retina, however. As noted in the previous chapter, if the occurrence of an adaptation effect depends on the retinal location of the adaptor, then it cannot be explained as an effect on cognition. If the effect depends purely on location in the world, however, then it is likely to be cognitive, probably reflecting a semantic association between the adaptor and the location in question.

To test this, the adaptor events were presented at a given position relative to fixation point, while eye position was monitored. After adaptation period, the subjects either maintained fixation point, or shifted fixation point to a different location. Depending on the point of fixation, and the location of the adaptor and test events relative to point of fixation, the adaptor and test event either fell on the same retinal location but different spatial location; the

[13] Another alternative is that in the first experiment, the adaptor stimuli, instead of altering perception of causation, altered *perceived timing* of the events, which again affected *judgments* of causation. Whether you see the test events as a launch will depend on the timing between the motion stop and start of the first and the second disc. To exclude this possible interpretation Rolfs et al. also conducted a control experiment where they, instead of varying the degree of overlap in the test events, varied the delay between the stop of the first disc and the start of the second. They found that the results of the first experiment could not be explained by adaptation to timing.

same spatial location but on a different retinal location; the same spatial and retinal location; or on different retinal and spatial locations. Rolfs et al. found adaptation effects only when the adaptor and test stimuli fell on the same retinal location.

Note how each experiment in this study is a step towards securing the conclusion. First, Rolfs et al. provide evidence that the representation of causation is subject to adaptation, which indicates that the visual system is able to detect and represent events as causal. Then, in the second experiment, they rule out the low-level worry, and show that the effect cannot be explained by adaptation to other visual features. Finally, they rule out a cognitive explanation by showing that the effect is retinally specific. In other words, the study not only provides evidence for what appears to be adaptation for causal properties, it also excludes alternative interpretations, leaving only one plausible conclusion; that (at least one type of) causation is visually processed.

4.4 The Perceptual Adaptation Hypothesis, final revision

The low-level worry is a genuine worry. Perceptible low-level features are (at least usually) the applicational basis both for perceptual and cognitively applied high-level properties. To see an object as a face, the object must instantiate some specific low-level properties associated with faceness. Whether you see the object as a face or not, depends on whether these low-level properties are instantiated. Thus, changes in the representation of low-level features of an object can also change which high-level properties you apply to it, both perceptually and cognitively. This opens the possibility that, when adaptation alters the representation of a high-level property, adaptation has not altered that representation directly, but rather that adaptation only has adjusted to the low-level features of the stimulus, and thereby altered the applicational basis for the representation of the high-level property in question. In short, the worry is that what seems like adaptation to a high-level property is a result of low-level adaptation.

The main reason this is hard to test is that a high-level stimulus will always instantiate certain low-level features, which usually are the application basis for the high-level property in question. Thus, low-level adaptation will always occur concurrently with high-level adaptation. You cannot adapt to a high-level property in isolation, because the occurrence of the high-level property depends on the occurrence of certain low-level properties.

Thus, I will revise the hypothesis once more, to make sure that it does not capture low-level adaptation disguised as high-level adaptation. That adaptation for a given stimulus property should not be due to adaptation to low-level features of the stimulus is implicitly captured by the "selectivity" requirement – the requirement that the adaption must be selective for the property in question. However, I think the low-level worry is of such importance that it should to be addressed explicitly in the hypothesis. Below is the final revision:

The Perceptual Adaptation Hypothesis, final revision (PAH): *If a represented property is susceptible to selective and automatic adaptation with a lawful and specific readjustment pattern, and adaptation to that property is not a result of adaptation to other visual features of the stimulus instantiating the property, then the property is perceptually represented.*

And correspondingly, the stronger version:

PAH^{STRONG}: *A represented property is perceptually represented if and only if it is susceptible to selective and automatic adaptation with a lawful and specific readjustment pattern, and adaptation to that property is not a result of adaptation to other visual features of the stimulus instantiating the property.*

We have seen examples of how we can determine whether adaptation for a property is a result of adaptation to other visual features of the adaptor stimulus. Further, we saw that timing considerations, retinal specificity and brain location can serve as relevant evidence in determining at which level a given adaptation process operates.

Susilo et al. (2010) studied the transfer of adaptation between upright and inverted faces and T-shapes. Rolfs et al. (2013) compared the effect of adapting to causal events with the effect of adapting to events that shared the same low-level characteristics, but lacked the causal property. Both studies make use of similar strategy, which involves comparing adaptation to a stimulus instantiating a high-level property, with adaptation to a stimulus that shares some of the low-level characteristics of the high-level stimulus, but lacks the high-level property in question. The idea is that, if adaptation to the low-level stimulus produce similar aftereffects as adaptation to the high-level stimulus, then the aftereffect can be explained in terms of low-level adaptation. If the low-level stimulus does not yield similar aftereffects, or only to a smaller extent, on the other hand, then the aftereffect produced by adaptation to the high-level stimulus is likely to involve high-level adaptation.

This strategy might sometimes be hard to realize, however. To make use of the strategy, we need to come up with a stimulus that is sufficiently similar to the stimulus instantiating the high-level property we wish to test for, but crucially does not have that property itself. In Rolfs et al.'s (2013) case, this was easy. The nature of the causal stimulus made it relatively straight forward to generate a new stimulus that shared almost every low-level property with the causal stimulus, without instantiating causality. However, the more intimately the high-level property is connected to the low-level properties of the stimulus, the more complicated the task of separating the will be. For many facial characteristics, for example, it might be hard to generate a stimulus similar enough to the facial characteristic, without it becoming a representation of that facial characteristic. At the same time, if the new stimulus becomes too abstracted from the original facial characteristic, comparing the effects of adapting to them becomes worthless. My point is that, we must expect that sometimes we will be forced to find creative solutions to overcome this worry. I think Susilo et al.'s (2010) study is a good example of such creativity. Arguably, faces and T-shapes are not, in themselves, similar enough to show that, since adapting to a face yields larger aftereffects on faces then adapting to T-shapes does, the aftereffect is face specific. However, in showing that if you do the same test with the stimulus upside down, the aftereffect is similar across stimuli, their conclusion is supported.

5 Do *all* perceptual properties show adaptation?

At the end of the previous chapter, we arrived at a hypothesis that excludes both a cognitive and a low-level explanation of adaptation. That is, the effects that the hypothesis will apply to can arguably only be given a perceptual explanation. The upshot of our discussion is that the method of adaptation can show, in an empirically warranted way, that a given property is perceptually represented.

The method is not as simple as it might initially have seemed, however. Unfortunately, we cannot conclude that a property is perceptual from the observation that it is susceptible to adaptation alone. Although the observation of an adaptation aftereffect makes the inference plausible, to be warranted in actually making the inference, we first needed to exclude two alternative explanations.

First, we must make sure that the alleged adaptation aftereffect is not a result of a cognitive change in category boundaries. As we saw, we do not have reason to think that adaptation occur in thought (considerations about the dynamics of thought rather suggest the contrary). However, there is a cognitive phenomenon called contrast effects, which, on the surface, might look similar to adaptation aftereffects. Therefore, whenever we observe what we believe to be an adaptation aftereffect, we must be sure that that we don't confuse it with a cognitive contrast effect.

Second, we must eliminate the possibility that the observed adaptation aftereffect is a result of adaptation to other (low-level) features of the adaptor stimulus. I have discussed various experimental strategies, as well as other evidential sources, that can contribute to excluding these possibilities. Presently, the best example of someone managing to both establish an adaptation aftereffect, and eliminate alternative explanations of the effect, all in one study, is that of Rolfs et al. (2013), described in the previous chapter.

Of course, it would be great to have a straightforward test for determining whether a property is perceptually represented. However, as these processes are extremely complex, it would be naïve to expect the method for uncovering them to be simple.

The main focus of the present chapter is PAH^{STRONG}. First, I discuss whether we should expect that every perceptually represented property is susceptible to adaptation. I also discuss whether the hypothesis will be testable for every potentially perceptually represented property. I end the chapter by discussing a possible objection to PAH^{STRONG}.

5.1 Will we find adaptation for every perceptually represented property?

We have seen that the adaptation methodology can determine that a property is perceptually represented. But can we expect all perceptually represented properties to show adaptation? That is, should we endorse the strong version of the Perceptual Adaptation Hypothesis? PAH can only partially distinguish perception from cognition. PAH can establish that a property is perceptually represented, PAH is silent, however, with regards to properties that are not susceptible to adaptation. Given that PAH, but not PAH^{STRONG}, is true, we will need a further method for determining the representational nature of properties that is not susceptible to adaptation. In other words, for the adaptation methodology to be successful in distinguishing perception from cognition completely, PAH^{STRONG} (or something like it), must be true.

The question is whether adaptation is a universal characteristic of all perceptual processing. At least some psychologists seem to think so. We have seen that adaptation plays an important role in perception, in that it helps perception continuously adjust to environmental variations. Moreover, we find signs of adaptation throughout the visual stream. According to Webster, the research on visual adaptation has "…led to an emerging view of adaptation as a fundamental and ubiquitous coding strategy impacting all aspects of how we see" (Webster, 2015, p. 547).

Consider the following statement by Webster (2015), a statement in which he modestly concedes that "does not seem far from the truth" (p. 548):

> If adaptation is an intrinsic feature of neural processing, then we should expect to see signs of it throughout the visual stream, reflecting at each stage a plasticity for the kinds of information the neural circuits are designed to represent. That is, the types and patterns of visual aftereffects should be nearly as rich and complex as the gamut of our perceptions. (Webster, 2015, p. 548)

If adaptation plays a fundamental role in how perception processes information, then we should expect that the perceptual systems adapt to all the aspects of the world it detects and distinguishes among. In discussing perception of numerosity, Burr and Ross also seems to suggest that we should find adaptation for all properties that the visual system represents: "All primary visual properties are susceptible to adaptation […]. If numerosity was a primary visual property […], it too should be prone to adaptation" (Burr & Ross, 2008, p. 425).

This is ultimately an empirical question. It is at the very least consistent with the present evidential situation, and in accordance with what experts in the field seem to think, that every perceptually represented property is susceptible to adaptation, in other words, that the strong version of the hypothesis is true.

Given that perceptual systems adapt to all the properties they process, a further question is whether the hypothesis is *testable* for all potentially perceptual properties. Fish (2013) expresses such a worry:

> …to test whether or not adaptation occurs, we need to somehow identify a dimension containing the test property, an "opposite" and a neutral "half-way house" […]. With these constraints in mind, it is not easy to see how one might test whether or not adaptational effects occur with the kinds of higher-level properties that philosophers are typically interested in. How might we create such a dimension for the property of being a tree, for example? (Fish, 2013, p. 52)

Fish uses the waterfall illusion as an example. The waterfall illusion shows that vision adapts to motion. Construed as a test, the downward moving waterfall is what Fish calls the "test property"[14] (what we have called the adaptor stimulus), the stationary scene serves as the neutral "half-way house" (or the test stimulus), and upwards motion is the "opposite" property, manifested in the adaptational effect. What Fish seems to suggest is that, for the adaptation methodology to be testable on a given property, the property must have an opposite and a neutral counter-part. Thinking along these lines, it is not easy to see how we could test whether kind properties, like that of being a tree, are susceptible to adaptation. I think Fish over-simplifies the matter, however. If we look beyond the surface, it might become intelligible how to construe tests also for kind properties.

[14] Strictly speaking, I would say that the more general property type 'motion' is the test property in this example, if test property is to be understood as the property we test for.

As noted earlier, adaptation is generally understood as renormalization. This is a matter of adjusting responses to stimuli, either by re-centring a defined norm, or by averaging responses in accordance to the current stimuli condition. It is therefore natural to think that the visual system adjusts along dimensions of which the property in question is represented. While colours in general are represented along various dimensions (hue, saturation, brightness), a colour's hue, is represented one-dimensionally; from green to red; blue to yellow; and black to white. Faces are thought to be represented multi-dimensionally, in so-called *face-space*. In short, face-space is a multidimensional space, where each dimension corresponds to some facial characteristic (like, for example, face length, distance between the eyes, or masculinity/femininity). Each face corresponds to a specific location in this space. Faces that are similar are located nearby, whereas dissimilar faces are further apart. The centre of face-space corresponds to the average face, or the norm (Valentine, Lewis & Hills, 2015).

Fish seems to suggest that, for a property type to be testable for adaption, the property type in question must be represented along a one-dimensional spectrum, with opposing tokens of the property at each end, and a neutral point in the middle. In other words, Fish seems to think that, to test whether representation of trees are susceptible to adaptation, we must first find an adaptor tree, wish belongs to one end of the spectrum. Then, we must identify a "neutral tree", and see whether adapting to the adaptor tree makes the neutral tree look like the opposite of the adaptor tree (whatever that might be).

The classical adaptation examples, like the waterfall illusion and the tilt aftereffect, involves a logical opposition between the adaptor property and the aftereffect. Downward and upward motion are logical opposites, and so is being tilted clockwise and being tilted counter-clockwise. Moreover, both examples involve intuitive neutral points; 'staticity' and 'verticality'. I think these examples is what drives Fish's reasoning.

However, in many cases, adaptation does not involve either clear oppositions, or obvious neutral points. This is typical for higher-level cases, such as adaptation to faces. We have seen that adapting to a fearful face makes ambiguous faces look angry and vice versa. However, we cannot say that being fearful is the opposite of being angry. Moreover, the ambiguous face in this case is not strictly speaking a neutral face; it is a mix between the angry and the fearful face, and is therefore neutral only with respect to expressing anger and fear.

In general, this is how adaptation tests for facial features are set up. For example, adapting to an Asian face makes a face ambiguous between Asian and Caucasian appear Caucasian, and adapting to a Caucasian face makes the ambiguous face appear Asian (Webster & Macleod, 2011). This test is not based on the assumption that being Asian and being Caucasian are opposites on a racial spectrum. Neither does it assume that there exists some special neutral racial point. The test face is merely a hybrid between the two faces, which naturally, given that one face clearly looks Caucasian and the other clearly looks Asian, makes it ambiguous between Asian and Caucasian. The point is that we use a face that by assumption corresponds to some location in face-space, and compare it with a face that corresponds to a different location in face-space. The assumption is that, adapting to either of the faces will shift the "facial norm" in the direction of the face in question, which changes the appearance of subsequently viewed faces, biasing it in opposite directions in face space. This opposite direction, however, does not have to correspond to a logical or intuitive opposite in terms of property type. Arguably, many facial characteristics, like, for example race, depends on several dimensions in face-space. But even if a property is represented one-dimensionally, it does not imply that the left and the right end of the spectrum are either logical or intuitive opposites, nor that there must be a point where the property is obviously neutral. Of course, norm-based coding assumes that properties are represented by how they deviate from a given norm, but the norm does not have to correspond to an obvious neutral point (although this is sometimes the case for simple properties). At any rate, adaptation tests do not require that we test the property against the norm. Moreover, testing the hypothesis on a given property type does not require that we have already identified the dimensions of which the property in question is represented along. The idea is that this is what the adaptation methodology can help us do. That is, by testing the effects of adapting to variations of a property type, we can uncover the how the visual system processes that property, including the dimensions it is represented along.

Due to the complexity and variation among trees, it seems reasonable to think that, if the property of being a tree is perceptually represented, then it is likely to be represented multi-dimensionally, in "tree-space". To test whether trees are susceptible to adaptation, we would *not* first need to identify two opposite trees, and a neutral tree. We could for example, use illustrations of two trees that are different in certain respects (or in other words, two trees that would correspond to different locations in tree-space with regards to certain dimensions), for example a pine tree and a birch. Then we generate a hybrid illustration of the two, and test whether adapting to the pine tree makes the hybrid look more like a birch, and vice versa. (Given that such aftereffects are found, we would of course, have to exclude both that the effect was due to a cognitive boundary shift or to low-level adaptation, before concluding that trees are perceptually represented). If it would turn out that trees are in fact susceptible to adaptation, then we could, by testing adaptation with various different trees, uncover the dimensions of which they are represented along. I think we could easily construe similar examples for many other kind properties, like 'being a piano', 'being a bird', 'being a tomato' and so on, and therefore that we do not have to worry that the methodology will not generally be applicable to kind properties.

There might be other reasons why the adaptation methodology will not be applicable to certain properties, however. In their 2013 paper, Scholl and Gao discuss whether we can perceive animacy and intentionality, that is, whether certain objects can be perceptually represented as living agents with goal directed behaviour.

While Scholl and Gao seems to wish that we could apply the adaptation methodology, they say that, "[u]nfortunately, this sort of strategy does not seem to be available in the case of the perception of animacy, in part because the cues to animacy in this domain are so necessarily dynamic in both space and time" (Scholl & Gao, 2013, p. 206).

Perceiving an object as a living agent depends on how the object moves and behaves. Both the waterfall illusion and Rolfs et al.'s (2013) study on causation illustrates that we can indeed construe adaptation tests for moving stimuli. And like Rolfs et al.'s study (2013), many studies on the perception of animacy involves moving dots (or other simple geometrical objects) (Gao & Scholl 2011; Gao, McCarthy & Scholl, 2010; Gao, Newman & Scholl, 2009). The task often involves reporting whether systematically varied moving dots appear alive and engaged in goal directed behaviour, or whether their behaviour seems mechanical and artificial. Thus, I think it is no principled reason why the adaptation methodology could not be applicable also here. However, since animacy involves complex behavioural patterns, and therefore are so "necessarily dynamic in both space and time", I see that it might be practically problematic to construe adaptation tests in cases like these.

In lack of an applicable adaption test, Scholl and Gao (2013) makes use of alternative evidence, from five different evidential sources, which taken together show that representation of animacy is perceptual in nature.

First, we see animacy and intentionality in similar ways as we see other clearly perceptual phenomena, that is, fast, effortlessly and automatically. Moreover, we cannot resist seeing something as animate by choice. Scholl and Gao admit that “[o]f course, phenomenology alone cannot settle the question at hand […]. Indeed, perhaps the central lesson of cognitive science is that our introspective intuitions about how the mind works are fantastically poor guides to how the mind actually works” (Scholl & Gao, 2013, p. 209). However, they still find it worth noting that the phenomenology of animacy is very similar to the phenomenology of other perceptual phenomena and “…very much in contrast to the phenomenology of many other forms of slow deliberative, intentional, and eminently resistible decisions” (p. 209).

Second, as with other perceptual representations, perception of animacy and intentionality is strictly dependent on subtle visual display details; “…percepts seem to be irresistibly controlled by the nuances of the visual input regardless of our knowledge, intentions, or decisions” (Scholl & Gao, 2013, p. 209). Studies show that systematic and algorithmic variations of subtle visual clues (which arguably is too subtle to affect our cognitive judgments about animacy) affect how and whether we perceive an object as animate (Gao et al., 2009).

Third, the perception of animacy show irresistible influences on visual performance. One way to study perception of animacy is to construe computer games, where subjects control one dot, and their task is to avoid other moving dots, some of which are chasing you (Gao et al., 2010; Gao & Scholl 2011). The task is then implicitly to detect the ‘animate’ dots that are chasing you. In this way, such studies measure “…visuomotor *performance* rather than explicit reports of ratings” (Scholl & Gao, 2013). Such studies show that variations in visual cues of animacy influence subjects’ performance on these tasks, independently (an even sometimes contrary) to their explicit judgments. Scholl & Gao contend that the irresistible influences on visual performance “…reflect some properties and constraints of automatic perceptual processing rather than higher-level decisions that subjects are overtly making about the contents of the displays” (Scholl & Gao, 2013, p. 216).

Fourth, perception of animacy and intentionality show activation of visual brain areas. I have already discussed how physiological evidence can bear on these issues. Gao, Scholl, and McCarthy (2012) found that perception of animacy implicates activation in the fusiform face area, and the motion-selective region MT+, both of which are strongly associated with visual processing.

Fifth, perception of animacy and intentionality show rich interaction with other visual processes. Specifically, Gao, New and Scholl (under review) showed that attention is systematically, reliably and very quickly shifted towards objects that appear animate. As Scholl & Gao (2013) argue, "[t]his is exactly what would be expected if animacy was controlling attention involuntarily as a part of ongoing visual processing, but it would be surprising for such fast, reliable and repetitive shifts to occur in the context of voluntary higher-level attentional control" (p. 221).

To sum up, we have seen that, although this is ultimately an empirical question, there are reasons to think that adaptation is a fundamental part of perceptual processing. I therefore conclude that PAH^{STRONG} is plausible. However, that PAH^{STRONG} is true, does not imply that the hypothesis is testable in all cases. I do not think we have reason to worry that the test will not be applicable to kind properties. However, there might be reasons (like for example that a property depends on complex dynamics in space and time) that it will be practically hard to construe adaptation tests for some potentially perceptible properties. Scholl & Gao (2013) offers an example of how alternative sources of evidence can be utilized in such cases. As this alternative strategy seems even more complex, on the one hand, and less decisive on the other, I think it is not to be favoured over the adaptation methodology, however.

5.2 A possible objection to PAH^{STRONG}

I think most, by now, will accept that genuine adaptation for a given property implies that the property is selectively processed. After all, genuine adaptation ultimately amounts to the visual system's adjustments to that property specifically. I also think most will accept that the fact that a property is selectively processed implies that the property is perceptually represented. Selective processing of a property implies that the system is able to detect that property type when it is present, and distinguish it from other features of the incoming stimuli. In other words, I think most will accept that if the visual system has specialized operations for the detection and processing of a given visual feature, that feature will be present in the output of those processes (whenever it is detected).

However, it is possible to question why we should assume that a property must be selectively processed in order to be represented. This would be an objection against PAH^{STRONG}. That is, even if someone accepts that adaptation can show that a property is selectively processed and thereby perceptually represented, which entail an endorsement of PAH, it is still possible to object that the visual system can represent properties without selectively processing them.

How could one make sense of this claim? We know that the visual system selectively process low-level properties, such as geometrical shape, colour, contrast and so on. We have also seen that there is evidence that the visual system selectively process some high-level properties, such as various facial features, bodies, animacy and causation, to mention some. We could imagine, for example, that at the very end of the processing chain, after all of these selective processes have come together and produced a three-dimensional representation of the current environmental scene, the visual system had the ability to "label" (some of) the elements of the scene, before delivering the end product to our central cognitive systems. Metaphorically speaking, we could imagine each selective process as a painting brush, each responsible for painting a specific part of a picture. We have brushes for colour, shape and so on, and also some special face-brushes, body and animacy brushes. When each brush is finished painting their part, we have a full picture of an environmental scene. But before the picture is finished, we have a labelling stamp that stamps different parts of the picture according to the categories they belong to. For example, we could have a stamp that marked each car in the picture as a car, each tree as a tree, each building as a building, and so on.

It might be possible in principle that the visual system represents properties without selectively processing them. However, the question that emerges is how, without any kind of selective processing, the visual system would be able to detect the property in question. How would the visual system detect a car as a car or a tree as a tree, if it did not have some operations tuned to detecting them and distinguishing them from other things?

One possibility is that of top-down influence. We could for example imagine that our cognitive conceptual apparatus could penetrate visual processes and apply categories to the visual information as a finishing touch, just before the output is finalized. As we saw in chapter 1, whether there is top-down influence on perception is highly controversial, and the proposed evidence for top-down effects usually have alternative explanations that seem more plausible. However, even if we accept the possibility of top-down effects, it seems unlikely that this is the kind of top-down influence the defender of the cognitive penetrability of perception has in mind. Defenders of cognitive penetration argue for a kind of cognitive influence on visual processes that alters the visual outputs in non-trivial (and often radical) ways. However, it is hard to see what the real difference is between the visual information being "labelled", by cognitive influence, right *before* it is delivered to the cognitive system, or *right* after it has entered the cognitive system, by the cognitive system itself. In both scenarios, the visual outputs remain the same, except for the labels, and there is nothing interestingly *perceptual* about the labelling in the first scenario. It seems reasonable to think that even the top-down theorist would argue that, to the extent that a cognitive concept can influence a visual process, it does so by leading to a certain kind of selective processing for stimuli corresponding to the concept in question, which makes a difference to the resulting output, above merely applying a label to the stimuli.

The visual system engages in adaptation at various levels of the visual hierarchy. The adaptation methodology is *not* based on the assumption that every perceptually represented property is selectively processed from beginning to end. In other words, it is not assumed that the visual system picks out every perceptually represented property from the proximal stimulation and processes each property separately throughout the process. What is assumed, however, is that, for a property to be perceptually represented, the visual system must at *some* stage of the process, detect that property, which involves selective processing of some sort (further, it is assumed, if we endorse PAH^{STRONG}, that adaptation is a fundamental part of such processing). I think it is hard to see how the visual system could be able to represent a property without at some point in the process selectively "picking out" the property in question. I find it unlikely that visual representations can suddenly, out of thin air, come to appear in perceptual outputs.

6 Conclusion: how to put the hypothesis to use

I have now developed (two versions of) the hypothesis and considered various strategies for testing it. I wish to end by using our discoveries to roughly sketch how the methodology might be applied to a couple of controversial cases.

Whether we can perceive kind properties has been widely debated. As noted in chapter 1, Siegel (2006; 2010) (but also Bayne (2009)), has argued on basis of the method of phenomenal contrast that we can perceive kind properties, such as pine trees. Others, like for example Tye (1995) and Prinz (2005), Rejects that we can perceive kinds (or any other high-level property, for that matter). I think that the adaptation methodology could help us settle this question. For many kind properties, especially those that are culture specific, such as cars, tea cups, and so on, there is little reason to suppose that we are born with an innate capacity to perceptually represent them. Thus, getting clear on this issue will arguably also give us insight into whether we can acquire new perceptual representations, that is, whether we can learn to perceive new properties.

I have already sketched how we could construe a basic adaptation test for trees. My suggestion was to take, for example, an illustration of a pine tree and an illustration of a birch, respectively, as the adaptor stimuli, and use a (digitally generated) hybrid of these stimuli as the test stimulus. If adapting to the trees does not yield any aftereffects, however, then, given that we endorse PAH^{STRONG}, we have evidence that the visual system does *not* have the capacity to represent trees. If we only endorse PAH, on the other hand, the fact that representations of trees are not susceptible to adaptation does not show that tree representations are non-perceptual.

If we find that adaptation to the pine tree makes the test stimuli appear more like a birch, and vice versa, we have an indication of an adaptation aftereffect. Given that we find such effects, we must be sure that it is caused by adaptation, and that it is not a contrast effect caused by a cognitive shift in category boundary (between the pine trees and birches). By repeating the test with variations in adaptation times, while measuring the strength and duration of the aftereffect, we can chart whether the effect follows the adjustment patterns associated with adaptation. If this pattern is similar across test subjects, this is also an indication that the effect is an automatic process by the visual system. By varying the test stimuli, we can also make sure that the effect does not transfer between properties (adapting to a tree should not produce aftereffects on light poles, for example). The “selectivity” requirement will also be tested when addressing the low-level worry, however. Additional evidence that what we have found is in fact a case of genuine adaptation be obtained by (1) testing whether we can connect the effect to response changes in brain areas associated with perceptual processing, and (2) whether the effect depends on retinal location. A further possibility is to design an experiment that is able to measure the effect independent of the subject’s verbal reports, as in Schwiedrzik et al’s (2013) study, described in chapter 3. This strategy will involve creative methodological resources.

Given that the results show that the aftereffect is produced by adaptation, the next step is to rule out the low-level interpretation of the effect. Here, one strategy is to generate an alternative adaptor stimulus that shares as many low-level properties with the original adaptor stimulus (pine tree/birch) as possible, without instantiating the high-level tree property (which might be a creative challenge). If adapting to this low-level adaptor stimulus yields similar aftereffects as adapting to the pine tree (birch), then we have evidence that the pine tree/birch aftereffects can be explained by low-level adaptation. If not, however, we have evidence that the aftereffect is indeed due to selective adaptation to tree properties. Further support for this conclusion can be obtained by running the tests with inverted versions of the stimuli, and compare the effects. Another strategy would be to vary the low-level properties of the test stimulus, while holding the high-level property constant, for example by testing whether we can obtain the effect on various different trees (which differ in low-level properties). Evidence of (1) brain location, (2) retinal dependence, and (3) timing considerations might also help determine at which stage of the visual hierarchy the effect in question occur.

I think we can design similar experiments for most kind properties. This, of course, is just a rough sketch of the general strategy and the various evidential sources that can be invoked. A detailed account of the scientific methodology behind these experiments goes beyond the scope of this thesis. However, I believe that the studies described in the previous chapters show that we have the methodological tools required for carrying out such tests, and that making use of these strategies can yield determinate answers.

Another live debate, which I think the adaptation methodology is able to settle, is whether we can perceive the mental states of others. As noted earlier, there has been found adaptation for various facial expressions. Adaptation to anger/fear, has been my main example. These effects follow the readjustment pattern associated with adaptation (as opposed to contrast effects) (Hsu & Young, 2004; Leopold et al., 2005). They also obtain through variations in low-level features between the adaptor and test stimulus (Fox & Barton, 2007), supporting that the effects are not due to low-level adaptation. Moreover, we have seen evidence that other facial features are selectively processed (Schwiedrzik et al., 2013; Yamashita et al., 2005). Thus, I think the adaptation methodology has already come some way in proving that at least some emotional states can be visually represented. I think further investigations, and extending these strategies to other mental state properties as well, can ultimately reveal which mental state properties can be present in the outputs of the visual system.

I am also optimistic that the methodology can be applicable to other perceptual modalities. Adaptation and adaptation aftereffects have been found in each of the traditional perceptual modalities (Palumbo et al., 2017). Adaptation is wide spread in the auditory system, for example (Perez-Gonzalez & Melmierca, 2014). Di Bona (forthcoming) has already used evidence that adapting to male voices makes ambiguous voices appear female and vice versa (Schweinberger et al., 2008), to argue that we can auditorily perceive gender properties.

I wish to mention another interesting, and perhaps even more complex, case. The question is whether, in hearing someone speak, we can literally hear the meaning of the words uttered. In other words, whether grasping the meaning of vocal language is a perceptual or a cognitive achievement. In his 2016 paper, Anders Nes defends what he calls *perceptualism*, the view that "… grasp of meaning is achieved at a perceptual level" (Nes, 2016, p. 59). Most of the argumentation is based on the method of phenomenal contrast. At the end of the paper, however, Nes describes a case of what seems like adaptation to the comprehension of words, which he regards as a potential source of evidence for perceptualism with regards to grasping meaning.

Nes describes a study by Tian & Huber (2010), based on a phenomenon called *semantic satiation*. Semantic satiation refers to cases where repetition of a word causes it to temporarily lose meaning to the listener. This phenomenon might be familiar to some readers. Try repeating any word, for example 'vehicle', out loud over and over. After some repetitions, you are likely to experience that the word suddenly sounds meaningless and unfamiliar.

Tian & Huber (2010) tested how semantic satiation affected performance in matching categories. Subjects performed blocks of several trials where they were presented with words (like 'fruit') for one second, and then presented with a second word (like 'apple', or 'vehicle'), and asked to decide whether the two words belonged to the same category or not. This task require that subjects grasp the meaning of the words. Their result showed that, if the same word had been repeated 5 times or more, subjects gradually became slower in deciding whether the words were categorically related or not.[15]

The thought is that "[t]he repetition of presentation of a word in semantic satiation is akin to the prolonged staring at a stimulus […] in classical cases of sensory adaptation" (Nes, 2016, p. 82). If we are to describe this example in terms of adaptation, we could say that repeated presentation of the word 'fruit', for example, makes you less sensitive the meaning of the word. That it "loses meaning" could be similar to when prolonged exposure to a given colour or face, makes it appear more neutral, or less characteristic. There is a disanalogy when it comes to the test stimuli, however. In the classical adaptation paradigm, the adaptor stimulus is tested against an ambiguous (or neutral) stimulus. The classical adaptation aftereffect shows that adaptation biases the appearance of ambiguous stimulus away from the adaptor stimulus, in opposite (of different) directions. However, the test stimuli in Tian & Huber's study are words that are either related, in virtue of its meaning, to the "adaptor stimulus", or not. What is measured is the time you use to decide whether the "adaptor" and test stimuli are related, relative to how many times the "adaptor stimulus" have previously been presented. What the study arguably shows is therefore that repeated exposure to a given word makes you slower in grasping the meaning of that word. If this is a case of adaptation, then it only shows that adapting to the meaning of a word "neutralizes" the word in question by weakening its meaning. The study does not address whether adapting to a given word yields aftereffects when subsequently perceiving (auditorily or otherwise) other words with similar or related meaning.

[15] In this study, the words were presented visually on a screen. This is, in other words, not a case of auditory adaptation. To the extent that this study address meaning, it should be regarded as addressing the perception of meaning in general, and not directly the *hearing* of meaning. One could, however, design similar experiments with auditory stimuli.

It seems that the most straightforward way of getting an indication of whether adaptation aftereffects occur for the meaning of words, would be to run semantic satiation tests using ambiguous words as test stimuli. The word ‘pound’, for example, has several meanings; it refers to a unit of weight, a monetary currency, and it is also a verb for hitting (heavily). We could for example, test what effects repeated presentation of a word that corresponds to one of these meanings have on grasping the meaning of ‘pound’. If the meaning of words is susceptible to adaptation, then we would expect repeated presentation of the word ‘hit’ (ignoring, for the sake of the example, that this word is also ambiguous), would bias you away from the meaning of the word, and therefore that when you are presented with the word ‘pound’, you grasp it as referring to either of its alternative meanings, that is, a weight unit, or monetary currency.

It is possible that semantic satiation is an instance of adaptation. Settling this would require further testing, however. First, we would need to test whether semantic satiation yields aftereffects on subsequently perceived meanings. If semantic satiation indicates that the meaning of words is susceptible to adaptation, we would still need to rule out a cognitive and a low-level explanation of the phenomena. Since meaning is intimately connected to thought, I think alternative explanations should be even more thoroughly examined in this case. One potential explanation for example, is that adapting to the word ‘fruit’ makes you less sensitive to the low-level phonetic elements of the word in a way that disrupts the cognitive process of ascribing it meaning. To test such alternative explanations, we would need to redesign the strategies applied in studies on visual adaptation as to fit auditory cases. Nonetheless, I think this is a highly interesting case to which systematic application of the adaptation methodology could be able to yield answers. I also think this case illustrates the potentially broad applicability of the methodology.

All in all, I find the adaptation methodology very promising. Whenever we find adaptation for a given property, as long as we can carefully show that the effect is not due to cognitive shifts in category boundary, and also not merely a result of low-level adaptation, I see no other possible explanation than that the effect is due to the visual system’s selective adjustment to the property in question, and consequently, that the property is perceptually represented. As it seems highly plausible that adaptation is a fundamental feature of perceptual processing, I find it plausible that every property that the perceptual system represents will show adaptation (although there might be complications with testing this for certain properties). I therefore conclude that the adaptation methodology has the potential to determinably distinguish perception from cognition.

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