Executive functions in relation to task orientation in preschoolers with attention problems.

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Preface

By writing this thesis I gained more insight into the development of executive functions in preschoolers. Because the study was based on data from the PeuterPlus! project, it was very interesting to see how certain measures were or were not found to be interrelated.

I want to thank my supervisor dr. H. Mulder for helping me to find the right direction and for her feedback which helped my thinking process to move along. Also I want to thank Nicolien Lettinga, Danielle Herkelman and Marjolein Fontijn for their support during the writing process. Lastly, I want to thank my friend Ilse van de Groep for her advice and feedback.

Abstract

Self-regulatory capacities are often investigated in a laboratory setting, using test batteries that measure executive functions (EF), which are believed to underlie self-regulatory capacities. However, to gain a better understanding of the (self-regulatory) problems caused by deficits in EF skills in real life situations, it may be beneficial to observe these capacities in a more naturalistic environment, like a classroom. Therefore, in the present study, it was examined how various components of EF (inhibition, working memory, and shifting) are related to classroom task orientation in preschoolers with attention problems. We hypothesized that inhibition and working memory would have the largest effect on task orientation. The sample consisted of 65 preschoolers with attention problems (aged 35-46 months). EF were measured using diagnostic tasks from a neuropsychological test battery. To observe self-regulatory capacities in the classroom, we employed the task orientation scale of the PC BOS. Only inhibition was found to be significantly (and negatively) related to task orientation and had a medium effect on task orientation. These results suggest that primarily the ability to inhibit impulses and responses to distracters is of importance in task situations in a preschool setting in preschoolers with attention problems.

Key words: Task orientation, Executive functions, Inhibition

Samenvatting

Zelfregulatie vaardigheden worden veelal onderzocht door gebruik te maken van test batterijen die executieve functies (EF) meten in een laboratorium setting. Echter, om meer inzicht te verkrijgen in (zelfregulatie) problemen veroorzaakt door problemen in EF zou het mogelijk bevorderlijk zijn om deze vaardigheden te observeren in een meer natuurlijk omgeving zoals een klas. Om die reden is in het huidige onderzoek onderzocht hoe verschillende executieve functies (inhibitie, werkgeheugen, en cognitieve flexibiliteit) samenhangen met taakoriëntatie op de groep. We verwachten dat inhibitie en werkgeheugen het meest van invloed zullen zijn op taakoriëntatie. De sample bestond uit 65 peuters met aandachtproblemen (leeftijd van 35-46 maanden). De executieve functies werden gemeten aan de hand van taken uit een neuropsychologische testbatterij. De taakoriëntatie schaal van de PC BOS werd gebruikt om zelfregulatie vaardigheden te meten in de klas. Er werd enkel een significante relatie gevonden tussen inhibitie en taakoriëntatie, het verband was negatief. Inhibitie had een medium effect op taakoriëntatie. Deze resultaten wijzen met name op het belang van inhibitie in taak situaties in een voorschoolse setting bij peuters met aandachtsproblemen.

Key words: Executieve functies, Taakoriëntatie, Inhibitie

Introduction

Self-regulation refers to goal directed behavior and consists of three main components: (i) endorsing, representing and monitoring standards; (ii) motivation; and (iii) capacity (Hofmann, Schmeichel, and Baddeley, 2012). Executive functions are "general-purpose control mechanisms" (Miyake & Friedman, 2012, p. 8) which regulate several cognitive control processes that are thought to have their origin in the prefrontal cortex (Garon, Bryson, & Smith, 2008; Miyake et al., 2000). It is generally assumed that executive functions (EF) underlie self-regulatory capacities (Hofmann, Schmeichel, & Baddeley, 2012; Miyake & Friedman, 2012). Working memory, inhibition and shifting can be discerned as components of EF (Miyake & Friedman, 2012). The working memory is implied in the storage and manipulation of information in the mind (Garon et al., 2008) as well as in the active representation and shielding of self-regulatory goals (Hofmann et al., 2012). Inhibition can be described as a mechanism that helps withholding and restraining initial motor responses (Garon et al., 2008) and is of great importance in overriding impulses and habits that are incompatible with self-regulatory goals (Hofmann et al., 2012). Shifting involves cognitive flexibility when it comes to shifting from one rule to another (Garon et al., 2008) and is used to abandon suboptimal self-regulatory goals or pursue alternative goals (Hofmann et al., 2012).

The measurement of EF skills and self-regulatory capacities in both children and adults often occurs by using test batteries that are administered in a laboratory setting (Manchester, Priestley, & Jackson, 2004; McClelland & Cameron, 2012). However, it is argued that this structured setting, free of distractions and coordinated by a test administrator, might partly account for the problems that people with EF deficits experience. Therefore, people who have deficits in EF might not all perform poorly on these tasks (Manchester et al., 2004). Manchester, Priestley, and Jackson (2004) suggest that behavioral observations in a naturalistic environment might be more sensitive to the problems in real life situations caused by deficits in EF skills.

A classroom setting could be a naturalistic environments in which EF and self-regulation can be observed in children. In the classroom children employ several executive functions such as attentional flexibility, working memory and inhibitory control in task situations, while surrounded by many distractors (Fitzpatrick, McKinnon, Blair, & Willoughby, 2014). When translating EF skills to a classroom setting, working memory helps children to hold in mind instructions and information; inhibition helps children to ignore internal and external distractions; and shifting helps children to shift from an old to a new rule

or between tasks (Fitzpatrick et al., 2014). All three skills are found to be essential for learning in elementary school (Fitzpatrick et al., 2014).

The preschool period is considered to be a "period of high malleability" for the development of EF which coincides with increasing demands placed on EF in preschool and later on in elementary school (Zelazo & Carlson, 2012, p. 357). Therefore, it is important to gain knowledge on the development of EF in this age group and on any potential problems that can be caused by a suboptimal development of self-regulation. In preschool, on-task behavior, which is predictive of later school success (Fitzpatrick et al., 2014; Hughes & Ensor, 2011), can be observed during structured tasks and play by observing task orientation. As well as EF, task orientation can be regarded as an aspect of self-regulation (McClelland & Cameron, 2012) and can be defined as the extent of active involvement in classroom tasks, structured play, and learning (Downer, Booren, Lima, Luckner, & Pianta, 2010). By observing task orientation in a preschool setting, insight might be gained on how EF skills are used in a naturalistic situation by young children.

The purpose of the present study is to shed light on how self-regulatory behaviors in real-life situations are related to the self-regulatory behaviors as examined by laboratory tasks in preschoolers with attention problems. Firstly, the present study investigates how the different components of EF (working memory, inhibition and shifting) are related to task orientation in preschoolers with attention problems. This population is studied because they are known for having a deficit in their self-regulatory capacities; they seem to be especially drawn to rewarding stimuli and accordingly have difficulty staying focused on their goal because of this (Barkley, 1997; Baumeister & Heatherton, 1996; Hofmann et al, 2012). Secondly, the effect of the different components of EF on task orientation is investigated. Studying the effect of the different components of EF may illuminate which part primarily contributes to real-life self-regulatory problems as represented by task orientation. To our knowledge, this is the first study that uses an observational measure to gain information on the self-regulatory capacities of preschoolers. Working memory and inhibition are expected to be positively related to task orientation and have a larger effect on task orientation than task-switching in preschoolers with attention problems. In previous research, both of these components have been found to be of great influence on self-regulation (Hofmann, Friese, & Roefs, 2009; Hofmann et al., 2012). Working memory capacities are described as playing "a primary role" in self-regulation by helping people "resist the attentional capture of tempting stimuli at early stages of processing" (Hofmann et al., 2012, p. 175). In addition, inhibition plays a key role in controlling bad habits and impulses (Hofmann et al., 2012). The effect of

task switching on self-regulation is still largely unknown and dependent of context (Hofmann et al., 2012).

Method

Participants

The population consisted of 175 children aged between 26 and 47 months who were enrolled in the PeuterPlus!-program (see table 1). These children were enrolled in the program for slow or no progress in their language development; being extremely shy or quiet; having difficulties with maintaining attention and being overactive; or showing oppositional behaviors.

A subsample of preschoolers with attention problems was selected for the current study. This sample consisted of 65 preschoolers (see table 1). The sample was selected using SDQ data, which was available for all children. Preschoolers were selected when their score was (sub)clinical (6 or higher) on the Hyperactivity/ Attention-Deficit scale of the SDQ (M = 8.05, SD = 1.58, range 6-10).

Measures

Questionnaires.

Strengths and Difficulties Questionnaire (SDQ). The SDQ (Goodman, 2005) is a behavioral screening instrument which assesses the child's functioning on several dimensions,

Table 1. Characteristics of the participants

	Total population	Attention problems
Total *N*	175	65
Mean age in months (SD)	40.36 (3.32)	40.63 (2.69)
Minimum age in months	26	35
Maximum age in months	47	46
Boys (%)	59,4	58,5
Nationality (%)		
- Dutch	73,1	76,9
- Turkish	4.0	3.1
- Turkish and Dutch	2.9	3.1
- Moroccan	3.4	4.6
- Moroccan and Dutch	5.7	4.6
- Other	6.2	6.1

namely: Emotional Problems, Behavior Problems, Hyperactivity/ Attention-Deficit, Problems with Peers and Prosocial Behavior. It also includes impact questions to assess the severity of the problem behavior. In the present study, the SDQ was filled out by the teacher. The SDQ was used to identify the children with attention problems, by selecting the children who rated (sub)clinical (a score of 6 or higher) on the Hyperactivity/ Attention-Deficit scale of the SDQ. The reliability and validity of the SDQ were found to be satisfactory and the psychometric properties were found to be strongest in the teacher version (Stone, Otten, Engels, Vermulst, & Janssens, 2010).

EF tasks.

Inhibition. The inhibition task (Kochaska, Murray, & Harlan, 2000; Mulder, Hoofs, Verhagen, Van der Veen, & Leseman, 2014) consisted of a delay of gratification task in which preschoolers were given the instruction to try not to touch an attractive object (item 1: a box of raisins; item 2: a present) for one minute. The score was determined by noting whether a child touches the raisins/ present, eats the raisins, or tears the wrapping paper or bow of the present. When the children showed any of these behaviors a score of 1 was assigned, when a child did not show any of these behaviors a score of 0 was assigned. The scores of both items (raisins and present) were added up. Children could get a score ranging from 0 to 2, with 0 being considered the highest score and 2 being considered the lowest score. In order to match the scores with the other variables this scale was reversed.

Working Memory. The six boxes task (Diamond, Prevor, Callender, & Druin, 1997) was used to measure visuospatial working memory capacities. The task (Mulder et al., 2014) included a practice item, in which children had to find two wooden figures hidden in two identical boxes. Between search attempts the children were distracted for 1s. If they succeeded at finding both figures the first time, the test administrator could move on to the test items. If a child did not succeed in finding both figures, the procedure was repeated before the test administrator moved on to the test items. For the test items preschoolers had to find six wooden figures hidden in six identical boxes with lids. They had to open one box at a time and had to remember which boxes were empty and which contained a figure. Between every search attempt, the children were distracted for 6s. Every time a child found one of the figures a point was assigned adding up to a maximum score of 6.

Shifting/ Reverse Categorisation. In the shifting/ reverse categorization task (Wijnroks & Idenburg, 2011) preschoolers had to sort wooden blocks in a large or a small box. Practice trials were administered in which the children had to put the large blocks in the large box and the small blocks in the small box. After the practice trials, the test items of part

A were administered and the rule was reversed, the children now had to put the large blocks into the small box and the small blocks into the large box. If they scored at least 10 out of 12, the test administrator moved on to part B in which the children had to sort non uniformly shaped blocks (cylinder, half circle, triangle and flat blocks) by the same reversed rule (small blocks in the large box and large blocks in the small box). Cognitive flexibility was measured by changing the sorting rule. Every time the children put a wooden block in the correct box, a point was assigned adding up to a maximum score of 18.

Observational instruments.

PC BOS (partly based on the inCLASS). The inCLASS (Downer et al., 2010) is an observational scale that measures several dimensions: Teacher interactions (positive engagement, teacher communication, teacher conflict), peer interactions (peer sociability, peer assertiveness, peer communication, peer conflict), task orientation (engagement with tasks, self-reliance). In the Dutch version called the PC BOSS (Wijnroks, 2014) two dimensions were added: Self-regulation (anxiety, impulsivity and hyperacitivity, disruptive behavior, emotionality, rigidity, reactivity) and language development (passive language, active language, speech, grammar).

From this observational instrument the task orientation scale was used to measure on-task behavior in a classroom setting. The observation was conducted during one or two sessions in which the child was observed a minimum of three and a maximum of five observation cycles of approximately 10-30 minutes each. By including several cycles, the behavior of the children could be observed during different situations at the preschool like big circle, small circle, free play, doing a task or having a snack/ drink. The task orientation contains two scales, i.e.; an on-task behavior scale measuring engagement with tasks by looking at whether a child remains focused and is actively involved with a task or activity. Also it contains a self-confidence scale measuring whether a child shows self-confidence by taking initiative and discovering new tasks, is independent or needs guidance of a teacher, shows perseverance during a task and can find opportunities to learn on its own. A score was assigned ranging from 1 to 7 points, with 1 being considered as the lowest score and 7 being considered as the highest score. The score was determined by matching the observed behavior with the description as given in the manual.

Data on the reliability and validity of the PC BOS is not yet available, as it is a measure that has only recently been translated and adapted for use in the Netherlands. Preliminary results of the reliability and validity of the inCLASS (on which the PC BOS is partly based) show a solid inter-rater reliability as well as adequate criterion validity and

discriminant validity. Revisions of the task orientation scale were suggested as this scale interactions with peers might have to be disentangled somewhat more from task-related interactions (Downer, Booren, Lima, Luckner, & Pianta, 2010).

Data analysis

Before analyzing the data, assumptions of normality, linearity, multicollinearity and homoscedacity for parametric tests were checked and outliers were located. Normality was tested by looking at the histogram of the residuals and the Normal P-P Plot. Linearity was judged using a matrix scatterplot of the predictor and dependent variables. In order to investigate both linearity and homoscedacity the scatterplot of the residuals against the predictor variable was examined. Multicollinearity was examined by the collinearity diagnostics from SPSS (Allen & Bennett, 2010). Outliers were located and excluded.

How working memory and shifting related to task orientation and each other was examined using Pearson correlations. Because the inhibition task scores were more categorical in nature, Pearson correlations were not considered fit to examine the relation between inhibition and any of the other variables. Spearman's rank order correlations would yield more fitting results; therefore, for inhibition, Spearman rho coefficients were calculated (task orientation, working memory, and shifting). Because of the small sample size, only the variables that significantly related to task orientation would be included in a (multiple) regression analysis. Age and gender were considered as control variables, but would only be entered into the regression model if they significantly related to task orientation or any of the components of EF that would be entered into the regression model.

Results

Descriptive statistics

Table 2 contains the sample size, mean scores and standard deviations of the sample. On task orientation, a mean score of 3.88 was found. In the study of Downer, Booren, Lima, Luckner, and Pianta (2010) a mean score of 4.64 (*SD* = .64, *Range* = 2.08-6.08) was found for the task orientation scale in sample of American children aged 3-5. In our sample of children with attention problems the mean score was found to be slightly lower than in the afore mentioned study, the difference seemed not to be significant. However, this difference should be interpreted with great caution because the study of Downer et al. (2010) was conducted using the inCLASS, for the PC BOS no norm information is yet available. For the EF measures, norm scores were available that could help shed light on the performance of the children with attention problems compared to typically developing children (see note table 2; Wijnroks & Idenburg, 2011). As can be seen in table 2, the mean score in the sample lies slightly above

Table 2. Mean scores, standard deviations and range

	Preschoolers with attention problems (*n=65*)				
	M	*SD*	*Range*	*N*	*Missings*
Task orientation	3.88	1.10	1.5-6	56	9
Inhibition	1.06	.86	0-2	57	8
Working memory	4.55	.71	2-6	57	8
Cognitive flexibility	10.64	6.20	0-18	55	10

Note: Norm scores for EF measures: Inhibition 1.75 (unreversed 0.25), Working memory 5, Cognitive flexibility 15.
Cut off (5th percentile) scores for EF measures: Inhibition 1 (unreversed 2), Working memory 3, Cognitive flexibility 7.

the cut off on the inhibition task. On the working memory task and shifting task the children with attention problems on average score below the norm scores but above the cut off scores. Table 2 also includes information on missing data. All the variables had several missing cases; however no patterns were found in the missing data when looking at age, gender or nationality.

Correlations and analyses

Pearson correlations showed that working memory and shifting were not significantly related to task orientation and the effect of both variables could be considered small (Cohen, 1992). Therefore both were excluded from further analyses. Spearman correlations showed that inhibition was significantly and negatively related to task orientation and the effect would be considered medium. Age and gender were considered as control variables. However, age was only found to be related to working memory and gender was only found to be related to shifting. The effect of age and gender on task orientation could also be considered small (Cohen, 1992) and therefore these two variables were also excluded from further analyses.

Table 3. Summary of correlations

	Preschoolers with attention problems (*n=65*)					
Measures	*1*	*2*	*3*	*4*	*5*	*6*
1. Task orientation	-					
2. Inhibition[a]	-.395**	-				
3. Working memory	-.182	.224	-			
4. Cognitive flexibility	-.065	.301*	.222	-		
5. Age	.149	-.111	-.475**	-.090	-	
6. Gender[a]	.053	.035	.251	.316*	.058	-

Note. *p<.05, **p<.005
[a] Correlations with these variables are Spearman rho coefficients.

Table 4. Unstandardized (B) and Standardized (*β*) Regression Coefficients for the predictor variable

	Preschoolers with attention problems (*n=47*)			
Variables	*B*	*SE B*	*β*	*p*
Inhibition	-.496	.167	-.401	.005

The assumptions for a regression analysis of normality, linearity, multicollinearity and homoscedacity were met. No outliers were detected. The regression model explained 16.1% of the variance in task orientation, R^2=.161, $F(1, 46) = 8.828$, $p = .005$. The regression model reached significance, indicating that inhibition significantly predicted task orientation (see table 4). The effect of inhibition on task orientation could be considered medium when looking at the R^2 (Allen & Bennett, 2010; Cohen, 1992).

Discussion

The present study investigated how the different components of EF (inhibition, working memory, and shifting) were related to task orientation in preschoolers with attention problems. Furthermore, it examined which of the components of EF had the largest effect on task orientation. It was expected that inhibition, working memory and shifting would all be significantly and positively related to task orientation. Moreover, working memory and inhibition were expected to have the largest effect on task orientation in preschoolers with attention problems. The expectations were partly met. Inhibition was found to be significantly but negatively related to task orientation in preschoolers with attention problems and had a medium effect on task orientation.

These results are partly in line with the conclusions drawn in the review of Hofmann, Schmeichel, and Baddeley (2012). The present study supports the claim that executive functions as assessed with laboratory measures are of importance to self-regulation in a more naturalistic classroom setting as represented by task orientation. However, children who had trouble inhibiting their responses to external distracters were found to have less trouble staying focused on a task. Based on the review of Hofmann et al. (2012) working memory and shifting were also expected to affect task orientation. Both working memory and shifting only had a small effect on task orientation in preschoolers with attention problems and the relationship did not reach significance.

This discrepancy in the results might indicate that the model of Miyake and Friedman (2008) of EF is not a good fit for the sample used in the current study. Over the years researchers have debated alternative structures of EF in young children, as a fit was not found

with the three-factor model found in adolescents and adults (Zelazo & Carlson, 2012). Both an one-factor model (Wiebe, Espy, & Charack, 2008; Wiebe et al., 2011) and a distinction between hot and cool EF (Zelazo & Müller, 2002) have been considered. It goes beyond the scope of the present study to do a confirmatory factor analysis to see what model would have the best fit. However, the results seem to support the distinction between hot and cool EF in preschoolers with attention problems. The delay of gratification task used to measure inhibition in the present study can be considered a hot EF task, which indicates that regulation of motivation is involved (Hongwanishkul, Happaney, Lee, & Zelazo, 2005). The six boxes task used to measure working memory and the reverse categorization task used to measure shifting appear to be more decontextualized in nature and could therefore be considered cool EF task (Hongwanishkul et al., 2005). The results of the present study could be interpreted as implicating that hot EF is related to task orientation in a classroom, whereas cool EF seems not to be of importance in a classroom situation for preschoolers with attention problems. Therefore hot EF measures might be more representative of a real life situation in which motivation and affect play an important role. The unexpected negative relation between inhibition and task orientation that was found, could point to differences in motivational factors during the delay of gratification test and a task situation in class. This explanation is in line with the results of a study of Mischel, Shoda, & Rodriguez (1989) who found that children waiting time increased when a reward was not exposed during the task. Future research should further investigate whether the distinction between hot and cool EF is useful in studying more naturalistic self-regulation measures.

The present study has several limitations. First, the small sample size and large number of missings limit the generalizability of the results. The PeuterPlus!-program was still in development over the course of the data collection which caused certain measures not being administered uniformly. Especially in the PC BOS, many changes can be seen over the course of years which caused a variance in the use of the instrument and the number of observation cycles used every year. However, the content of the scales of the PC BOS remained the same, and therefore this measure was still considered fit to represent self-regulation in a naturalistic environment. Also, it is inherent to the PeuterPlus!-program that the person responsible for the trajectory of a specific child selects the diagnostic instruments from the test battery. Therefore, not for all children scores on the EF tasks were available. Another limitation of the present study lies within the sample. The children in the PeuterPlus! population show a great diversity in problem behaviors. The present sample was selected for having attention problems. However, it is possible that these problems co-occur with other

problems, like language delays or aggressive behavior. Because of the small sample size it was not possible to exclude children with multiple problems. In future research, the use of a larger, more uniform sample would be recommended.

Overall, it can be concluded that the ability to inhibit impulses and responses to distracters is of importance in task situations in a preschool setting in preschoolers with attention problems. Working memory and shifting might not be of importance in task situations in the preschool setting, but might be more important later on in a primary school. Future research should further examine more naturalistic measures of self-regulation in both preschoolers and school-aged children with and without attention problems. Possibly the hot-cool EF framework could be of use.

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