The Relationship between Maternal Executive Functions and Mother-Child

Interaction

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Master's thesis in Psychology

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Summary of Master's Thesis

Subject: Psychology
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Title: The Relationship between Maternal Executive Functions and Mother-Child Interaction
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Abstract: Emerging evidence suggests that cognitive control capacities like executive functioning (EF) are central for the development and maintenance of caregiver-child interaction. The present study examined the relationship between maternal EF and mother-child interaction. Based on previous research, it was hypothesized that maternal EF would be positively correlated with healthy mother-child interaction. The sample ($n = 48$) was drawn from the FinnBrain birth cohort study. Maternal EF was measured with three tasks from the *CogState Battery: Groton Maze Learning Test, 2-back,* and *Set-Shifting Test.* The mother-child interaction was assessed with the *Emotional Availability Scales,* and this study included the caregiver dimensions *sensitivity, structuring, non-intrusiveness* and *non-hostility.* The results showed no significant relationships between maternal EF and mother-child interaction. Weak associations were found between WM updating and the interaction measures structuring and sensitivity, but the direction of these non-significant effects was opposite to the hypothesis. This surprising outcome may be due to the limitations of the measures used. Because this area of research is new, further research is called for to clarify the relationships between maternal EF and mother-child interaction. The implications of the present results are discussed.
Key words: executive functions, interaction, Emotional Availability, CogState
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Sammanfattning av avhandling pro gradu

Ämne: Psykologi
Författare: Jenny Selenius
Titel: Förhållandet mellan mödrars exekutiva funktioner och deras sätt att samspela med sina barn
Handledare: Matti Laine (Åbo Akademi) och Elisabeth Nordenswan (Åbo Akademi)
Sammanfattning: Kognitiv självreglering, så som exekutiva funktioner (EF), verkar på basis av tidigare forskning vara en central del av interaktionen mellan vårdnadshavare och barn. Denna studie har undersökt sambandet mellan mödrars EF och deras sätt att samspela med sina barn för att öka kunskapen om faktorer som ligger bakom både positiva och negativa beteendemönster hos vårdnadshavare. På basis av tidigare forskning var hypotesen att mödrars EF och interaktionen mellan dem och deras barn skulle korrelera positivt. Samplet ($n = 48$) kom från ett större sampel från kohortstudien FinnBrain. EF mättes med tre uppgifter från *CogState Battery: Groton Maze Learning Test, 2-back* och *Set-Shifting Test.* Det sociala samspelet mellan mödrarna och deras barn bedömdes med *Emotional Availability Scales,* och denna studie använde de fyra vårdnadshavardimensionerna *sensitivitet, strukturering, icke-inkräktande* och *icke-fientlighet.* Inga signifikanta samband hittades mellan mödrarnas EF och deras samspel med sina barn. Svaga samband mellan arbetsminnesuppdatering och interaktionsvariablerna strukturering och sensitivitet hittades, men riktningen i dessa icke-signifikanta samband var motsatt i förhållande till hypotesen. De överraskande resultaten i denna studie kan bero på de använda mätinstrumenten, men eftersom detta forskningsområde är nytt behövs mera studier för att klargöra det aktuella sambandet. Implikationerna av resultaten diskuteras.
Nyckelord: exekutiva funktioner, interaktion, Emotional Availability, CogState
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Contents

1. Introduction

Understanding the factors that contribute to positive as well as negative parenting behavior is critical in preventing child abuse, and reducing behavioral and emotional problems in children and adolescents (Crandall et al., 2015). Almost without exception, parents wish the best for their children and want to parent well, although unfortunately, not all parents succeed in this desire (Crandall et al., 2015). Many parents struggle to form healthy attachments and to interact in a warm and responsive manner with their children (i.e. positive parenting) (Crandall et al., 2015). In the worst case, this lack of positive parenting can ultimately lead to abuse or neglect (Deater-Deckard et al., 2010).

Emotional and behavioral self-regulation is a key factor in caregiving. The caregiver must regulate his or her behavior as well as emotions to avoid harsh parenting behavior. Challenging behavior in children, such as anger and opposition, requires that the parent evaluates the situation and potential responses, and regulates his or her own as well as the child's negative emotions (Deater-Deckard et al., 2010). As opposed to responding with reactive negativity towards the child (e.g., with anger and hostility), this kind of parental behavior could lessen the child's problematic behavior (Deater-Deckard et al., 2012). Parents who respond reactively towards their children's negative behavior, however, encourage angry and oppositional behavior (Deater-Deckard et al., 2010). Harsh reactive negativity in parenting is one of the central factors in the etiology of child psychopathology (Deater-Deckard et al., 2010). This kind of parental behavior could escalate toward abuse if it were to occur repeatedly and become a pattern (Deater-Deckard et al., 2010).

Emerging evidence suggests that besides emotional control processes, cognitive control capacities like executive functioning (EF) are central for the

development and maintenance of caregiver-child interaction (Crandall et al., 2015).

This area of research is new but promising (Crandall et al., 2015), and will be the

topic of the present study.

1.1 EF and self-regulation

The ability to regulate one's own thoughts and behavior varies greatly between

individuals (Friedman et al., 2008). While some people seem to manage well to

control their actions, others seem to be ruled by their emotions and impulses instead

of the other way around (Friedman et al., 2008). Cognitive psychology accounts for

this kind of variation in one's ability to self-control and -regulate by individual

differences in EF (Friedman et al., 2008). The most widely used model of EF is the

unity and diversity model by Miyake et al. (2000). It describes EF as self-regulatory

processes, monitoring lower-level cognitive functions through

1) controlling one's attention and inhibiting irrelevant stimuli ("inhibition"),

2) manipulating and updating working memory (WM) contents ("updating"), and

3) redirecting attention or adjusting to changed demands ("shifting").

EF and self-regulation are thus very similar by definition and intricately linked

(Hofmann et al., 2012). Recent research has also proved that EF, especially WM,

contribute to successful self-regulation of different sorts of behavior (Hofmann et al.,

2012).

1.2 Maternal EF and parenting behavior

A review on intergenerational transmission of self-regulation by Bridgett et al. (2015)

summarizes research on the relationships between parent self-regulation and parenting

behavior. According to this review, cross-sectional studies have shown that mothers with poorer WM tend to react more negatively to their children's demanding behavior compared to mothers with better WM. In a study on the relationships between WM and reactive parenting by Deater-Deckard and colleagues (2010), 216 mothers and their same-sex twin children were observed completing frustrating cooperation tasks. The results showed that the differences in challenging behavior among siblings were significantly associated with maternal negativity (Deater-Deckard et al., 2010). One of the limitations of the study is that the observations used were very brief (10 minutes), and are therefore not fully representative of the relationship between the mothers and their children in general (Deater-Deckard et al., 2010).

Very similar results were obtained in a study by Deater-Deckard et al. (2012) where 147 mothers of 3-7 year-old children completed questionnaires to measure self-reported harsh parenting, child conduct problems and household chaos, as well as a laboratory assessment to measure maternal EF (Deater-Deckard et al., 2012). The results showed that child conduct problems were significantly associated with maternal harsh negativity in mothers with poorer EF, but this was not the case for mothers with better EF (Deater-Deckard et al., 2012). In that study, one of the limitations concerned the mothers' self-reports, which could be a source of potential method and informant variance (Deater-Deckard et al., 2012).

Chico et al. (2014) examined the associations between executive functions and maternal sensitivity in teen mothers. The sample consisted of two groups: 30 teen mothers and 27 adult mothers. To measure their executive functions, computerized tasks assessing WM and cognitive flexibility were employed (Chico et al., 2014). Maternal sensitivity was measured by 20-minute observations of the mothers and their child interacting in free play (Chico et al., 2014). They found that adult mothers

showed increased maternal sensitivity in comparison to the teen mothers, and that the adult mothers performed better on the tasks that measured maternal executive functioning (Chico et al., 2014). However, given that the two groups were so different in both age and demographic characteristics (e.g., education and socio-economic status), they were not ideal groups to compare (Chico et al., 2014).

In a longitudinal study by Cuevas et al. (2014), the relationships between maternal EF, caregiving behavior and the development of child EF were analyzed. A group of mothers and their children were observed interacting with each other at 10, 24 and 36 months of age, and maternal EF was measured in a laboratory assessment (Cuevas et al., 2014). The results show that negative caregiving behaviors were negatively associated with both maternal and child EF (Cuevas et al., 2014).

1.3 Aim and hypothesis of the study

The aim of the current study was to further explore the associations between maternal EF and mother-child interaction in order to advance our understanding about the nature of this relationship. Based on earlier findings described above, it was hypothesized that maternal EF would be positively correlated with healthy mother-child interaction.

2. Methods

This study was conducted as part of the FinnBrain birth cohort study (Karlsson et al., 2017), which is carried out at the University of Turku. The FinnBrain study started in 2010 and its purpose is to investigate the combined influence of environmental and genetic factors on children's development. Within FinnBrain, there is a Child

Development and Parental Functioning Lab, which studies the early development of emotional and cognitive self-regulation. Among other topics, mother-child interaction and both child and parental neurocognitive functioning are studied. This study was conducted as part of the Child Development and Parental Functioning Lab.

2.1 Participants

The sample was drawn from the FinnBrain study population ($n = 4000$ families, 11000 individuals), recruited in connection to the families' first ultrasonography at gestational week 12. The recruitment took place at maternity clinics in the Turku region and the Åland Islands during December 2011 – April 2015. In addition to a verified pregnancy, inclusion criteria for the FinnBrain study were sufficient knowledge of Finnish or Swedish. Exclusion criteria were severe malformation revealed during an ultrasound, miscarriage before gestational week 25, and still baby births. Participation was voluntary, and no compensation was provided. The sample of the present study was drawn from a so-called Focus cohort of the FinnBrain study. The Focus cohort was established to compare groups of mothers with high (cases, $n = 519$) and low (controls, $n = 700$) levels of stress symptoms based on self-reported depression and anxiety symptom questionnaires administered during pregnancy. Mothers from the Focus cohort were invited to take part in a neuropsychological assessment during pregnancy. Altogether 240 mothers participated in this assessment during pregnancy, and 76 of them underwent a repeated assessment 12 months after giving birth.

From the Focus Cohort, mothers were also recruited to take part in an assessment of their interaction with their child during a free-play situation 8 months

postpartum. Out of the invited mothers, 182 chose to take part in the interaction assessment together with their child.

The data for the present study comprised of the mothers' neuropsychological assessment results combined with the interaction assessment. Altogether 48 mothers underwent both the interaction assessment 8 months after giving birth, and the neuropsychological assessment 12 months after giving birth. Table 1 presents demographic information on the study sample.

Table 1. *Demographic characteristics of the study sample.*

		Total sample n = 48
Age Mean (Range)		34 (25-42)
Education %	High school/vocational	16,7
	Polytechnics	43,8
	University level	37,5
First or second time mothers n	First	30
	Second	17

2.2 Procedure

Ethics approval for the present study was given by the Joint Ethics Committee of the Turku University Hospital and the University of Turku. Written informed consent was obtained from each participant before the study sessions.

The neuropsychological assessment took place in a quiet examination room at FinnBrain's research facilities at the University of Turku. It was supervised by a graduate student who offered help when needed. Voluntary feedback was also offered to the mothers after the testing was completed. The assessment comprised of 13 different tasks, each measuring specific areas of cognition. The tasks constituted a cognitive test battery, CogState (www.cogstate.com), and measured processing speed, attention, memory, learning, executive functioning and social cognition. The test

battery was presented on a laptop computer and took about 60 minutes to complete. Task instructions were presented on the computer screen before each task and were followed by a practice session that stopped after the required amount of correct responses, or after a certain amount of practice time.

The mother-child interaction assessment also took place at FinnBrain's research facilities by employing the Emotional Availability Scales (see chapter 2.4). The mothers were instructed to play with their child like they would do normally at home. They were seated on a mat on the floor, and provided with age-appropriate toys. They were left in the room to interact for about 20 minutes, and the situation was recorded on film by a graduate student. The student was in the same room but did not interact with them. The mothers were instructed to play freely with their child for the first 10-15 minutes. After that they were asked to put the toys away and bring crackers, juice and water from a cupboard in the room, and have a snack on the mat together with their child. The recordings were coded by two psychologists that have undergone the official EA Distance Training and Certification that is required for professionals to use the EA systems.

2.3 Neuropsychological measure: CogState

The CogState neuropsychological test battery (CS) is a standardized, customizable computer-based test battery designed to assess a range of cognitive functions, including information processing speed and psychomotor speed, attention and WM (Pietrzak et al. 2008). The tasks have been developed to detect cognitive change, which makes the battery appropriate to use in within-subjects designs (Maruff et al., 2009). CS has the advantage of easy and rapid administration, as it is automatically

administered, thus putting less training demands on test administrators (Kataja et al., 2016). It is also portable and mostly language-independent, which means that it is cross-culturally adaptable (Bangirana et al., 2015; Kataja et al., 2016). CS has shown high test-retest reliability and no practice effects among adults at an interval of one month (Falleti et al., 2006), but only moderate test-retest reliability among a sample of Ugandan children at an interval of two months (Bangirana et al., 2015). It has also shown adequate construct and criterion validity among patients with mild traumatic brain injury, schizophrenia and AIDS dementia complex (Maruff et al., 2009). In a study on the associations between CS and WAIS-IV among birth cohort mothers (Kataja et al., 2016), statistically significant moderate correlations between the CS Total Cognitive Score and the WAIS-IV index scores for perceptual reasoning, WM and processing speed were found.

In this study, three of the CS tasks were used as measures of maternal EF. The task selection was based on the influential model by Miyake et al. (2000) presented in chapter 1.1. The three tasks were as follows:

1) Groton Maze Learning Test (GMLT), an integrated EF task considered to measure several aspects of EF (Pietrzak et al., 2007; CogState, 2016),

2) 2-back (TWOB), considered as a WM updating task (CogState, 2016),

3) Set shifting test (SETS), assumed to tap flexible shifting between tasks (CogState, 2016).

These three tasks and their properties are presented below in more detail.

2.3.1 Groton Maze Learning Test

GMLT is a computerized hidden maze-learning test in CS. A 10 x 10 grid of grey tiles is presented on the screen, and the participant is to find a hidden pathway consisting

of 28 moves and 11 turns, starting from the upper left corner and ending in the lower right corner. The computer informs the participant whether a move is correct or not with a green check mark on the tile and a musical tone when correct, and a red cross when incorrect. The participant is informed that he or she is not allowed to move backwards or diagonally, or to touch the same tile twice, and is to return to the last correct tile when an error is made. The participant should then try to complete the maze, and once he or she has moved through the maze all the way to the lower right corner of the grid, the trial ends. The task is to be completed in five trials within the same session.

The outcome variable of GMLT in this study was the total number of errors made in attempting to learn the same hidden pathway on five consecutive trials at a single session, with a lower score indicating a better performance.

GMLT measures several aspects of executive function (Pietrzak et al., 2007). It requires WM to remember the feedback given on previous moves, shifting ability to change strategy according to feedback, and cognitive inhibition to avoid making the same mistakes (Thomas et al., 2016). Previous research has provided support to the construct validity for GMLT as a measure of concentration, attention, processing speed, planning and problem solving in healthy adults (Pietrzak et al., 2007). It has also been found to be sensitive to detecting rule-break errors and measuring error monitoring functions in children (Thomas et al., 2016).

2.3.2 Two-back task

TWOB assesses WM (Cogstate, 2016). A playing card is presented face up in the center of the screen. The participant is to decide whether the card is identical to the

card presented two cards back or not. Thus, the first two answers are always "No". The next card will be revealed as soon as the participant has given an answer. The participant is encouraged to work as quickly and accurately as possible. The task finishes after 32 correct responses.

The outcome variable of TWOB in this study was accuracy of performance, measured as an arcsine transformation of the square root of the proportion of correct responses (CogState, 2016). A higher score indicated a better performance.

The widely used n-back tasks like TWOB have become the gold standard in neuroimaging studies of WM (Kane & Engle, 2002). Although the n-back task has been used as a measure of WM in cognitive neuroscience for a long time, relatively little is known about its psychometric properties as not many studies have assessed its construct validity (Kane et al., 2007). However, in their review on the role of prefrontal cortex in EF and WM, Kane & Engle (2002) state that the n-back task clearly shows dorsolateral prefrontal cortex (dPFC) involvement in functional brain imaging studies, supporting its role as an EF task. Previous research shows extensive support that especially dPFC is crucial for WM functions (Kane & Engel, 2002).

2.3.3 Set-shifting test

SETS assesses one aspect of EF, namely set shifting (Cogstate, 2016). A playing card is presented on the screen and the participant is asked to determine whether the card contains a target stimulus dimension (a "correct" color or number). In the beginning of the test, the participant has to guess whether the card is a target card. As the participant guesses, the software provides feedback with different sounds depending on the correctness of the response, and the next card is not be presented until a correct

response has been made. In this way, the participant is taught that a specific dimension of the card (color or number) is correct. After a while, the target stimulus dimension changes, either to the opposing example within the same dimension (e.g. from red to black), or to an altogether different stimulus dimension (e.g. from color to number). The participant is not told when these set shifts occur, and must learn the new "rule" to proceed through the test. The participant is encouraged to work as quickly and accurately as possible.

The task consisted of five rounds (i.e., shifts). The outcome variable of SETS in this study was the accuracy of performance, measured as total number of errors across all rounds. A lower score indicated a better performance.

SETS is similar to the Wisconsin Card Sorting Test, a frequently used EF task that together with its analogues has been found to tap on shifting ability (Kane & Engle, 2002; Miyake et al., 2000).

2.4 Interaction assessment measure: Emotional Availability

Emotional availability (EA) as a construct refers to the emotional qualities of the connection between two people (Saunders et al., 2015). The EA Scales are designed to assess this construct on the basis of six dimensions of caregiver-child interaction during toddlerhood and beyond (Bretherton, 2000; Biringen et al, 2014). The six dimensions measure the affect and behavior of both a child and a caregiver, and are divided into four caregiver components and two child components (Biringen et al., 2014). The caregiver components are sensitivity, structuring, non-intrusiveness and non-hostility, and the child components are responsiveness (to the caregiver) and involvement (of the caregiver) (Biringen et al., 2014). Each dimension is measured

using a Likert scale ranging from 1 to 7, where a higher score reflects a better result (Saunders et al., 2015). Even though the caregiver and child components are distinguished from one another, emotional availability is a dyadic construct, which means that it can only be assessed with the qualities of both the child and caregiver taken into account (Biringen et al., 2014). Thus, rather than scoring them individually, the system evaluates their relationship (Biringen et al., 2014).

The EA Scales constitute a method for researchers and clinicians to summarize the emotional qualities, beyond attachment, of caregiver-child relationships (Biringen et al., 2014). Previous research has shown that the EA Scales have acceptable validity and reliability (Biringen et al., 2014; Ziv et al., 2000). For example, in a test-retest and inter-rater reliability study (Biringen et al., 2014), 52 mother-child dyads were observed twice in their homes for one hour, one week apart. Intra-class correlations yielded reliabilities ranging between 0.79 (for non-hostility) and 0.92 (for sensitivity) (Biringen et al., 2014). Another study (Ziv et al., 2000) examined links between the EA Scales and attachment, evaluated with the Strange Situation Procedure, in 687 Israeli dyads. Findings in the study showed that infant attachment security is related to higher scores on the EA Scales (specifically maternal sensitivity and infant's responsiveness and involvement) (Ziv et al., 2000). This implies construct validity and cross-cultural applicability of the EA Scales (Ziv et al., 2000).

In this study, the four caregiver dimensions of the EA Scales were employed in the analyses. These four dimensions are presented next.

2.4.1 Structuring

Adult structuring refers to the adult's ability to support the child in learning and to guide the child's activites (Biringen et al., 2014). It entails setting limits and laying down rules, but still allowing a certain degree of autonomy, thus making it possible for the child to learn independently (Saunders et al., 2015). Optimal structuring refers to meeting the child at his or her current level of understanding, and giving consistent but not excessive directives, both verbal and non-verbal (Saunders et al., 2015; Biringen et al., 2014). It also entails more implicit ways of setting a framework for the relationship (Biringen et al., 2014).

2.4.2 Non-intrusiveness

Adult non-intrusiveness refers to the adult's ability to follow the child's lead, and to be available when needed without interfering or interrupting in an overprotective or overwhelming manner (Saunders et al., 2015). A non-intrusive caregiver allows the child age-appropriate levels of autonomy and has an ability of emotionally "being there" for the child without taking charge (Biringen, 2000).

2.4.3 Sensitivity

Adult sensitivity refers to the manner in which the adult reacts to the child's emotional expressions (Salo & Flykt, 2013). It entails the adult's ability to create and maintain a generally positive and genuine emotional climate in the interaction with the child (Biringen et al., 2014). The affective expressions of a sensitive parent are

attuned to the child's emotional expressions, i.e., the sensitive parent interprets the child's emotional cues correctly and reacts appropriately (Biringen et al., 2014).

2.4.4 Non-hostility

Non-hostility refers to the adult's ability to regulate his or her own negative emotions, and to which degree the adult expresses these toward the child (Saunders et al., 2015). Hostility can be both covert and overt. Forms of covert, or hidden hostility, are subtle expressions of negative emotions such as impatience, boredom and frustration (Biringen et al., 2014). Overt hostility refers to openly hostile responses, such as losing one's temper in face of frustration, threatening with separation, or physical aggression (Saunders et al., 2015; Salo & Flykt, 2013). The optimally non-hostile adult does not show any signs of either covert or overt hostility (Biringen et al., 2014).

3. Results

Descriptive statistics on the variables are shown in Table 1. The correlation analyses that have been conducted are presented in chapter 3.1 and Table 2. Lastly, the multiple regression analyses are presented in chapter 3.3, and a summary of the results is depicted in Table 3.

3.1 Descriptive statistics

Descriptive statistics on the variables of interest are given in Table 1.

Table 1. *Descriptive statistics of the EF measures and the social interaction variables.*

	Total sample $n = 48$		
	Mean	SD	Range
GML	38.58	10.22	17-70
SETS	15.69	9.35	8-54
TWOB	1.33	.14	1.08-1.57
Sensitivity	5.49	1.27	2.5-7.0
Structuring	5.13	1.37	2.5-7.0
Non-intrusiveness	5.55	1.32	2.0-7.0
Non-hostility	6.03	1.01	4.0-7.0

Note: GML = Groton Maze Learning; SETS = Set Shifting; TWOB = 2-back

3.2 Correlation analyses

Prior to the regression analyses presented below, correlation analyses were conducted to examine the bivariate relationships between level of education, maternal EF and mother-child interaction variables. Pearson product-moment correlations were used to study the relationships between the EF measures and social interaction variables, and Spearman's rho correlations were employed for the relationships between level of education, EF and social interaction variables. No significant correlations between education and EF or social interaction were found. The only significant correlation between the EF measures and the social interaction variables was observed between the 2-back task and sensitivity ($r = -.29$, $p = .047$). An almost significant correlation was also found between the 2-back task and structuring ($r = -.28$, $p = .056$).

The within-domain correlations indicated that all the social interaction variables correlated significantly with each other (range of $r = .37 - .81$), but the EF measures did not correlate with each other. The correlation matrix is depicted in Table 2.

Table 2. *Correlations between education, EF and social interaction variables.*

	1	2	3	4	5	6	7
1. Education							
2. GML	- .04						
3. SETS	- .05	.05					
4. TWOB	.13	- .17	- .13				
5. Sensitivity	.01	- .01	.05	**- .29***			
6. Structuring	.00	- .01	.02	**- .28**	**.81****		
7. Non-intrusiveness	.22	- .05	.21	- .23	**.51****	**.46****	
8. Non-hostility	- .15	- .13	.05	- .15	**.72****	**.55****	**.37***

*Note: * $p < .05$, ** $p < .01$; the almost significant correlation is also bolded*

3.3 Multiple regression analyses

Four two-stage hierarchical multiple regression analyses were conducted to predict the mother-child interaction dimensions based on maternal EF. Education was entered at stage one as a control variable. All EF measures were entered in the same model at stage two, predicting either sensitivity, structuring, non-intrusiveness or non-hostility. The collinearity diagnostics qualified the use of the data for the modelling, as the predictors showed tolerance values ranging between .94 - .98 and VIF values between 1.01 – 1.06. A summary of the results of the regression analyses is presented in Table 3.

The hierarchical multiple regression analyses revealed that at stage one, education did not significantly contribute to the models for any of the social interaction variables, neither sensitivity ($F(1, 45) = .036$, $p = .54$), structuring ($F(1, 45) = .06$, $p = .80$), non-intrusiveness ($F(1, 45) = 3.10$, $p = 0.08$) nor non-hostility ($F(1, 45) = .52$, $p = .47$).

Introducing the EF measures at stage two increased the predictive value of the models slightly, albeit clearly non-significantly, for all the interaction variables

sensitivity ($F(4, 42) = 1.07$, $p = .38$), structuring ($F(4, 42) = .96$, $p = .43$), non-intrusiveness ($F(4, 42) = 2.09$, $p = .10$) and non-hostility ($F(4, 42) = .56$, $p = .69$). Thus, neither level of education nor the EF measures could account significantly for the outcome on any of the interaction variables tested in the present study.

Table 3. Summary of the hierarchical regression analyses for the EF variables predicting the four mother-child interaction scale scores

	Sensitivity				Structuring				Non-intrusiveness				Non-hostility			
	b	**SE**	β	*p*	**b**	**SE**	β	*p*	**b**	**SE**	β	*p*	**b**	**SE**	β	*p*
Step 1																
Constant	5.11	.61		.000	4.96	.66		.000	4.49	.61		.000	6.34	.48		.000
Education	.16	.26	.09	.548	.07	.28	.03	.803	.46	.26	.25	.085	- .15	.20	- .10	.472
Step 2																
Constant	8.70	2.17		.000	9.05	2.36		.000	7.30	2.16		.002	8.21	1.76		.000
Education	.21	.26	.12	.426	.12	.28	.06	.663	.51	.26	.27	.058	- .14	.21	- .10	.510
GML	- .005	.02	- .04	.787	- .008	.02	- .06	.696	- .009	.02	- .07	.615	- .01	.01	- .15	.319
SETS	.002	.02	.01	.927	- .003	.02	.02	.891	.02	.02	.18	.191	.005	.01	.04	.780
TWOB	-2.63	1.36	- .29	.059	-2.87	1.47	1.47	.059	-2.20	1.35	- .23	.109	-1.02	1.09	- .14	.358
R^2 for step 1	.008 (*p* = .548)				.001 (*p* = .803)				.064 (*p* = .085)				.012 (*p* = .472)			
ΔR^2 for step 2	.084 (*p* = .287)				.083 (*p* = .298)				.102 (*p* = .180)				.039 (*p* = .633)			

4. Discussion

This study explored the relationships between maternal executive functions and mother-child interaction. Maternal EF was measured with the CogState computerized cognitive test battery, and the social interaction was observed and assessed with the Emotional Availability scales. Based on earlier research, it was hypothesized that maternal EF would be positively associated with healthy mother-child interaction.

The present results failed to find any statistically significant relationships between maternal EF measures and mother-child interaction variables. Weak associations were found between WM updating and the interaction measures structuring and sensitivity, but the direction of these non-significant effects was opposite to the hypothesis.

4.1 Maternal EF and mother-child interaction

Previous research has found support for the link between maternal cognitive functions and parenting behavior, indicating that negative parenting behavior in mothers is associated with poorer EF (Bridgett et al., 2015). However, the results in the present study did not support those findings. This surprising outcome could be related to differences in the measures used. Although the measures for parenting behavior in several previous studies (Cuevas et al., 2014; Chico et al., 2014) have been similar to the observational assessments used in this study, no previous study has used exactly the same social interaction measures. This is true for the cognitive measures as well: previous studies have probed maternal cognitive functions with similar computerized tasks as in this study (Cuevas et al., 2014; Chico et al., 2014; Deater-Deckard et al.,

2012), but they have not used the CogState battery. This raises the question as to how ideal measures CogState and EA were for this kind of study (see chapter 4.3). Given this variability in methods, it appears to be too early to draw any definite conclusions on the relationships between maternal EF and the characteristics of mother-child interaction.

Although the results in this study failed to find any significant relationships between maternal EF and social interaction, nearly significant, weak associations were found between WM updating performance and sensitivity and structuring. However, the direction of these associations was opposite to the hypothesis: better WM updating performance was related to worse structuring and sensitivity in the mother-child interaction situation. This runs against current conceptualizations of these relationships. For example, a review by Hofmann et al. (2012) concludes that previous studies have established a positive connection between WM and successful self-regulation of behavior, including emotional responding and aggression. In light of this, as well as the previous studies on maternal EF (including especially WM) and parenting behavior (Deater-Deckard et al., 2010; Deater-Deckard et al., 2012; Chico et al., 2014; Cuevas et al., 2014), the present finding should be taken as an anomaly, calling for further research especially on the role of assessment methods in the result patterns in this research field.

4.3 Limitations and advantages of the study

Computerized neuropsychological assessment devices (CNADs) such as CogState have many advantages. CNADs make it possible to test a large amount of individuals in a short time, measure performance features such as reaction times more precisely,

and administer tests in multiple languages regardless of the administrator's language skills (Bauer et al., 2012). Still, there are factors to take into consideration while using CNADs. When a test usually administered in a traditional face-to-face contact is computerized, it is no longer the same test as the setting is different: instead of an examiner, the participant has a computer in front of him or her (Bauer et al., 2012). There is not anymore human interaction, and usually there is no one making behavioral observations (Bauer et al., 2012). Different aspects of the technological devices or the operating systems, as well as personal qualities of the participant, influence test performance and whether the test is completed in the manner intended by the developer (Bauer et al., 2012). Further research in CNADs is therefore of utmost importance to increase the understanding of how to develop and use them in the most efficient way.

As was noted in chapter 2.3, previous research on CogState has shown adequate validity (Maruff et al., 2009). However, the results of a study by Hammers et al. (2012) showed that the battery did not succeed in differentiating between various dementias, indicating weak criterion validity, as the tasks thus seem to measure multiple cognitive domains. In this study, EF was measured with three tasks, based on the unity and diversity model by Miyake et al. (2000), but as can be seen in the correlation matrix in table 2, the EF measures in this study do not correlate. However, this is not an uncommon problem when it comes to tasks that are generally considered to measure EF, indicating lacking convergent validity for these tasks (Paap & Sawi, 2014; Jylkkä, 2017). When Miyake et al. (2000) conducted a factor analysis of six EF tasks that are typically taken to tap into either one of the three core EFs, the factor loadings were modest and mostly unexplained by the model (see also Jylkkä, 2017).

Considering these issues, it thus remains unclear whether the tasks chosen for this study are valid measures of EF or not.

The fact that the data for this study had been gathered in the context of a larger cohort study constitutes a limitation in itself. Due to this, the social interaction assessment and the neuropsychological assessment were conducted four months apart. Even though cognitive functions in previous research have shown stability through the lifespan (Deary et al., 2000), it is known that e.g. sleep deprivation and stress impair several aspects of cognitive performance, including EF (Nilsson et al., 2005; McEwen & Sapolsky, 1995). Considering that the sample in this study consisted of mothers of eight or twelve months old children, both stress and sleep deprivation are probable factors that could have affected mothers' performance on the neuropsychological assessment. These kinds of effects are of course not stable from time to time but fluctuate, and thus it is not ideal that the assessments were conducted at different points in time. Moreover, although the EA Scales have shown acceptable validity and good inter-rater reliability (see chapter 2.4), little is known about the test-retest reliability or longitudinal stability of EA (Biringen et al., 2014).

4.4 Future directions

In future studies, it would be of interest to examine the relationships between WM and parenting behavior in more detail. In this study, an unexpected weak negative association between these measures was found. Further experiments are needed to test whether possibly more ecologically valid WM measures would show results that would concur with the initial hypothesis.

In a study by Davis et al. (2017), a relatively new measure on the interaction between a mother and her child, predictability, was used. Davis and her colleagues examined the relationship between the degree of predictability of mother's sensory signals (visual, auditory and tactile) towards their child, and the cognitive functions of the child (Davis et al., 2017). A significant positive relationship between predictability of maternal signals and child cognitive function was found (Davis et al., 2017). Predictability was assessed by observing mother-child interaction in a semi-structured 10-minute play episode (Davis et al., 2017), similar to the EA assessment. Given the significant findings in the study, a suggestion for future studies would be to use the predictability measure to evaluate parenting behavior.

As stated in chapter 1.3, the aim of this study was to advance our understanding of the nature of the relationship between maternal EF and mother-child interaction, and in this way further positive changes in parenting. In order to help parents develop their positive parenting skills, various skill training and home visiting programs have been carried out successfully (Crandall et al., 2015). Although they have been helpful to many parents, no intervention has been helpful to all parents (Crandall et al., 2015) This field of research is of importance in increasing the understanding not only on what parenting skill training programs and interventions should focus on, but also on how they should be designed to be effective for as many parents as possible (Crandall et al., 2015).

4.5 Conclusions

Based on earlier research, the present study set out to test the hypothesis that positive parenting behavior would be positively correlated to maternal EF. The results failed to

support the hypothesis, as maternal EF measured with the CogState battery was not significantly related to mother-child interaction as assessed by Emotional Availability scales. The only almost significant relationships were found between the WM and the sensitivity and structuring domains of mother-child interaction, but the direction of these as such weak associations was against the hypothesis. Because this area of research is fairly new, further research is called for to clarify the relationships between maternal EF – mother-child interaction, and the role of different measurement instruments in the obtained results.

Swedish summary/svensk sammanfattning:

Förhållandet mellan mödrars exekutiva funktioner och deras sätt att samspela

med sina barn

Introduktion

Förståelse för och kunskap om faktorerna som ligger bakom både positiva och negativa beteendemönster hos föräldrar eller vårdnadshavare är viktigt för att minska risken för illabehandlande av barn, samt för att minska beteende- och emotionell problematik hos barn och unga (Crandall et al., 2015).

Beteende- och känslomässig självreglering är en viktig faktor i omvårdnad av barn. För att undvika att reagera barskt gentemot sitt barn måste vårdnadshavaren reglera både sitt beteende och sina känslouttryck i interaktionen med sitt barn (Deater-Deckard et al., 2010). Vårdnadshavare som besvarar barnets negativa beteende genom att själv reagera starkt negativt uppmuntrar oppositionellt beteende (Deater-Deckard et al., 2012). Upprepat barskt negativt beteende hos föräldrar kan i värsta fall eskalera till misshandel, och är en viktig etiologisk faktor i psykopatologi hos barn (Deater-Deckard et al., 2010).

Utöver beteende- och känslomässig självreglering tyder ny forskning på att kognitiv självreglering, så som exekutiva funktioner (EF), är en central del i interaktionen mellan vårdnadshavare och barn (Crandall et al., 2015). Detta forskningsfält är nytt men lovande, och är vad föreliggande studie kommer att fokusera på.

Förmågan till självreglering varierar i hög grad från människa till människa (Friedman et al., 2008). Den kognitiva psykologin förklarar denna variation med individuella skillnader i EF (Friedman et al., 2008). EF består enligt Miyakes et al.

(2000) inflytelserika modell av *kognitiv inhibition*, *uppdatering och monitorering av arbetsminne*, samt *växling av uppmärksamhet*. Färsk forskning har visat att EF, varav särskilt arbetsminne, påverkar förmågan till självreglering (Hofmann et al., 2012). EF och självreglering är således mycket likartade konstrukt och komplext sammankopplade.

Tidigare forskning inom området har pekat på ett positivt samband mellan EF och social interaktion. Flera tvärsnittsstudier har visat att mödrar med svagare arbetsminne tenderar reagera mer negativt på deras barns krävande beteende jämfört med mödrar som har bättre arbetsminneskapacitet (Bridgett et al., 2015). Andra studier har visat på ett positivt samband mellan mödrars EF och deras känslighet i interaktionen med sina barn (Chico et al., 2014), samt på ett positivt samband mellan barns uppförandeproblematik och deras mödrars negativa beteende gentemot dem, vilket var signifikant endast när det gällde mödrar med svagare EF (Deater-Deckard et al., 2012). I en longitudinell studie där förhållandet mellan mödrars EF, omvårdnadsbeteende samt deras barns utveckling av EF analyserades, pekade resultaten på ett negativt samband mellan negativa omvårdnadsbeteenden och både mödrarnas och deras barns EF (Cuevas et al., 2014).

På basis av tidigare forskning inom området är hypotesen i denna studie att ett positivt samband mellan mödrars EF och interaktionsmönster mellan dem och deras barn kommer att hittas. Målet med studien är att utforska det aktuella sambandet djupare för att öka förståelsen och kunskapen om faktorer som påverkar vårdnadshavares beteende gentemot sina barn.

Metod

Denna studie utfördes som en del av kohortstudien FinnBrain vid Åbo Universitet (Karlsson et al., 2018) som startade år 2010 och fortgår. Samplet bestod av totalt 48 mödrar som deltagit i både FinnBrains-studiens neuropsykologiska testningar och i en observationsbedömning av interaktionen mellan mödrarna och deras barn. Observationsbedömningen ägde rum när barnen var åtta månader gamla, och de neuropsykologiska testningarna fyra månader senare.

De neuropsykologiska testningarna tog 60 minuter och administrerades på en dator med en testadministratör närvarande i situationen. Det neuropsykologiska testbatteriet, *CogState* (CS), bestod av 13 deltest, av vilka tre användes i denna studie och kommer att presenteras kort nedan. CS är ett standardiserat, anpassningsbart, datoriserat testbatteri utvecklat för att undersöka förändring i olika kognitiva funktioner, som t.ex. processeringshastighet, uppmärksamhet och arbetsminneskapacitet (Pietrzak et al., 2008). Testbatteriet har visat sig ha god test-retest reliabilitet (Falleti et al., 2006) och kriterievaliditet (Maruff et al., 2009).

De tre deltesten som använts i denna studie som mått på mödrarnas exekutiva funktioner är:

1) *Groton Maze Learning Test* (GMLT), som anses mäta flera aspekter av EF,

2) *2-back* (TWOB), ett mått på arbetsminnesuppdatering, samt

3) *Set shifting test* (SETS), som mäter förmåga att växla uppmärksamhet.

I GMLT ska testpersonen hitta en gömd rutt i en labyrint bestående av ett 10 x 10 rutsystem. Rutten består av 28 rutor, och upprepas fem gånger med samma rutt varje gång. Genom direkt återkoppling i form av programmet som informerar om man gör rätt eller fel varje gång man tar ett steg, ska testpersonen lära sig rutten med så få fel som möjligt. Som resultatvariabel användes totala antalet utförda fel, där lägre poäng

indikerade en bättre prestation. GMLT har visat sig vara ett reliabelt mått på

processeringshastighet, spatiellt arbetsminne och felmonitorering (Pietrzak et al.,

2007).

I TWOB ska testpersonen avgöra om ett kort som visas på datorskärmen är

identiskt med kortet som visades två kort tidigare. Resultatvariabeln var prestationens

noggrannhet, där högre poäng indikerade en bättre prestation.

I SETS ska testpersonen med hjälp av direkt återkoppling av programmet lära

sig vilken dimension (antingen ett specifikt nummer eller färg) av korten som är rätt,

och således om korten som i tur och ordning visas på skärmen är s.k. "målkort". I

början måste testpersonen gissa sig fram till rätt svar, men efter hand lär sig

testpersonen den gällande regeln, tills den byts och testpersonen måste lära sig den

nya regeln. Resultatvariabeln var totala antalet fel, där lägre poäng indikerade en

bättre prestation. SETS är ett likartat test som Wisconsin Card Sorting Test, som

särskilt har visat sig mäta förmåga till s.k. shifting, dvs. växling av kognitiva

strategier (Kane & Engle, 2002; Miyake, 2000).

Det sociala samspelet mellan mödrarna och deras barn mättes med *Emotional*

Availability Scales, som är en metod konstruerad att sammanfatta och bedöma

samspelet mellan vårdnadshavare och barn utgående från sex dimensioner

(Bretherton, 2000; Biringen et al., 2014). *Emotional Availability* (EA), dvs.

emotionell tillgänglighet, hänvisar till de emotionella egenskaperna i relationen

mellan två personer (Saunders et al., 2015). De sex dimensionerna består av

vårdnadshavarens sensitivitet, strukturering, icke-inkräktande och icke-fientlighet,

samt barnets mottaglighet gentemot vårdnadshavaren och barnets engagemang av

vårdnadshavaren (Biringen et al., 2014). Alla dimensioner poängsätts på en Likert

skala på 1-7, där högre poäng innebär ett bättre resultat (Saunders et al., 2015).

I denna studie har alla fyra vårdnadshavardimensioner använts som mått för mödrarnas samspel med sina barn, och dessa presenteras kort nedan. I bedömningssituationen instruerades mor att leka med sitt barn som om de vore hemma. Bedömningen tog 20 minuter och filmades in, varpå psykologer med utbildning i att använda EA Scales kodade bedömningssituationen utgående från den inspelade filmen.

Sensitivitet innebär vårdnadshavarens förmåga att vara lyhörd för barnets emotionella uttryck (Salo & Flykt, 2013). Det betyder att vårdnadshavaren tolkar barnets emotionella signaler rätt och reagerar adekvat därefter (Biringen et al., 2014).

Strukturering innebär vårdnadshavarens förmåga att stöda barnets inlärning genom att handleda och sätta gränser och ramar, men samtidigt också tillåta barnet att lära sig självständigt genom att prova sig fram (Biringen et al., 2014; Saunder et al., 2015).

En *icke-inkräktande* vårdnadshavare finns till hands när barnet behöver och tillåter samtidigt barnet åldersadekvat autonomi utan att vara inkräktande eller överbeskyddande (Saunders et al., 2015; Biringen et al., 2000).

Icke-fientlighet syftar på vårdnadshavarens förmåga att reglera sina negativa känslor och i vilken grad han eller hon uttrycker dessa för barnet (Saunders et al., 2015).

Resultat

För att undersöka bivariata samband mellan mödrarnas utbildningsnivå, deras EF och interaktionen mellan dem och deras barn utfördes Pearson korrelationsanalyser. Signifikanta samband hittades varken mellan utbildningsnivå och exekutiva funktioner eller social interaktion. Den enda signifikanta korrelationen mellan de

exekutiva måtten och interaktionsvariablerna hittades mellan 2-back och sensitivitet (r = - .29, p = .047). Ett nästan signifikant samband hittades dessutom mellan 2-back och strukturering (r = - .28, p = .056).

En multipel regressionsanalys i två steg utfördes för att undersöka hurdan effekt EF hade på social interaktion. Som kontrollvariabel i steg ett fungerade utbildningsnivå. I steg två togs alla tre exekutiva mått med för att predicera de fyra olika interaktionsmåtten. Det visade sig att varken utbildningsnivå eller de exekutiva måtten kunde predicera resultaten på något av interaktionsmåtten, varken sensitivitet ($F(4, 42)$ = 1.07, p = .38), strukturering ($F(4, 42)$ = .96, p = .43), icke-inkräktande ($F(4, 42$ = 2.09, p = .10) eller icke-fientlighet ($F(4, 42)$ = .56, p = .69). Ingen av modellerna var alltså signifikant.

Diskussion

Syftet med denna studie var att undersöka sambandet mellan mödrars exekutiva funktioner och deras sätt att samspela med sina barn. Målet var att öka förståelsen och kunskapen om faktorer som påverkar vårdnadshavares beteende gentemot sina barn. På basis av tidigare resultat (Deater-Deckard et al., 2010; Deater-Deckard et al., 2012; Chico et al., 2014; Cuevas et al., 2014) förväntades ett positivt samband mellan exekutiva funktioner och social interaktion, men resultaten visade dock inga statistiskt signifikanta samband. Nästan signifikanta, svaga samband mellan arbetsminne och interaktionsmåtten strukturering och sensitivitet hittades, men riktningen var däremot åt motsatt håll än förväntat. De överraskande resultaten kan bero på skillnaderna mellan måtten som använts för att mäta både socialt samspel och EF. Även om metoderna i tidigare studier varit liknande, och man använt sig av likartade observationsbedömningar som EA Scales (Cuevas et al., 2014; Chico et al., 2014), har

dock ingen studie använt sig av samma metod. Detta gäller även de exekutiva måtten: tidigare studier har använt sig av likartade datoriserade test för att mäta kognitiva funktioner (Cuevas et al., 2014; Chico et al., 2014; Deater-Deckard et al., 2012), men ingen studie har använt just CogState.

En ytterligare svaghet i studien var att samplet kom från en större studie, vilket innebar att datat var insamlat vid olika tidpunkter. Detta är inte idealt med tanke på att olika faktorer, som t.ex. stress och sömnbrist, kan påverka flera olika kognitiva funktioner, inklusive EF (Nilsson et al., 2005; McEwen & Sapolsky, 1995).

Med tanke på att tidigare studier har visat på ett positivt samband mellan arbetsminne och beteendemässig självreglering, inklusive emotionell respons och aggression (Hofmann et al., 2012), är det anmärkningsvärt att denna studie fann nästan signifikanta, men negativa samband mellan just arbetsminne och interaktionsvariablerna sensitivitet och strukturering. Mot bakgrund av resultaten i tidigare studier (Hofmann et al., 2012; Deater- Deckard et al., 2010; Deater-Deckard et al., 2012; Chico et al., 2014; Cuevas et al., 2014) ska dessa fynd betraktas som en avvikelse. Vidare forskning bör fokusera på metoderna som används inom detta forskningsområde och hur de påverkar resultaten.

Slutsats

Sammanfattningsvis gav resultaten i denna studie inte stöd för att det skulle finnas ett positivt samband mellan mödrars EF och interaktionsmönster mellan mödrarna och deras barn, vilket var hypotesen på basis av tidigare studier inom området. Inga signifikanta samband hittades, och riktningen för det enda nästa signifikanta sambandet som hittades var motsatt i förhållande till hypotesen. På grund av att detta forskningsområde tills vidare är så nytt och outforskat behövs mera studier för att

klargöra sambandet mellan mödrars EF och deras sätt att samspela med sina barn,

samt hurdan roll valet av mätinstrument spelar för resultaten.

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PRESSMEDDELANDE

Färsk studie hittar inte samband mellan mödrars exekutiva funktioner och mödra-barn interaktion

En färsk pro gradu-avhandling vid Åbo Akademi har undersökt sambandet mellan mödrars exekutiva funktioner och deras sätt att samspela med sina barn. I avhandlingen av Jenny Selenius hittades inga signifikanta samband. Avhandlingen är en del av FinnBrain-projektet vid Åbo Universitet och har undersökt hur mödrars exekutiva funktioner relaterar till fyra dimensioner av interaktionen mellan mödrarna och deras barn. Nästan signifikanta, svaga samband hittades mellan arbetsminnesuppdatering och två av interaktionsdimensionerna: mödrarnas sensitivitet och struktureringsförmåga, men riktningen i dessa samband var motsatt i förhållande till hypotesen.

Resultaten i Selenius avhandling avviker från tidigare forskningsfynd där positiva samband mellan exekutiva funktioner och social interaktion har hittats. De överraskande fynden kan bero på begränsningar i mätinstrumenten, men Selenius lyfter fram att forskningsområdet tills vidare är nytt och outforskat och mer forskning behövs för att klargöra det aktuella sambandet.

Studien hade sammanlagt 48 deltagare. Exekutiva funktionerna mättes med hjälp av tre datoriserade uppgifter ur ett neuropsykologiskt testbatteri som testpersonen skulle lösa, och interaktionen mellan mödrarna och deras barn observerades och utvärderades av psykologer med utbildning i bedömningsmetoden.

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