Temperament and executive function problems in preschoolers

The importance of age and gender

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# Table of contents

Abstract ................................................................................................................................3

1. Introduction ......................................................................................................................4

2. Method ..............................................................................................................................9

   2.1. Participants ..................................................................................................................9
   2.2. Procedures ...................................................................................................................9
   2.3. Instruments ................................................................................................................10
      2.3.1. Temperament.......................................................................................................10
         2.3.1.1 CBQ-VSF ......................................................................................................10
      2.3.2. Executive function problems .................................................................................11
         2.3.2.1 BRIEF-P ......................................................................................................11
   2.4. Statistical analyses .....................................................................................................12

3. Results .............................................................................................................................13

   3.1 Descriptive statistics ...................................................................................................13
   3.2 Temperament and executive function problems ...........................................................14
   3.3 Temperament and inhibition problems ..........................................................................14
   3.4 Temperament, gender, and age ....................................................................................15
   3.5 Moderation with gender and age ................................................................................16
      3.5.1 General executive function problems ..................................................................17
      3.5.2 Inhibition problems .........................................................................................18

4. Discussion ........................................................................................................................20

References ...........................................................................................................................24

Appendices ..........................................................................................................................30

Appendix 1 .......................................................................................................................30
Appendix 2 .......................................................................................................................31
Abstract

Whilst studies in young adults and adolescents have showed associations among temperamental traits and executive functioning, research on this relation in young children whose executive functions are still in development is scarce. Temperament is often described in terms of effortful control, negative affectivity, and extraversion in young children. The current study focused on the direct relation between temperament and executive function problems in 590 preschoolers aged three to five years. The relation between temperament and inhibition problems specifically was examined as well. Age and gender were included to examine possible differences in the relation between temperament and executive functioning. Information about preschoolers’ temperament and executive functions were rated by their parents who were recruited via Dutch schools and nurseries. Parents completed the Behavior Rating Inventory of Executive Function – Preschool version (BRIEF-P) as well as the Child Behavior Questionnaire – Very Short Form (CBQ-VSF). The findings demonstrated that effortful control was related with less executive function problems, although this relation was stronger for younger children. Extraversion and negative affectivity were related with more executive function problems. Within children with traits of negative affectivity, boys showed more executive function problems than girls. These children showed more inhibition problems when they were older as well. Longitudinal research is needed to consider the development of executive functioning and its relation to temperament. The relevance of these findings may contribute to a better implementation of early identification and training programs, which may lead to reducing executive function problems in children at early age.

Key words: temperament; executive function problems; inhibition; preschoolers; age; gender
1. Introduction

Executive functions are engaged in adaptive, goal-directed behaviors that enable individuals to override more automatic or established thoughts and responses (Ardila, 2008; Lezak, 1995; Mesulam, 2002) and are located in the prefrontal cortex. The maturation of the frontal lobes is controlled by an interplay of genetic coding as well as in response to environmental stimuli, and determines the quality of executive functioning (De Luca & Leventer, 2008). Executive function problems include a variety in representations, such as an inability to maintain or shift attention, disinhibition, reduced working memory, and inabilities to plan actions (Anderson, 2008). These problems can increase the risk for later developmental psychopathology, such as behavioural, attentional, and social interaction problems (Bridgett, Valentino, & Hayden, 2012; Darwish, Esquivel, Houtz, & Alfonso, 2001; Floyd & Kirby, 2001; Riggs, Blair, & Greenberg, 2003). Consequently, it is important to ascertain executive function problems and its associations with genetic or early stable factors, such as temperament, at an early age.

Temperament refers to stable individual differences in emotional, motor, and attentional reactive tendencies and regulative capacities. These appear from birth onward and presumably have strong genetic and neurobiological bias (Rothbart & Bates, 2006). In the past decades, research on temperament and developmental processes have mainly been put forward by psychobiologists (Rothbart, Ahadi, & Evans, 2000). However, due to the lack of consensus several approaches can be considered to explain the nature of temperament (Mervielde & De Pauw, 2012). The behavioural approach (Thomas & Chess, 1977) explained the nature of temperament by the reciprocal interaction between the child and its environment. Temperament is considered as the degree of the behaviour (i.e. how intensely), rather than the content (what) or the motivation (why). According to Buss and Plomin (1975) several criteria should be met to define traits as temperament, in which these are inherited, relatively stable during childhood, evolutionary adaptive, and present in the phylogenetic relatives. The approach of Goldsmith and Campos (1982) defines temperamental categories as experiencing and expressing basic emotions. Temperament is emotional in nature, refers to behavioral tendencies, and is indexed by expressive acts of emotions. In the biotypological approach by Kagan (1994) behavioral inhibition is the core component of temperament. Each temperamental type inherits a distinct neurochemistry that affects the excitability of the extended amygdala. Finally, the psychobiological approach of Rothbart and colleagues (1981;
1992) explains individual differences in temperament largely by the responsiveness of underlying psychobiological processes related to emotion, motivation and attention. This approach distinguishes temperamental traits in young children in terms of effortful control, extraversion, and negative affectivity, in which temperamental differences emerge during the first years of life (Rothbart & Bates, 2006). The psychobiological approach served as framework for the current study.

Executive functions can be expected to be related with temperament in at least three ways\(^1\) (Lengua & Wachs, 2012). First, there may be direct effects whereby individual differences in temperament, either in isolation or in combination with other risk factors, independently impact a child’s development (a). Second, temperament may indirectly influence outcomes through increasing the child’s exposure to risk and promotive factors. Risk factors increase the likelihood of adverse development, whereas promotive factors increase the likelihood of an optimal development (b). Third, temperament may act as moderator, either mitigating or exacerbating the impact of risk factors upon development (c). The extent to which successful functioning of a child can exist in a context of significant risk is referred to resilience, and results from the interplay between risk and promotive factors.

The direct relation between temperament and executive functioning has recently been studied. In a study of Cassimjee & Murphy (2010) the relation between temperament and neuropsychological test performance was examined in a postgraduate student sample. Results showed that temperament dimensions related to negative affect and reward dependence were positively related with reaction time on several neuropsychological tasks, including inhibition and working memory tasks. (Cassimjee & Murphy, 2010). A recent study on negative affectivity and executive functions in toddlers found that increases in negative affectivity between 9 and 27 months of age were associated with poorer delay of gratification (Leve et al., 2013).

Further, more studies examined the relation between effortful control and executive functioning. Effortful control can be defined as the ability to inhibit a dominant response to perform a subdominant response and to detect errors (Rothbart, 2012). In a study of Bridgett and colleagues (2013) effortful control was related to working memory, but not inhibition. However, findings in a study of Yücel and colleagues (2012) demonstrated effortful control was positively associated with inhibitory control in young female adolescents. This

\(^1\) See also Figure 1 in Appendix 1. The links among temperament and child development are represented by the figure’s arrows (a), (b), and (c).
association was absent for young male adolescents (Yücel et al., 2012). Several developmental studies found support for the relation of effortful control to executive attention during early childhood (Gerardi-Caulton, 2000; Rothbart, Ellis, Rueda, & Posner, 2003; Rueda, Posner, & Rothbart, 2004). Executive attention was related to error detection and the ability to resolve conflict among different response tendencies (Botvinick, Braver, Barch, Carter, & Cohen, 2001). In a qualitative review of Zhou, Chen and Main (2012) it was suggested that effortful control and executive functions have substantial overlap and the authors advocated an integrative model for both constructs.

The interplay of temperament and executive functioning can be of predictive value for the development of later psychopathology. The ability to flexibly shift attention was thought to play an important role in adaptive regulation of negative temperamental reactivity (Eisenberg Smith, Sadovsky, & Spinrad, 2004; Rothbart et al., 1992). The importance of executive functions’ attention shifting and inhibitory control as moderating role between behavioral inhibition and the later development of anxiety problems was also suggested in an ongoing longitudinal study in early childhood (White, McDermott, Degnan, Henderson, & Fox, 2012). A study of Lahat et al. (2012) examined the moderating role of attention shifting and inhibitory control on the link between exuberant temperament in infancy and the propensity for risk taking in childhood. Temperamental exuberance can be defined as positive reactivity to novelty, approach behavior and sociability (Putnam & Stifter, 2005). Findings indicated that children with an exuberant temperament across early childhood and low attention shifting in the preschool period displayed increased propensity for risk taking, which was associated with antisocial behaviors in adolescence and adulthood. Low inhibitory control was not found to have a moderating role on the link between an exuberant temperament and risk taking behavior (Lahat et al., 2005).

Temperament has been demonstrated as a factor in which children can benefit from attention training during the development of executive functions (Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005; Conway & Stifter, 2012). In a study on executive attention training in four- and six years old children strong improvement in executive attention and intelligence was found after five days attention training (Rueda et al., 2005). The authors suggested that more introvert and controlled children may be less in need of attention training, because they found that attention performance was associated with stronger effortful control and less surgency/extraversion. Conway and Stifter (2012) examined mother-child dyads to determine whether maternal attention-directing behaviors and toddlers’
temperament predicted executive processes during preschool. Results indicated that maternal-attention directing behaviors may enhance the development of executive functions, but only for children with inhibited and exuberant temperaments.

The findings of studies in the preschool period may not, by definition, be generalized to other age groups and vice versa, because of the highly important development of executive functions between three and five years of age (e.g. Diamond, 2006; Munakata, 2001; Rothbart & Posner, 2001). Historically, two broad approaches can be distinguished in the development of executive functions. The first approach considers executive functions as unitary construct with subprocesses (e.g. Baddeley 1986; Norman & Shallice, 1986; Shallice, 1988), whereas the other approach assumes the presence of dissociable EF processes (e.g. Carlson & Moses, 2001; Diamond, 1991, Pennington, 1997; Welsh, Pennington, & Groisser, 1991). Over the last decades there is accumulating evidence for an integration of the unitary and the dissociable executive function processes views, which is represented in the integrative executive function model of Miyake et al. (2000). The model demonstrates two main stages in the development of EF in early childhood. The first stage (before three years of age) consists the emerge of basic skills to perform EF in which the child gains more voluntary control over attention, such as selective attention, response inhibition, and response shifting. Developments in the age of three to five years demonstrate the change towards complex skills that involve coordination of simpler skills, resulting in performing attention shifting, complex response inhibition tasks, and complex working memory tasks (Garon, Bryson, & Smith, 2008).

Differences in executive functioning seem to be present for gender as well. In general it has been suggested that girls show higher accuracy in attentional performances, while boys seem to demonstrate better speed performance (Brocki & Bohlin, 2004; Sobeh, & Spijkers, 2013). Temperamental differences within gender have also been shown in a meta-analysis of Else-Quest, Hyde, Goldsmith and Van Hulle (2006). It has been found that girls were better at controlling or inhibiting impulsive behaviors, and boys showed higher levels of activity. It has been concluded that gender moderates links between temperament and developmental outcomes (Else-Quest et al., 2006). A recent study suggested that differences in attentional performances in gender were still unclear (Sobeh & Spijkers, 2013).

The current study examined the direct relation between temperament and executive function problems in the preschool period. The examination of this relation is important for several reasons. First, the extent to which children can benefit from training to improve
executive function is likely to be influenced by temperament (Rueda et al., 2005; Conway & Stifter, 2005). Second, temperament and executive functions appear to interact in the development of behavioral problems (Eisenberg et al., 2004; Lahat et al., 2012; Rothbart et al., 1992; White et al., 2011). Finally, the direct relation between temperament and executive functioning has mainly been studied in young adult and adolescent samples (Bridgett et al., 2013; Cassimjee, & Murphy, 2010; Liew, 2012; Yücel et al., 2012), of which conclusions may not by definition be generalized to the preschool period.

The aim of this study was to examine the relation between temperament and executive function problems in children aged three to five years. In line with childhood studies on temperament and executive functioning (e.g. Rueda et al., 2004; Zhou et al., 2012), it was expected that effortful control was inversely related to problems in executive functioning. It was also expected that extravert children showed more executive function problems, because attention performance has been related with less surgency/extraversion (Rueda et al. 2005). Further, the relation between temperament and inhibition problems was also examined, because the existing literature mainly focused on temperament and inhibition problems, and the findings were not consistent. It was expected that effortful control was inversely related to inhibition problems as well (Cassimjee & Murphy, 2010; Yücel et al., 2012). Negative affectivity was expected to be positively related with inhibition problems, because it was shown negative affectivity was associated with poorer delay of gratification (Leve et al., 2013), and increased reaction time on an inhibition task (Cassimjee et al., 2010).

Additionally, influences of age and gender were included. Age was included due to the strongly developmental period of executive functioning within the preschool period (Diamond, 2006; Munakata, 2001; Rothbart & Posner, 2001). It was expected that younger children would show more executive function problems, because the ability to perform more complex skills was expected to increase with age (Garon, Bryson, & Smith, 2008). With regard to gender it was expected that in general boys would show more executive function and inhibition problems than girls (e.g. Else-Quest et al., 2006; Sobeh & Spijkers, 2013). Further, it was expected that gender moderated links between temperament and executive function problems (Else-Quest, 2012).
2. Method

2.1. Participants

The sample consisted of 590 children, including 300 boys (51%) and 290 girls (49%), with a mean age of 4.14 years (range 3-5 years, SD=0.75). The sample at baseline assessment consisted of 730 children, of which 140 children were excluded because they did not meet the criterium of age for the temperament questionnaire CBQ (age 3+). For most of the cases children were nurtured in a family with a shared responsibility of both parents (64.4%), followed by families with main responsibility of the mother (34.2%), another caregiver (1.0%), and the father (0.3%). For the current study questionnaires were completed for 87.5% by the mother, 10.0% by the father, and in 2.5% of the cases by another caregiver than the biological parents.

2.2. Procedures

In order to reach a broad range of preschoolers, several schools and nurseries were approached to inform about the goal of the study. Principals of schools and nurseries were motivated to support the study by giving permission to reach parents via their institution. First contacts with directors of schools and nurseries were made by phone. When schools and/or nurseries were motivated for participation in the study, informed consent was given in paper format. Schools and nurseries signed for permission to approach parents of preschoolers for participation in the study. A student-researcher of Leiden University met the principal of a school or nursery when this was requested, and further agreement was made about the procedure of data collecting (e.g., agreement about submission dates of the informed consent).

Parents were approached to participate in the study by an invitation on paper. They were requested to sign the informed consent to confirm their participation in the study. When parents signed for informed consent, they received the questionnaires on paper via the teacher or nurse in the class or via an e-mail including a link to LimeSurvey (an online survey application). After completion parents returned the questionnaires via a box at the school or nursery or the data were automatically saved with LimeSurvey. Parents took about 25-30 to complete the questionnaires. When parents did not return the questionnaires in the expected time (two weeks), they were reminded to complete (and return) the questionnaires. All parents completed the questionnaires before or after the first reminder.
2.3. Instruments

2.3.1. Temperament

2.3.1.1 CBQ-VSF

The Dutch version of the Children’s Behavior Questionnaire – Very Short Form (CBQ-VSF) was used to assess different aspects of temperament. The Children’s Behavior Questionnaire (CBQ) is a well-established parent-report measure of temperament for children aged three to eight years (Rothbart, Ahadi, Hershey, & Fisher, 2001). The very short form (CBQ-VSF) consists of three broad factors similar to three of the five Big Five personality dimensions (McCrae & John, 1992). The CBQ-VSF contains 36 of the 194 of the items of the standard CBQ and is effective for obtaining information for the three factors Surgency/Extraversion (12 items), Negative Affectivity (12 items), and Effortful Control (12 items) (Putnam & Rothbart, 2006). Surgency/Extraversion involves the tendency to show impulse, active, pleasure-seeking behavior coupled with low levels of shyness. This factor is characterized by high positive loadings on the following scales of the standard CBQ: Impulsivity, High Intensity Pleasure, and Activity levels, and negative loadings on the Shyness scale. Negative Affectivity refers to the predisposition to automatic or involuntary experience high levels of sadness, fear, discomfort, and low levels of soothability. The factor is derived from high positive loadings of the Sadness, Fear, Anger/Frustration, and Discomfort scales, and negative loadings for Falling Reactivity/Soothability scales of the standard CBQ. Effortful control is characterized by high attention control and inhibitory control along with low perceptual sensitivity and can be regarded as the self-regulation aspect of temperament (Rothbart et al., 2001; Sleddens, Kremers, Candel, De Vries, & Thijs, 2011). This factor matches with high positive loadings for the scales Inhibitory Control, Attentional Control, Low Intensity Pleasure, and Perceptual Sensitivity of the standard CBQ. The three factors demonstrate adequate internal consistency for the Dutch translation of the CBQ-SFV; Cronbach’s alpha coefficients were .72 for both Negative Affectivity and Effortful control, and .76 for Surgency/Extraversion. The very short form of the CBQ was recently validated for measurement of temperament in Dutch children (Sleddens et al., 2011).

Participants were asked to rate how well the items describe their child in the past six months. Responses on a seven-point Likert scale range from ‘extremely untrue of my child’ (1) to ‘extremely true of my child’ (7). All items are presented statement wise and are
formulated in the third person. For example, “prefers quiet activities to active games”, and “gets angry when s/he can’t find something s/he wants to play with”.

2.3.2. Executive function problems

2.3.2.1 BRIEF-P

The Dutch translation of the Behavior Rating Inventory of Executive Function – Preschool version (BRIEF-P) was used in this study to assess executive function problems (Van der Heijden, Suurland, de Sonneville, & Swaab, in press). The BRIEF-P is a 63-item rating scale for children aged two to five years and can be completed by different raters such as parents, caregivers, preschool teachers, and/or childcare workers. The questionnaire is developed to assess executive functioning in preschoolers, in which language, memory, and motor skills are not yet established and for those who have difficulties to focus on tasks for prolonged periods of time (Gioia, Espy, & Esquith, 2003, quoted by Sherman & Brooks, 2010).

The BRIEF-P domains of interest were the clinical scale Inhibit and the index Global Executive Composite. Adapted from Gioia and colleagues (2003, as quoted by Sherman & Brooks, 2010) Inhibit is characterized as impulse control, which indicates the ability to stop and modulate behavior. The Global Executive is described as the overall executive function level and is the summary score of the five clinical scales of the BRIEF-P; Inhibit (16 items), Shift (10 items), Emotional Control (10 items), Working Memory (17 items), and Plan/Organize (10 items). The five scales can be summarized in three overlapping indexes: Inhibitory Self-control Index (Inhibit and Emotional Control), Flexibility Index (Shift and Emotional), and Emergent Metacognition Index (Working Memory and Plan/Organize). The overall composite index is the Global Executive Composite. For a graphical overview of the measurement model of the BRIEF-P, see Figure 2 in Appendix 2.

The instrument includes questions of the child’s behavior in terms of how often the particular behaviors have been a problem in the last period of six months. Responses are rated on a three-point scale with categories ‘Never’, ‘Sometimes’, and ‘Often’. In the current study the BRIEF-P was rated by one of the parents who had the most contact with the child in the past six months. Higher ratings indicated more impairment in executive functioning.

The Dutch version of the BRIEF-P has been validated by the department Education and Child Studies of Leiden University and is expected to be published in 2013 (Van der Heijden et al., in press). Gioia and colleagues (2002, as quoted by Isquith, Crawford, Espy, &
Gioia, 2005) reported internal consistency for parent ratings for the original BRIEF-P. Cronbach alpha values were determined for each domain: Inhibit = .90, and Global Executive Composite (GEC) = .95, in a U.S. normative sample with parents as informants. The findings indicated very high magnitudes of coefficients for the Inhibit scale and GEC overall (.90+).

2.4. Statistical analyses

The Statistical Package for Social Sciences version 19 (IBM SPSS Statistics) was used for the statistical analyses. Pearson correlations (r) were calculated to examine the relation between several temperament traits, and also for the relation between general executive function problems and inhibition problems.

To investigate the main effect of temperament on executive function problems, multiple regression analyses (ANOVAs) were run (Method: Enter) with general executive function problems and inhibition problems as dependent variables separately. The ANOVAs were executed two-tailed, and a significance level of .05 was used.

To investigate whether age and gender influenced executive functioning, ANCOVA analyses were run with age and gender as fixed factors, and Surgency/Extraversion, Effortful Control, and Negative Affectivity as covariate variables. Age and gender were used as categorical variables. In analyses general executive function problems and inhibition problems were included separately as dependent variable.

To further investigate whether age and gender moderated the association between temperament and executive function problems, interaction variables were computed for age and gender with temperament dimensions. The interaction variables were added in the ANCOVA model as covariate variables, and all ANCOVA analyses were rerun. For all ANCOVA analyses p < .05 was used.

After finding a covariate x factor interaction, separate regression lines were drawn for the different subgroups of the factor. Regression lines were drawn via scatterplots of the dependent variables with the covariate with markers set by the factor. Differences between groups (age or gender) were interpreted via the graphs of the scatterplots.
3. Results

3.1 Descriptive statistics

Frequencies and descriptive statistics for temperament and executive function problems are presented in Table 1. The frequencies are presented for the total sample and the different age groups and also sorted by gender. The descriptive statistics are presented for both the total sample and the age groups.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Age in years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>N (%)</td>
<td>590 (100%)</td>
<td>133 (23%)</td>
</tr>
<tr>
<td>Male</td>
<td>300 (51%)</td>
<td>66  (11%)</td>
</tr>
<tr>
<td>Female</td>
<td>290 (49%)</td>
<td>67  (11%)</td>
</tr>
<tr>
<td>Temperament, M (SE)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgency/Extraversion</td>
<td>4.22 (.70)</td>
<td>4.22 (.71)</td>
</tr>
<tr>
<td>Effortful Control</td>
<td>4.96 (.84)</td>
<td>4.92 (.95)</td>
</tr>
<tr>
<td>Negative Affectivity</td>
<td>3.20 (.86)</td>
<td>3.23 (1.01)</td>
</tr>
<tr>
<td>EF problems, M (SE)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>89.26 (17.75)</td>
<td>90.56 (18.84)</td>
</tr>
<tr>
<td>Inhibit</td>
<td>23.66 (5.64)</td>
<td>23.76 (5.80)</td>
</tr>
</tbody>
</table>

The sample is evenly distributed for gender, also with regard to the age groups. With regard to the descriptive statistics it can be seen that for temperament the highest mean score was found for Effortful Control, followed by Surgency/Extraversion, and Negative Affectivity. The mean scores of the factors of temperament did not significantly differ between the age groups; Surgency/Extraversion (F (2, 587) = 0.293, p = .746), Effortful Control (F (2, 587) = 0.114, p = .892), Negative Affectivity (F (2, 587) = 0.352, p = .704). Also, the total mean score of general executive function problems and inhibit problems were representative for all ages, because the mean scores of these variables did not significantly differed between the age groups; general executive function problems (F (2, 580) = 0.375, p = .688), inhibition problems (F (2, 579) = 0.038, p = .962).

Correlation analyses were run separately for the temperament factors, and general executive function and inhibition problems. The three factors of temperament (Surgency/Extraversion, Negative Affectivity, and Effortful Control) were not interrelated;
Surgency/Extraversion was not significantly associated with Effortful control (Pearson correlation $r (590) = .003$, $p = .935$) and Negative Affectivity (Pearson correlation $r (590) = .021$, $p = .619$), and Effortful Control was not significantly associated with Negative Affectivity (Pearson correlation $r (590) = -.014$, $p = .739$). These analyses suggested that the three factors of temperament did not overlap and there were no problems for further interpretation. General executive function problems and inhibition problems were significantly correlated (Pearson correlation $r (582) = .896$, $p < .001$), which indicated that an increase in general executive function problems was associated with an increase in inhibition problems.

3.2 Temperament and executive function problems

It was hypothesized that temperament was related with executive function problems. A multiple regression analysis (ENTER), with Surgency/Extraversion, Negative Affectivity and Effortful Control as predictor variables, and the overall executive function score as dependent variable, was run to examine this relation (Table 4). Surgency/Extraversion and Negative Affectivity were both positive predictors of executive function problems. Although both were significant, Negative Affectivity ($\beta = .45$) was a stronger predictor of executive function problems than Surgency Extraversion ($\beta = .10$) was. Effortful Control negatively predicted executive function problems.

3.3 Temperament and inhibition problems

In order to examine the relation between temperament and inhibition problems, a multiple regression analysis (ENTER), with Surgency/Extraversion, Negative Affectivity, and Effortful Control as predictor variables, and Inhibit as dependent variable was run to examine this relation (Table 4). In line with general executive function problems, Surgency/Extraversion and Negative Affectivity were positive predictors of inhibition problems. Effortful Control negatively predicted inhibition problems.
Table 4

*Regression analyses of temperament on executive function problems and inhibition problems*

<table>
<thead>
<tr>
<th></th>
<th>GEC overall (R² = .36)</th>
<th>Inhibit (R² = .32)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B (SE)</td>
<td>β</td>
</tr>
<tr>
<td>(Constant)</td>
<td>87.77 (5.50)</td>
<td>18.16 (1.81)</td>
</tr>
<tr>
<td>Surgency/Extraversion</td>
<td>2.51 (.85)</td>
<td>.10***</td>
</tr>
<tr>
<td>Effortful Control</td>
<td>-7.84 (.70)</td>
<td>-.37***</td>
</tr>
<tr>
<td>Negative Affectivity</td>
<td>9.32 (.68)</td>
<td>.45**</td>
</tr>
</tbody>
</table>

Note. * p < .05, ** p < .01, *** p < .001

3.4 Temperament, gender, and age

To investigate whether gender and age were related to executive function problems, and to investigate whether gender and age moderated the relation of temperament to executive function problems, ANCOVA analyses were performed. Executive function problems and inhibition problems were run separately as dependent variable in an ANCOVA analysis, with temperament, gender, and age as independent variables (Table 5; Model 1).

As shown as in Table 5 (Model 1), addition of age and gender as main effects did not result in significant differences for the associations between temperament and executive function problems, as well as temperament and inhibition problems. Age was not associated with executive function problems as well as inhibition problems. Gender was significant associated with executive function problems (F (1, 574) = 11.99, p < .01) as well as inhibition problems (F (1, 573) = 15.85, p < .01). It can be seen in Model 1 that boys showed more problems within general executive functioning and inhibition than girls.
Table 5

Moderation of age and gender on the relation between temperament and executive function and inhibition problems

<table>
<thead>
<tr>
<th>Model 1</th>
<th>GEC overall (R² = .38)</th>
<th>Inhibit (R² = .34)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Square (df)</td>
<td>F</td>
</tr>
<tr>
<td>Surgency/Extraversion</td>
<td>1684.89 (1)</td>
<td>8.49**</td>
</tr>
<tr>
<td>Negative Affectivity</td>
<td>37334.84 (1)</td>
<td>188.01***</td>
</tr>
<tr>
<td>Effortful Control</td>
<td>19952.44 (1)</td>
<td>100.48***</td>
</tr>
<tr>
<td>Gender</td>
<td>2380.82 (1)</td>
<td>11.99**</td>
</tr>
<tr>
<td>Age</td>
<td>71.36 (2)</td>
<td>.36</td>
</tr>
<tr>
<td>Gender*Age</td>
<td>15.90 (2)</td>
<td>.92</td>
</tr>
</tbody>
</table>

Note. * p < .05, ** p < .01, *** p < .001

<table>
<thead>
<tr>
<th>Model 2</th>
<th>GEC overall (R²=.40)</th>
<th>Inhibit (R²=.35)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Square (df)</td>
<td>F</td>
</tr>
<tr>
<td>Surgency/Extraversion</td>
<td>610.77 (1)</td>
<td>3.13</td>
</tr>
<tr>
<td>Negative Affectivity</td>
<td>327.70 (1)</td>
<td>1.68</td>
</tr>
<tr>
<td>Effortful Control</td>
<td>3275.67 (1)</td>
<td>16.77***</td>
</tr>
<tr>
<td>Gender</td>
<td>126.98 (1)</td>
<td>.65</td>
</tr>
<tr>
<td>Age</td>
<td>217.04 (1)</td>
<td>1.11</td>
</tr>
<tr>
<td>Gender*Surgency/Extraversion</td>
<td>301.42 (1)</td>
<td>1.54</td>
</tr>
<tr>
<td>Gender*Negative Affectivity</td>
<td>812.33 (1)</td>
<td>4.16*</td>
</tr>
<tr>
<td>Gender*Effortful Control</td>
<td>83.73 (1)</td>
<td>.43</td>
</tr>
<tr>
<td>Age*Surgency/Extraversion</td>
<td>240.10 (1)</td>
<td>1.23</td>
</tr>
<tr>
<td>Age*Negative Affectivity</td>
<td>560.55 (1)</td>
<td>2.87</td>
</tr>
<tr>
<td>Age*Effortful Control</td>
<td>934.86 (1)</td>
<td>4.79*</td>
</tr>
<tr>
<td>Gender*Age</td>
<td>86.41 (1)</td>
<td>.44</td>
</tr>
</tbody>
</table>

Note. * p < .05, ** p < .01, *** p < .001

3.5 Moderation with gender and age

In Table 5 (Model 2) interaction effects of both gender and age with temperament are presented. The results are further discussed for executive function problems and inhibition problems separately.
3.5.1 General executive function problems

When interactions of gender and age were added, the model explained 40% of variance for executive function problems. An interaction was found for gender and Negative Affectivity (F (1, 568) = 4.16, p < .05). Also, age interacted with Effortful Control (F (1, 568) = 4.79, p < .01). An exploration of the interaction effect of gender and Negative Affectivity on executive function problems is shown in Figure 3. It can be seen that boys with higher levels of negative affectivity showed more executive function problems than girls.

Figure 3

Negative affectivity and executive function problems moderated by gender

In Figure 4 the interaction of age and effortful control on executive problems is presented. The figure demonstrates that the inverse relation of effortful control and executive function problems was found for children aged 3 and 4 years. The relation between effortful control and executive function problems was less strong in 5-year old children, compared with 3- and 4-year olds. However, it can be seen in Figure 4 that the relation between effortful control and executive function problems has the same (inverse) direction for all age groups.
3.5.2 Inhibition problems

When interactions of gender and age were added, the model explained 35% of variance for inhibition problems. An interaction was found for age and negative affectivity on inhibition problems (F (1, 567) = 4.30, p < .05). An exploration of the interaction effect revealed that children with temperamental traits of negative affectivity showed more inhibition problems when these children were older of age (Figure 5).
Figure 5

Negative affectivity and inhibition problems moderated by age
4. Discussion

The current study examined the relation between temperament and executive function problems in Dutch preschoolers. Results indicate that the temperament factor effortful control was related to less executive function problems. The temperament factors extraversion and negative affectivity were related to more executive function problems. With regard to inhibition problems specifically, the same associations with temperament were found as for executive function problems. With regard to age children who had less effortful control showed more executive function problems when they were younger. Children who were characterized by negative affectivity showed more inhibition problems when they were older. With regard to gender boys showed more executive function problems than girls when both were characterized by negative affectivity.

The findings on effortful control and less executive function problems in preschoolers are consistent with prior research in childhood samples (e.g. Rueda et al., 2004), adolescent and adult samples (Cassimjee, & Murphy, 2010; Bridgett et al., 2013). However, the current study also found support for the inverse relation between effortful control and inhibition problems, which was not found in the study of Bridgett and colleagues (2013). This discrepancy may be due to the differences in the sample and method of measurement. Bridgett and colleagues (2013) used a sample of university students, which is most likely not representative for the general population. Based on Liew (2012) it can be generally adopted that effortful control and inhibition share partially conceptual overlap, because inhibitory control mechanisms are central processes to both constructs.

Consistent with the expectation with regard to extraversion, it was found that extravert children showed more executive function and inhibition problems. This was in line with earlier work by Rueda and colleagues (2005), who found that outgoing and less controlled children showed more problems with attention performance and would benefit from attention training. The finding was also in line with studies in adolescent and young adult samples, in which it was found that behavioural activation and extraversion were inversely related with executive function performance accuracy (Cassimjee & Murphy, 2010). It can be suggested that the negative association of extraversion and executive functioning may be present at early age and might be stable during the lifespan.

Lastly, it was expected that negative affectivity was positively related with inhibition problems (Leve et al., 2013). The current study found that children who were characterized by a more negatively affected temperament showed more executive function and inhibition
problems, which was in line with the findings of the study of Leve and colleagues (2013). The finding can also be linked to a broader psychobiological framework, which provides a bridge between temperament and personality. The Behavioral Inhibition System (BIS) proposed by Gray (1987) is a system that causes a person to be sensitive to potential punishment and disposed to avoid potential threat and potential punishments. According to Rothbart and colleagues (2000) the BIS was linked with negative affectivity. Children with traits of negative affectivity might constantly be aware or in search of punishment or threat, which influences their accuracy on executive function and inhibition tasks.

Interesting results were found when age was included in the relation between temperament and executive function problems. First, effortful control was only related with less executive problems for younger children. Unfortunately, relatively few studies examined the stability of effortful control in the early years of life (Eisenberg et al., 2004). Only research by Kochanska and colleagues (2000; 2003) examined the stability of effortful control in young children. They found that effortful control, as reported by teachers and parents, was relatively stable over a period of four years from toddlerhood through preschool and into early school years (Kochanska et al., 2000; Kochanska & Knaack, 2003). Although this stability was seen for three- and four year old children in the current study, it remained unclear what could be an explanation for the change toward five year old children. More research on the stability of effortful control is needed to draw further conclusions about these results. Second, it was found that children with more traits of negative affectivity showed more executive function problems when they were older. An explanation could be that in the preschool period children face a lot of complexities to master and control the world around them, which can create a lot of stressful situations, according to Erikson's theory on social and emotional development (De Hart, Sroufe, & Cooper, 2004). According to Rothbart and colleagues (2000) children with negatively affectivity can see a lot of potential punishments and threats. When preschoolers become older they might experience more stress because they increasingly have to deal with new social and academic demands. Consequently, these children might even more be aware of potential punishments and threats when they are older, which could explain the increase of executive function problems with age.

It remained unclear why boys with traits of negative affectivity showed more executive function problems than high scoring girls did. It was suggested that no gender differences would be present in negative affectivity, although gender as moderating role on temperament effects in the development of psychopathology could be different for boys and
girls (Else-Quest, 2012). Future research should examine whether gender moderates the relation between negative affectivity and executive functions in other samples of preschoolers as well to interpret these findings and draw further conclusions. It could be possible that negative affectivity is a greater risk factor for executive function problems for boys than girls. It would also be interesting to examine whether gender moderates the relation between negative affectivity and specific executive functions. Furthermore, a longitudinal research design could provide more information about the development of executive function problems in children with traits of negative affectivity, in which it is recommended to examine the development for boys and girls separately.

The findings should be considered with two major limitations in mind. First, temperament and executive function problems of the children were assessed at only one moment. Consequently, it was only possible to draw conclusions about the relation between temperament and executive function problems for different age groups. The correlational research design made it impossible to draw conclusions about the development of executive function problems. Second, the age of the children was rounded by full years. For example, a child aged 3 years and 10 months was coded in the category '3 years of age'. This may have distorted the age related results of the current study.

The current study provided some implications for clinical practice. The relation between temperament and executive function problems can be assessed in the preschool period, in which there should be extra care for preschoolers with traits of extraversion and negative affectivity who have a predisposition to show executive function problems. These children can benefit from attention training in the preschool period, in line with the suggestion of Rueda and colleagues (2005), and this might decrease a further development of executive function problems. The findings indicated that inhibition problems increased for traits of negative affectivity when children were older and it is possible that these children develop more inhibition problems when they become older. Therefore, these children may be in need of early identification and intervention programs. Similarly, boys with traits of negative affectivity might be in extra need of early identification and intervention programs, because they might have a predisposition to develop more executive function problems than girls with traits of negative affectivity. Improvement of executive functioning may have a progressive influence on the development of later psychopathology, though it is suggested that strong executive function skills are a protective factor for later emerging developmental disorders (Johnson, 2012).
In sum, it can be concluded that temperament was related with executive function problems. Based on the temperament traits included in this study, preschoolers who can be characterized as extravert, negatively affected and less effortful controlled showed more executive function and inhibition problems. Exploring the moderations of age and gender on these associations, temperament seemed to contribute differently as a risk factor for executive function and inhibition problems at different ages, and for boys and girls.

The need for further and ongoing research on the development of executive function problems through the preschool period is emphasized. The findings of the study provide support to age and gender differences in the meaning of temperament and executive functioning, which should be considered in further research. For future studies it would be very interesting to work with a longitudinal research design to draw conclusions about the development of executive function problems, especially for children with a extravert and negatively affected temperament. It also would be interesting to study whether these children can benefit from executive function training programs and whether potential benefits, as in improvements in executive functioning, can serve as protective factor for the development of later psychopathology.
References


28


Appendices

Appendix 1

Figure 1

*Links among temperament, risk and promotive influences, child development problems, resilience, and vulnerability*
Appendix 2

Figure 2

Measurement model of the BRIEF-P

Clinical scales: Inhibit, EC (Emotional Control), Shift, WM (Working Memory) and PO (Plan/Organize).
Indices: ISCI (Inhibitory Self-Control Index), FI (Flexibility Index) and EMI (Emergent Metacognition Index).
GEC (Global Executive Composite).