Investigating inhibitory control in preschoolers
The influences of emotional stimuli and BIS/BAS reactivity

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Abstract

There is variation in the ability to manage emotions. From the perspective of cognitive psychology, there has become an increasing interest in the concept of executive functions as a contributor to such individual differences. Executive functions are vital to cognitive functioning. Research has therefore previously been focused on the cognitive, ‘cold’ executive functions. In recent years, the emotional, or ‘hot’ executive functions have garnered interest. The focus of the current study is inhibition; a subdivision of executive function. Inhibition is the ability to suppress a dominant response. The behavioral inhibition- and activation system is a theory of reactivity. The way reactivity manifests itself differs for each person. Individual differences in reactivity may affect inhibitory abilities. The current study aimed to replicate previous findings that emotional contexts impair performance, and to discover whether individual differences in reactivity would affect inhibitory control ability. The participants were 30 children between the ages of 4 - 6. Inhibitory control ability was assessed using the neutral day-night task and the emotional happy-sad task. BIS/BAS reactivity was tested using the parental-report version of the behavioural inhibition- and activation scales. Results replicated previous findings that the emotional stimuli were detrimental to performance on inhibitory control tasks. Research on this is important because the conditions under which emotion may impair cognitive abilities in children can for instance, affect performance in school. The BIS-BAS reactivity did not affect performance on the interference control tasks. This may be because the interference control tasks used in this study were not strongly related to the type of reactivity that the BIS/BAS scales measure. Another reason may be the small sample size of the study. The relation between interference control and reactivity could be studied in future studies using a larger sample.
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References
1 Introduction

It has been known for decades that the frontal lobes are involved in cognition (Peterson & Welsh, 2014). Cognitive skills enable problem solving and complex reasoning (Blair & Dennis, 2010). Cognition is affected by emotional influences in a bidirectional way; cognition can regulate emotional influences but also be affected by emotional influence (Blair & Dennis, 2010; Lewis, 2005; Welsh, Parke, Widaman, & O’Neil, 2001). The ability to control emotion relates to better cognitive skills (Blair & Razza, 2007; Blankson, Leerkes, Marcovitch, Calkins, & Weaver, 2013; Espy et al., 2004). The ability to manage emotions and behaviors varies greatly from person to person (Izard et al., 2011). The factors that contribute to this variation are many-faceted and complex, and discerning them equally so. From the perspective of cognitive psychology, there has become an increasing interest in the concept of executive functions as a contributor to such individual differences (Zelazo & Carlson, 2012). Executive functions are a branch of cognitive skills that have become prominent in cognitive research (Peterson & Welsh, 2014). The executive functions are the brain’s control systems. They are responsible for a variety of cognitive operations that can broadly be summarized as facilitation of goal-directed behaviour (Best & Miller, 2010). They are an interconnected system in the prefrontal cortex (Montgomery & Koeltzow, 2010; Peterson & Welsh, 2014), a region vital to cognitive functioning (Peterson & Welsh, 2014). Therefore, these functions have traditionally been researched from a cognitive perspective, and the large amount of research on the prefrontal cortex has up until recently overlooked the role of emotion in prefrontal functioning (Zelazo, Qu, & Kesek, 2010; Peterson & Welsh, 2014). Research is showing an increasing interest in the influence of motivational contexts on executive functioning (Peterson & Welsh, 2014), as these demand different top-down processes (Zelazo & Carlson, 2012) and affect executive functions differently (Zelazo & Carlson, 2012). Cognitive processing has been dubbed the ‘cold’ executive functions, and processing of emotional information have been named ‘hot’ executive functions (Zelazo et al., 2010). The preschool years are a sensitive period during which the hot and the cold executive functions both develop substantially, however, it’s not yet clear whether their developmental trajectories are independent from one another (Peterson & Welsh, 2014). The development of executive functions in childhood has been a focal point for research because of the swift trajectory of many key aspects in this period (Blair & Dennis, 2010). There is a marked difference in these functions in children and adults. Some researchers adhere to the notion that the improvements in the executive functions underpin the major differences between children.
and adults (Denckla, 1996, as cited in Posner & Rothbart, 2000). There is uncertainty about whether the executive functions are a unitary concept consisting of sub-processes or whether they are operationally separate functions that are somewhat related (Mueller, 2011). Broadly speaking, cognitive flexibility, working memory and inhibitory control are considered agreed-upon divisions, as they have been found to be distinct, yet related subfunctions of the executive functions (Miyake et al., 2000). The focus of the current study is on inhibitory control.

1.1 Inhibition and its development

Inhibition is the suppression of a response that is well-learned and automatic in favor of a response that is appropriate for the situation, but not dominant (Dempster & Corkill, 1999; Montgomery & Koeltzow, 2010; Nigg, 2000). There are subcategories of inhibition that are separable from one another. Several different terms have been proposed to classify the same constructs. The terms proposed by Nigg (2000), will be used here. Behavioral inhibition is concerned with suppressing a response that is dominant, or prepotent (Friedman & Miyake, 2004; Nigg, 2000). Cognitive inhibition involves the suppression of distracting, irrelevant information from working memory (Friedman & Miyake, 2004; Nigg, 2000). Interference control involves the inhibition of interference caused by stimulus competition (Montgomery & Koeltzow, 2010; Nigg, 2000). The type of inhibition concerning the current study is interference control.

The terms ‘inhibition’ and ‘interference’ have often been used in place of one another in the research literature (Harnishfeger & Bjorklund, 1994). Inhibition is the ability to actively suppress a response that has become dominant through practice, in instances where they no longer are appropriate, whereas interference is about conflicting stimuli competing for the same cognitive resources (Montgomery & Koeltzow, 2010). This requires the ability to suppress distracting stimuli, in order to enhance a weaker response (Harnishfeger & Bjorklund, 1994). The two concepts are not completely synonymous, but they are closely related to one another (Harnishfeger & Bjorklund, 1994), and will be used interchangeably in this thesis.

The subcategories of inhibition do not develop simultaneously (Dempster, 1992; Nigg, 2000; Rothbart & Bates, 1998). Around 30 months of age, children attain a higher accuracy on inhibition tasks (Posner & Rothbart, 2000). In addition, response times on incompatible trials – which for children under 30 months are quite high – decrease (Posner & Rothbart,
Together, this leads to an improved ability to inhibit the dominant response, indicating that the implementation of resources for conflict resolution has become more strategic (Posner & Rothbart, 2000; Wiebe, Sheffield, & Espy, 2012). For inhibition specifically, a shift happens between the ages of 3 ½ and 4 (Diamond, Prevor, Callender, & Druin, 1997; Posner & Rothbart, 2000; Willoughby, Wirth, Blair, 2012), during which time there has been found great improvement in the ability to inhibit. Children at around 3 years old have great difficulty with inhibitory tasks (Posner & Rothbart, 2000), whereas by 5 years of age, they manage such tasks much better, with few mistakes (Gerstadt, Hong, & Diamond, 1994; Simpson & Riggs, 2005). The great leap of improvement in this period may be attributed to the developments within the executive functions. Successful interference control depends on the ability to resist the distraction of the dominant response (Kipp, 2005). This difficulty is overcome by the development of a stronger ability to inhibit the dominant response by directing attention away from it (Kirkham, Cruess, & Diamond, 2003; Müller, Zelazo, Hood, Leone, Rohrer, 2004; Simpson & Riggs, 2009). According to Kipp (2005), this requires selection procedures to isolate the processes that are needed to perform the correct response instead of the dominant response. This ability requires use of the prefrontal cortex (Harnishfeger & Bjorklund, 1994; Montgomery & Koeltzow, 2010). Children of 3-4 years are more vulnerable to interference (Harnishfeger & Bjorklund, 1994) because the immaturity of the prefrontal regions means they are not yet sufficiently connected to direct cognitive resources in a way that will enable successful interference control (Montgomery & Koeltzow, 2010). The maturation of the prefrontal cortex and the development of its connections to subcortical regions in the fronto-striatal circuitry thus contributes to these improvements in inhibitory ability in children (Lepsien & Nobre, 2006; Nelson, de Haan, & Thomas, 2006).

### 1.2 Measuring interference control

A prominent task that is often used to assess interference control, is the Stroop task (Stroop, 1935). In the original Stroop task, the stimuli are colour words written in the ink of an opposing colour. The purpose of the task is to name the ink colour, which requires inhibiting the automatic response of reading the word. Participants have difficulty with this. Their response time is longer when the objective is to name the ink colour rather than read the word.

There have been proposed several models to explain the Stroop effect. According to the automaticity account, naming the ink colour requires more processing and more attentional resources than reading the word does (MacLeod, 1991; Posner & Snyder, 1975).
Word reading is a more common, automatic act than naming colours. The automaticity of the reading response occurs because it has been primed, and the relation the words have to colour makes them interfere with naming the colour word. This leads to interference. The automaticity theory aligns with Cohen’s conflict monitoring model of the Stroop task which is a neural network model illustrating how interference control occurs (Cohen, Dunbar & McClelland, 1990; MacLeod, 1991). This model posits that processing occurs within a network made up of pathways of different strengths. Conflict occurs when two different patterns of activation compete for the same response module. In the Stroop task, both the reading of the word and naming the colour are activated. The word response is more salient because it is more common and thus has been practiced more. This conflicts with the aim of the task, which is to name the ink colour.

1.3 Child versions of Stroop.

Because the literacy aspect of the Stroop task makes it difficult to use on pre-literate children, there has been created versions more applicable to younger children. One of these tasks is the day-night task by Gerstadt, Hong, & Diamond (1994). In this task, participants are shown cards with pictures of the sun and the moon. The objective is to label the cards with the opposite label; to say ‘night’ for the picture of the sun and ‘day’ for the picture of the moon. This task is similar to the Stroop task in that an automatic response must be inhibited. However, the correct responses in the day-night task are further removed from the stimuli than in the Stroop task, where the correct responses are present in the stimulus. Only one rule must be remembered – that the colour is the correct response. In the day-night task, the correct response words are related to the pictured stimuli, but not present. This requires both the rule of the task and the associated words to be kept in working memory (Gerstadt et al., 1994). Children at 3½ – 4 years old have difficulty with the task, but for 6-7 year olds, it is no longer difficult (Diamond, Kirkham, & Amso, 2002; Gerstadt et al., 1994). In fact, at the age of 7, there is a ceiling effect for the day-night task; 90% of children make 1 or fewer mistakes. In a review of the day-night task, Montgomery & Koeltzow (2010) found that for the majority of studies that had used the task, there was no significant difference between the performances of 3- and 4 year olds. The age period from 3 to 4 involves great improvements in many executive function tasks, but this finding suggests that the development in performance on the day-night task does not follow this pattern. Montgomery & Koeltzow (2010) hypothesise that there is a more gradual improvement for the day-night task. As previously explained by the automaticity account (MacLeod, 1991) and the neural account by
Cohen, Dunbar, & McClelland, (1990), the familiarity of the incorrect response makes it more
dominant, and it therefore requires less resources than the correct response (which needs to be
strengthened to prevail) (Montgomery & Fosco, 2012; Montgomery & Koeltzow, 2010).
Despite knowing the rules of the task, preschoolers often return to respond using the familiar
picture name because they have more difficulty with the interference than adults do
(Montgomery & Fosco, 2012). This effect is explained by Montgomery & Fosco (2012) by
the structure of the day-night task, which exacerbates the response competition because the
response that must be suppressed is depicted on the card, and the incorrect response was
primed by the previous trial. Younger children tend to perform better on the day-night task
when they are allowed a delay before responding (Diamond et al., 2002; Montgomery &
Koeltzow, 2010). One theory proposes that the delay improves accuracy because it allows the
activation level of the dominant response to fade before the participant responds. Another
theory posits that the delay gives the participant time to reflect on the task rules and get ready
to make the correct response (Montgomery & Koeltzow, 2010; Simpson & Riggs, 2007).

1.4 Emotional versions of Stroop.
An emotional version of the Stroop task was developed by Gotlib & McCann (1984).
The purpose of their study was to research attentional processing in depression. Adapting
cognitive tasks such as the Stroop task to include emotional stimuli, allow for an evaluation of
emotional processing (Eide, Kemp, Silbertstein, Nathan, & Stough, 2002). They attempted to
discover whether depressed individuals are more sensitive to negative stimuli than others by
being “naturally primed” (Gotlib & McCann, 1984, p. 428) to it. As the Stroop effect is
caused by response competition (Gotlib & McCann, 1984), it is an ideal task to use to study
priming effects because primed stimuli become more salient and will thus be more readily
attended to. The Stroop task had previously been used successfully by others to investigate
priming effects (Conrad, 1974; Warren, 1972), and Gotlib & McCann also amended this task
for their purposes. The emotional version of the task included negatively loaded words which
were presented to participants in coloured ink. The task objective was, as for the original
Stroop task, naming the ink colour. Compared to controls, the depressed participants took
significantly longer to name the colour of the negative words than the neutral words.
Although the study was aimed at depressed individuals, even participants who do not have an
affective disorder find it more difficult to inhibit this version of the Stroop task than when the
words are neutral (Gotlib & McCann, 1984).

There has been developed an emotional version of the child version of Stroop as well.
The happy-sad task is a variant of the day-night task with emotive stimuli. Created by Lagattuta, Sayfan & Monsour (2011), it also involves a deck of cards and the instructions are to label the cards opposite to what is natural. Instead of the sun and the moon, they depict sad and happy facial expressions. The participant must say ‘happy’ when presented with a sad face, and ‘sad’ when presented with a happy face. Participants generally have greater difficulty with happy-sad than with day-night; there are more errors and longer response times for this task (Kramer, Lagattuta & Sayfan, 2015), and even adult participants have no ceiling effect for accuracy. According to previous research, it is not merely the presence of the emotional stimuli that makes the happy-sad task challenging (Kramer et al., 2015). In order to complete the task, attending to and processing the emotional stimuli is required, which influences performance to a greater degree than if the emotional information is more peripheral to the task objective (Kramer et al., 2015). The reason it disrupts is that processing the emotional stimuli requires the use of emotional regions of the brain. These regions overlap with those processing cognitive information, which causes poorer performance because as there are fewer resources left to inhibit the dominant response (Izard et al., 2011; Kramer et al., 2015; Pessoa, 2009).

1.5 The entanglement of emotion and cognition

A previously common assumption in cognitive research was that cognition and emotion are two entirely distinct functions (Blair & Dennis, 2010). This belief is now being challenged. The idea that emotion is only a distractor, the antithesis to cognition is also being dispelled (Blair & Dennis, 2010). Researchers now bring the two together as they begin to see that emotion may in some cases be a facilitator instead of a disturbance to “goal-directed activity” (Calkins & Bell, 2010, p. 5). In fact, both are necessary for an adaptive regulation of emotion (Calkins & Bell, 2010). Emotions are necessary because they “incline us to act” (Gross, 2014, p. 4), directing cognition towards pursuing a beneficial goal.

Depending on the nature of the interaction, the involvement of emotion in collaboration with cognition can either improve or weaken task performance (Pessoa, 2009). In Pessoa’s dual competition model, this is explained by the fact that there is some overlap between the brain regions involved in processing cognitive and emotional information (Pessoa, 2009). In motivational contexts, the hot executive functions are deployed (Zelazo & Carlson, 2012). A different type of top-down processing using medial regions like the orbitofrontal cortex is required during processing using the hot executive functions, whereas the cold executive functioning requires use of the lateral prefrontal cortex (Zelazo & Carlson,
2012). The effect that emotional task stimuli has on performance depends on how it
influences the executive functions. If the emotional stimulus is strongly distracting to the task
at hand, it will disrupt performance (Pessoa, 2009). For instance, for stimuli that is highly
threat-related, more resources will be prioritised to analyse it, as part of the defensive
mechanism of the motivational system (Gray, 1982, cited in Derryberry & Rothbart, 1997).
As stimuli that is threat-related requires further processing (Pessoa, 2009), resources get
depleted in the attempt to process both the cognitive task and the emotional stimulus. Thus,
there will be less resources available for the executive functions to perform the task at hand,
and task performance will be impaired. By contrast, for emotional stimuli that is not threat-
related, performance will not be impaired because it does not require further processing. In
fact, performance tends to be positively affected, because performance is biased in favour of
the non-threatening emotional stimuli (Pessoa, 2009).

Motivational contexts have an impact on executive functioning as well; if the emotion-
laden (or ‘hot’) context is not compatible with the current goal, it may impact executive
functioning detrimentally (Zelazo et al., 2010). If the hot context does not interfere with the
goal, and is positively valenced, it could be beneficial to executive functioning because a
positive mood will be evoked (Zelazo et al., 2010). The efficiency of the executive function
system can thus depend on the degree of processing required, the type of emotional stimuli
that it is exposed to, as well as on the motivational context. Several studies have found the
presence of emotional stimuli on cognitive tasks to debase performance (Harris & Pashler,
2004; Hinojosa, Mercado, & Carretie, 2015; Pessoa, Kastner, & Ungerleider, 2002; Stout,
Shackman, Johnson, & Larson, 2015), although others have not found evidence that the
emotional stimuli impacts performance negatively (Bluell & Montgomery, 2014). Such
conflicting findings may be caused the fact that the way the executive functions are affected
by emotions differ depending on context.

Childhood is a period that is particularly sensitive to both the positive and the negative
influence of emotion because emotional processing ability develops earlier than the executive
functions do (Zelazo et al., 2010). There is evidence to suggest that the hot and cold executive
functions develop in parallel, although some research has found that the development of hot
executive function lags behind (Zelazo, & Carlson 2012). There is some evidence from adult
studies that the executive functions are dissociable from one another, but research has been
more inconclusive on this for children (Peterson & Welsh, 2014). It may be that they become
more clearly divisive with further maturation (Zelazo & Carlson, 2012). However, there is no
question that hot and cold executive functions do in some cases overlap and work together (Peterson & Welsh, 2014). The collaboration between hot and cold executive functions is one aspect of how cognition and emotion intertwine, but whether or not cognitive functioning is successful also depends on quite another factor; the way an individual reacts to emotional stimuli.

1.6 Emotional processing and reactivity

Emotion and cognition have a symbiotic collaboration in which they contribute to each other’s functioning (Zelazo et al., 2010). The optimal balance hypothesis posits that emotion and cognition under ideal conditions, should be equally balanced (Blair & Dennis, 2010). The emotional system has traditionally been divided into two categories; one of approach and one of withdrawal (Blair & Dennis, 2010). These are manifested in physiological systems called the behavioral inhibition and activation systems (BIS/BAS) (Gray, 1987). The BIS/BAS is a theory posited by Gray that built upon the aspect of Eysenck’s model of personality that proposed a physiological basis of its core traits of introversion and extroversion (Nigg, 2000). Introversion, as described by Eysenck and Rachman (1965), involves a sensitivity to arousal, anxiety and restlessness, while extroversion is characterised by stability of emotion and less sensitivity to arousal. In a similar way, the behavioral inhibition and activation systems reflect an affinity towards either appetitive or aversive stimuli. Negative emotions induce mechanisms for withdrawal through the behavioral inhibition system (BIS), and positive emotions activate the behavioral activation system (BAS), which promotes approach (Blair & Dennis, 2010). Although inspired by it, Gray’s theory diverges from Eysenck’s not least because it is not a theory of personality; rather, the behavioral inhibition- and activation system is a theory of reactivity (Rothbart & Bates, 2006). A person’s reactivity is their “responsiveness” to behavioural and physiological systems and environmental changes (Rothbart & Bates, 2006, p. 100; Rothbart, Ahadi, Evans, 2000). These are dispositions that are situation-dependent. For instance, being in an unfamiliar situation may elicit an anxious feeling that would not appear in a setting more predictable and familiar (Rothbart et al., 2000). Not every person would react anxiously to a novel and unfamiliar situation, however. The way reactivity manifests itself differs for each person.

1.7 Individual differences in reactivity

Individual differences in reactivity occur by differences in the balance between the BIS and the BAS (Rothbart, et al., 2000; Rothbart & Bates, 2006). People high in BIS are predisposed to react more to aversive stimuli and have a higher level of arousal than those
high in BAS (Gray, 1987). Higher level of BAS has been associated with lower levels of the stress hormone cortisol (Blair, Peters, & Granger, 2004), suggesting a lower level of arousal. The way the individual differences are manifested also depends on the control abilities of the executive functions (Rothbart et al., 2000). The inhibitory control abilities are deployed when distracting information needs to be suppressed. The efficiency of this ability depends on the individual’s level of arousal. Individuals high in BIS tend to have better cognitive control than those high in BAS (Blair & Dennis, 2010). Preschool children with high levels of BIS were found to perform better on a task of interference control than children with high levels of BAS (Blair et al., 2004). The reason is that individuals high in BIS are more easily aroused, and as such have a lower threshold for deploying cognitive control functions. Situations that are quite ordinary might prompt arousal and require cognitive functions (Blair & Dennis, 2010). As these children therefore need to employ cognitive control functions relatively often to manage their arousal, they can do so more easily when required (Rothbart, Sheese & Posner, 2014). By contrast, a person high in BAS generally does not experience such high levels of arousal in ordinary situations, and does not require the deployment of top-down inhibitory functions as often, and indeed have more difficulty deploying them when required to. As we have outlined, cognitive processes moderate reactivity, and reactivity also affects how that moderation occurs. Reactivity and inhibitory control are part of an “integrated system” of affective and cognitive processes (Rothbart & Derryberry, 1981, cited in Rothbart et al., 2000, p. 123). Studying them together makes it possible to gain perspective on how they affect each other, which increases knowledge on how individuals’ cognitive abilities are differently affected by emotional contexts. Cognitive control allows for flexibility in how to approach situations, and its success depends on factors like the individual differences of reactivity and also on the motivational contexts (Rothbart, 2004).

1.8 The present study

Although it is still contested, several studies indicate that emotional stimuli may be detrimental to performance on cognitive tasks (Harris & Pashler, 2004; Hinojosa, et al., 2015; Kramer et al., 2014; Lagattuta et al., 2011; Pessoa, 2002; Pessoa, 2009; Stout et al., 2014). Studies have found this effect of emotion when comparing neutral and emotional versions of interference control tasks, for both children and adults (Lagattuta et al., 2011; Paelecke, Paelecke-Habermann, Brokenau, 2012). With a basis of this previous research in mind, the current study aimed to investigate whether the same would be found on performance on child
versions of the Stroop task in a sample of Norwegian preschoolers. At the ages of 4-5, their inhibitory abilities have developed sufficiently for adequate task completion (Best & Miller, 2010; Zelazo & Carlson, 2012). This is therefore an ideal age at which to investigate the involvement between the ‘hot’ and ‘cold’ executive functions. As the independence and interaction of hot and cold executive functions is still not clear, investigating the relation of the emotional Stroop task and the neutral Stroop task would also be worthwhile.

Cognitive control ability is affected by variability within reactivity (Rothbart, 2004). Individual differences in the balance between the BIS and the BAS determines how successful inhibition is in some contexts. Given that, it is reasonable to assume that there will be a relation between reactivity and inhibitory control ability. Children with a high level of BIS employ cognitive control more often day-to-day (Blair & Dennis, 2010), and thus generally perform better at cognitive control tasks, than those high in BAS. Previous research has found reactivity to be related to interference control ability in pre-schoolers (Blair et al., 2004). Blair and colleagues (2004) used the BIS/BAS scales to measure reactivity, and used the peg-tapping task (Luria, 1966) for inhibitory control. This study did find a significant relation, which suggests that attempting the same on a different task of similar function is worthwhile. The association between BIS/BAS reactivity and interference control has as of yet not been tested using child versions of the Stroop task. As completion of the Stroop tasks requires inhibitory cognitive abilities to regulate distracting stimuli, investigating relations between this task and BIS/BAS could be conducive. Given that the relation motivational contexts have on BIS/BAS, investigating whether there is a differential relation between BIS/BAS and the emotional happy-sad task and the neutral day-night task is also of interest.

Against the backdrop of the research outlined above, the hypotheses for the current study were the following; 1. Inhibition is more demanding in the emotional condition than in the neutral condition, 2. The ability to inhibit is affected positively by BIS and negatively by BAS, and there will be a stronger relation between the BIS/BAS and the emotional happy-sad task than the neutral day-night task, and 3. The happy-sad task and the day-night task will be investigated for a possible relation.

2 Method

2.1 Participants

The sample included 30 children between the ages of 49 and 71 months ($M = 64$, $SD = 4.63$; females = 13). One participant was excluded from the original 32 due to missing data
caused by error during testing. Another participant was excluded as an outlier, following previous research using the day-night and happy-sad tasks that excluded participants whose scores were 2.5 standard deviations below or above the mean (Kramer et al., 2014). Participants were recruited through kindergartens in different neighborhoods in Oslo. The managers of the kindergartens were recruited by telephone. If they agreed to a collaboration, they received further information about the study and consent forms to email the parents. If parents wished for their children to participate, dates for testing were decided upon in accordance with the kindergarten’s timetable. Socioeconomic status (SES) was calculated by adding the level of education (1 – 6) and income (1 – 7) of each parent and dividing this by two. The majority of the parents represented high SES status ($M = 11.62, SD = 1.71$).

### 2.2 Procedure and Research design

The study was a within-groups design, and was part of a larger study on the association between cognition, emotion, psychological well-being and upbringing experiences (e.g., maltreatment and/or low SES). Participants in the present study comprised of the control group and consisted of typically developing children without any known history of maltreatment. Testing took place in the kindergartens. A quiet room was offered for testing purposes, and each participant was tested one-on-one with an experimenter. The participants performed a number of tests of inhibition and cognitive functioning. The whole procedure lasted 1 ½ hours per participant, including breaks. The test protocol had two different orders that were alternated between to prevent confounding effects of tiredness. Parents and caretakers reported on the behavioral and emotional skills and abilities of the children. Preschool teachers filled out the Caregiver-Teacher Report Form for Ages 1 ½ - 5 (C-TRF). The parents received a pamphlet of questionnaires to respond to. Included in this were the Behavioral inhibition and behavioral activation system scales for children (BIS/BAS scales), the Trauma Symptom Checklist for Young Children (TSCYC), the Child Behavior Checklist (CBCL 1 ½ - 5). For the purposes of the current study, the questionnaire of interest was the BIS/BAS scales.

### 2.3 Materials and procedure

#### 2.3.1 Tests of interference control

**Day-night task (Gerstadt, Hong & Diamond, 1994).** The stimuli for the day-night task were laminated cards with images in grayscale on a white background. Each card was 6.5 cm x 6.5 cm. There were 20 cards in total. 10 of the cards belonged to the “night” condition.
and depicted a sun. There were also 10 in the “day” condition, which depicted a round moon surrounded by stars. The images used are shown in Figure 1 below. These stimuli were identical to the ones used by Lagattuta, Sayfan & Monsour (2011). A randomized order had been decided upon for the task, and a sticker at the back of each card indicated its place in the deck.

![Figure 1. Picture stimuli for the day-night task (Lagatutta, Sayfan, & Monsour 2011).](image)

The cards were presented in two fixed, randomized orders. These were alternated for each participant. The participants were instructed to say ‘night’ when they were shown a card with a picture of the sun, and when shown the picture of the night sky, the correct response was ‘day’. The purpose was thus to inhibit the inclination to say the word that was more naturally associated with the picture on the card.

Prior to administration, the cards in the deck were checked to be in the correct order. Before the testing period, the experimenter explained the rules to the participant. A trial session then ensued, in which the experimenter showed four of the cards after another, and the participants were to respond according to the rules they had just been explained. At least once during this session, two cards with the same motif had to be shown in succession, to make sure they were responding according to the rule, and not simply alternating between responses. Only when this trial was managed 100% correct would the session commence to the actual testing period.

As the testing session began, a voice recorder and a stopwatch were both started. The experimenter was not to correct mistakes. However, if the participant had made four subsequent errors, it was assumed they may have forgotten the rule. They would therefore be reminded of the rule (‘remember, you’re supposed to say the opposite’). The order in which
day-night and happy-sad were applied in, was alternated for each participant. This was to ensure that practice effects would not affect performance; if all participants did the day-night task first, they might perform better on the happy-sad task due to familiarity with task criteria.

Correct responses and mistakes were evaluated by two experimenters independently of each other, post testing, by listening to the recordings. Responses would be considered a mistake if any of the following occurred: 1) the response was the word normally associated with the picture on the card, 2) the response was any other word that did not indicate the opposite to the picture on the card, 3) the response was self-correcting (for instance, saying ‘day – no, night!’ when the correct response was ‘night’), or 4) a word was only partially uttered. The response time for each participant was measured from the moment the card hit the table, to the last response uttered by the participant.

**Happy-sad task (Lagattuta, Sayfan & Monsour, 2011).** The stimuli for the happy-sad task were laminated cards depicting black-and-white photographs of faces. Each face had either a happy or a sad expression. The images used were identical to the ones used by Kramer et al. (2014) and Lagattuta et al. (2011), who used photographs of emotional facial expressions from NimStim (http://www.macbrain.org/resources.htm). As publication of these photographs is prohibited (Lagattuta et al., 2011), they cannot be shown here. The card dimensions were 7 cm x 7 cm. There were 40 cards in total – 20 of a male face and 20 of a female face. Within each gender group, there were 10 cards for the happy condition and 10 cards for the sad condition. Male participants were shown the male faces, and female participants were shown the female faces.

The task procedure for the happy-sad task followed the procedure described for the day-night task, with the exception of the stimuli used and the responses they required. The participants were instructed to say ‘happy’ when they were shown a card with a picture of a sad face, and ‘sad’ when they were shown a picture of a happy face. As there is one deck of cards with pictures of male faces and one deck of cards with female faces, female participants are shown the deck with female faces and the male participants are shown the deck with male faces. In the original study of the happy-sad task, the experimenter would shuffle the deck to create a random order for each participant (Lagattuta et al., 2011). A follow up study found that creating a randomized order prior to testing that is fixed for all participants, is just as reliable as creating a random order for each participant (Kramer et al., 2014). There are two fixed orders for each gender that are alternated for each participant. The same fixed orders as in the study by Kramer et al. (2014), was used in the current study.
2.3.2 Questionnaires

The behavioural inhibition- and activation (BIS/BAS) scales (Blair et al., 2004).
The questionnaire used was a version of the behavioral inhibition and activation scales (Carver & White, 1994) that had been altered from a self-report instrument to a parental report instrument by Blair et al. (2004). It consists of 20 items divided into four subgroups. Each group taps a certain aspect of reactivity. Seven of the items belong to the BIS subscale. The remainder make up the three BAS subscales; five belong to Reward Responsiveness, and four each to the Fun Seeking and Drive scales respectively. The original uses a 4-point Likert scale, but in the alteration to parental report, it was changed by Blair et al. (2004) into a 7-point scale. It ranges from very true to very untrue of the child.

The original BIS/BAS scales, designed for adults, had strong Chronbach alpha reliabilities of between .66 to .76 for all subscales. The original study on the scales found that the items for BAS made up three subscales that tapped the same overall latent factor. They did not correlate highly with each other and were therefore considered different enough from one another to be categorised as separate. However, not all studies using the scales on children have found three factors for BAS. They have therefore combined the subscales of the BAS in various ways (Bjørnebekk, 2008; Blair et al., 2004; Muris, Meesters, de Kanter, Timmerman, 2005; Yu, Branje, Keijsers, Meeus, 2011). Blair et al., (2004) found that the combined BAS scale for their sampled yielded a higher reliability coefficient than the individual subscales did. Because previous research had found the combined BAS scale to also be reliable (Blair et al., 2004), the subscales were combined in the current study, and used in addition to the individual BAS scales. The individual BAS scales for the current sample yielded moderate to high alpha reliability coefficients (.85 for Drive, .74 for Reward, and .53 for Fun Seeking), and so did the combined BAS scale, with a reliability coefficient of .80.

2.4 Statistical analyses

The dependent variables analysed were response times and error rates. These have been used in previous research on the same inhibitory control tasks as those used here (Gerstad et al., 1994; Kramer et al., 2015; Lagattuta et al., 2011). Data were analysed using SPSS (version 22). Outliers for the dependent variables were defined as scores 2.5 standard deviations above or below the mean, in accordance with definitions for outliers used by previous research on the day-night and happy-sad tasks (Kramer et al., 2015; Lagattuta et al., 2011). The cut-off value was multiplied by the standard deviation of the sample, and this
value was then added to the mean score to get the value of scores that would be considered outliers. During preliminary analyses, the distributions of the variables were checked for assumptions of normality, and influences of age and gender. A one-way analysis of variance was used to examine possible gender differences. A correlational analysis was used to study effects of age. A correlation analysis was also used to study whether there was a relation between the error rates and response times of the inhibitory control tasks. The intention was to investigate whether there had been a speed/accuracy trade-off during testing.

For the main analyses, paired-sampled t-tests were conducted to study whether the response times and error rates of the inhibitory control tasks differed significantly in the neutral and emotional conditions. A correlational analysis was used to investigate whether any of the dependent variables (response time and error rates on the happy-sad and day-night tasks) were related to the independent variables (the subscales of the BIS/BAS scales). A regression analysis would then be conducted on variables that were significantly related to one another. An analysis of variance (ANOVA) was used to test whether the BIS/BAS would be differentially related to the emotional and neutral conditions. A correlational analysis was used to investigate whether there was a relation between the day-night- and happy-sad tasks.

3 Results

The training and trial sessions on both the day-night task and happy-sad task were completed successfully by all participants. Most of the participants required only one training trial before moving on to the task, although one did require six.

3.1 Preliminary analyses

One participant was excluded from both the emotional and the neutral condition as it was considered an outlier because it was 2.5 standard deviations above the mean. The assumption of normally distributed data was investigated for all variables. The majority met the assumptions of normality, except the distributions of BAS Drive, the RT variables for both emotional and neutral conditions, and the variable for Socioeconomic Status (SES). The variables in question were transformed. After both log transformations and square root transformations, all except RT for the emotional condition still did not meet the assumption of normality. The transformed scores for the RT variable for the emotional condition were used for the correlational analyses and the analysis of variance (ANOVA) where normally distributed data is preferable. A one-way analysis of variance (ANOVA) was performed to investigate whether there were any effects of gender. There was a significant effect of gender
on the number of errors in the emotional condition, $F(1, 28) = 5.877, p = .022$. On average, males made more mistakes ($M = 5.06, SD = 2.39$) on the happy-sad task than females did ($M = 3.08, SD = 1.98$). There were no other significant effects found between gender and the other outcome variables in this analysis. For the independent variables, no significant gender effects were found either. A correlational analysis was used to examine possible effect of age. The correlational analysis showed no significant associations between age and the dependent variables. A one-way ANOVA was used to investigate whether the order the tasks were given in, had an effect on the dependent variables; none were found.

A partial correlational analysis controlling for gender was performed between the response time and the number of errors on the day-night task and the happy-sad task. There was not found a significant correlation which indicates that there was no speed/accuracy tradeoff.

### 3.2 Main analyses

The number of errors in the happy-sad and day-night task are presented in Figure 2. Because of the gender difference in the emotional condition, an analysis of covariance (ANCOVA) was conducted – with gender as covariate – to evaluate whether the difference between number of errors on the day-night task and the happy-sad task was significant. A significant difference was not found here.
Figure 2. Number of errors on the happy-sad and day-night tasks by gender

The response times on the neutral and emotional conditions are presented in Figure 3. There was conducted a paired-sampled T-test on differences in response time between the two tasks. There was a significant difference between the RT scores for the emotional condition ($M = 57s, SD = 9.38$) and the neutral condition ($M = 51s, SD = 7.93$); $t (29) = 3.67, p = .001$, $\eta^2 = .32$. Although the effect size is small, the results do suggest that the happy-sad task was more difficult than the day-night task. This result supports our first hypothesis, and is consistent with previous findings that performance on interference control tasks is poorer in the emotional conditions.
Means and standard deviations of the subscales of the BIS/BAS scales are reported in table 2.

Table 2

<table>
<thead>
<tr>
<th>Scale</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIS</td>
<td>30</td>
<td>4.06</td>
<td>.87</td>
</tr>
<tr>
<td>BAS Drive</td>
<td>30</td>
<td>3.32</td>
<td>1.17</td>
</tr>
<tr>
<td>BAS Reward</td>
<td>30</td>
<td>5.43</td>
<td>.76</td>
</tr>
<tr>
<td>BAS Fun</td>
<td>30</td>
<td>5.03</td>
<td>.73</td>
</tr>
<tr>
<td>BAS Combined</td>
<td>30</td>
<td>4.66</td>
<td>.64</td>
</tr>
</tbody>
</table>

Correlational analyses were conducted between the dependent variables of response time and number of errors on the day-night and happy-sad tasks, and the independent variables of BIS and the subscales of BAS Drive, BAS Reward, BAS Fun Seeking and the combined BAS variable to investigate the second hypothesis. No significant correlations between any of these variables were found. As no significant correlations emerged, regression was not performed.

Figure 3. Response time on the day-night and happy sad tasks by gender
Table 3

*Correlations between BIS/BAS and inhibition*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Neutral RT</th>
<th>Neutral N. of errors</th>
<th>Emotion RT</th>
<th>Emotion N. of errors</th>
<th>BIS Drive</th>
<th>BAS Reward</th>
<th>BAS Fun</th>
<th>BAS Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral RT</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>Neutral N. of errors</td>
<td>.17</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>Emotional RT</td>
<td>.52**</td>
<td>.10</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>Emotional N. of errors</td>
<td>-.08</td>
<td>.34</td>
<td>.20</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>BIS</td>
<td>.06</td>
<td>.04</td>
<td>.01</td>
<td>-.13</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>BAS Drive</td>
<td>-.00</td>
<td>.23</td>
<td>.10</td>
<td>.22</td>
<td>.26</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>BAS Reward</td>
<td>.20</td>
<td>-.11</td>
<td>.08</td>
<td>-.25</td>
<td>.49**</td>
<td>.31</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>BAS Fun</td>
<td>-.06</td>
<td>-.04</td>
<td>-.07</td>
<td>.08</td>
<td>-.15</td>
<td>.08</td>
<td>.48**</td>
<td>__</td>
</tr>
<tr>
<td>BAS Combined</td>
<td>.07</td>
<td>.07</td>
<td>.07</td>
<td>.04</td>
<td>.31</td>
<td>.74**</td>
<td>80**</td>
<td>.62**</td>
</tr>
</tbody>
</table>

*Note.** Correlation is significant at the .01 level.

Blair et al. (2004) split the BIS and BAS variables into low and high values using a median split, in order to investigate whether the degree of BIS or BAS a person has differentially impacts their interference control ability. Although there were not found significant correlations between BIS/BAS and interference control in the current study, splitting the BIS/BAS variables gave an opportunity to examine a relation in a different way. To see whether the low or high scores would yield a relation to the inhibition tasks in our study, we split the variables of BIS and BAS Combined. A one-way ANOVA was conducted on the split variable. However, neither low nor high scores on the BIS and BAS were significantly related to performance on the interference control tasks.

The second part of hypothesis 2 was whether there was a differential connection between BIS/BAS and the day-night and happy-sad tasks. A one-way ANOVA was conducted to investigate this. This analysis showed that the differences between the BIS/BAS variables and the emotional and neutral conditions were not significant.
Lastly, there is evidence in favour of the third hypothesis. As can be seen in table 3, the correlations between the emotional happy-sad task and the neutral day-night task correlate significantly on the response time variables.

4 Discussion

In part supporting the first hypothesis, the participants were significantly slower on the emotional happy-sad task compared to the non-emotional day-night task. However, the second hypothesis failed to be confirmed, as no significant relationship was found between performance on the interference control tasks and scores on the BIS/BAS scales. There was a second part of hypothesis 2 on whether there would be a stronger relation between BIS/BAS and the emotional happy-sad task. This was not confirmed. There was, however, found evidence that the happy-sad- and day-night task were related, which supports the third hypothesis. In addition, a gender difference was revealed in the emotional condition, where males made significantly more errors than females.

4.1 Inhibitory control tasks

Previous research has found the happy-sad task to be more challenging than the day-night task (Kramer et al., 2014; Lagattuta et al., 2011). The original study on the development of the happy-sad task, by Lagattuta et al., (2011), found children and adults alike to perform significantly better on the day-night task on both response time and number of errors. This finding was only partially replicated in the current study. The participants in the current study spent significantly longer on the happy-sad task, suggesting they found it more difficult. However, although there were more errors in the emotional condition than the neutral condition, this difference was not significant. Previous studies using these tasks have found neither ceiling effects nor floor effects for age groups of 4–5 year olds. In the current study, there was not found a ceiling effect. There were, however, three participants who did not make any mistakes; one participant in the neutral condition, another in the emotional condition, and one participant made no mistakes on either of the tasks. Even though this only concerned a small minority, given the small overall samples size, it might have affected the results in that it could have made the error rate difference smaller between the two conditions. There were no floor effects: none of the participants had error rates above 50%.

The significant difference found in response times indicates that the happy-sad task was found more difficult. This supports findings of previous research (Kramer et al., 2014;
Lagattuta et al., 2011), and the argument that stimuli of emotional facial expressions impair performance on tasks of which processing the emotional information are an integral part of the task objective (Kramer et al., 2014). As outlined in the introduction, there are a number of ways emotional information affects the abilities of interference control. The emotional aspect of the task elicits the deployment of the hot executive functions (Peterson & Welsh, 2014; Zelazo & Carlson, 2012; Zelazo et al., 2010). The way the happy-sad task is designed means the emotional information needs to be directly attended to as it is integral to solving the task (Kramer et al., 2014). This is a vital reason for the detrimental effect the happy-sad task has; had the emotional information been peripheral, it would not have caught attention and become disruptive, as the hot and cold executive functions would not have had to compete with one another (Kramer et al., 2014). If the emotional aspect of a task conflicts with the goal, it will be distracting to the cognitive abilities (Zelazo et al., 2010). The stimuli in the happy-sad task are conflicting for each trial, as the card presented is the opposite to the correct response. This emotional version is therefore more difficult than the day-night task because having to process emotional information that is not compatible with the current goal, disrupts performance (Zelazo et al., 2010). Given the emotional nature of this stimulus, it does require additional processing, meaning that processing cannot be focused solely on inhibition. The happy-sad task requires use of both hot and cold executive functions. Emotional information is more difficult to inhibit because of the shared neural pathways of emotion processing and cognitive control (Pessoa, 2009; Zelazo & Carlson, 2012; Zelazo et al., 2010). As some of the resources are contributing to processing the emotional stimuli, there are less resources available respond correctly (Izard et al., 2011; Pessoa, 2008, 2009). Because they are more impeded by the processing of this emotional information, it takes participants longer to manage to inhibit the dominant response and enhance the correct response. The valence of emotion also has an effect; positive emotional information tends to positively affect performance, and negative emotional information tends to negatively affect performance (Izard et al., 2011; Pessoa, 2009). For this task, however, there is both positive and negative emotional information. As the response time used in the happy-sad task is the total of all trials, it can be assumed that the effects of the negative and positive emotional stimuli cancel each other out.

One reason that a significant difference in error rates was not found could have been due to error during testing. For instance, although there were two different orders to the test protocol as a whole, the orders of the day-night task and the happy-sad task were not
alternated between in the beginning of testing. It became apparent that these should have been alternated quite late in the testing period. This might have affected the error rates, as most of the participants took the day-night task first, followed by the happy-sad task. Many of the children in the study may thus have benefited from practice effects on the day-night task. However, an ANOVA-analysis was conducted which did not find a significant difference on task order, which may suggest this did not have a notable effect on performance. Another factor may have been the size of the sample. Previous studies using these tasks have had between 200 to 300 participants. Had the sample been larger, larger variation between participants on error rates may have been found.

The analysis conducted between the day-night task and the happy-sad task showed that the neutral and emotional conditions were significantly correlated with one another. With regards to the debate on whether or not the hot and cold executive functions are independent from one another, this result lends support to the theory that they are not. Previous research has found evidence both pointing towards their unity and their independence (Peterson & Welsh, 2014; Zelazo & Carlson, 2012). As mentioned in the introduction, some studies on adults and adolescents have found the executive functions to be independent from one another (Zelazo & Carlson, 2012) while research on children generally has found the hot and cold executive functions to be connected. The reason could be that the two functions do not become separated until later in development (Zelazo & Carlson, 2012). According to Kramer et al. (2014), difficulty with the happy-sad task increases with age. Whether or not the executive functions are separate or not, this illustrates that they do collaborate, and supports the idea that they become more integrated with development.

4.2 Individual differences

In the present study, individual differences in the form of scores on the BIS/BAS scales were not related to performance on response time nor error rates on the day-night and happy-sad tasks. Relations between the BIS/BAS scales and inhibitory tasks for this age group has been found previously by Blair et al., (2004). In their study, Blair et al. (2004) also divided the BIS and BAS scores into low and high levels using a median split, to investigate whether low and high scores related differently to interference control ability. They found those with a high BAS score to do worse on inhibition and those with a high BIS score to do better on inhibition. The BIS and BAS scores were similarly divided in the current study, but there was not found any significant differences between the scores on the tasks and differences in low and high levels of BIS and BAS. Blair et al. (2004) did not use the day-
night or the happy-sad task to measure inhibition. The task they used was the peg-tapping-task (Luria, 1966), in which both participant and experimenter tap a surface with a dowel. The aim is to give the opposite response; if the experimenter taps once, the participant must tap twice. This requires inhibiting the impulse to do the same as the experimenter, and keeping this rule – and the number of taps – in mind. The task does involve inhibitory control, although it requires a motor response instead of a verbal response. Both the peg-tapping task and the day-night task require holding two rules in mind at the same time as inhibiting a dominant response to activate a different one. Despite the two being conceptually very similar, they are not equal to one another. In a study in which both of these tasks were compared to the Preschool and Kindergarten Behaviour Scales (PKBS), the peg-tapping task turned out to be a more suited measure of socio-emotional functioning (Rhoades, Greenberg & Domitrovich, 2009; Watson & Bell, 2013), and the two inhibitory control tasks only correlated moderately with one another (Rhoades et al., 2009). The major difference between the two tasks is that the tapping task relies on a motor response instead of a verbal response. In fact, motor and verbal inhibitory tasks have been found through factor analysis to be independent from one another (Klenberg, Korkman & Lahti-Nuuttila, 2001), and seem to rely on different neural networks (Utendale et al., 2014).

Given that the tapping task seems to be better related to emotional functioning on the PKBS, it may be a better measure for tapping individual differences. Even so, Rhoades et al. (2009) did find day-night to be significantly associated with PKBS, albeit not as strongly as the tapping task. The fact that this association was not corroborated in the present study could be due to at least two reasons: Firstly, the sample size for Blair’s study is considerably larger than for our study. A larger sample gets a more precise indication of the variability of the inhibitory skills and individual differences in the population at large. Secondly, there may have been bias in the parental report of the BIS/BAS scales, as the validity of such measures for temperamental research has been criticised (Kagan, 1998; Rothbart & Bates, 2006). Parents may either be biased in how they view their child, or in their reluctance to report on aspects that they may deem negative, especially in a psychological questionnaire (Kagan, 1998; Rothbart & Bates, 2006). However, given that the parental report versions of the BIS/BAS scales were also used by Blair et al. (2004), it is more likely that the lack of significant relations between BIS/BAS scales and inhibition for the current study was caused by other possibilities, like sample size, the choice of inhibitory tests and measure of reactivity, or a combination of these explanations.
4.3 Effects of gender

An effect of gender was found on the number of errors in the emotional condition. Males made more mistakes than females on the happy-sad task. Although the effect size is not large, it is consistent with the literature, in which males have been found to have more difficulty overall with these tasks of interference control and other aspects of executive functions (Montgomery & Koeltzow, 2010). However, if this is likely not the main reason, because if that were the case, a gender effect would have been expected to also be found on the day-night task. Kramer et al. (2014) also found this gender difference on only the emotional condition. They suggest that this could be due to female superiority in face processing. Several meta-analyses of studies on adults found that women to be better both at processing and remembering faces (Sommer, Hildebrandt, Kunina-Habenicht, Schacht, & Wilhelm, 2013). Meta-analyses have also found females to be better at interpreting facial expressions (McClure, 2000), and thus also recognise emotions easier (Kret & De Gelder, 2012). Female infants have been found to focus more on faces than male infants do (Herlitz & Loven, 2013). It may be that these differences have evolved evolutionarily, in part due to the different tasks that females and males performed which caused men to have better spatial awareness and women to process facial expressions better (Hampson, van Anders, & Mullin, 2006). Societal norms of females being encouraged to talk about emotions more than males may also be a contributing factor here (Adams, Kuebli, Boyle, & Fivush, 1995).

4.4 Limitations

Choices made in administration and testing may have influenced results in this study. So may the sample size and characteristics of the tests. As far as the sample was concerned, it may have been too small to yield significant effects. Though there are practical advantages to using a convenience sample, it is difficult to predict in advance how many participants it will yield, even though a considerable effort is spent on recruitment. Considering the limited time available to us, the sample size we did get was reasonable. The suitability of using parental report measures for temperament has been questioned, as the validity has often been found to be low when compared with observational measures (Rothbart & Bates, 2006). As previously mentioned, there is also a risk of biased reporting (Kagan, 1998). Experimenter effects were controlled for in that the parents filled out the questionnaires without any of the experimenters present, in the privacy of their homes. Although questionnaires for parent- and teacher report both have their weaknesses, observational studies are not always an alternative, and there are both practical and methodological issues with this as well. Despite concern as to their
feasibility, parental report measures are still considered useful because parents observe their children and their reactions in multiple settings. They are therefore witness to unique behaviours, and their children’s reactions to infrequent events (Rothbart & Bates, 2006). The development of a teacher version of the BIS-BAS scale could be one way of countering some of the possible bias in the parent report. It is not a perfect solution, because such a questionnaire would also be privy to biases like the parent report is, but it would add another perspective which could perhaps balance the biases from the parental report measure. The day-night and happy-sad tasks may not be most suited tasks for testing BIS/BAS sensitivities. Motor response tasks like the peg-tapping task might be better suited to this (Rhoades et al., 2009; Watson & Bell, 2013).

4.5 Future research

Future research could compare the day-night task and happy-sad tasks using a larger sample, and perhaps compare them to other tasks of interference control. In particular, it could be advantageous to clarify whether there is a difference between motor response measures and verbal response measures, and whether they relate differently to reactivity. Developing an emotional version of a motor response tasks could allow the emotional conditions for these two types to be compared as well, which could investigate whether emotional stimuli distracts performance differently for motor or verbal tasks. A larger sample may also be able to replicate the finding from (Blair et al., 2004) that found interference control ability to vary according to which combination of BIS/BAS participants were reported to have. With regards to participants, there has previously been done research on interference control on samples from lower socioeconomic backgrounds (Rhoades et al., 2009) – doing this could increase the generalisability of findings and could therefore be advantageous. Participants in the current study were very close in age – using several age groups could allow for comparisons of the developmental trajectory of the day-night and happy-sad tasks. Inhibitory abilities develop for a long time – even into adolescence (Kipp, 2005). Including more age groups could therefore give an impression of how the ability to inhibit changes. Including different age groups could also contribute to findings on how the relation between interference control and individual differences on reactivity develop in relation to one another.

4.6 Conclusion

This study aimed to replicate the finding that the happy-sad task is more difficult for preschoolers than the day-night task. This aim was met, as performance was impeded on the
emotional happy-sad task. This could be seen in our response time data, as participants spent longer on the emotional condition. The emotional stimuli did not affect the number of errors participants made, however. Our findings thus support previous research that emotional information within a task impedes performance in circumstances where attending to the emotional stimuli is necessary for successful task completion. One theory for the reason for these findings is that attending to emotional stimuli that conflicts with the task goal, can require further processing, which depletes the resources needed to adequately solve the task. Another finding from the study was that the day-night and happy-sad tasks were related to each other, which supports the theory that the hot and cold executive functions may be unified as opposed to independent from one another (Peterson & Welsh, 2014; Zelazo & Carlson, 20102), at least for the subdivision of inhibitory control at preschool age.

BIS/BAS reactivity did not affect performance on the interference control tasks. Dividing the BIS/BAS into low and high scores did not alter this finding. Such a relation has been found previously using another type of inhibitory task, so the reason it was not found in the current study may be that the interference control tasks used in this study were not be strongly related to the type of reactivity that the BIS/BAS scales measure. It is possible that task characteristics such as response type may relate differently to measures of BIS/BAS reactivity. Another reason for this finding may be the fact that the current study had a small sample.

This study strengthened the finding that emotional information that is attended to and incompatible with task goals, does impair performance. Research on this is important because the conditions under which emotion may impair cognitive abilities in children can for instance, affect performance in school. The day-night and happy-sad tasks are an ideal pair to use for delving further into the effect emotional information has on children’s performance during inhibitory control tasks. Investigating them in relation with other measures of reactivity or behavioural- and emotion regulation may be furthered in future research. Investigating the way individual differences like reactivity impact inhibitory abilities, is important, as knowledge of how children are differently affected, can lead to more informed ways of addressing their particular difficulties with emotional control in both academic and social settings. The relation between interference control and reactivity could also be studied in future studies using a larger sample.
References


