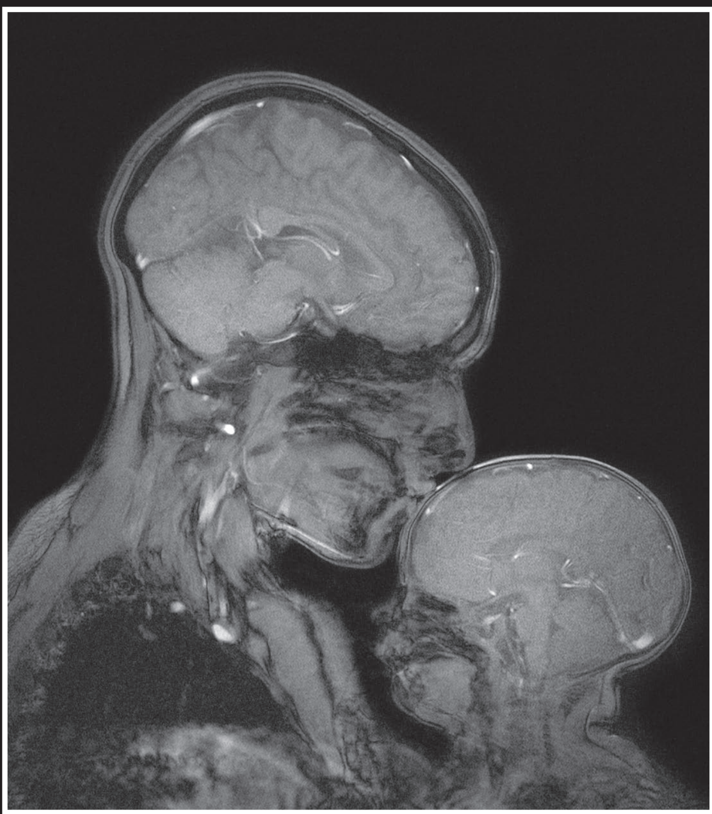
Elisabeth Nordenswan

The Interplay between Maternal Executive Functioning and Psychological Risk Factors in the Context of Early Caregiving Behavior

Findings from the FinnBrain Birth Cohort Study



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Turku, April 2022

Elisabeth Nordenswan

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original publications, which are referred to in the text as Studies I-IV.

I. Nordenswan, E., Kataja, E.-L., Deater-Deckard, K., Korja, R., Karrasch, M., Laine, M., Karlsson, L., & Karlsson, H. (2020). Latent Structure of Executive Functioning/Learning Tasks in the CogState Computerized Battery. SAGE Open. doi: 10.1177/2158244020948846

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III. Nordenswan, E., Deater-Deckard, K., Karrasch, M., Laine, M., Kataja, E.-L., Holmberg, E., Eskola, E., Hakanen, H., Karlsson, H., Karlsson, L., & Korja, R. (2021). Maternal Executive Functioning, Emotional Availability and Psychological Distress During Toddlerhood: A FinnBrain Birth Cohort Study. Frontiers in Psychology, 12, 735734–735734. doi: 10.3389/fpsyg.2021.735734

IV. Nordenswan, E., Deater-Deckard, K., Kataja, E-L., Karrasch, M, Laine, M., Pelto, J., Holmberg, E., Hakanen, H., Ahrnberg, H., Kajanoja, J., Karukivi, M., Karlsson, H., Karlsson, L., & Korja, R. Maternal Alexithymia and Caregiving Behavior: The Role of Maternal Executive Functioning. *(Submitted)*

ABSTRACT

Recent studies have indicated executive functioning (EF) to be one of the parental variables that shape caregiving behavior. Besides being directly associated with caregiving, EF has joint effects with other parenting determinants on caregiving behavior. As this novel research field is still emerging, further studies on the influence of parental EF on caregiving in varied populations are called for. This is especially relevant during early childhood, when psychosocial factors can have profound effects on child development over the long term. In the present thesis, the interrelationships between maternal EF, psychological risk factors (psychological distress, alexithymic traits) and caregiving behavior were explored in Finnish general population mothers of toddlers. As regards caregiving behavior, the present focus was at the degree of parental emotional availability (EA), a key aspect in child development and well-being.

The thesis sub studies employed overlapping samples of participants from the FinnBrain Birth Cohort. The main data was collected at 2.5 years after delivery.

Study I (N = 233) examined the latent structure of five Cogstate EF/learning tasks, and evaluated the suitability of a sum score based on these tasks to assess EF/learning among healthy adults. First-round results for tasks with multiple test rounds were interpreted to tap more onto EF, while summative scores were thought to tap more onto learning. An important outcome of this study was a new Cogstate EF/learning composite score including first-round results, that was then employed in Study II-IV.

Study II (N = 150) explored whether psychological distress domains that are prevalent during early parenthood (depression, anxiety, insomnia, poor couple relationship adjustment) were associated with maternal EF. While subclinical symptoms and single clinically elevated distress domains were not significantly associated with EF, a higher number of simultaneously clinically elevated distress domains was associated with lower EF.

Study III (N = 137) examined the association between maternal EF and the degree of emotional availability (EA) in maternal caregiving behavior, while accounting for maternal psychological distress levels. Higher EF had a weak but significant association with more emotionally available caregiving. Psychological distress levels did not significantly moderate the association.

Study IV (N = 119) examined the association between maternal alexithymic traits and EA, while accounting for maternal EF. Higher levels of alexithymic traits were associated with poorer caregiving quality. This association was moderated by maternal EF, so that higher EF seemed to buffer against the effect of alexithymic traits on caregiving behavior.

The thesis results have several implications for both parenting research and parenting interventions. As general population mothers' EF capacity appears to both directly influence the ability to be emotionally available for toddlers,

and to moderate how risk factors like alexithymic traits impact caregiving behavior, it is recommendable to consider the influence of maternal EF when assessing parental caregiving resources. Alongside socioemotional assessments, EF assessments could facilitate the formulation of optimally supportive parenting interventions. Furthermore, interventions supporting parental EF in the context of caregiving behavior could facilitate the capacity to be emotionally available in caregiving situations. As lower levels of maternal psychological distress were neither significantly associated with EF nor significantly moderated the EF/EA association, general population mothers of toddlers (amongst whom these lower levels are commonplace) do not seem to run any greater risk for EF-related problems during caregiving situations. However, as a higher number of concurrent clinically elevated distress domains were linked to lower EF even among general population mothers, and as the effect of EF on EA has previously been reported to be significantly stronger among mothers experiencing notably higher psychological distress levels than those in the present study group, the influence of maternal EF on EA could be especially relevant acknowledge among severely distressed mothers. If psychological distress depletes maternal EF capacity, then interventions that relieve these symptoms are also likely to allow for recovered EF, enabling mothers to make optimal use of their EF capacity in caregiving situations. Further parental EF research is called for to confirm and extend these findings, by e.g. exploring the role of parental EF during different child developmental phases, among fathers, and in varying populations.

SVENSK SAMMANFATTNING

Under det senaste årtiondet har studier indikerat att exekutiva funktioner (EF) är en av de föräldraskapsvariabler som formar föräldrars omvårdnad av sina barn. Förutom att ha ett direkt samband med omvårdnadsbeteenden, formar EF även omvårdnadsförmågan genom interaktionseffekter med andra föräldraskapsvariabler. Då detta nya forskningsområde fortfarande håller på att ta form, behövs vidare studier som kartlägger hur föräldrars EF influerar omvårdnadsbeteenden inom olika populationer. Det här är speciellt viktigt att utreda under den tidiga barndomen, då psykosociala faktorer kan ha en omfattande, långsiktig inverkan på barns utveckling. I denna avhandling undersöktes bland småbarnsmödrar från den allmänna finländska befolkningen sambanden mellan mödrarnas EF, psykologiska riskfaktorer (psykologisk belastning, alexitymiska drag), och omvårdnadsbeteenden. Mer specifikt låg fokus på graden av emotionell tillgänglighet i mödrarnas omvårdnadsbeteenden, vilket centralt inverkar på barns utveckling och välmående.

Avhandlingens delstudier inkluderade överlappande deltagarsampel från FinnBrain födelsekohorten. Det huvudsakliga datat samlades in 2,5 år efter barnens födelse.

I studie I (N = 233) undersöktes fem Cogstate EF/inlärningsuppgifters latenta struktur. Vidare utvärderades hur väl en summavariabel baserad på de här fem uppgifterna lämpar sig för att mäta EF/inlärning bland friska vuxna. För uppgifter med flera testomgångar ansågs den första testrundan vara bäst lämpad för att mäta EF, medan summavariablerna ansågs bättre lämpade för att mäta inlärning. Ett centralt resultat i denna studie var en ny Cogstate EF/inlärningssumma, som därpå användes i studie II-IV.

I studie II (N = 150) undersöktes om olika psykologiska belastningsdomäner som är prevalenta under tidigt föräldraskap (depression, ångest, sömnstörningar, låg parförhållandeharmoni) var relaterade med mödrars EF. Subkliniska symptomnivåer samt kliniskt förhöjda symptomnivåer inom enstaka belastningsdomäner var inte signifikant relaterade med EF, men ett högre antal samtidigt kliniskt förhöjda belastningsdomäner var relaterat till lägre EF.

I studie III (N = 137) undersöktes sambandet mellan mödrars EF och graden av emotionell tillgänglighet i mödrarnas omvårdnadsbeteende, så att även mödrarnas psykologiska belastningsnivåer beaktades i analyserna. Högre EF hade ett svagt men signifikant samband med mer emotionellt tillgänglig omvårdnad. Psykologiska belastningsnivåer hade inte en signifikant modereringseffekt på det här sambandet.

I studie IV (N = 119) undersöktes sambandet mellan mödrars alexitymiska drag och graden av emotionell tillgänglighet i omvårdnadsbeteendet, så att även mödrarnas EF beaktades i analyserna. Högre nivåer av alexitymiska drag var relaterade till mindre emotionellt tillgänglig omvårdnad. Mödrarnas EF modererade det här sambandet, så att högre EF verkade dämpa inverkan av alexitymiska drag på omvårdnadsbeteendet.

Avhandlingens resultat omfattar flera aspekter som är värdefulla att uppmärksamma inom föräldraskapsforskning och föräldraskapsstödjande interventioner. Då mödrars EF verkar ha både en direkt effekt på förmågan till emotionellt tillgänglig omvårdnad av småbarn, samt moderera hur riskfaktorer som alexitymiska drag inverkar på omvårdnadsbeteendet, är det vid bedömningar av föräldraskapsresurser tillrådligt att observera inverkan av föräldrars EF. Vid sidan av socioemotionella bedömningar kunde bedömningar av EF främja utformningen av optimalt stödjande föräldraskapsinterventioner. Vidare kunde interventioner som stödjer föräldrars EF i omvårdnadssituationer befrämja föräldrars förmåga till emotionellt tillgänglig omvårdnad. Då lägre nivåer av psykologisk belastning varken var signifikant relaterade till EF, eller på en signifikant nivå modererade sambandet mellan EF och emotionellt tillgänglig omvårdnad, verkar småbarnsmödrar som upplever lägre nivåer av psykologisk belastning (vilket är vanligt förekommande bland den allmänna befolkningen) inte befinna sig i riskzonen för utmaningar relaterade till EF i omvårdnadssituationer. Eftersom ett högre antal kliniskt förhöjda belastningsdomäner var relaterat till lägre EF till och med bland mödrar från den allmänna befolkningen, och då EF tidigare har rapporterats ha en klart starkare effekt på förmågan till emotionellt tillgänglig omvårdnad bland mödrar som upplever betydligt högre psykologisk belastning än mödrarna i denna studie, verkar det vara speciellt angeläget att beakta effekten av föräldrars EF på emotionell tillgänglighet bland avsevärt belastade mödrar. Om psykologisk belastning försvagar EF, skulle stödåtgärder som lindrar denna belastning sannolikt också möjliggöra återhämtade EF, vilket skulle stödja optimal användning av EF vid småbarnsvård. Vidare forskning kring föräldrars EF behövs för att bekräfta och utveckla dessa resultat, genom att t.ex. undersöka vikten av föräldrars EF under olika faser av barns utveckling, bland fäder, och i olika populationer.

ABBREVIATIONS

AIS = The Athens Insomnia Scale

CFA = Confirmatory factor analyses

CPAL = The Continuous Paired Associate Learning Test

DIF = Difficulty Identifying Feelings

DDT = Difficulty Describing Feelings

EA = Emotional Availability

EAS = Emotional Availability Scales

EF = Executive functioning

EOT = Externally Oriented Thinking

EPDS = The Edinburgh Postnatal Depression Scale

GML = The Groton Maze Learning Test

ISL = The International Shopping List Test

RDAS = The Revised Dyadic Adjustment Scale

SCL-90 = The Symptom Checklist 90

SETS = The Set-Shifting Test

TAS-20 = The 20-Item Toronto Alexithymia Scale

TWOB = The Two Back Test

WAIS-IV VCI = The Wechsler Adults Intelligence Scale - Fourth Edition, Verbal Comprehension Index

1. INTRODUCTION

Parenting toddlers is an engaging task. Toddlers develop rapidly, while eagerly exploring the physical world, social interactions, and their own physical abilities (Payne & Isaacs, 2017; Madigan et al., 2019). Besides gladly sharing this exploration with their parents, toddlers also need active and regulating parental caregiving during this intense developmental phase (Karreman et al., 2006). Parents' time with their toddlers is likely to be filled with play and cuddles, but also with the management of oppositional behavior and temper tantrums (Alink et al., 2006), and with the restriction of unsafe activities. A parent's capacity to answer to a toddler's caregiving needs varies from one situation to the next. Sometimes they have the resources to provide calm, structured and emotionally supportive caregiving, but other times they might not be capable of this, and end up upsetting instead of stabilizing their child. But what shapes a parent's capacity to respond to their child's caregiving needs during this formative period? Many might come to think of factors like parental mood, stress levels, or childhood experiences, but could neurocognitive functioning also play a part in this equation? The emerging research field of parental executive functioning (EF) indicates that this is indeed the case (Bridgett et al., 2015; Crandall et al., 2015). The present thesis examines the role of maternal EF in caregiving behavior during early parenthood. Acknowledging the central role of EF in the self-regulation of thoughts, emotions and behaviors, the thesis furthermore explores how maternal EF operates together with maternal psychological distress and the personality construct alexithymia in relation to caregiving behavior.

Parenting exerts a key influence on child development and well-being, and this effect is especially strong during early childhood (Nelson et al., 2019). Thus, researchers and health care providers often focus on parental caregiving behavior as the optimal setting for child development supporting interventions. For these interventions to be successful, in-depth knowledge about the components of caregiving behavior is required. The complex phenomenon of parenting is molded by a multitude of determinants. At the societal level, it is influenced by e.g. parental culture/ethnicity, socioeconomic status, and neighborhood quality. At the familial level, parenting is shaped by circumstances like the parental couple's relationship quality and financial situation, and by the family's life events and social network. At the level of the individual parent, factors like developmental history, personality, and psychological well-being are known to centrally influence caregiving behavior (Belsky, 1984; Kotchik & Forehand, 2002). In contrast to these extensively studied determinants of parenting, there is limited knowledge about the role of parental EF in caregiving behavior. As EF (i.e., higher-level cognitive processes that enable goal-directed behavior like reasoning and problem-solving) is known to be central in human every-day functioning (Diamond, 2013; Miyake et al., 2000), it seems reasonable to assume that EF would also play a part in parenting.

Indeed, a growing body of research has identified EF to be one of the individual parental variables that shape caregiving behavior (Bridgett et al., 2015; Crandall et al., 2015). Generally, studies have reported higher parental EF to be related to caregiving behavior which is more beneficial for child development and well-being, while lower EF has been linked to poorer caregiving (Bridgett et al., 2015; Crandall et al., 2015). Besides being directly associated, the parental EF/caregiving association also seems to be modified by parental stress levels. Some findings indicate that EF capacity can have a stronger influence on caregiving behavior when stress levels are high (Chary et al., 2020), while other results point to high stress levels having a diminishing effect on the EF/caregiving association (Deater-Deckard et al., 2012). Considering that psychological distress, like symptoms of depression, anxiety, insomnia, and poor couple relationship adjustment, is prevalent during early parenthood (Canário & Figueiredo, 2017; Kluwer, 2010; Mindell, et al., 2015), further research on the links between psychological distress and parental EF during early parenthood is called for.

Parental EF has furthermore been reported to have joint effects on caregiving behavior with other caregiving determinants, like parental adverse childhood experiences (Bridgett et al., 2017; Gonzalez et al., 2012; Guss et al., 2020) and socioeconomic risk (Sturge-Apple et al., 2017). However, little is known about the joint effects of parental personality traits and EF in relation to caregiving behavior. Personality traits, which are relatively stable reaction patterns that influence how individuals experience and respond to their environment (McCrae & Costa, 2006), are known to be associated with parental caregiving quality (Prinzie et al., 2009). Among the potential personality constructs that could be studied in relation to parenting, alexithymic traits seem especially relevant. Alexithymia is characterized by a decreased ability to identify and verbalize emotions, along with a pragmatic way of thinking and a lack of interest in emotional experiences (Sifneos, 1973). Research on the role of alexithymic traits in parenting is still scarce, but two recent studies indicate that higher levels of maternal alexithymic traits are associated with poorer caregiving quality during early childhood (Ahrnberg et al., 2021; Porreca et al., 2020). Considering that alexithymia encompasses personality traits related to emotion processing and regulation (Luminet et al., 1999), that emotion regulation is known to centrally influence the quality of parental caregiving behavior (Rutherford et al., 2015), and that alexithymic traits have been associated with caregiving quality (Ahrnberg et al., 2021; Porreca et al., 2020), alexithymia appears to be an especially suitable personality construct to include in studies exploring the joint effects of parental EF and other parenting determinants on caregiving behavior.

To date, few studies have examined parental EF in relation to caregiving observation frameworks that can be employed in clinical practice. One such framework is emotional availability (EA; Biringen et al., 2014), which assesses the parent-child dyad's capacity to share an emotionally healthy relationship. Two studies have indicated that better maternal EF is associated with higher EA (Harris et al., 2021; Porreca et al., 2018). This suggests that a dyad's EA, which is known to be associated with multiple outcomes in the child (Clark et al., 2021; Saunders et al., 2015), is influenced by parental EF, but further research is needed to support and expand these findings. Considering that EA focuses on the emotional components of the dyad's relationship, this framework is especially suitable for studying how EF together with psychological distress and alexithymic traits influences caregiving behavior, as emotional processes are central components of both psychological distress and alexithymia.

As beautifully portrayed by the cover picture of this book, this thesis focuses on the neurocognitive dimension of parental caregiving behavior. In the cover picture, neuroscientist Rebecca Saxe is curled up with her infant son in a magnetic resonance imaging scanner. Although facial expressions and vocalizations are not captured by this image, the mother's embrace unmistakably communicates that she is compassionately caring for her child. The visible brain structures simultaneously guide the viewer to reflect on how neurocognitive functioning, like EF, plays a part in the mother's caregiving. To answer some of the central questions within the emerging research field of parental EF, the current thesis examines: 1) the associations between maternal psychological distress and EF, 2) the associations between maternal EF and EA, and 3) the moderating effect of maternal EF on the association between maternal alexithymic traits and EA. Recognizing the especially large impact of parenting on child development during early childhood, mothers of toddlers are studied. The studied associations are depicted in *Figure 1*, and prior research related to the thesis topic is presented in the upcoming sections. Exploring the interplay between maternal EF and psychological risk factors in the context of early caregiving behavior provides professionals working with parenting interventions (e.g., child health clinic employees, social workers, and child psychiatric clinic employees) with more nuanced knowledge about the determinants that shape a parent's capacity to provide EA caregiving. If varying parental EF levels are found to function beneficially/constitute a vulnerability in relation to the capacity to provide EA caregiving, then it is not only relevant to consider parental EF when assessing a parent's caregiving resources, but it could also be constructive to structure parenting interventions so that they strengthen parents' ability to make optimal use of their EF resources when caring for their child. As the interplay between maternal EF, psychological risk factors, and caregiving behavior might vary between populations, e.g. within low-risk samples in comparison to high-risk samples, the dynamics of these phenomena are relevant to study within varying populations. This thesis focuses on general population mothers, providing results that are generalizable to a large proportion of the population.

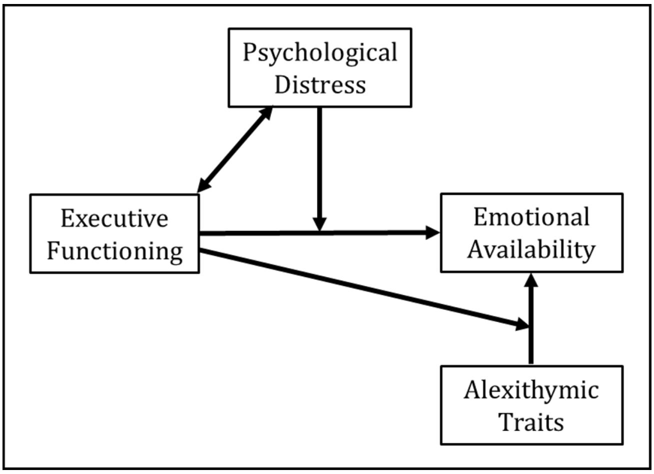


Figure 1. Depiction of the main associations studied in the present thesis, that explores the role of maternal executive functioning and psychological risk factors (i.e., psychological distress and alexithymic traits) in caregiving behavior among general population mothers of toddlers.

1.1. Executive functioning: Construct and assessment

The umbrella-term EF refers to higher-level abilities that enable goal-directed behavior. According to the highly influential study by Miyake and colleagues (2000), three interrelated core functions, namely working memory updating, inhibitory control and set-shifting, make up the foundation of EF. *Working memory updating* involves mentally working with information that is held in mind. Information that is relevant for a task at hand is processed by monitoring and coding incoming information, and by replacing no longer relevant information with more recent and more relevant information. *Inhibitory control* refers to the ability to suppress prepotent responses, by e.g. resisting temptation, refraining from impulsive acts, and utilizing selective attention. *Set-shifting* involves seeing things from different perspectives and adapting to changing circumstances, by flexibly shifting between multiple mental sets or tasks. Higher-order goal-directed behavior like planning and problem-solving are thought to build upon these core functions. EF plays a central role in our everyday life, enabling us to e.g. pay attention, concentrate, think before acting, mentally play with ideas, and meet novel challenges (Diamond, 2013; Miyake et al., 2000). EF capacity is associated with diverse outcomes throughout the lifespan, like school and job success, mental and physical health, marital harmony, and the likelihood for risk-taking and criminal behavior (Diamond et al., 2013).

At the neural level, EF is supported by a superordinate cognitive control network, which includes dorsolateral prefrontal, anterior cingulate, and parietal cortices (Friedman & Miyake, 2017; Niendam et al., 2012; Smolker et al., 2018). The prefrontal cortex is thought to play a central role in this network, by coordinating activity across diverse areas (Friedman & Miyake, 2017). EF development is a protracted process. Basic EF components emerge during infancy, show marked improvements during toddlerhood and the preschool years, and develop through adolescence and early adulthood into more complex EF capacities (Best & Miller, 2010; Ferguson et al., 2021). Individual differences in EF have been suggested to be almost entirely driven by heritable components (Engelhardt et al., 2015; Friedman et al., 2008). There is however robust evidence of environmental influences on EF development. Both positive parental caregiving behaviors (e.g., sensitivity and scaffolding) and adverse family environments (e.g., disorganized/ unpredictable family life, maltreatment and neglect) have been associated with children's EF development (Hughes, 2011; Hughes & Devine, 2019). The role of environmental factors in EF development becomes especially clear when considering orphaned and institutionalized children, who following environmental deprivation characterized by e.g. inadequate caregiving develop a lowered EF capacity (Merz et al., 2016). Furthermore, genetically informed studies indicate that parental caregiving behavior uniquely affects EF development above and beyond the influence of hereditary components (Bridgett et al., 2018; Fujisawa et al., 2017).

An integrative framework has developed during recent years, linking together constructs like EF, effortful control and risk-taking behavior, which stem from scientific disciplines like neuropsychology, temperament theory and personality theory. Assimilating these related constructs under the joint topic of self-regulation (referring to the flexible regulation of emotion, cognition and behavior) has catalyzed research on their shared neural substrates, developmental trajectories, and roles in human functioning and well-being (Bridgett et al., 2015; Nigg, 2017). Simultaneously, knowledge about the role of EF for everyday functioning has broadened from primarily cognitive processes to include e.g. Theory of Mind (Wade et al., 2018) and emotion regulation (Zelazo & Cunningham, 2007).

EF is usually assessed with standardized neuropsychological tasks performed in a controlled environment. Performance on EF tasks is typically fractioned. As described by Friedman & Miyake (2017), this is in part due to the diversity and complexity of the measured construct. Different tasks capture separate aspects of EF, resulting in low intercorrelations between an individual's task performances. EF measurement is also complicated by task impurity. Because EF involves controlling lower-level processes, any EF measure also taps onto nonexecutive processes (Friedman & Miyake, 2017). Due to these circumstances, it is recommendable to base EF assessment on multiple tasks. Combining results from several measures (which include different lower-level processes) in latent variables captures EF-specific variance more reliably than single tasks (Friedman & Miyake, 2017). Another psychometric challenge concerning EF assessment is that these tasks typically show low test-retest reliability. This is understandable, given that EF is activated especially in novel situations (Chan et al., 2008), and repeated encounters can reduce a task's efficiency in capturing EF (Miyake et al., 2000). Considering these measurement-related challenges, latent variables that reflect the joint variance of several novel EF tasks are best suited for reliable assessment.

1.2. Executive functioning and parental caregiving

Although EF plays a central role in our everyday lives, knowledge about its role in parenting is limited. During the past decade, parental EF has been increasingly studied. Findings indicate that EF is a central component of parenting alongside e.g. stress and emotion regulation systems (Barrett & Fleming, 2011). Reviews summarizing research on the parental EF/caregiving association conclude that higher parental EF is generally linked to involved, sensitive caregiving, while lower EF is associated with harsher caregiving and an increased risk of engaging in child maltreatment (Bridgett et al., 2015; Crandall et al., 2015). The connection between parental EF and caregiving quality is understandable when childcare is considered from a neuropsychological perspective. Children's continuously changing developmental needs are equated with a constant stream of novel caregiving tasks for parents, requiring higher-order EF like flexible problem-solving and planning (Azar et al., 2008). From the angle of core EF components, parents utilize their working memory capacity to maintain and manipulate childcare-related information in their mind. Set-shifting ability is required to flexibly shift attention between diverse situational demands in occasionally highly stimulating settings, while inhibitory control allows parents to pay attention to their child's needs and respond to them in a timely and contingent way (Barrett & Fleming 2011).

In 2010, Deater-Deckard and colleagues published the first study on parental EF in relation to caregiving behavior. They found lower working memory to be related with more negative reactions to challenging child behavior among mothers of 6-year-olds, implicating working memory in the etiology of harsh parenting. Interestingly, maternal verbal and spatial abilities did not moderate the association between child challenging behavior and the mother's negativity towards the child. Hence, EF seems to have a different effect on caregiving behavior than other cognitive capacities (Deater-Deckard et al., 2010). In a subsequent study, Deater-Deckard and colleagues (2012) diversified the assessment of maternal EF by utilizing a composite based on several EF tasks. Among mothers of 3–7-year-olds, child conduct problems were associated with harsh parenting only among mothers with lower EF. This was interpreted to indicate that maternal EF could be a central component in the regulation of negative parental emotions that arise from challenging child behavior, i.e., mothers with lower EF are less able to cognitively control their emotions and behaviors which results in more reactive negative parenting (Deater-Deckard et al., 2012). Focusing on positive caregiving behavior, Gonzalez and colleagues (2012) found better maternal EF (measured with set-shifting and spatial working memory tasks) to be associated with more maternal sensitivity during interactions with infants. The authors interpreted that working memory and set-shifting centrally influence the capacity to recognize and attend to an infant's cues, as well as to integrate environmental demands with the infant's needs (Gonzalez et al., 2012). Similarly, Chico and colleagues (2014) also found better maternal EF to be associated with more sensitive caregiving during mother-infant interactions. Interestingly, the EF components were differently associated with caregiving depending on maternal age. Only in adult mothers, lower spatial working memory was associated with more time engaged in instrumental caregiving and reduced attention to the infant. In contrast, poorer set-shifting ability was associated to lower maternal sensitivity only among teenage mothers. This exemplifies how EF can be differently related to caregiving behavior among teenage mothers, whose EF development is still ongoing. Moving from cross-sectional studies to a longitudinal perspective, Cuevas and colleagues (2014) reported lower maternal EF (measured with an EF composite) to be associated with more negative caregiving, which was repeatedly assessed as the children were 10, 24 and 36 months old. Parental EF has also been examined in relation to caregiving within ADHD populations, as EF deficits are a central aspect of ADHD. One review (Johnston et al., 2012) and one meta-analysis (Park et al., 2017) have been published on this topic. In line with the maternal EF/caregiving findings from general population samples, parental ADHD symptoms are associated with more harsh and lax caregiving (Park et al., 2017), like over-reactive and inconsistent discipline, less monitoring of child behavior, less effective child-rearing problem-solving, and family disorganization and chaos (Johnston et al., 2012).

Publications from the first decade of research on parental EF and caregiving indicate that besides being directly associated, these parental variables are also associated in other, more complex patterns. For example, the associations between parental EF and caregiving behavior can be modified by the parent's stress levels. Firstly, some research findings indicate a *cumulative stressor effect*. As larger stress loads equal greater demands on self-regulatory capacities, EF capacity has a stronger influence on caregiving behavior when stress levels are high. Chary and colleagues (2020) reported a finding adhering to this pattern. In their study, poorer maternal EF predicted more negative caregiving behavior only among mothers experiencing more restlessness and night waking, and not among mothers with better sleep quality. In other words, the burden of poor sleep quality intensified the effect of maternal EF on caregiving behavior. Secondly, some findings point to an *overriding stressor effect*, diminishing the positive influence of better EF in the reduction of negative parenting. Chary and colleagues (2020) found that better EF was associated with less negative parenting, but only among mothers with moderate to long sleep durations, and not among mothers with short sleep durations. Thus, short sleep durations seem to override the effect of better EF in minimizing negative caregiving behaviors. A similar pattern was reported by Deater-Deckard and colleagues (2012), who found maternal EF to be associated with harsh caregiving in calm, predictable environments, but not in chaotic environments.

Furthermore, maternal EF can both mediate and moderate the influence of other factors on caregiving behavior. A few studies have found adverse maternal childhood experiences/negative parenting received in childhood to be linked through maternal EF with more negative maternal caregiving behavior when caring for infants (Bridgett et al., 2017; Gonzalez et al., 2012), and for 1–5-year-old children (Guss et al., 2020). This indicates that maternal EF might be one mechanism that transmits negative parenting behaviors across generations (Bridgett et al., 2017). In contrast, Harris and colleagues (2021) did not find maternal EF to mediate an association between maternal adverse childhood experiences and caregiving behavior in a low-risk sample studied from toddlerhood to the preschool period. Considering the mothers' low levels of childhood adversity, the authors suggested that these associations might be found especially in populations experiencing high levels of childhood adversity (Harris et al., 2021). Relatedly, Sturge-Apple and colleagues (2017) found maternal EF to mediate the association between socioeconomic risk (operationalized as maternal education, family income-to-needs ratio, and level of chaos in the neighborhood) and maternal sensitivity during caregiving of 3.5-5-year-old children. Furthermore, Sturge-Apple and colleagues (2014) found that among mothers of 3-year-olds, working memory moderated the association between dysfunctional child-centered responsibility attributions and harsh parenting. The authors concluded that poorer working memory could make mothers more susceptible to the influence of negative child attributions in discipline situations, while a better working memory capacity could allow mothers to better disaggregate parenting from negative child-oriented attributions.

To date, there is still scarce knowledge concerning how parental EF and caregiving behavior jointly influence child development and well-being. The few studies in the area have primarily focused on child EF. Cuevas and colleagues (2014) found maternal EF and negative caregiving behavior to each account for unique variance in child EF during toddlerhood, concluding that although maternal EF and negative caregiving are related, they might have unique influences on child EF development. Distefano and colleagues (2018) found that both maternal and child EF were associated with maternal autonomy-supportive parenting, and that maternal autonomy-supportive behaviors mediated the link between mothers' and 3–5-year-old children's EF. Korucu and colleagues (2020) found maternal EF to be associated with child EF partly through mothers' engagement in EF-specific activities. Taken together, these studies indicate that the effect of parental EF on caregiving behavior is reflected in child developmental outcomes, underscoring the relevance of further parental EF research.

In summary, the emerging research field of parental EF has established that EF is directly associated with caregiving behavior (Bridgett et al., 2015; Crandall et al., 2015), that the EF/caregiving association can differ depending on the parent's stress levels (Chary et al., 2020; Deater-Deckard et al., 2012), and that EF can mediate/moderate the influence of various parenting determinants on caregiving behavior (Bridgett et al., 2017; Gonzalez et al., 2012; Guss et al., 2020; Sturge-Apple et al., 2014; Sturge-Apple et al., 2017). Consequently, EF should be considered within parenting interventions/research as one of the parental variables that shape caregiving behavior. To facilitate this, further studies within diverse populations on the role of parental EF in caregiving behavior are needed, clarifying the joint effects of EF and different parenting determinants on caregiving behavior. As the first years of life constitute a sensitive period during which psychosocial influences like caregiving behavior produce long-term effects on child development (Wachs et al., 2014), research on parental EF is especially called for during early parenthood.

1.3. Psychological distress, executive functioning and caregiving

When studying parental EF in relation to caregiving behavior during early parenthood, it is important to consider parental psychological distress for several reasons. Firstly, psychological distress is known to be negatively associated with adult EF. Common adversities like the lack of social support, sadness, and sleep deprivation are generally negatively associated with EF (Diamond, 2013). Acute stressors, i.e. stressors that occur and cease relatively quickly (like the Trier Social Stress Test), have been found to impair working memory and set-shifting capacity, while concurrently having a facilitatory effect on response inhibition (see Shields et al., 2016, for a review of acute stress and EF among adults). Chronic stressors, i.e. stressors that persist over time like unemployment, poverty and inadequate housing, have not been as extensively studied in relation to EF. There are however a few reports of links between chronic stress and poorer EF performance among young adults (Orem et al., 2008; Tomeo, 2014). Furthermore, chronic stress occurring over the lifespan has been associated with structural changes in brain regions that are central for EF (Shields & Slavich, 2017). Taken together, these studies suggest that besides acute stress, chronic stress can also have a deleterious influence on adult EF capacity.

Secondly, as described above in section 1.2, parental stress levels have been found to modify associations between parental EF and caregiving behavior. Both cumulative stressor effects, (larger stress loads strengthening the effect of parental EF on caregiving behavior) and overriding stressor effects (higher stress levels overriding the effect of EF on caregiving) have been reported (Chary et al., 2020; Deater-Deckard et al., 2012). These studies indicate that parental stress levels should be taken into account to better understand associations between parental EF and caregiving behavior.

Thirdly, several stressors that are negatively associated with EF are common during early parenthood. The transition to parenthood along with the first years of parenthood are often experienced as happy and gratifying times. However, this period can simultaneously be stressful and challenging. Young children's caregiving needs can be taxing and negatively influence parental well-being, taking the form of parental depression and anxiety, sleep disturbance, and strained partner relationships (Canário & Figueiredo, 2017; Nelson et al., 2014).

In the following paragraphs, research on these psychological distress domains is reviewed, focusing on their prevalence during early parenthood and on their associations with adult EF.

Depression and anxiety are frequent during early parenthood. Postpartum depression has a global prevalence of 17.7% during the first year after delivery (Hahn-Holbrook et al., 2018), while 8.5% of mothers experience one or more anxiety disorders during this time (Goodman et al., 2016). Postpartum depression usually emerges during the first few months after delivery and typically remits within a few months, but a chronicity can develop. According to Goodman (2004), up to one third of the mothers who experience postpartum depression still suffer from depressive symptoms at two years after delivery (Goodman, 2004). Similarly, longitudinal findings of depression and anxiety symptom trajectories stretching 2.5 years into the postpartum period indicate that these parental psychological distress symptoms can last beyond infancy into toddlerhood (Canário & Figueiredo, 2017). Both depression and anxiety are negatively associated with adult EF capacity (see e.g. Castaneda et al., 2008; Snyder, 2013). In their review of the association between psychopathologies and EF impairments, Snyder and colleagues (2015) describe a wealth of evidence indicating that adults suffering from different psychopathologies (like depression and anxiety) perform worse on EF tasks than healthy controls. In the context of parenthood, there are findings of maternal symptoms of depression/anxiety being associated with lower EF as early as in the prenatal period. Kataja and colleagues (2017) reported that mothers who had higher levels of depression/pregnancy related anxiety symptoms during pregnancy performed significantly poorer on an EF task than mothers reporting low symptom levels.

Sleep disturbances, like shorter sleep duration and nighttime awakenings, are common among mothers of young children. Of mothers with children younger than three years, approx. 30% feel that their daytime functioning is influenced by their child's sleep pattern (Mindell et al., 2015). Insomnia is known to be negatively associated with adult EF: adults diagnosed with insomnia perform worse on EF tasks than healthy controls (Ballesio et al., 2019). Relatedly, there are reports of sleep deprivation triggering brain activity changes, which predict the severity of impairment in working memory tasks (Krause et al., 2017). Sleep patterns and EF have also been found to be associated in the context of early parenthood. Chary and colleagues (2020) reported that for mothers of 2.5-year-olds, both maternal sleep activity (i.e., night waking and restlessness) and sleep duration came together with EF to statistically interact in predicting the degree of harsh parenting.

Couple relationship quality declines for some couples during the early parenthood years. This is understandable, as the infant's needs of care and attention reduces the amount of time parents can spend together or by themselves, and parents are required to cope with sometimes stressful caregiving situations (Kluwer, 2010). A small but reliable decrease in couple relationship quality is common during early parenthood, with approx. 50% of the couples in western countries experiencing these negative changes. Longitudinal studies furthermore suggest that this decline in couple relationship quality can endure over time, influencing couples for several years after childbirth (Kluwer, 2010). The effects of poor couple relationship quality on EF have not been widely studied, but an association is likely, as poor couple relationship quality is a well-recognized stressor that can have wide-reaching negative health effects (Cohen et al., 2019), and stressors are known to influence adult EF negatively (Diamond, 2013). In studies of couples' interactions that have included physiological assessments, marital conflict has been associated with health-related physiological mechanisms, like cardiovascular activity, alterations in stress hormones, and dysregulation of immune function (Robles & Kiecolt-Glaser, 2003). Similar physiological mechanisms are implicated in the research linking chronic stress to structural changes in brain regions that are central for EF (Shields & Slavich, 2017). This further strengthens the likelihood of an association between poor couple relationship quality and a lowered EF capacity.

To summarize, psychological distress is generally known to be negatively associated with adult EF, parental stress levels have been found to modify associations between parental EF and caregiving behavior, and several stressors that are negatively associated with EF are prevalent during early parenthood. Hence, research on the links between psychological distress and parental EF during early parenthood is called for, to shed light on mechanisms that can directly affect parental EF levels, as well as modify the influence of EF on caregiving behavior.

1.4. Alexithymia, caregiving, and executive functioning

In the exploration of the interplay between EF and other parenting determinants in relation to caregiving behavior, the joints effects of parental EF and personality traits are poorly understood. Personality traits are relatively stable emotional, cognitive, and behavioral reaction patterns, which influence how individuals experience, interpret, and respond to their environment (McCrae & Costa, 2006). Decades of research has indicated that parental personality influences the quality of caregiving behavior (Belsky, 1984; Prinzie et al., 2009). In their meta-analysis, Prinzie et al. (2009) conclude that parental personality is modestly but meaningfully related to caregiving behavior. Basing their conceptualization of personality on the most predominant model of personality structure, the Five-Factor Model (McCrae & Costa, 2006), Prinzie et al. (2009) reported that across studies, parents who are agreeable, emotionally stable, extraverted, conscientious, and open to experience, engage in more warm and structured caregiving behavior.

Among the personality constructs that could be studied in relation to parental caregiving behavior, alexithymia appears to be particularly relevant as it encompasses personality traits related to emotion processing and regulation, and emotion regulation is known to centrally influence the quality of parental caregiving behavior (Rutherford et al., 2015). The word "alexithymia" translates from ancient Greek into "no words for emotion". This personality construct is characterized by a decreased ability to identify and verbalize emotions, an externally oriented thinking style, i.e., thinking pragmatically and lacking interest in emotional experiences and introspection, and a limited imaginative capacity (Sifneos, 1973). These features are believed to impede emotion regulation, predisposing individuals with alexithymic traits to psychological and somatic symptoms. Relatedly, alexithymia has been linked with numerous physical and mental health problems, like pain disorders, cardiovascular disease, substance abuse, somatization, depression, and anxiety (Kajanoja, 2019).

Comparing alexithymia levels (as measured with the Twenty-Item Toronto Alexithymia Scale) to the Five-Factor Model of personality (as measured with the Revised NEO Personality Inventory) among British undergraduate students, Luminet et al. (1999) found alexithymia to reflect individual differences in emotional experiences and behavior, which were captured by an intricate combination of specific personality traits. On the level of personality dimensions, higher alexithymia levels were associated with lower emotional stability, lower extraversion, and lower openness. On the level of lower order traits, higher alexithymia levels were associated with a higher tendency to experience depressive affect, a lower tendency to experience positive emotions, a lower openness to emotions and actions, a lower tendency for altruism and tender-mindedness, a higher tendency for modesty, and a lower experience of competence. These findings were interpreted to indicate that individuals with high levels of alexithymic traits are likely to experience undifferentiated emotional distress, have difficulties in regulating negative affect, experience anhedonia, have difficulties to form close emotional relationships, lack receptivity to feelings, have a limited range of emotional experiences, lack interest to try new activities, prefer familiarity and routine, lack empathy, make rational decisions based on cold logic, be modest rather than arrogant, and have low self-esteem. Although generalizations from these findings to clinical populations should be made cautiously, as they are based on university students who generally score in the low range on alexithymia measures, the results indicate that the alexithymia construct captures individual differences in how emotions are experienced and how they influence behavior (Luminet et al., 1999).

Within the general Western population, alexithymic traits appear to be normally distributed. Approximately 10% of the population cross the threshold criterion for alexithymia, which is more common among men, and among individuals with higher age, lower education level, depression, and poorer perceived health (Franz et al., 2008; Mattila et al., 2006). In contrast, alexithymia seems to be less frequent among parents, with a prevalence of 2.8% among mothers and 6.0% among fathers in the FinnBrain Birth Cohort Study (Kajanoja et al., 2017). This discrepancy has been hypothesized to be associated with the negative effects of alexithymia on intimate relationships, resulting in an underrepresentation of these personality traits among parents (Kajanoja et al., 2017). Although alexithymic traits are likely to have a negative influence on parenting, considering that parental emotion processing and regulation is known to affect caregiving behavior, the research field of parental alexithymia is still novel. Recently, two studies have reported associations between maternal alexithymic traits and caregiving behavior during early parenthood within both general population and clinical samples (Ahrnberg et al., 2021; Porreca et al., 2020). Studying partly the same general population mothers as the present thesis, Ahrnberg and colleagues (2021) found that higher levels of maternal alexithymic traits were associated with less sensitive and more hostile caregiving behavior during a free-play situation at 8 months postpartum. Exploring these links in a sample of mothers with substance use disorder, among whom alexithymia was highly prevalent with 43% of the participants reaching the threshold for alexithymia, Porreca and colleagues (2020) reported higher levels of alexithymic traits to be associated with poorer maternal structuring during a free-play situation. This was interpreted to indicate that a parent's difficulties in becoming aware of feelings might jeopardize the ability to scaffold caregiving interactions and set age-appropriate limits for the child in an emotionally attuned way.

In summary, although knowledge about the influence of parental alexithymic traits on caregiving behavior is still limited, this personality dimension is likely to be a determinant of caregiving behavior, considering that it conceptualizes individual differences in how emotions are experienced and influence behavior (Luminet et al., 1999), and emotion processing and regulation are known to centrally influence the quality of parental caregiving behavior (Rutherford et al., 2015). The few studies that have explored this topic confirm that higher levels of alexithymic traits are indeed associated with poorer caregiving quality (Ahrnberg et al., 2021; Porreca et al., 2020). Consequently, further studies on the links between alexithymic traits and caregiving behavior are needed within varied populations and during different child developmental phases, to better understand how this parenting determinant shapes caregiving. Considering its relevance in the context of parenting, alexithymic traits also appears to be an especially suitable personality construct to include in studies exploring the joint effects of parental EF and other parenting determinants on caregiving behavior.

1.5. Emotional availability

To date, few studies have examined parental EF in relation to caregiving behavior within observation frameworks that can be employed in clinical practice. One such framework is emotional availability (EA; Biringen et al., 2014). The EA framework describes a parent-child dyad's capacity to share an emotionally healthy relationship, which is central for supportive and effective caregiving behavior. As EA focuses on the emotional components of the dyad's relationship, it is especially well-suited for research on the joint effects of EF, psychological distress, and alexithymic traits on caregiving behavior, considering that emotional processes are central components of both psychological distress and alexithymia.

While being rooted in attachment theory, EA broadens the conceptualization of dyadic interaction to include several aspects of parental functioning, i.e., sensitivity, structuring, non-intrusiveness and non-hostility. The EA framework recognizes the child's role in the dyadic interaction, and highlights the emotional feedback loop between the child and the parent (Biringen et al., 2014). A dyad's EA is related to multiple outcomes in the child, like language abilities, social competence, emotion regulation, and internalizing/externalizing problems (Saunders et al., 2015). EA has also been found to have neurobiological implications, and has been linked to child stress physiology (Clark et al., 2021).

A parent-child dyad's EA can be operationalized with the Emotional Availability Scales (EAS). The EAS is an observational rating system that differentiates parent and child experiences and perspectives, and it can be utilized from infancy to adolescence. Within the EAS, the parent's behavior is viewed and rated in a manner that depends on the child's ways of responding. Parental sensitivity is the ability to attend to the child's emotional needs and behavioral cues. Parental structuring refers to the ability to support the child's autonomy and activities through scaffolding, guidance and mentorship. Parental non-intrusiveness is the lack of interference with the child's behavior through over-stimulation, over-protection, over-direction or interference. Parental non-hostility is the absence of intentional or unintentional hostile acts that are directly target towards the child (Biringen et al., 2014).

The role of maternal variables like "mind mindedness", sociodemographic variables, depression, and substance abuse have been examined in relation to EA (Biringen et al., 2014). However, less is known about the role of parental EF in EA. To date, only two studies have explored the role of parental EF in EA. Studying 114 mostly highly educated Canadian mothers, Harris and colleagues (2021) combined inhibitory control and set-shifting measurements into an EF composite, and performed repeated EA assessments as the children were one-and-a-half, three, and five years old. A positive association between maternal EF and EA trajectories was found, with higher maternal EF predicting an increase in EA over time. Similarly, Porreca and colleagues (2018) reported better maternal EF to be significantly associated with higher EA in a sample of 29 Italian mothers with substance abuse disorder, who were assessed as their children were approx. two years old. These findings point to maternal EF as one of the individual maternal factors that molds EA. To support and expand knowledge about these associations, further studies on EF/EA associations within diverse samples are needed. As the joint influence of EF with psychological distress/alexithymic traits on EA is yet to be studied, an exploration of these associations would shed more light on the role of parental EF in EA.

1.6. Summary of the current literature

Taken together, the first decade of parental EF research indicates that EF is one of the variables at the level of the individual parent that should be considered in parenting research and clinical interventions (Bridgett et al., 2015; Crandall et al., 2015). To facilitate this, more studies on the links between parental EF and caregiving behavior in varying populations are required. One framework for conceptualizing caregiving behavior that is especially relevant to study in this context is EA, which is suitable for caregiving behavior assessments within both clinical practice and research settings, and is related to multiple child outcomes (Saunders et al., 2015). Two recent publications point to maternal EF having an effect on EA (Harris et al., 2021; Porreca et al., 2018), underscoring the relevance of further studies in this area. Considering that parenting has an especially large impact on child development during the first years of life (Wachs et al., 2014), research on parental EF is particularly important during early parenthood.

The current parental EF literature sheds some light on the complexity of the EF/caregiving association. For example, findings indicate that these links can vary depending on parental stress levels (Chary et al., 2020, Deater-Deckard et al., 2012). When also considering that psychological distress is negatively associated with adult EF (Ballesio et al., 2019; Castaneda et al., 2008; Cohen et al., 2019; Snyder et al., 2015), and that several domains of psychological distress are prevalent during early parenthood (Canário & Figueiredo, 2017; Kluwer, 2010; Mindell et al., 2015), it becomes clear that studies on parental EF during early parenthood should take psychological distress into account.

Parental EF has furthermore been found to mediate/moderate the effects of other parenting determinants on caregiving behavior. One parenting determinant which is yet to be studied in this context is alexithymia. As this personality construct has been associated with parental EA, future studies on the joint effect of alexithymic traits and EF on EA would offer more insight in the mechanisms behind the alexithymia/EA link.

Finally, due to the complexity and diversity of EF, and due to task impurity issues that accompany EF assessments, it is recommendable to base EF assessment on multiple, preferably novel tasks. Hence, parental EF studies benefit from utilizing latent EF variables that reflect the joint variance of several EF tasks.

1.7. Study aims

The current thesis aimed to expand the knowledge about parental EF during early parenthood, by exploring the associations between maternal EF and EA in a general population sample of mothers with toddlers, while also accounting for maternal symptoms of psychological distress and alexithymic traits. The specific aims and hypotheses for Study I-IV are described below. The aims for Studies II-IV (which all employ the EF composite developed in Study I) are furthermore depicted in *Figure 2*.

Study I examined the latent structure of five EF/learning tasks from the computerized neuropsychological test battery Cogstate, by comparing two single-factor EF/learning models including either summative scores for each task, or first test round results for the tasks providing this data. The suitability of sum scores based on these two models to assess EF/learning among healthy adults was also evaluated. The model including summative scores was expected to tap more onto learning, while the model including first test round results was hypothesized to tap more onto EF, as it highlights initial task novelty that should engage executive resources.

Study II explored whether psychological distress domains that are prevalent during early parenthood (i.e., symptoms of depression, anxiety, and insomnia, along with poor couple relationship adjustment) were associated with maternal EF among general population mothers of 2.5-year-olds, while accounting for both the effect of individual distress domains, as well as for the cumulative effect of several concurrent distress domains. Higher levels of psychological distress were expected to be associated with lower EF. Cumulative effects were hypothesized, so that the psychological distress/EF associations would be stronger when concurrently considering several domains, in comparison with the associations between single distress domains and EF.

Study III examined the association between maternal EF and EA among general population mothers of 2.5-year-olds, and furthermore, whether this association was moderated by maternal psychological distress (i.e., symptoms of depression, anxiety and insomnia). Better maternal EF was hypothesized to be associated with higher maternal EA. Furthermore, maternal psychological distress was expected to moderate this association, so that the EF/EA association would be stronger for participants with low symptom levels and weaker for participants with high symptom levels. Lastly, cumulative effects were predicted, so that cumulative distress scores would have a more pronounced moderation effect than single distress domains.

Study IV explored the association between maternal alexithymic traits and EA among general population mothers of 2.5-year-olds, and furthermore, whether this association was moderated by maternal EF. Higher levels of alexithymic traits were expected to be associated with lower maternal EA. Higher maternal EF was expected to buffer against this effect, so that the alexithymia/EA association would be weaker for participants with higher EF, and stronger for participants with lower EF.

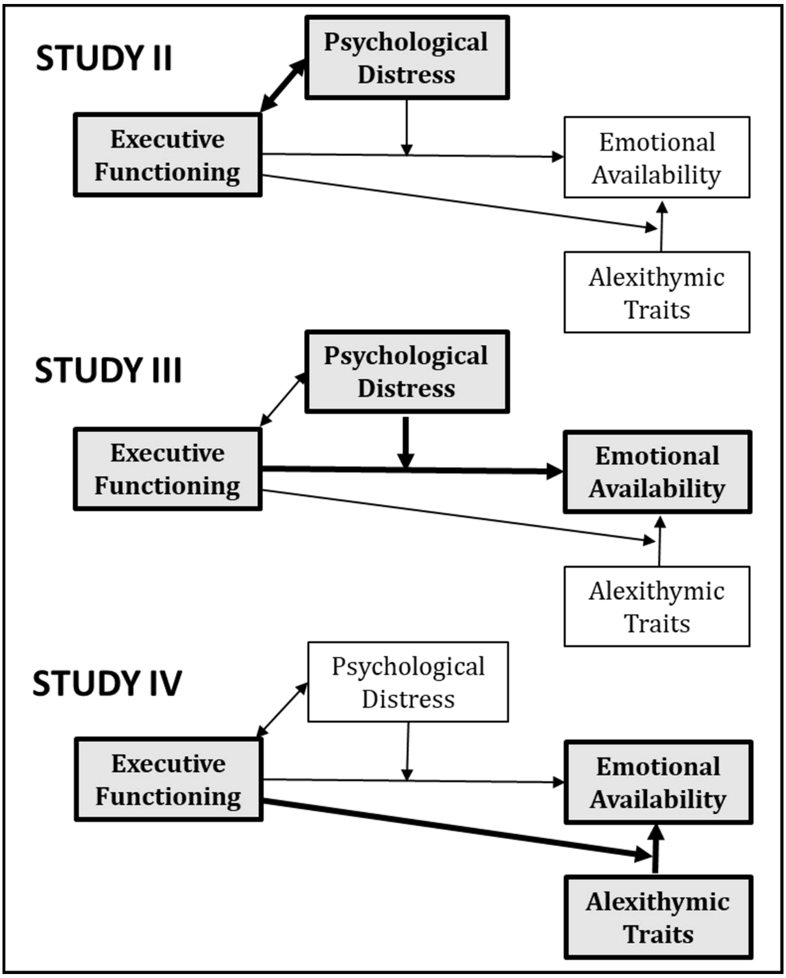


Figure 2. Aims for Studies II-IV are indicated with grey boxes/bolded arrows.

2. MATERIALS AND METHODS

2.1. Participants

2.1.1. The FinnBrain Birth Cohort

The mothers and toddlers who participated in Study I-IV were drawn from the FinnBrain Birth Cohort Study (N = 3808 families). The FinnBrain Study is a Finnish pregnancy cohort, which prospectively studies the combined influence of environmental and genetic factors on child development and later health outcomes (www.finnbrain.fi). From December 2011 to April 2015, all expecting families living in the areas of the Southwest Finland Hospital District and the Åland Islands were invited during gestational week 12 to participate in the study. Recruitment took place through personal contact by a research nurse, during a free-of-charge ultrasound visit at maternal welfare clinics. Of the invited families, 66% gave written informed consent to participate in the study. The recruitment process and the sample characteristics on the FinnBrain Birth Cohort are described in more detail in Karlsson and colleagues (2018). The FinnBrain Birth Cohort is fairly representative of the general Finnish population. However, the prevalence of multiparous, younger, and smoking women, along with the prevalence of preterm births, is slightly lower in the Cohort than among all deliveries at Turku University Hospital (Karlsson et al., 2018).

2.1.2. Data collection points

The FinnBrain Birth Cohort is studied with two main methods - with questionnaires that are sent out to the whole Cohort, and with study visits organized by sub-studies within FinnBrain, to which subgroups from the Cohort are invited. The present thesis includes both data from questionnaires sent out to the whole Cohort, and data from study visits organized by the Child Development and Parental Functioning Lab, a FinnBrain sub-study. The data collection points during which Study I-IV's main variables were collected are depicted in *Figure 3*.

Questionnaire sets were sent to all families participating in the FinnBrain Study both during pregnancy (at gestational weeks 14, 24 and 34) and after birth (to date at 3 months, 6 months, 1 year, 2 years, 4 years, 5 years, and 9 years). The questionnaire sets chart, e.g., parental health and functioning, familial environment, and child health and development. Of the main variables included in this thesis, maternal alexithymic traits were assessed as part of the 6-month questionnaire, while maternal reports of couple relationship adjustment were collected as part of the 2-year questionnaire.

A sub-study within FinnBrain, The Child Development and Parental Functioning Lab, explores the early development of child self-regulation while accounting for the influence of parental variables like caregiving behavior and neurocognitive functioning. Within this sub-study, repeated study visits have been conducted both separately for mothers (during pregnancy, as well as 1 year, 2.5 years, and 5 years postpartum), and jointly for children and mothers (to date at 8 months, 2.5 years, 5 years, and 9 years). Of the main variables in this thesis, maternal EF was assessed during the mothers' 1-year and 2.5-year visits, while maternal symptoms of depression/anxiety/insomnia were measured during the mothers' 2.5-year visit, and EA was assessed during the joint study visit for toddlers and mothers at 2.5 years.

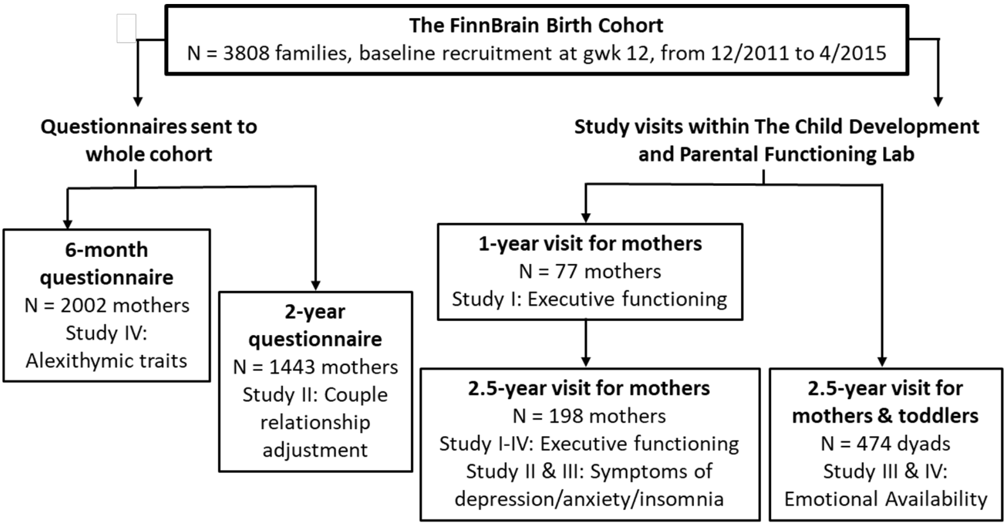


Figure 3. Flow chart of the FinnBrain data collection points from which data was included in the present thesis. The main variables employed in Study I-IV are listed according to their data collection points. The sample sizes refer to the data collection point's complete samples, of which sub samples were included in the present thesis. gwk = gestation week.

The questionnaires sent to the whole FinnBrain Cohort were both at the 6-month and 2-year-data collection points sent to all mothers who had enrolled in the study during pregnancy, and who had not chosen to interrupt their participation before the data collection points.

Recruitment to the study visits for mothers was based on a random selection of participants from the FinnBrain Birth Cohort during 2012 to 2013. Insufficient Finnish language skills and self-reported psychiatric or neurologic illness were exclusion criteria. Participants who attended the first study visit assessing neurocognitive functioning during pregnancy (N = 274) were invited back for follow-up visits at 1 year and 2.5 years after delivery. During recruitment to the 2.5-year visit, the recruitment list was expanded with mothers whose children had participated in separate study visits assessing child self-regulation.

Recruitment to the study visits for mothers and children was primarily based on a nested case-control study within the main Cohort, that was established to compare families exposed to prenatal stress with their non-exposed controls.

This Focus Cohort (N = 1227 families) included mothers reporting high/low prenatal stress and/or the use of serotonin uptake inhibitors during pregnancy, and was followed more intensely than the remaining Cohort both pre- and postnatally. The sociodemographic characteristics, as well as the mean symptom scores of depression and anxiety of the first 500 participants in the Focus Cohort resembled the rest of the Cohort. The Focus Cohort is described in more detail in the FinnBrain Cohort Profile (Karlsson et al., 2018). Mother-infant dyads were recruited from the Focus Cohort to attend a study visit organized by the Child Development and Parental Functioning Lab at 8 months postpartum (N = 427 dyads). These study visits were conducted between 2013 and 2016. Besides assessments of child temperament and emotional attention, this visit included a free-play situation. Subsequently, mothers and toddlers who had participated in the 8-month-study visit were invited back to a follow-up visit within the Child Development and Parental Functioning Lab at 2.5 years after delivery. Children who had participated in study visits organized by other FinnBrain sub studies were additionally invited to participate in the 2.5-year study visit.

2.1.3. Study I-IV samples

The study samples in Study I-IV included all participants for whom data on the main study variables of interest had been collected.

In Study I, the main study variable was maternal neurocognitive functioning. As a more extensive neurocognitive test battery was utilized during the 1-year and 2.5-year follow-up visits than during the pregnancy assessments, the pregnancy data was excluded from Study I. For each participant, results from only one data collection point were included in Study I, i.e., either from the 1-year or from the 2.5-year data collection point. To obtain optimally equal group sizes from the two data collection points, and because the 1-year sample (N = 77 mothers) was smaller than the 2.5-year sample (N = 198 mothers), data from the 1-year measurements were included in Study I for the mothers who had attended both measurement points. Consequently, in Study I the final sample consisted of 233 mothers. For 76 mothers the neurocognitive data had been collected at 1 year after delivery, while it had been collected at 2.5 years after delivery for 157 mothers.

In Study II, the main study variables were neurocognitive functioning and depression/anxiety/insomnia symptoms which were assessed during the mothers' 2.5-year study visit, along with couple relationship adjustment that was assessed as part of the 2-year questionnaire set. Of the 198 mothers who had completed the study visit at 2.5 years, 150 mothers had also filled out the questionnaire measuring couple relationship adjustment at 2 years after delivery. Thus, these 150 mothers formed the final sample in Study II.

In Study III, the main study variables were neurocognitive functioning and symptoms of depression/anxiety/insomnia assessed during the mothers' 2.5-year study visit, along with the dyad's EA that was assessed based on the free-play situation included in the mothers' and toddlers' joint 2.5-year study visit. Of the 198 mothers who had completed the study visit at 2.5 years, 137 had also participated in the joint study visit for mothers and toddlers at 2.5 years. Thus, these 137 mothers were included in the final Study III sample.

In Study IV, the main study variables were maternal alexithymic traits assessed as part of the 6-month questionnaire set, neurocognitive functioning measured during the mothers' 2.5-year study visit, and the dyad's assessed based on the free-play situation included in the mothers' and toddlers' joint 2.5-year study visit. Of the 198 mothers who had completed the study visit at 2.5 years, 137 had participated in the joint 2.5-year study visit for mothers and toddlers. Of these 137 mothers, 119 had completed the alexithymia questionnaire at 6 months after delivery. Hence, these 119 mothers formed the final sample in Study IV.

It is central to note that although the study samples are not completely overlapping, there is a large degree of overlap between the samples in Study I-IV. As shown at the center of *Figure 4*, 89 mothers were included in all four samples. Consequently, the studies included in the current thesis present results from partially the same group of mothers.

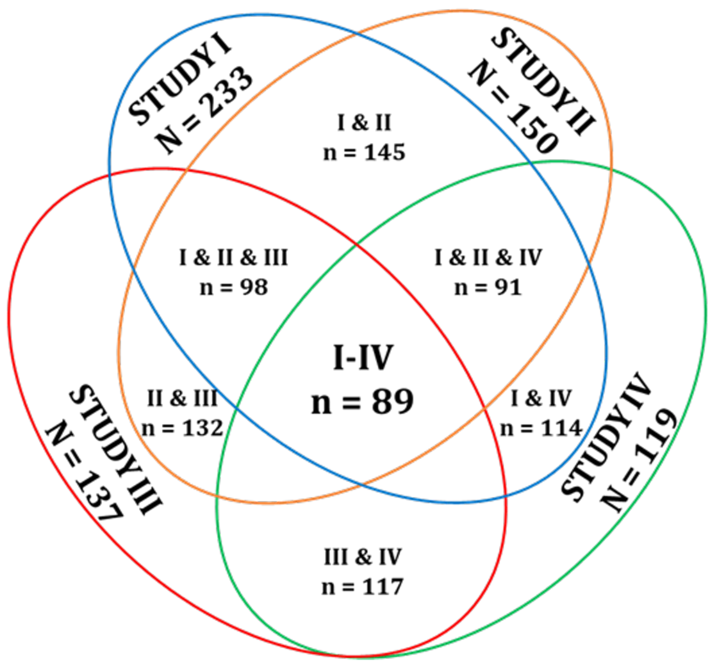


Figure 4. Overlap of participants included in Study I-IV. Capital N indicates the sub-studies' complete sample sizes, while lowercase n indicates the number of participants included in multiple study samples.

As can be seen in *Table 1*, the sociodemographic characteristics of the participants included in Study I-IV were very similar. On a group level, the sociodemographic data reflects that these were not disadvantaged populations. During pregnancy, the mothers were fairly highly educated (almost half reported a university level education), and roughly four-fifths of the mothers were employed. At two years after delivery, a large proportion of the mothers reported being in a partner relationship. Furthermore, at 2.5 years after delivery none of the mothers were teenagers, and quite many were primiparous.

In comparison to the remaining mothers in the whole FinnBrain Cohort, the participants in Study I-IV were on average both older (Study I: $t[3806] = 3.96$, $p = .00$; Study II: $t[3806] = 4.40$, $p = .00$; Study III: $t[3806] = 2.39$, $p = .02$; Study IV: $t[3806] = 2.04$, $p = .04$) and had attained a higher level of education (Study I: $X^2[2, N = 3078] = 29.93$, $p = .00$; Study II: $X^2[2, N = 3078] = 26.19$, $p = .00$; Study III: $X^2[2, N = 3078] = 13.53$, $p = .0$; Study IV: $X^2[2, N = 3078] = 10.79$, $p = .01$).

Table 1
Sociodemographic characteristics of the participants in Study I-IV

	Study I (n = 233)			Study II (n = 150)			Study III (n = 137)			Study IV (n = 119)		
	%	*M*(*SD*)	Range	%	*M*(*SD*)	Range	%	*M*(*SD*)	Range	%	*M*(*SD*)	Range
Age		33 (4.7)	21.8-46.3		35.8 (4.47)	24.05-46.18		34.30 (4.83)	21.81-44.92		34.17 (4.71)	21.8-44.92
Parity												
Primiparous	42.9			34			62.5			41.2		
Education level												
University	44.8			48.7			46.3			45.4		
Polytechnics	33.5			32.0			29.4			29.4		
High school/vocational	21.7			19.3			24.3			25.2		
Monthly income after taxes												
≤1500€	33.2			30.2			29.6			28.6		
1501€-2500€	55.5			59.1			57.8			59.3		
2501€-3500€	10.5			8.7			10.4			9.3		
≥3500€	0.9			2			2.2			2.5		
Occupation												
Employed	78.6			80			78.7			78.1		
Unemployed	4.8			5.3			2.9			3.4		
Stay-at-home mother	7.0			7.3			7.4			7.6		
Student	6.6			4			6.6			5.9		
Otherwise occupied	2.6			3.4			4.4			5		
In partner relationship	69			100			73.7			79		

Data on participant age and parity were collected at 2.5 years after delivery. Data on partner relationship status was collected at 2 years after delivery. Data on education level, income, and occupation were collected at the beginning of pregnancy, i.e., approx. 3 years prior to the main variables of interest in Study II-IV.

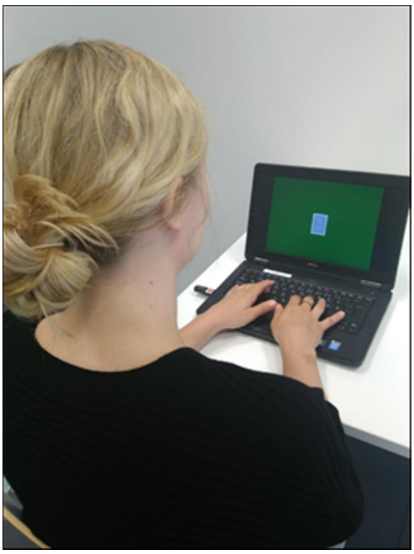
2.2. Methods

2.2.1. Procedure

Ethical approval for this study was given by the Ethics Committee of the Hospital District of Southwest Finland. Written informed consent was obtained from the mothers prior to participation in the study.

The questionnaires sent to the whole cohort were either delivered and returned as paper copies by post, or in a digital format that could be filled out and returned electronically, depending on the participants' preferences.

The study visits were conducted by graduate students in quiet examination rooms at FinnBrain's research facilities, and were overseen by psychologists/PhD candidates. During the study visits for mothers at 1 year and 2.5 years after delivery, computerized neurocognitive tasks, verbal intelligence tasks, and questionnaires assessing depression, anxiety, and insomnia were completed among other measures. The neurocognitive tasks were presented on a laptop computer under supervision, as shown in *Picture 1*. During the joint study visit for mothers and their 2.5-year-old children, a 15-20 min. long free-play situation was completed and video-recorded, among other measurements. As can be seen in *Picture 2*, the free-play situation was conducted on a comfortable floor-carpet, and age-appropriate toys were provided. The mothers were instructed to play with their children like they usually play together at home.



Picture 1. Neurocognitive testing.

Picture 2. Free-play situation.

2.2.2. Measures

2.2.2.1. Executive functioning

Maternal EF was assessed with five tasks from the computerized neuropsychological test battery Cogstate, which is designed for repeated assessments with minimal practice effects (www.cogstate.com; Pietrzak et al., 2008). As Cogstate stimuli are mostly nonverbal (e.g., pictures, mazes, and playing cards), the cultural bias in these computerized adaptions of standard neuropsychological tests is minimized (Pietrzak et al., 2009; Zhong et al., 2013). Based on the core functions that are seen as the basis for higher-order EF (Miyake et al., 2000), and in line with previous factor analytic studies on Cogstate's latent structure (Chou et al., 2015; Lees et al., 2015; Yoshida et al., 2011; Zhong et al., 2013), five Cogstate tasks were selected for the assessment of maternal EF in Study I-IV.

Following the examination of the suitability of these five Cogstate tasks for EF assessments among general population adults in Study I, the tasks were combined into an EF composite in Study II-IV. To optimize the specificity of the EF composite, first round test scores were selected as outcome variables for tasks with several test rounds (i.e., the Groton Maze Learning Test, the Continuous Paired Associate Learning Test, and the International Shopping List Test), instead of the generally recommended summative scores of all test rounds. The EF composite was constructed by 1) reversing the outcome variables for the Groton Maze Learning Test and the Continuous Paired Associate Learning Test, so that a higher score equaled a better result for all five tasks, 2) standardizing all five outcome variables, 3) calculating an average EF score, and 4) re-standardizing this EF average score. Higher values on this EF composite reflected better EF. For the few participants with excluded task scores due to insufficient result integrity/task completion rate (see section 3.1.), the EF composite was based on the mean value of the remaining task scores. The five Cogstate tasks that were first examined in Study I, and then included in the EF composite utilized in Study II-IV, are described in more detail in the next paragraphs.

The Two Back Test (TWOB) measures working memory and is based on the *n*-back paradigm. In the TWOB, a playing card is shown at the center of the screen, and the participant is to decide whether it is the same card as the one shown two cards ago. The task terminates after 32 correct responses. For the TWOB, the arcsine transformation of the square root of the proportion of correct responses was used as outcome variable in all four sub-studies in the present thesis.

The Set-Shifting Test (SETS) is similar to the Wisconsin Card Sorting Test and assesses set-shifting ability. In this task, a playing card is shown at the center of the screen, and the participant is to guess whether the card contains a target stimulus (i.e., a color or number). A sound indicates whether the response was correct, and the next stimulus is only displayed after the correct response has been made. In this way, the participant is taught the correct card dimension. After a while, the card dimension changes, and the new rule must be learnt to proceed. The task terminates after 120 correct responses. Both the total number of errors and the arcsine transformation of the square root of the proportion of correct responses were used as outcome variables in Study I, while only the arcsine transformation of the square root of the proportion of correct responses was used as outcome variable in Study II-IV.

The Groton Maze Learning Test (GML) is based on earlier hidden maze tasks. This task encompasses a notable visuospatial component and taps on multiple and more complex aspects of EF, like working memory updating, problem solving and planning. The participant is first taught the task rules in a smaller practice grid. In the actual task, the participant guesses a hidden, 28-step pathway from the top left corner to the bottom right corner of a 10 x 10 grid of tiles on the screen. Feedback is provided concerning the correctness of each guess. After an incorrect move, the participant must click on the last correct tile and then make a different choice. The task is repeated 5 times, with the same pathway. Both the total number of errors from all test rounds and the number of errors from the first test round (i.e., the round after the first learning trial) were employed as outcome variables in Study I, while only the number of errors from the first test round was utilized as outcome variable in Study II-IV.

The Continuous Paired Associate Learning Test (CPAL) measures the ability memorize sets of associations between spatial locations and simple patterns, so that later exposure to one aspect of that same information stimulates recall of the other. The task is based on the visual paired associate learning paradigm. In the CPAL, the participant is first taught the task rules with two practice figures. In the actual task, the participant is first taught where eight differently shaped and colored figures are located on the screen, which are covered by neutrally colored circles. Two additional, empty circles are also present on the screen. As the figures are one at a time shown at the center of the screen, the participant is to click on the circle under which the figure is hidden. Incorrect responses result in an error sound, and the correct response is required to proceed. During the six test rounds, the figures are presented in varied orders. Both the total number of errors from all test rounds and the number of errors from the first test round (i.e., the round after the first learning trial) were employed as outcome variables in Study I, while only the number of errors from the first test round was utilized as outcome variable in Study II-IV.

The International Shopping List Test (ISL) is a verbal list learning task, i.e., a neuropsychological measure frequently employed to assess verbal memory. In the ISL, the participant listens to a shopping list of 12 items that is read aloud, and then repeats the recalled items. The same process, with the same shopping list, is repeated three times. Both the total number of correct responses from all test rounds and the number of correct responses from the first test round were used as outcome variables in Study I, while only the number of correct responses from the first test round was used as outcome variable in Study II-IV.

2.2.2.2. Psychological distress

Symptoms of depression were measured with The Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987). EPDS is a 10-item self-report questionnaire, in which depression symptoms are reported according to how they have been experienced during the past two weeks. The questionnaire is scored using a 4-point Likert scale. The EPDS has been extensively studied and is considered to be a valid measure of postnatal depression (Smith-Nielsen et al., 2018). The total EPDS sum score (in which a higher value indicates more symptoms of depression) was utilized in Study II and III. This sum score was also further employed in slightly differing ways in the two studies. In Study II, the EPDS sum score was dichotomized (i.e., split according to the cutoff value of 11, which according to Smith-Nielsen and colleagues [2018] indicates depression), and additionally combined into a sum score of concurrently elevated distress domains with other dichotomized distress measures. In study III, the EPDS sum score was combined with other distress measures into a continuous distress composite.

Symptoms of anxiety were evaluated with the anxiety subscale from the Symptom Checklist 90 (SCL-90; Derogatis et al., 1973). This self-report anxiety subscale is comprised of 10 items, which assess anxiety symptoms experienced during the past month. Items are rated on a 5-point Likert scale. The total SCL-90 anxiety subscale sum score (in which a higher value reflects more symptoms of anxiety) was employed in Study II and III. This sum score was furthermore utilized in the studies similarly to the EPDS score. In Study II, the SCL-90 anxiety sum score was dichotomized based on the cutoff value of 7.5 points (which according to Schmitz et al. [2000] separates clinically elevated anxiety levels from subclinical levels), and subsequently combined into a sum score of elevated distress domains. In study III, the SCL-90 anxiety sum score was combined into a continuous distress composite with other distress measures.

Symptoms of insomnia were measured with the Athens Insomnia Scale (AIS; Soldatos et al., 2000). AIS is an eight-item self-report questionnaire, which is designed for brief and easy quantification of sleep difficulty based on the International Classification of Diseases (ICD-10) criteria. AIS has sound psychometric properties (Soldatos et al., 2003). The total AIS score (in which a higher value indicates more symptoms of insomnia) was utilized in Study II and III. Similarly to the EPDS and SCL-90 anxiety subscale sum scores, the AIS sum score was also further employed slightly differently in the studies. In Study II, the AIS sum score was dichotomized based on the cutoff value of 6 points (which according to Soldatos et al. [2003] indicates insomnia), and additionally combined into a sum score of elevated distress domains. In study III, the AIS sum score was combined into a continuous distress composite with other distress measures.

Couple relationship adjustment was assessed with the Revised Dyadic Adjustment Scale (RDAS; Busby et al., 1995). RDAS is a 14-item questionnaire that charts self-reported partner relationship adjustment. It has sound psychometric properties and is widely used (Turliuc & Muraru, 2013). The RDAS produces an overall marital adjustment score, in which higher scores indicate greater relationship satisfaction and lower scores indicate greater marital distress. A reversed overall adjustment score (i.e., a higher value equaled worse couple relationship adjustment) was employed in Study II. Similarly to the EPDS, SCL-90 anxiety subscale, and AIS sum scores, the RDAS sum score was also dichotomized in Study II (based on the cutoff score of 47, which according to Turliuc & Muraru [2013] differentiates distressed/non-distressed couples), and then combined into a sum score of elevated distress domains.

2.2.2.3. Alexithymic traits

Alexithymic traits were measured with the 20-Item Toronto Alexithymia Scale (TAS-20; Bagby, Parker, et al., 1994; Bagby, Taylor, et al., 1994). This self-report questionnaire is one of the most commonly used assessment methods of alexithymia, and is considered to be valid and reliable (Bagby et al., 2020). A validated Finnish-language version of the questionnaire was employed (Joukamaa et al., 2001). TAS-20 items are rated on a 5-point Likert scale. The total score ranges from 20 to 100, and higher values reflect more alexithymic traits. TAS-20 total scores exceeding 60 points are considered to indicate a high level of alexithymia, while total scores from 52 to 59 are thought to reflect a moderate level of alexithymia (Taylor et al., 1997). Besides the alexithymia sum score, the TAS-20 includes three subscales: Difficulty Identifying Feelings (DIF), Difficulty Describing Feelings (DDF), and Externally Oriented Thinking (EOT). Because the TAS-20 subscales have previously been found to associate differently with caregiving behavior (Ahrnberg et al., 2020), we included both the TAS-20 sum score and the three subscales in the analyses. Prior to the inclusion in the EOTxEF interaction term, the EOT subscale was standardized.

2.2.2.4. Emotional availability

Maternal EA was coded based on the mothers' caregiving behavior during a free-play situations with their toddlers, using the Emotional Availability Scales (EAS, 4th ed.; Biringen, 2008). The EAS assesses a dyad's ability to share an emotionally healthy relationship (Biringen et al., 2014). This behavioral coding system separates four dimensions of parental caregiving behavior. *Sensitivity* refers to the parent's ability to be emotionally connected with the child. A sensitive parent has an authentic and positive emotional presence in caregiving situations, while appropriately interpreting and flexibly reacting to the child's emotional cues. Sensitive parenting is reflected by the child's enjoyment of the interaction. *Structuring* describes the parent's capacity to mentor the child's pursuits, while simultaneously strengthening the child's sense of autonomy. An optimally structuring parent scaffolds the interaction in an unforced way, offering subtle suggestions to guide the child in the right direction for the situation, while also setting boundaries appropriate for the situation. Structured parenting is mirrored by the child's explorative stance and receptiveness to guidance. *Non-Intrusiveness* describes the parent's ability to be available to the child without being intrusive, i.e., being overprotecting, overstimulating, interfering, or overdirecting. A non-intrusive parent has the ability to let the child lead the interaction when appropriate, and can respect the child's ongoing activities and wishes. *Non-Hostility* refers to the absence of overt or covert behavior that is threatening, hostile, or frightening to the child. A non-hostile parent is emotionally well-regulated, does not lose composure in challenging situations, and creates a non-hostile emotional climate for the child. The EAS also comprises two dimensions that describe the child's part of the interaction (responsiveness and involvement), which were not included in this thesis as the focus was on parental behavior in the caregiving context.

The EAS have been extensively studied and are considered to be a valid and sensitive measure of relational dyadic affective quality. Dyadic EA as assessed with the EAS has been found to be predictive of central aspects of child development and well-being, like child–parent attachment and child socioemotional adaptation (see Biringen et al.[2014] for a review of the EAS' psychometric properties/the links between dyadic EA and child outcomes). Reports of moderate to strong short-term test-retest reliability when comparing EAS assessments completed at home and in a laboratory environment (Bornstein et al., 2006; Endendijk et al., 2019) indicate that the EAS parental dimensions reliably reflect dyadic characteristics that transcend both time and context.

The EAS dimensions are scored from 1 to 7 points, on a 14-point Likert scale. For all dimensions, a higher score equals better EA. Scores from 1 to 2 are considered highly problematic, scores from 2.5 to 3.5 indicate detachment in the relationship, scores from 4 to 5 are viewed as somewhat problematic and indicate complicated EA, while scores from 5.5 to 7 are indicative of healthy EA in the relationship (Biringen & Easterbrooks, 2012). The coding was performed by three coders who had received training and a certificate of reliability from the developer of the EAS (Zeynep Biringen). Interrater-reliability was checked for 1/10th of the 474 free-play episodes conducted during the joint study visit for mothers and toddlers at 2.5 years. Divergent coding was negotiated between the coders. The intraclass correlation coefficient for sensitivity ranged from 0.83 to 0.91, for structuring from 0.84 to 0.91, for non-intrusiveness from 0.84 to 0.90, and for non-hostility from 0.70 to 0.85. In Study III & IV, the four parental EAS dimensions were combined into an EA composite. Higher values on this caregiving composite describe better EA, i.e., more sensitivity, more structuring, less intrusiveness, and less hostility.

2.2.2.5. Covariates

The analyses in Study I did not require the inclusion of covariates. However, associations between the Cogstate EF measures and EF-related background variables (i.e., age, education level, and verbal intelligence) were probed. In Study II-IV, the associations between the dependent variables and covariates (i.e., participant age, parity, education level, verbal intelligence) were examined. As only educational attainment correlated significantly with the dependent variables, this covariate was included in the subsequent analyses in Study II-IV.

Verbal intelligence was assessed with the Wechsler Adults Intelligence Scale-Fourth Edition, Verbal Comprehension Index (WAIS-IV VCI; Wechsler 2012). The WAIS-IV is a widely used intelligence test for adults, and the VCI is based on the verbal subtests Information, Similarities, and Vocabulary. The VCI is calculated using scaled scores, which are based on age-specific norms.

2.3. Statistical analyses

2.3.1. Initial analyses, Study I-IV

All four sub-studies encompassed initial analyses, which probed study variable distributions, Cogstate data reliability, as well as the participants' levels of cognitive functioning, psychological distress symptoms, EA, and alexithymic traits. As described in section 2.1.3., the sub-studies' samples were largely overlapping. Thus, the initial analyses are presented together for Study I-IV.

In all four studies, study variable distributions were examined with descriptive statistics (e.g., variable mean values and standard deviations). All studies also included calculation of the Cogstate completion pass rates and integrity pass rates. In Study II-IV, the Cogstate tasks with available normative data (i.e., TWOB, GML, CPAL, and ISL) were compared with unpublished normative data for healthy adults. In Study I, the potential confounding effect of measurement time was explored by comparing the Cogstate scores for mothers tested at 1 year vs. 2.5 years after delivery with the Mann-Whitney *U* test. As some of the participants in Study II-IV had undergone a previous Cogstate testing, practice effects were controlled for by comparing the first-time participants' results with the re-tested participants' results using the Mann-Whitney *U* test. In Study I-IV, the scaled scores for the WAIS-IV verbal tasks and VCI were calculated using Finnish norms. In Study I, the potential confounding effect of measurement time was examined by comparing the WAIS-IV VCI scores for mothers tested at 1 year vs. 2.5 years after delivery using the independent samples *t*-test.

In Study III & IV, the participants' EAS scores were compared with recommended cutoff values. Psychological distress symptom levels were compared with recommended cutoff values in Study II & III, while alexithymic trait levels were compared with recommended cutoff values in Study IV.

2.3.2. Main analyses

2.3.2.1. Study I

The main research questions were tested by 1) comparing through confirmatory factor analyses (CFA) two EF/learning single-factor models containing partially different outcome variables from the same five Cogstate tasks, and 2) examining the associations between EF/learning-related variables (i.e., age, education level, and verbal intelligence) and sum scores based on the two separate Cogstate EF/learning single-factor models.

Of the two EF/learning single-factor models, Model A included the Cogstate-recommended primary outcome measures (i.e., the summative scores for tasks with multiple test rounds), while Model B included outcome measures which were hypothesized to tap more onto EF (i.e., the first test rounds for tasks with multiple test rounds).

In accordance with Models A and B, Sum Score A and B were calculated by combining standardized (Z-transformed) task outcome measures. To explore the association between the two EF/learning single-factor models and other EF/learning-related variables, bivariate correlations were calculated between the sum scores, the single task scores, and participant age/education level/verbal intelligence. The sum score/participant age associations were further examined with scatterplots, in which both the linear and quadratic slopes were plotted.

2.3.2.2. Study II

After the calculation of bivariate correlations between the study variables, the main research questions were explored with three separate sets of hierarchical multiple regression analyses, which examined the associations between a variation of psychological distress variables and EF. Due to education level being the only control variable that correlated significantly with EF, education level was included in Step 1 in all the regression models, while the other control variables were omitted.

Firstly, the single and additive effects of psychological distress symptoms on EF were studied by adding EPDS, SCL-90, AIS and RDAS as continuous variables in Step 2. Secondly, we examined whether the psychological distress/EF association varied depending on whether symptoms crossed cutoff values indicating clinically elevated levels. The continuous distress variables EPDS, SCL-90, AIS and RDAS were dichotomized, so that all values below clinical cutoffs were recoded as 0, and all values above clinical cutoffs were recoded as 1. The four dichotomized distress measures were then added one-by-one to Step 2 of four separate hierarchical multiple regression analyses (after controlling for education level in Step 1). Thirdly, we explored whether a cumulative amount of clinically elevated distress levels in different distress domains was associated with the maternal EF level. The dichotomized EPDS, SCL-90, AIS and RDAS variables were combined into a sum variable, describing the number of clinically elevated distress domains that were simultaneously reported by the participants. After controlling for education level in Step 1, the sum variable of concurrently clinically elevated distress domains was added to Step 2 of a hierarchical multiple regression analysis. The association between the number of concurrently elevated distress domains and EF was further visualized in a scatterplot with a fitted regression line.

2.3.2.3. Study III

Following the calculation of bivariate correlations between the study variables, the main research questions were examined with four separate hierarchical multiple regression models. To test the robustness of the EF/EAS association and the potential moderation effects, these regression models were first run without covariates, and then with education level as a covariate in Step 1. Education level was the only covariate which correlated significantly with the EAS composite, therefore the other covariates were excluded from the regression analyses.

The first three regression models explored the individual influences of the three continuous psychological distress domains on the EF/EAS association. In all three models, only the EF composite was added to Step 1, examining the individual effect of maternal EF on the EAS score. In Step 2, one distress domain was added per model (Model 1: EPDS, Model 2: SCL-90, Model 3: AIS). In Step 3, the interaction terms between the distress domains and EF were added (Model 1: EPDS x EF, Model 2: SCL-90 x EF, Model 3: AIS x EF). These three regression models were then re-run, with education level included as a covariate in Step 1.

The fourth regression model examined whether the three psychological distress domains had a combined, cumulative effect on the EF/EAS association. The EF composite was again added in Step 1. In Step 2, an EPDS/SCL-90/AIS composite was added, which reflected the joint variation of the three distress variables. This composite was created by standardizing the EPDS, SCL-90 and AIS variables, and combining them into an average score, which was then re-standardized. In Step 3, an interaction term between the psychological distress composite and EF (EPDS/SCL-90/AIS x EF) was added. Finally, this fourth regression model was re-run with education level controlled for in Step 1.

2.3.2.4. Study IV

The calculation of bivariate correlations between the study variables indicated an association between the TAS-20 subscale EOT and the EAS composite. In contrast, the TAS-20 subscales DIF and DDF did not correlate significantly with the EAS composite. The TAS-20 EOT/EAS association, along with the potential moderating effect of EF on this association, was consequently further examined thorough hierarchical multiple regression analysis. Education level was the only covariate which correlated significantly with the EAS composite, therefore the other covariates were excluded from the regression analyses. To explore the robustness of the TAS-20 EOT/EAS association and the potential moderation effect, the hierarchical regression model was first run excluding the covariate (Step 1: TAS-20 EOT, Step 2: EF, Step 3: EF x TAS-20 EOT), and then including the covariate (Step 1: Education level, Step 2: TAS-20 EOT, Step 3: EF, Step 4: EF x TAS-20 EOT).

The regression models' interaction effects were additionally examined by estimation of simple slopes, in which TAS-20 EOT was employed as the independent variable, the EAS composite as the dependent variable, and the EF composite as the moderator. The simple slopes were estimated at the mean, and at 1 *SD*, 1.5 *SD* and 2 *SD* above and below the mean of the moderator. Furthermore, a Johnson-Neyman plot was utilized to illustrate the pattern of the moderation effect across the full range of the moderator (Bauer, Curran, & Thurstone, 2005).

3. RESULTS

3.1. Initial results, Study I-IV

The study variable distributions for Study I are presented in *Table 2*, and for Study II-IV in *Table 3*. The completion and integrity checks classified nearly all Cogstate scores as reliable measurements. For GML, ISL and CPAL, the integrity pass rates and completion pass rates were 100% in all four sub-studies. Seven of the TWOB measurements were excluded from all four sub-studies due to an insufficient result integrity, i.e., the accuracy of the excluded results was below chance level. A few SETS scores were also excluded due to insufficient task completion rates. More specifically, two SETS scores were excluded from Study I and III, while one SETS score was excluded from Study II and IV.

Table 2
Study Variable Distributions, Study I

CogState tasks	**Mean scores (*SD*)** **N = 233**
ISL, number of correct responses, all test rounds	29.34 (3.31)
ISL, number of correct responses, first test round	7.93 (1.56)
CPAL, amount of errors, all test rounds	40.52 (34.43)
CPAL, amount of errors, first test round	12.64 (8.83)
GML, amount of errors, all test rounds	38.80 (11.22)
GML, amount of errors, first test round	8.46 (3.70)
TWOB, arcsine transformation of the proportion of correct responses	1.28 (0.18)
SETS, amount of errors	19.30 (12.90)
SETS, arcsine square root of the proportion of correct responses	1.21 (0.10)
WAIS-IV	**Mean score (*SD*)** **N = 216**
Similarities	10.42 (3.02)
Vocabulary	10.26 (3.22)
Information	9.84 (3.30)
VCI	100.99 (15.88)

The study variables are described in section *2.2.2. Measures*. For the Cogstate tasks, both the outcome measures that were utilized in Model A/Sum Score A, and the outcome measures that were utilized in Model B/Sum Score B are included in the table.

Table 3.

Study Variable distributions, Study II-IV

Study Variables	**Mean**			**Standard Deviation**			**Range**		
	Study II	Study III	Study IV	Study II	Study III	Study IV	Study II	Study III	Study IV
Cogstate Tasks									
GML	8.64	8.33	8.28	3.33	3.42	3.36	1-19	1-19	1-19
CPAL	12.44	12.91	12.70	8.41	8.70	8.38	0-40	0-40	0-40
ISL	7.87	8.05	8.08	1.50	1.62	1.59	4-12	4-12	5-11
TWOB	1.30	1.31	1.31	0.13	0.12	0.13	1.00-1.57	1.03-1.57	1.03-1.57
SETS	1.19	1.19	1.18	0.11	0.11	0.11	0.92-1.33	0.92-1.33	0.92-1.33
Emotional Availabitity Scales									
EAS composite	-	5.69	5.70	-	0.97	0.91	-	2.75-7.00	3.25-7.00
Sensitivity	-	5.11	5.13	-	1.15	1.12	-	2-7	2-7
Structuring	-	5.25	5.24	-	1.23	1.22	-	2-7	2-7
Non-Intrusiveness	-	5.92	5.92	-	1.28	1.22	-	3-7	3-7
Non-Hostility	-	6.49	6.53	-	0.79	0.70	-	3-7	4-7
Distress Measures									
EPDS	3.63	4.00	-	3.73	4.02	-	0-18	0-18	-
SCL-90, anxiety subscale	2.77	3.42	-	3.40	4.32	-	0-16	0-19	-
AIS	5.57	5.89	-	3.35	3.42	-	0-18	0-18	-
RDAS	49.67	-	-	8.01	-	-	21-66	-	-
Alexithymia Measure									
TAS-20 sum score	-	-	39.89	-	-	9.10	-	-	23-64
DIF	-	-	11.97	-	-	4.73	-	-	7-26
DDF	-	-	9.87	-	-	3.51	-	-	5-20
EOT	-	-	18.06	-	-	4.13	-	-	9-29

The study variables are described in section 2.2.2. Measures. For the Cogstate tasks, the outcome measures employed in the EF sum scores in Study II-IV are presented here (i.e., the first test round's results for tasks with multiple test rounds).

In Study II-IV, the TWOB and GML group mean scores were within the normal range (±1 *SD*) of normative data for the healthy adult age groups 18-34yrs and 35-49yrs, while the ISL results were slightly better than for both normative age groups. More errors were made on the CPAL in Study II-IV than expected based on the norms. However, the CPAL normative sample size is very small (18-34yrs N = 62, 35-49yrs N = 9) and should thus be referred to with caution. In Study I, participants tested 1 year vs. 2.5 years after delivery had similar Cogstate scores (*U* tests, $p = .21$-.95), apart from SETS in both Model A ($U = 7185.00$, $p = .01$) and Model B ($U = 4595.00$, $p = .01$). The mothers who were tested with SETS at one year after delivery made fewer errors ($M = 15.8$, $SD = 9.7$) than the mothers tested at 2.5yrs after delivery ($M = 21.0$, $SD = 13.9$). These differences were considered to be minor, and did not prevent the inclusion of participants tested at the two different time points in Study I's sample. In Studies II-IV, the mothers who encountered Cogstate for the first time did not have significantly different results than the re-tested mothers (Study II *U* tests: $p = .35$ -.95; Study III: *U* tests: $p = .15$ - .79; Study IV: *U* tests $p = .08$-.80).

As shown in *Table 2* above, the verbal intelligence level of the participants in Study I corresponded with the general Finnish population (normative $M = 100$, $SD = 15$). Similar WAIS-IV VCI mean group levels were found among the participants in the other sub-studies (Study II: $M = 102.72$, $SD = 15.33$; Study III: $M = 102.50$, $SD = 15.60$; Study IV: $M = 103.08$, $SD = 15.96$). In Study I, participants tested 1 year vs. 2.5 years after delivery had similar WAIS-IV VCI results ($t = -.52$, df = 214, $p = .60$, two-tailed), which in line with the Cogstate results supported the inclusion of participants from both time points in the same study sample.

The EAS scores in Study III & IV reflected mostly positive, emotionally available caregiving behavior. As can be seen in *Table 4* below, the majority of the free-play situations were coded as healthy EA, while some were coded as somewhat problematic, few were coded as detached in the relationship, and almost none were coded as highly problematic.

Table 4

Study III & IV EAS Results Grouped According to EA Level

EAS Dimension	Sub-Study	Healthy	Somewhat Problematic	Detached	Highly Problematic
Sensitivity	III	49.6%	37.2%	12.4%	0.7%
	IV	47.9%	39.5%	11.8%	0.8%
Structuring	III	50.4%	38.7%	10.2%	0.7%
	IV	48.7%	41.2%	9.2%	0.8%
Non-Intrusiveness	III	67.9%	24.8%	7.3%	0.0%
	IV	68.1%	26.1%	5.9%	0.0%
Non-Hostility	III	91.2%	8.0%	0.7%	0.0%
	IV	92.4%	7.6%	0.0%	0.0%

The EAS dimensions are described in more detail in section *2.2.2.4. Emotional Availability.*

As can be expected in a general population sample of mothers with toddlers, few participants reported clinically elevated depression/anxiety levels, while a clearly larger proportion reported symptoms of insomnia and couple relationship distress that crossed cut-off values for clinically elevated symptom levels. *Table 5* below presents psychological distress symptoms grouped according to clinical cutoff levels for participants in Study II and III.

Table 5
Study II & III Distress Measures Grouped According to Cut-Off Levels

Distress Measure	Sub-Study	No Symptoms	Subclinical Symptoms	Clinically Elevated Symptoms
EPDS	II	22.0%	70.7%	7.3%
	III	20.4%	68.6%	10.9%
SCL-90, anx. subscale	II	33.3%	55.4%	11.3%
	III	31.4%	54.0%	14.6%
AIS	II	3.3%	48.0%	48.7%
	III	4.4%	42.3%	53.3%
RDAS	II	0.0%	63.3%	36.7%
	III	-	-	-

See section *2.2.2.2. Psychological Distress* for distress measure descriptions.

Furthermore as expected among general population mothers, few participants simultaneously reported clinically elevated symptom levels within multiple distress domains. Of the participants in Study II, 38.0% did not report clinically elevated symptom levels within any of the four distress domains (i.e., depression, anxiety, insomnia, and poor couple relationship adjustment). Clinically elevated levels within one domain were reported by 32.1% of the participants, while 20.0% reported elevated levels within two domains, 8.0% reported elevated levels within three domains, and only 2.0% reported elevated levels within four domains.

In Study IV, the participants' alexithymia levels were low. Eight-point-four percent of the mothers had TAS-20 scores that indicated a moderate level of alexithymia, while only 1.7% had scores signifying high alexithymia.

Taken together, the initial results from Study I-IV demonstrate that the participants in the largely overlapping study samples had normative levels of verbal intelligence and EF. Moreover, the participants exhibited mostly positive, emotionally available caregiving behavior, and had notably low levels of alexithymia. Clinically elevated levels of insomnia and poor couple relationship adjustment were fairly frequent among the participants, while depression and anxiety symptoms were clearly less frequent.

3.2. Main results

3.2.1. Study I

The two single-factor EF/learning models' factor loadings and error terms are presented in *Figure 5*. The fit indices demonstrate that both models provide a good fit with the data - Model A: χ^2 [5] = 4.56, p = .47, SRMR = .03, RMSEA = .00 [90% CI = .00 - .09], CFI = 1.00; Model B: χ^2 [5] = 1.37, p = .93, SRMR = .02, RMSEA = .00 [90% CI = .00 - .03], CFI = 1.00. However, Model B captures the common variance of the five Cogstate tasks slightly better than Model A, which is indicated by Model B's moderately better model fit indices and more even factor loadings.

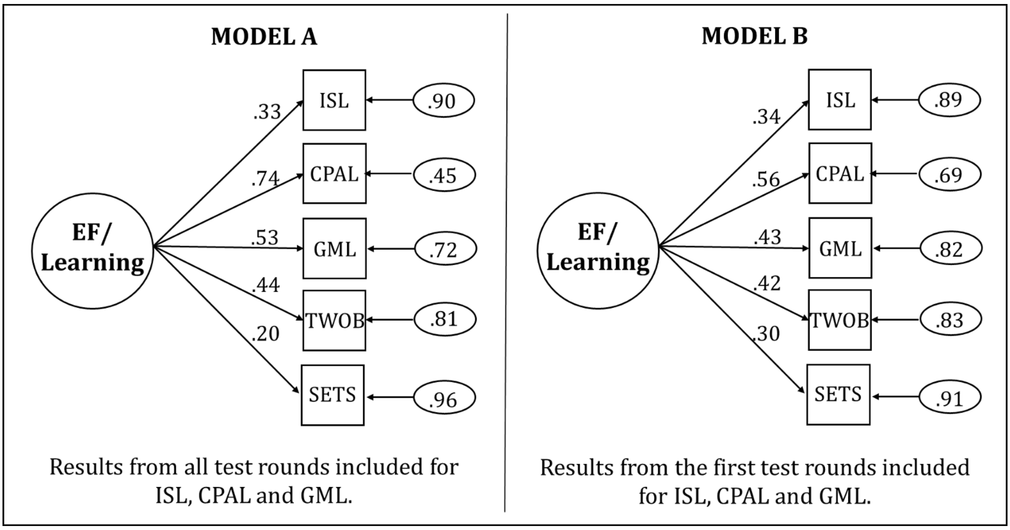


Figure 5. Ef/learning factor models A and B, along with factor loadings and error terms. EF = executive functioning, ISL = International Shopping List Test, CPAL = Continuous Paired Associate Learning Test, GML = Groton Maze Learning test, TWOB = Two back Test, SETS = Set-Shifting Test.

The bivariate correlations between the EF/learning sum scores, the single task scores, and participant age/education level/WAIS-IV VCI are presented in *Table 6*. Overall, Sum Score A and Sum Score B had fairly similar associations with participant age, education level, and verbal intelligence. As hypothesized, verbal intelligence and education level correlated positively with the sum scores, as well as with some of the single tasks. Furthermore, the expected inverted U-shaped curve appeared when the quadratic curve was plotted in the sum score/age scatterplots (see *Figure 6*). The model with the quadratic (and linear) term fitted significantly better than the model with only the linear term for both Sum Score A (p = .01, R^2 change = .03) and Sum Score B (p = .01, R^2 change = .03).

Table 6
Bivariate Correlations between Study I Variables

Variables	Age	Education level	WAIS-IV VCI
Sum Score A	**-.16****	**.20****	**.21****
Sum Score A ISL	-.03	.19**	.23**
Sum Score A CPAL	-.22**	.08	.08
Sum Score A GML	-.17**	.05	.00
Sum Score A TWOB	-.06	.10	.14*
Sum Score A SETS	-.05	.11	.13*
Sum Score B	**-.12***	**.20****	**.25****
Sum Score B ISL	-.05	.13*	.22**
Sum Score B CPAL	-.19**	.05	.09
Sum Score B GML	-.04	.14*	.12*
Sum Score B TWOB	-.06	.10	.14*
Sum Score B SETS	-.05	.11	.13*
Age	1		
Education level	.30**	1	
WAIS-IV VCI	.28**	.52**	1

Correlations significant at the .05 level are indicated with *, correlations significant at the .01 level with ** (all one-tailed). For correlations involving the variables education level, TWOB or SETS, Spearman's rho was used, for other correlations Pearson's *r* was used. For the sum scores, the single CogState tasks, and WAIS-IV VCI a higher value means a better result.

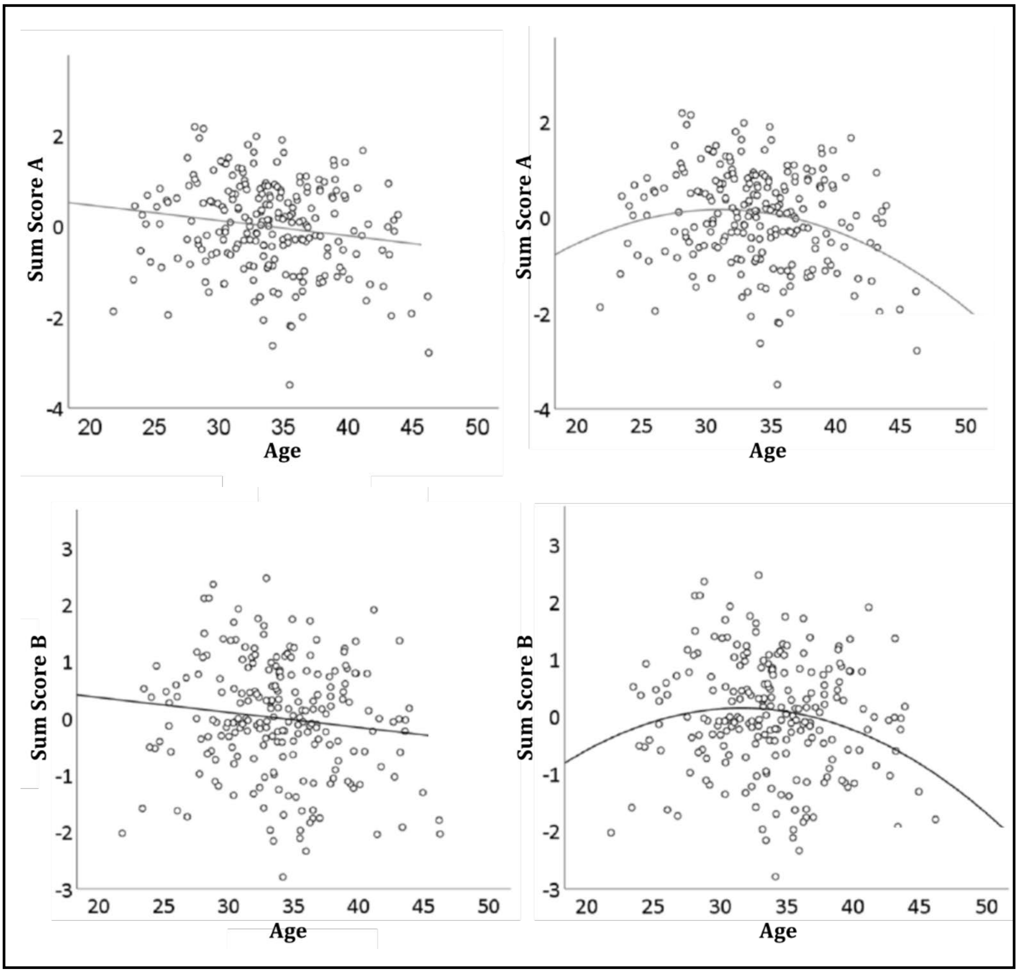


Figure 6. Linear and quadratic scatterplots between Sum Score A/participant age and Sum Score B/participant age. Sum Score A: R^2 linear = .03, R^2 quadratic = .06. Sum Score B: R^2 linear = .02, R^2 quadratic = .04.

3.2.2. Study II

The bivariate correlations between the study variables are presented in *Table 7*. As expected, for all distress measures higher levels of psychological distress were associated with lower EF, but these associations were weak. All four distress domains covaried on a significant level, so that a higher number of symptoms within different distress domains correlated with each other.

Table 7

Bivariate Correlations between Variables, Study II

Variable	1.	2.	3.	4.	5.	6.	7.
1. EPDS[b]	1						
2. SCL-90[b]	.75**	1					
3. AIS[b]	.51**	.42**	1				
4. RDAS[b]	.21**	.27**	.33**	1			
5. Age	.08	-.04	.14	.15	1		
6. Education level[a]	.17*	.03	.03	-.01	.30**	1	
7. WAIS-IV VCI[a]	.15	.02	-.07	.12	.31**	.40**	1
8. EF[a]	-.08	-.13	-.15	-.17*	-.12	.22*	.15

** = Correlation is significant at the .01 level (two-tailed). * = Correlation is significant at the .05 level (two-tailed). Pearson correlations were calculated for all variables except for education level, for which Spearman correlations were calculated. [a]Higher score = more advantageous. [b]Lower score = more advantageous. EPDS = Edinburgh Postnatal Depression Scale, SCL-90 = Symptom Checklist 90, Anxiety Subscale, AIS = Athens Insomnia Scale, RDAS = Revised Dyadic Adjustment Scale, WAIS-IV VCI = Verbal Comprehension Index, Wechsler Adult Intelligence Scale-IV, EF = Cogstate EF composite.

Maternal education level, which was included as a control variable in Step 1 of all the regression models, accounted for 4% of maternal EF variation on a significant level ($R^2 = .04$, $p = .01$). As Step 1 was identical in all models, these results are not repeated in the description of the regression results.

The first regression analysis, which explored the single and additive effects of EPDS, SCL-90, AIS and RDAS symptoms on EF, is presented in *Table 8*. Contrary to our hypotheses, the four continuous psychological distress domains added in Step 2 did not have a significant effect on EF ($\Delta R^2 = .04$, $p = .20$).

The next four regression models, which included dichotomized distress variables separating between participants reporting/not reporting clinically elevated symptom levels within the four distress domains, are presented in *Table 9*. Again contrary to our expectations, the dichotomized symptom domains that were added to Step 2 were not independently associated with EF (EPDS: $\Delta R^2 = .00$, $p = .46$; SCL-90 $\Delta R^2 = .01$, $p = .40$; AIS: $\Delta R^2 = .02$, $p = .11$; RDAS $\Delta R^2 = .02$, $p = .08$). These associations were clearly non-significant for EPDS and SCL-90, while they came close to significance for AIS and SCL-90.

The last regression model, which explored whether a cumulative amount of concurrently clinically elevated symptom levels within different distress domains was associated with EF, is presented in *Table 10*. As expected, the number of concurrently reported, clinically elevated distress domains was significantly associated with EF. The number of clinically elevated distress domains predicted 3% of the maternal EF variation ($\Delta R^2 = .03$, $p = .04$). This association is further depicted in the scatterplot with a fitted regression line (see *Figure 7*), which shows a trend of lower maternal EF as the number of concurrently clinically elevated distress domains increases from zero to two. This pattern is less clear for mothers reporting clinically elevated levels within more than two distress domains. For these participants, group sizes are small - twelve mothers reported clinically elevated levels in three domains, and only three reported elevated levels in four domains. These results should thus be interpreted with caution, as single extreme values can largely impact the distribution of groups this small. As can be seen in *Figure 7*, the group reporting concurrently elevated distress levels in three domains includes a participant with a particularly high EF level.

Table 8

Associations between Continuous Symptoms and Executive Functioning

	R^2	$R^2\Delta$	FΔ	FΔ *p*-value	B	β	t	B *p*-value	B, 95.0% Confidence Interval	sr^2
Step 1, Education	.04	.04	6.67	.01	.27	.21	2.58	.01	.06/.47	.04
Step 2	.08	.04	1.52	.20						
EPDS					.01	.05	.36	.72	-.06/.08	.00
SCL-90					-.02	-.08	-.67	.50	-.10/.05	.00
AIS					-.03	-.11	-1.12	.27	-.09/.03	.01
RDAS					-.01	-.11	-1.25	.21	-.04/.01	.01

EPDS = Edinburgh Postnatal Depression Scale, SCL-90 = Symptom Checklist-90 anxiety subscale, AIS = Athens Insomnia Scale, RDAS = Revised Dyadic Adjustment Scale.

Table 9

Associations between Single Elevated Symptom Domains and Executive Functioning

	R^2	$R^2\Delta$	FΔ	FΔ *p*-value	B	β	t	B *p*-value	B, 95.0% Confidence Interval	sr^2
DEPRESSION										
Step 1, Education	.04	.04	6.67	.01	.27	.21	2.58	.01	.06/.47	.04
Step 2, EPDS	.05	.00	.56	.46	-.23	-.06	-.75	.46	-.84/.38	.00
ANXIETY										
Step 1, Education	.04	.04	6.67	.01	.27	.21	2.58	.01	.06/.47	.04
Step 2, SCL-90	.05	.01	.72	.40	-.22	-.07	-.85	.40	-.71/.29	.00
INSOMNIA										
Step 1, Education	.04	.04	6.67	.01	.27	.21	2.58	.01	.06/.47	.04
Step 2, AIS	.06	.02	2.63	.11	-.26	-.13	-1.62	.11	-.57/-.06	.02
POOR COUPLE RELATIONSHIP ADJUSTMENT										
Step 1, Education	.04	.04	6.67	.01	.27	.21	2.58	.01	.06/.47	.04
Step 2, RDAS	.06	.02	3.06	.08	-.29	-.14	-1.75	.08	-.62/.04	.02

The dichotomized psychological distress measures were split according to cutoffs, separating between participants reporting/not reporting clinically elevated symptom levels. EPDS = Edinburgh Postnatal Depression Scale, SCL-90 = Symptom Checklist-90 anxiety subscale, AIS = Athens Insomnia Scale, RDAS = Revised Dyadic Adjustment Scale.

Table 10

Association between Number of Elevated Symptom Domains and Executive Functioning

	R^2	$R^2\Delta$	$F\Delta$	$F\Delta$ *p*-value	B	β	t	B *p*-value	B, 95.0% Confidence Interval	sr^2
Step 1, Education	.04	.04	6.67	.01	.27	.21	2.58	.01	.06/.47	.04
Step 2, Symptom nr.	.07	.03	4.19	.04	-.16	-.16	-2.05	.04	-.31/-.01	.03

Symptom nr. refers to the number of psychological distress domains (i.e., depression, anxiety, insomnia, and poor couple relationship adjustment), which cross cutoff values for clinically elevated symptom levels.

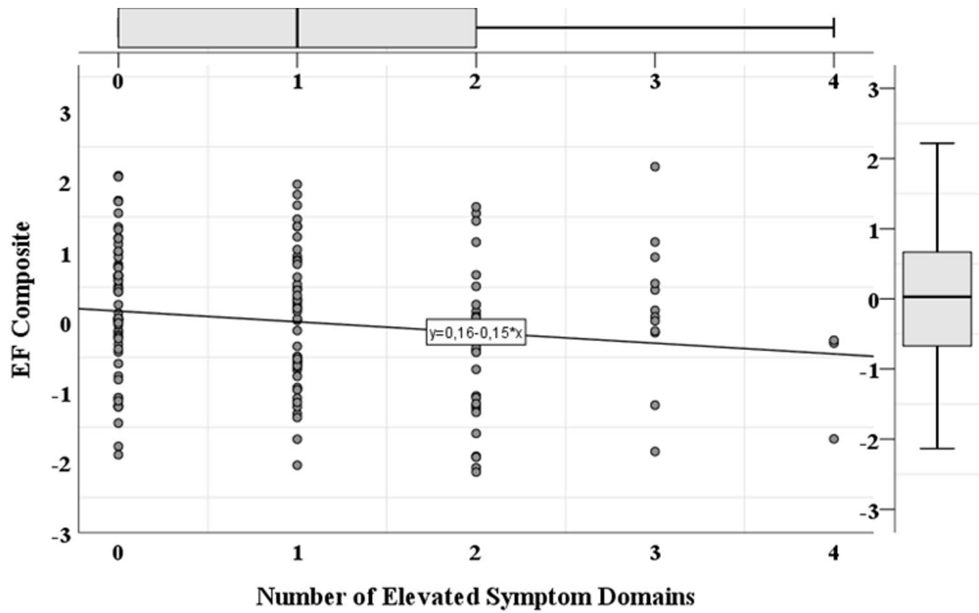


Figure 7. Scatterplot with a fitted regression line, showing the distribution of executive functioning (EF) as grouped according to the number of concurrent clinically elevated symptom domains (i.e., depression, anxiety, insomnia, and poor couple relationship adjustment). EF was measured with a five-task-Cogstate composite score, in which higher values indicate better EF. The EF composite's mean was set to zero through standardization, and the vertical axis values refer to standard deviations from the mean EF value. Psychological distress was assessed with the Edinburgh Postnatal Depression Scale, the Anxiety Subscale from The Symptom Checklist-90, the Athens Insomnia Scale, and the Revised Dyadic Adjustment Scale. The number of elevated symptom domains refers to the number of psychological distress domains which simultaneously cross cutoff values indicating clinically elevated symptom levels.

3.2.3. Study III

The bivariate correlations between the study variables and covariates are presented in *Table 11* below. As expected, higher EF correlated significantly with more EA caregiving, but the association's effect size was small. The psychological distress domains did not correlate significantly with either EF, or with caregiving behavior. However, the distress domains all covaried significantly with each other, so that higher symptom levels within one domain were associated with higher symptom levels within other domains. The depression/anxiety association had a large effect size, while the insomnia/depression and the insomnia/anxiety associations had a medium effect size. Of the potential control variables (i.e., participant age, number of children, and education level), only education level correlated significantly with the EAS composite. Hence, only education level was included as a control variable in the ensuing hierarchical multiple regression analyses.

Table 11

Bivariate Correlations Between Variables, Study III

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. EF composite[a]	1								
2. EAS composite[a]	.17*	1							
3. EPDS[b]	-.01	-.01	1						
4. SCL-90[b]	.02	.01	.79**	1					
5. AIS[b]	-.11	-.04	.52**	.40**	1				
6. Distress composite[b]	-.04	-.02	.91**	.87**	.76**	1			
7. Age	-.05	.03	-.02	-.13	.10	-.02	1		
8. Number of children	.10	.06	-.05	-.03	-.14	-.02	.36**	1	
9. Education level[a]	.23*	.17*	.02	-.07	.08	.02	.36**	.11	1

* = Correlation is significant at the .05 level. ** = Correlation is significant at the .01 level. Pearson correlations were calculated for all variables except for education level, for which Spearman correlations were calculated. [a]Higher score = more advantageous. [b]Lower score = more advantageous.

The results of the first three regression models, which explored the individual influences of the three continuous psychological distress domains on the EF/EAS association, are presented in *Table 12* without covariates, and then in *Table 13* including education level as covariate in Step 1. As can be seen in the first analyses steps in *Table 12*, better EF was significantly associated with a higher EAS score when education was not included as a control variable ($\Delta R^2 = .03$, $p = .04$); maternal EF accounted for 3% of the variation in caregiving behavior. The EF/EAS association weakened slightly and was no longer statistically significant when education level was controlled in Step 1 ($\Delta R^2 = .02$, $p = .12$).

As can be seen in the second analyses steps of *Table 12* and the third analyses steps of *Table 13*, symptoms of depression, anxiety and insomnia were not significantly associated with caregiving behavior, whether education level was controlled (EPDS: $\Delta R^2 = .00$, $p = .97$; SCL-90: $\Delta R^2 = .00$, $p = .76$; AIS: $\Delta R^2 = .00$, $p = .62$) or not (EPDS: $\Delta R^2 = .00$, $p = .94$; SCL-90: $\Delta R^2 = .00$, $p = .99$; AIS: $\Delta R^2 = .00$, $p = .78$). Contrary to our hypotheses, the interaction terms between the distress domains and EF were not significantly associated with caregiving behavior, whether education level was controlled (EPDS X EF: ΔR^2 = .01, p = .34; SCL-90 X EF: ΔR^2 = .00, p = .97; AIS X EF: ΔR^2 = .01, p = .20) or not (EPDS X EF: ΔR^2 = .01, p = .22; SCL-90 X EF: ΔR^2 = .00, p = .84; AIS X EF: ΔR^2 = .01, p = .17). Hence, when examined as individual distress domains, symptoms of depression, anxiety and insomnia did not have a significant moderation effect on the EF/EAS association.

The results of the fourth regression model, which examined whether the three psychological distress domains had a combined, cumulative effect on the EF/EAS association, are presented in *Table 14* without covariates, and then in *Table 15* including education level as covariate in Step 1. The distress composite was not significantly associated with the EAS composite, whether education level was controlled (ΔR^2 = .00, p = .95) or not (ΔR^2 = .00, p = .89). Contrary to our hypotheses, the interaction term between the distress composite and EF was not significantly associated with the EAS composite whether education level was controlled (ΔR^2 = .01, p = .39) or not (ΔR^2 = .01, p = .27). In other words, cumulative symptoms of depression, anxiety and insomnia did not moderate the EF/caregiving association.

Table 12

Single Distress Domains' Moderation of EF/Caregiving Association, Excluding Covariate

	R^2	$R^2\Delta$	FΔ	FΔ *p*-value	B	β	t	B *p*-value	B, 95.0% Confidence Interval	sr^2
DEPRESSION SYMPTOMS										
Step 1, EF	.03	.03	4.19	.04	.17	.17	2.05	.04	.01/.34	.03
Step 2, EPDS	.03	.00	.00	.94	-.01	-.01	-.08	.94	-.18/.16	.00
Step 3, EPDSxEF	.04	.01	1.53	.22	-.10	-.11	-1.24	.22	-.27/.06	.01
ANXIETY SYMPTOMS										
Step 1, EF	.03	.03	4.19	.04	.17	.17	2.05	.04	.01/.34	.03
Step 2, SCL-90	.03	.00	.00	.99	.00	.00	.01	.99	-.17/.17	.00
Step 3, SCL-90xEF	.03	.00	.04	.84	-.02	-.02	-.21	.84	-.19/.16	.00
INSOMNIA SYMPTOMS										
Step 1, EF	.03	.03	4.19	.04	.17	.17	2.05	.04	.01/.34	.03
Step 2, AIS	.03	.00	.08	.78	-.03	-.03	-.29	.78	-.19/.15	.00
Step 3, AISxEF	.05	.01	1.95	.17	-.12	-.12	-1.40	.17	-.28/.05	.01

EF = executive functioning, five-task-Cogstate composite; EPDS = Edinburgh Postnatal Depression Scale; SCL-90, Symptom Checklist-90 anxiety subscale; AIS, Athens Insomnia Scale.

Table 13

Single Distress Domains' Moderation of EF/Caregiving Association, Including Covariate

	R^2	$R^2\Delta$	$F\Delta$	$F\Delta$ *p*-value	B	β	t	B *p*-value	B, 95.0% Confidence Interval	sr^2
DEPRESSION SYMPTOMS										
Step 1, Education	.03	.03	4.38	.04	.22	.18	2.09	.04	.01/.43	.03
Step 2, EF	.05	.02	2.48	.12	.14	.14	1.57	.12	-.04/.31	.02
Step 3, EPDS	.05	.00	.00	.97	.00	.01	.04	.97	-.17/.17	.00
Step 4, EPDSxEF	.06	.01	.92	.34	-.08	-.08	-.96	.34	-.25/.09	.01
ANXIETY SYMPTOMS										
Step 1, Education	.03	.03	4.38	.04	.22	.18	2.09	.04	.01/.43	.03
Step 2, EF	.05	.02	2.48	.12	.14	.14	1.57	.12	-.04/.31	.02
Step 3, SCL-90	.05	.00	.09	.76	.03	.03	.30	.76	-.14/.20	.00
Step 4, SCL-90xEF	.05	.00	.00	.97	-.00	-.00	-.04	.97	-.18/.17	.00
INSOMNIA SYMPTOMS										
Step 1, Education	.03	.03	4.38	.04	.22	.18	2.09	.04	.01/.43	.03
Step 2, EF	.05	.02	2.48	.12	.14	.14	1.57	.12	-.04/.31	.02
Step 3, AIS	.05	.00	.25	.62	-.04	-.04	-.50	.62	-.21/.13	.00
Step 4, AISxEF	.06	.01	1.67	.20	-.11	-.11	-1.29	.20	-.27/.06	.01

EF = executive functioning, five-task-Cogstate composite; EPDS = Edinburgh Postnatal Depression Scale; SCL-90, Symptom Checklist-90 anxiety subscale; AIS, Athens Insomnia Scale.

Table 14

Distress Composite's Moderation of EF/Caregiving Association, Excluding Covariate

	R^2	$R^2\Delta$	$F\Delta$	$F\Delta$ *p*-value	B	β	t	B *p*-value	B, 95.0% Confidence Interval	sr^2
Step 1, EF	.03	.03	4.19	.04	.17	.17	2.05	.04	.01/.34	.03
Step 2, Symptoms	.03	.00	.02	.89	-.01	-.01	-.14	.89	-.18/.16	.00
Step 3, Sympt.xEF	.04	.01	1.21	.27	-.09	-.09	-1.10	.27	-.26/.07	.01

EF = executive functioning, five-task-Cogstate-composite. Symptoms = a cumulative composite score, combines concurrent psychological distress symptoms measured with the Edinburgh Postnatal Depression Scale, the Symptom Checklist-90 anxiety subscale, and the Athens Insomnia Scale.

Table 15

Distress Composite's Moderation of EF/Caregiving Association, Including Covariate

	R^2	$R^2\Delta$	$F\Delta$	$F\Delta$ *p*-value	B	β	t	B *p*-value	B, 95.0% Confidence Interval	sr^2
Step 1, Education	.03	.03	4.38	.04	.22	.18	2.09	.04	.01/.43	.03
Step 2, EF	.05	.02	2.48	.12	.14	.14	1.57	.12	-.04/.31	.02
Step 3, Symptoms	.05	.00	.00	.95	-.01	-.01	-.06	.95	-.17/.16	.00
Step 4, Sympt.xEF	.06	.01	.75	.39	-.07	-.07	-.86	.39	-.24/.09	.01

EF = executive functioning, five-task-Cogstate-composite. Symptoms = a cumulative composite score, combines concurrent psychological distress symptoms measured with the Edinburgh Postnatal Depression Scale, the Symptom Checklist-90 anxiety subscale, and the Athens Insomnia Scale.

3.2.4. Study IV

The bivariate correlations between the study variables and covariates are presented in *Table 16* below. Scatter plot examinations indicated that quadratic functions did not describe the TAS-20/EAS associations better than linear functions, and that the associations were not notably driven by outlier values. As hypothesized, higher levels of alexithymic traits correlated significantly with lower EAS values. However, this was only found for the TAS-20 subscale EOT, indicating that EOT is differently associated with EA than the other TAS-20 dimensions. Consequently, only EOT was included as an independent variable in the subsequent regression analyses. Furthermore, as three of the four EA scales (i.e., Sensitivity, Structuring, and Non-Hostility, but not Non-Intrusiveness) had very similar correlations with TAS-20 EOT as the EAS composite, the EAS composite was considered to be the most suitable dependent variable in the regression analyses. The moderator candidate, i.e., the EF composite, did not correlate significantly with either the TAS-20 variables, or with the EAS. Of the possible control variables (i.e., participant age, number of children, education level, and WAIS-IV VCI), only education level correlated significantly with the EAS composite. Therefore, only education level was included as a control variable in the hierarchical multiple regression analyses.

The TAS-20 EOT/EAS association: As can be seen in the first analysis step in *Table 17*, when education level was not controlled for, higher EOT levels were significantly associated with a lower EAS score (ΔR^2 = .05, p = .01). In other words, maternal EOT accounted for 5% of the variation in maternal caregiving behavior. As can be seen in *Table 18*, when education level was added as a control variable to Step 1, it accounted for 3% of the variation in the EAS score (ΔR^2 = .03, p = .05). Following the inclusion of the covariate education level in the regression model, the TAS-20 EOT/EAS association weakened slightly (ΔR^2 = .03, p = .05).

The moderating role of EF on the TAS-20 EOT/EAS association: The EF composite did not have significant direct associations with the EAS composite in the hierarchical multiple regression models, either when the covariate education level was excluded (*Table 17*, Step 2: ΔR^2 = .02, p = .13), or when in was included (*Table 18*, Step 3: ΔR^2 = .01, p = .18). The EF x TAS-20 EOT interaction term had a marginally significant association with the EAS composite in the regression model excluding the covariate education level (*Table 17*, Step 3: ΔR^2 = .03, p = .06), as well as in the model that included the covariate (*Table 18*, Step 4: ΔR^2 = .03, p = .07).

Table 16

Bivariate Correlations between the Study Variables

Variable	**1.**	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**	**11.**	**12.**	**13.**
1. EA Composite	1												
2. Sensitivity	.93**	1											
3. Structuring	.89**	.89**	1										
4. Non-Intrusiveness	.80**	.60**	.50**	1									
5. Non-Hostility	.78**	.62**	.58**	.59**	1								
6. TAS-20 Tot. Score	-.14	-.17†	-.22*	-.01	-.06	1							
7. DIF	.00	-.05	-.10	.10	.09	.79**	1						
8. DDF	-.08	-.10	-.16	-.03	.04	.81**	.59**	1					
9. EOT	-.23*	-.23*	-.24*	-.08	-.26*	.61**	.10	.27**	1				
10. EF Composite	.15	.11	.16†	.09	.16†	.00	.11	-.10	-.04	1			
11. Age	.02	-.01	.01	.00	.08	-.10	-.10	-.05	-.07	-.09	1		
12. Parity	.12	.08	.12	.06	.10	-.05	.03	-.05	-.06	.21*	.42**	1	
13. Education level	.19*	.18†	.18†	.12	.22*	-.21*	-.00	-.15	-.30**	.01	.32**	.17†	1
14. WAIS-IV VCI	.13	.15	.17	.05	.03	-.09	.05	-.07	-.19†	.23*	.29**	.10	.42**

For correlations involving the variables Parity or Education Level, Spearman's rho was used. For other correlations Pearson's *r* was employed.

Table 17

Hierarchical Multiple Regression Analysis Excluding the Covariate Education: Effect of Externally Oriented Thinking and Executive Functioning on the Emotional Availability Scales Composite

	R^2	$R^2\Delta$	FΔ	FΔ *p*-value	B	β	t	B *p*-value	B, 95.0% Confidence Interval	sr^2
Step 1: EOT	.05	.05	6.36	.01	-.06	-.23	-2.52	.01	-.10/-.01	.05
Step 2: EF	.07	.02	2.39	.13	.14	.14	1.55	.13	-.04/.32	.02
Step 3: EF x EOT	.10	.03	3.52	.06	.04	.80	1.88	.06	-.00/.09	.03

EOT = Externally Oriented Thinking, EF = executive functioning, five-task-Cogstate-composite, EF x EOT = interaction term between EOT and EF.

Table 18

Hierarchical Multiple Regression Analysis Including the Covariate Education: Effect of Externally Oriented Thinking and Executive Functioning on the Emotional Availability Scales Composite

	R^2	$R^2\Delta$	FΔ	FΔ *p*-value	B	β	t	B *p*-value	B, 95.0% Confidence Interval	sr^2
Step 1: Education	.03	.03	3.87	.05	.22	.18	1.97	.05	-1.00/.04	.03
Step 2: EOT	.07	.03	4.08	.05	-.05	-.19	-2.03	.05	-.09/-.00	.03
Step 3: EF	.08	.01	1.79	.18	.12	.12	1.34	.18	-.06/.30	.01
Step 4: EF x EOT	.11	.03	3.47	.07	.04	-.17	1.86	.07	-.00/.09	.03

EOT = Externally Oriented Thinking, EF = executive functioning, five-task-Cogstate-composite, EF x EOT = interaction term between EOT and EF.

When the marginally significant moderating effect found in the regression models was examined in more detail through estimation of simple slopes and a Johnson-Neyman plot, the TAS-20 EOT/EAS association was found to be notably different for mothers whose EF levels were below the group mean level in comparison to mothers whose EF levels were above the group mean level. As EF levels decreased from the group mean to lower levels, a significant association emerged between higher TAS-20 EOT scores and lower EAS values, which increased in strength with decreasing EF levels (1 *SD* below the mean: β = -.38, *p* = .00; 1.5 *SD* below the mean: β = -.47, *p* = .00; 2 *SD* below the mean: β = -.56, *p* =.01). In contrast, for mothers with higher EF levels than the group mean, TAS-20 EOT values were not significantly associated with EAS values (1 *SD* above the mean: β = -.02, *p* =.91; 1.5 *SD* above the mean: β = .08, *p* = .68; 2 *SD* above the mean: β = .17, *p* = .46). This pattern is depicted in the Johnson-Neyman plot (see *Figure 8*), and it is in line with the expected buffering effect of EF on the association between alexithymic traits and EA.

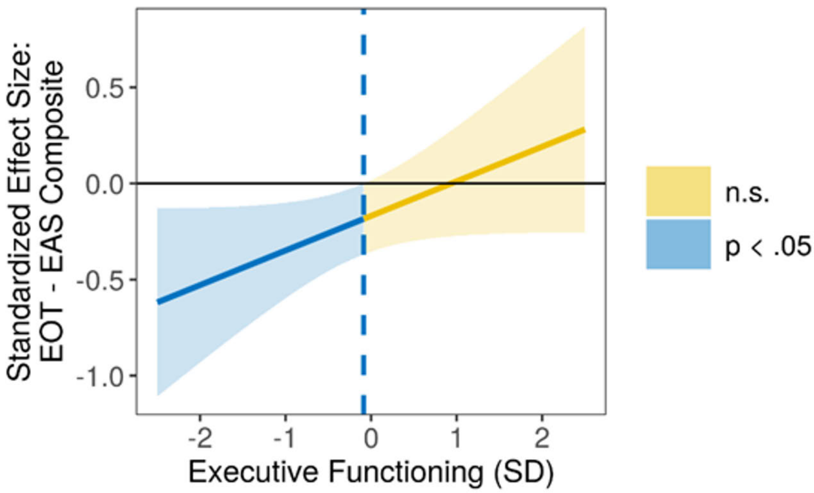


Figure 8. The blue-and-yellow line represents the regression coefficient of the TAS-20 subscale EOT on the EAS composite, as moderated by the Cogstate EF composite (and including the covariate education level). The regression coefficient is statistically significant when the colored area is below zero on the X-axis. The association between EOT and the EAS composite is significant for mothers with lower EF values than the group mean level, while it is not significant for mothers with higher EF levels than the group mean level.

3.2.5. Summary of the main results

The main results of Study I indicated that the five examined Cogstate tasks were suitable to be combined into an EF/learning sum score, which was used in the subsequent studies of this thesis as a measure of maternal EF. The main results from Study II-IV, that explored the role of maternal EF in caregiving behavior during early parenthood while accounting for psychological distress and alexithymic traits, are summarized in *Figure 9*. In this general population sample of Finnish mothers with 2.5-year-old children, higher maternal EF had a weak but significant association with more EA caregiving behavior (Study III). A higher number of concurrently clinically elevated psychological distress domains were significantly associated with lower EF, while associations between lower distress symptom levels and EF were nonsignificant (Study II). Maternal psychological distress levels did not moderate the EF/EAS association on a significant level (Study III). Besides being directly associated with EA, EF also moderated the association between higher alexithymic traits (more specifically, EOT) and less EA caregiving behavior. The association between more externally oriented thinking and less EA caregiving behavior was statistically significant only among mothers whose EF scores were lower than the group mean level (Study IV).

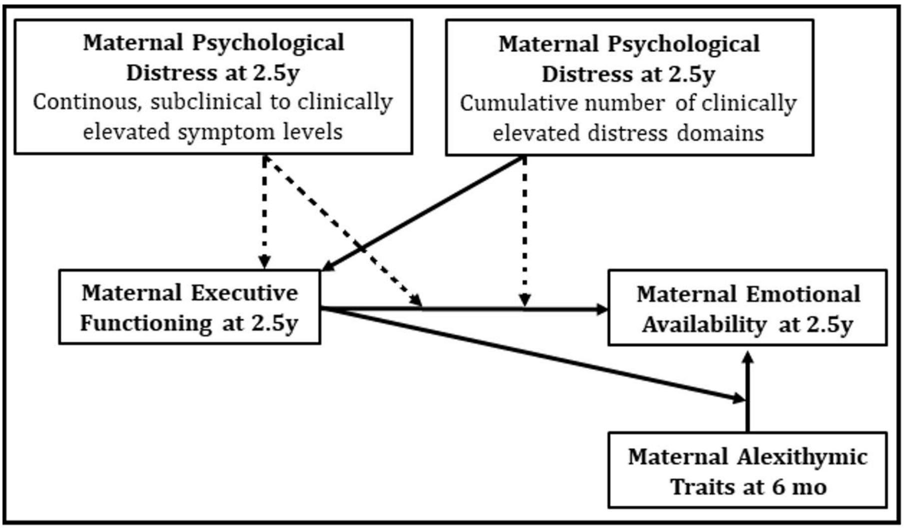


Figure 9. The main results related to the role of maternal EF in caregiving behavior during early parenthood. Solid lines represent significant associations, dotted lines represent nonsignificant associations.

4. DISCUSSION

This thesis explored the role of maternal EF in caregiving behavior among general population mothers during early parenthood, while accounting for maternal psychological distress symptoms and alexithymic traits. **Study I** examined the latent structure of five EF/learning Cogstate tasks, and evaluated the suitability of sum scores based on these five tasks to assess EF/learning among healthy adults. This EF/learning composite was subsequently employed in Study II-IV. **Study II** explored whether psychological distress domains that are prevalent during early parenthood (i.e., symptoms of depression, anxiety, insomnia, and poor couple relationship adjustment) were associated with maternal EF, while accounting for both the effect of individual distress domains and for the cumulative effect of several concurrent distress domains. **Study III** examined the association between maternal EF and the degree of emotional availability (EA) in caregiving behavior, and whether this association was moderated by the maternal psychological distress domains depression, anxiety and insomnia. **Study IV** examined whether maternal EF moderated the association between alexithymic traits and caregiving behavior. The main findings can be summarized as follows:

1) *The suitability of a Cogstate sum score for EF assessments*
    a) Sum scores based on the five studied Cogstate tasks appear to be suitable for EF/learning assessments among healthy adults.
    b) The selection of different outcome variables for tasks with several test rounds seems to affect to what degree they tap onto EF/learning.

2) *The association between maternal psychological distress and EF*
    a) Subclinical psychological distress levels, as well as clinically elevated distress levels within single distress domains that are prevalent during early parenthood (i.e., depression, anxiety, insomnia, poor couple relationship adjustment) were not significantly associated with EF among general population mothers of toddlers.
    b) A higher number of concurrently clinically elevated distress domains was negatively associated with EF, possibly due to a cumulative and depleting effect of several clinically elevated distress domains on EF.

3) *The association between maternal EF and caregiving behavior*
    a) Higher maternal EF was associated with more EA caregiving behavior among general population mothers of toddlers.
    b) Although observed moderation effects were in the expected direction, the EF/EA association was not moderated on a significant level by the distress domains depression, anxiety and insomnia.

4) *The role of EF in the alexithymic traits/EA-association*
   a) Higher levels of alexithymic traits (more specifically, externally oriented thinking, EOT) predicted lower maternal EA among general population mothers of toddlers
   b) High maternal EF had a buffering effect on this association, while the negative influence of EOT on EA was especially strong among low EF mothers.

4.1. The suitability of a Cogstate sum score for EF assessments

Study I explored the latent structure of five EF/learning tasks from the Cogstate test battery, i.e., the Two Back Test (TWOB), the Set-Shifting Test (SETS), the Groton Maze Learning Test (GML), the Continuous Paired Associate Learning Test (CPAL), and the International Shopping List Test (ISL). Confirmatory factor analyses indicated that the five tasks share sufficient common variance to be combinable into an EF/learning sum score, allowing for more reliable EF assessments in comparison to single task scores due to minimized measurement error variability. The comparison of two sets of task outcome variables for the three tasks with multiple test rounds (i.e., ISL, CPAL, GML) demonstrated that the choice of outcome variable for these three tasks affected the single-factor model's properties. These effects were interpreted to indicate that first test round scores are preferable when striving to assess primarily EF, while summative scores from all test rounds are preferable when striving to measure primarily learning. Furthermore, the two EF/learning sum scores correlated with participant age, educational attainment, and verbal intelligence in the expected fashion, lending some support to the sum scores' construct validity. Following these results in Study I, the sum score of the five studied Cogstate tasks was considered suitable for EF assessments among general population adults. To emphasize the sum score's EF component, the composite including the first test round results for ISL, CPAL and GML was subsequently employed in Studies II-IV to assess maternal EF. Considering the tasks included in this composite, it is relevant to note that it measures primarily working memory updating and set-shifting capacity, while it does not encompass tasks that assess inhibitory control. The composite furthermore contains a large visuospatial component, and notable elements of learning.

4.2. The association between maternal psychological distress & EF

Although the emerging research field of parental EF indicates that EF is one of the parenting determinants that shape caregiving behavior (Bridgett et al., 2015; Crandall et al., 2015), knowledge about factors that influence parental EF levels specifically in the context of early parenthood is limited. Several stressors that are known to be negatively associated with adult EF are common among general population mothers during early parenthood, like symptoms of depression, anxiety, insomnia, and poor couple relationship adjustment (Ballesio et al., 2019; Canário & Figueiredo, 2017; Castaneda et al., 2008; Cohen et al., 2019; Kluwer, 2010; Mindell et al., 2015; Snyder et al., 2015). To expand the knowledge about factors that influence parental EF levels during early parenthood, Study II explored the associations between self-reported psychological distress symptoms and EF among mothers of toddlers. Higher distress levels (i.e., symptoms of depression, anxiety, insomnia, and poor couple relationship adjustment) were expected to be associated with lower EF. Furthermore, cumulative effects were predicted, so that the distress/EF associations would be stronger when concurrently considering several distress domains. The results provided partial support for the hypotheses. Subclinical psychological distress levels, as well as clinically elevated distress levels within single distress domains, were not significantly associated with EF. However, the expected negative association with EF was found when the overall number of concurrently clinically elevated distress domains was examined.

If replicated, the novel null findings that continuous single/additive symptom scores, as well as single clinically elevated distress domains, were not associated with lower EF are reassuring. These results suggest that general population mothers who during early parenthood experience low symptom levels of depression, anxiety, insomnia, and poor couple relationship adjustment, or alternatively experience clinically elevated levels within a singular distress domain, are not at great risk of a depleted EF capacity.

In contrast, the significant negative association between the number of concurrently clinically elevated distress domains and EF performance warrants further attention. In line with previous research showing that stressors can have a deleterious influence on adult EF capacity (Diamond, 2013; Orem et al., 2008; Tomeo, 2014), these results could reflect a cumulative, depleting effect of common stressors during early parenthood on EF among general population mothers. Considering the correlative approach of Study II, it is however important no note that the cumulative psychological distress/EF-association could be bi-directional. Although prior research primarily points to psychological distress (like depression, anxiety, and insomnia) preceding EF impairments (Castaneda et al., 2008; Snyder et al, 2013; Krause et al., 2017; Ballesio et al, 2019), some findings also indicate that lower EF can precede psychological distress. In general, an individual's EF capacity can affect the different components of stress regulation, like stress exposure, stress reactivity, and stress recovery (Williams et al., 2009). More specifically in relation to psychological distress, Snyder and colleagues (2015) state that even though there is a wealth of findings linking psychopathologies like depression and anxiety to lowered EF task performance, it is unclear whether EF deficits are a consequence of psychopathology, or whether they are a causal risk factor for developing psychopathologies. Relatedly, Ballesio and colleagues (2019b) found poorer EF to partly predict rumination about the negative consequences of insomnia. This was interpreted to indicate that EF capacity could influence the development and maintenance of insomnia, as rumination about lack of sleep plays a central role in the maintenance of insomnia. Additionally, findings that adults who have had Attention Deficit/Hyperactivity Disorder (for which impaired EF is a central feature) since childhood experience poorer couple relationship adjustment than healthy controls (Eakin et al., 2004) suggest that EF might influence couple relationship adjustment. In summary, concurrently clinically elevated symptom levels within several distress domains could have a negative, cumulative influence on maternal EF during early parenthood. It is also possible that lower EF could increase the vulnerability to simultaneously develop clinically elevated symptom levels within multiple distress domains during early parenthood. These processes are not mutually exclusive, but could hold true for different mothers, or for the same mothers at different times. Consequently, it would be advisable to consider bi-directional links between psychological distress and EF among general population mothers during early parenthood, both within healthcare and research settings.

4.3. The association between maternal EF and caregiving behavior

To date, few studies have explored associations between parental EF and measures of caregiving behavior that besides research settings can be utilized within clinical interventions. One such framework is emotional availability (EA; Biringen et al., 2014), which refers to the parent-child dyad's capacity to share an emotionally healthy relationship. Considering that parental EF/caregiving behavior links have been found to vary depending on parental stress levels (Chary et al., 2020, Deater-Deckard et al., 2012), and that several psychological distress domains that are known to be negatively associated with adult EF are common among general population mothers during early parenthood (Ballesio et al., 2019; Canário & Figueiredo, 2017; Castaneda et al., 2008; Cohen et al., 2019; Kluwer, 2010; Mindell et al., 2015; Snyder et al., 2015), it is furthermore motivated to explore whether psychological distress domains that are common during early parenthood might influence the link between maternal EF and EA. Study III examined associations between maternal EF and EA among general population mothers of toddlers, while also accounting for the potential moderating effect of self-reported symptoms of psychological distress. Higher EF was expected to be associated with better EA, and this association was hypothesized to be stronger for mothers with low symptom levels/weaker for mothers with high symptom levels. Furthermore, cumulative effects were expected, so that the moderation effect would be more pronounced for cumulative distress scores in comparison to single distress domains. These hypotheses were partially supported by the results. Better maternal EF was significantly, albeit weakly, associated with more EA caregiving behavior. Although the observed moderation effects were in the expected direction, none of the individual distress domains, nor a cumulative distress composite, moderated the EF/EA association.

The association between higher maternal EF and better EA is in line both with previous literature that has linked higher maternal EF with more sensitive and involved caregiving generally (Bridgett et al., 2015; Crandall et al., 2015), and with the one prior study that has explored associations between maternal EF and specifically EA among general population mothers during early parenthood (Harris et al., 2021). Study III supports the findings reported by Harris and colleagues (2021), and complements them by shedding light on how slightly different EF core functions are related to EA (the EF composite employed by Harris and colleagues [2021] measured primarily set-shifting and inhibitory control, while the EF composite utilized in Study III measured primarily working memory and set-shifting). It is noteworthy that the EF/EA association in Study III was weak, and did not remain statistically significant when controlling for education level. This weak association is logical, as EF is only one determinant that shapes maternal EA alongside many other determinants, like maternal mental health, family socioeconomic status, and child characteristics (Biringen et al., 2014). The weakening influence of the covariate education level on the EF/EA-association is also understandable, when considering that educational attainment and EF are closely intertwined (Deary & Johnson, 2010). The EF/EA association found in Study III is very similar to the association reported by Harris and colleagues (2021). In their general population sample, the EF/EA correlation was .23**, while it was .17* in the general population sample examined in Study III. Taken together, these results indicate that maternal EF has a weak but significant effect on maternal EA among general population mothers during early parenthood. Thus, it is recommendable to alongside other caregiving determinants also consider the influence of EF on maternal EA during early parenthood within both research and clinical settings.

Although neither the single distress domains nor the averaged cumulative distress composite moderated the EF/EA association on a significant level, the directions of the observed interaction effects were in line with the hypotheses. This suggests that higher distress levels might weaken the association between higher EF/better EA on a significant level. Besides potentially being related to restricted distress symptom variance in the study sample, the non-significant results could also be due to the comparatively small sample size and therefore low power to detect interaction effects. Although Porreca and colleagues (2018) did not study specifically the moderating effect of psychological distress on the EF/EA association, their results suggest that EF might be differently associated with EA among more disadvantaged mothers in comparison to general population mothers. Studying mothers with substance use disorder, Porreca and colleagues (2018) found maternal EF to predict 25.5% of the variation in maternal EA. This effect size is a notably larger than in Study III, where maternal EF predicted only 3% of the maternal EA variation. To summarize, if the non-significant moderation results found in Study III are replicated in larger samples, then they indicate that general population mothers are not at great risk for psychological distress levels depleting the positive influence of higher EF on maternal EA during early parenthood. However, considering that the directions of the observed interaction effects were in the expected direction, and that EF/EA associations have been reported to be stronger among mothers experiencing higher levels of psychological distress (Porreca et al., 2018), it is possible that significant moderation effects could be found in more disadvantaged populations. Hence, it is central that the findings are not generalized to mothers experiencing higher levels of psychological distress in comparison to the participants in Study III.

4.4. The role of EF in the alexithymic traits/EA association

Although recent studies have reported that maternal alexithymic traits are associated with caregiving behavior during the first years of parenthood (Ahrnberg et al; 2021; Porreca et al., 2020; Yürümez et al., 2014), and EF is known to exert moderating effects on the associations between different parenting determinants and caregiving behavior (Deater-Deckard et al., 2012; Sturge-Apple et al., 2014), it is to date unknown whether the personality construct alexithymia and parental EF have a joint effect on caregiving behavior. Hence, the associations between maternal alexithymic traits and EA, along with the moderating effect of EF on this association, were examined in Study IV. As expected, higher levels of alexithymic traits were associated with lower EA. Interestingly, this association was driven by one of the subscales of the 20-item Toronto Alexithymia Scale (TAS-20), namely Externally Oriented Thinking (EOT). Also as hypothesized, EF levels moderated the EOT/EAS association, which was statistically significant for low EF mothers, and non-significant for mothers with high EF levels.

The notable difference between how EOT and the other TAS-20 subscales were associated with the EAS composite warrants reflection on whether the separable dimensions of alexithymia might have different functions in relation to the parental capacity to be EA during childcare. Previous alexithymia research indicates that the cognitive dimension EOT is separable from the TAS-20 affective dimensions Difficulty Identifying Feelings (DIF) and Difficulty Describing Feelings (DDF). DIF and DDF have repeatedly been associated with psychiatric symptomatology, while EOT has been linked with empathy deficits and detached social behavior (Grabe et al., 2004; Grynberg et al., 2010; Kajanoja, 2017; Kajanoja, 2019; Vanheule et al., 2011). The divergent results for EOT are also backed up by the TAS-20 subscale correlations among the participants in Study IV. As can be seen in *Table 16*, DIF and DDF correlate moderately with each other, while they correlate weakly with EOT. This illustrates that in the current sample, EOT captures separate variance than DIF/DDF. Relating to the role of EOT for caregiving behavior in early parenthood, Ahrnberg and colleagues (2020) reported higher levels of alexithymic traits to be associated with lower parental mentalizing/reflective functioning among general population parents.

Parental reflective functioning refers to the capacity to relate to the child as someone with a mind of his/her own and to show interest in the child's thoughts and feelings. This association was similarly to the findings in Study IV driven by the TAS-20 sub scale EOT. As better parental reflective functioning is also associated with better parental EA (Luyten et al., 2017), the effect of EOT on EA could be linked to parental reflective functioning. Considering that EOT is characterized by a non-introspective, unemotional cognitive style, these traits could impair the parental capacity to become aware of a child's mental states and emotions, thus negatively influencing the parent's EA. Combined with the results of Study IV, the findings of Ahrnberg and colleagues (2020) suggest that the effect of EOT on EA could be further understood by exploring the role of parental reflective functioning.

Turning to the moderating effect of maternal EF on the EOT/EAS composite association, it suggests that lower EF levels make mothers more vulnerable for the influence of EOT on EA, while higher EF levels have a buffering effect in this context. Considering the nature of EF, this buffering effect is likely to be due to higher EF levels enabling parents to pause and think before reacting, to suppress their own automatic impulsive reactions and instead consider the child's needs and situational factors, and to consider the consequences of different caregiving responses before reacting. When taking into account that higher maternal EF has been linked to better parental reflective functioning (Rutherford et al., 2018; Yatziv et al., 2020), and that the alexithymia dimension EOT has also been associated with parental reflective functioning (Ahrnberg et al., 2020), it seems probable that the buffering effect of parental EF on the influence of EOT on EA could be rooted in parental reflective functioning. As described by Rutherford and colleagues (2015), EF seems to create space for parental mentalizing in caregiving situations. The implications of the moderation findings in Study IV are thus twofold, indicating both that it is especially important to consider the potential influence of alexithymic traits among low EF mothers, and that it could be fruitful to incorporate parental reflective functioning when considering links between parental alexithymic traits, EF, and caregiving behavior.

4.5. Implications for parenting interventions

The novel findings from Studies II-IV offer several perspectives on the role of maternal EF in caregiving behavior during early parenthood, which are relevant for professionals working with parenting interventions, like child health clinic employees, social workers, and child psychiatric clinic employees. Firstly, the association between higher EF and better EA found in Study III indicates that *among general population mothers of toddlers, a mother's EF capacity has a slight but relevant direct influence on her ability to be EA when caring for her child*. As the EF tasks included in this thesis primarily measured working memory and set-shifting capacity, the results specifically indicate that these core EF components have an impact on maternal EA during early parenthood. However, as Harris and colleagues (2021) reported that an EF composite including inhibitory control had comparable associations with maternal EA within a similar study sample, EF seems to generally be associated with EA among general population mothers of toddlers. Considering this EF/EA association, it is recommendable to take into account the influence of parental EF on EA capacity when assessing parental caregiving resources. EF assessments could alongside socioemotional assessments facilitate the formulation of optimally supportive parenting interventions.

The thesis results further indicate that besides directly affecting the parental capacity for EA caregiving, higher parental EF can have a buffering effect on the influence of other negative parenting determinants on caregiving behavior, while lower EF levels can increase a parent's vulnerability for this influence. More specifically, Study IV demonstrated that maternal EF influences to what degree maternal alexithymic traits (more precisely an externally oriented thinking style) affects a mother's ability to be EA while caring for her child. This result supports previous reports of parental EF moderating to what degree negative parenting determinants (e.g., dysfunctional child-oriented attributions and challenging child behavior) influence caregiving behavior (Deater-Deckard et al., 2012; Sturge-Apple et al., 2014). Although further studies are called for to broaden the understanding for these dynamics, the pattern formed by these publications indicate that besides accounting for direct effects of parental EF on caregiving behavior, it is also advisable to consider how parental EF might influence the effect of other parenting determinants on caregiving behavior.

In Study II, *a cumulative number of clinically elevated psychological distress domains, but not lower distress levels within multiple domains, nor clinically elevated levels within single distress domains, were associated with lower maternal EF.* Relatedly, in Study III *psychological distress symptoms did not significantly affect the mothers' capacity to utilize their EF resources during caregiving.* Although these novel findings require confirmation through replication, the results have several clinically relevant implications:

- The finding that lower psychological distress levels, as well as clinically elevated symptom levels within single distress domains, were not associated with lower EF can be seen as reassuring. This null finding contributes to a more nuanced understanding regarding which mothers are not at great risk of a depleted EF capacity during early parenthood, i.e., general population mothers who experience just a few symptoms of psychological distress, or alternatively clinically elevated symptom levels within only one distress domain.

- The finding that clinically elevated symptom levels within several distress domains were associated with lower EF is in line with two separate (but not mutually exclusive) interpretations, as described above in section *4.2. The association between maternal psychological distress & EF*. If clinical symptom levels within several concurrent distress domains have a cumulative, depleting effect on parental EF capacity, then providing treatment for psychological distress can allow for a restored EF capacity, enabling parents to make optimal use of their EF resources in caregiving contexts. The distress domains that were examined in the present thesis (i.e., depression, anxiety, insomnia, and poor couple relationship adjustment) are often treated with psychosocial interventions that support parental stress/mood regulation specifically in the context of early parenthood. If on the other hand lower EF increases parents' vulnerability to develop clinically elevated symptoms within multiple distress domains during early parenthood, then offering low EF parents interventions that support their EF resources would likely reduce this vulnerability. Additionally, the cumulative distress/EF association holds an important clinical implication even if the association's directionality is disregarded. As both lower maternal EF and maternal psychological distress are linked to adverse child outcomes (Reid and Crisafulli, 1990; Bridgett et al., 2015; Crandall et al., 2015; Hahn-Holbrook et al., 2018), and cumulative clinically elevated psychological distress and lower EF appear to be associated, healthcare providers encountering mothers with one of these risk factors for adverse child outcomes are well advised to consider whether other risk factor is also present.

- Considering the cumulative distress/EF association reported in Study II, the finding in Study III that psychological distress symptoms do not significantly affect how general population mothers of toddlers can utilize their EF capacity during caregiving situations can seem surprising. It is however important to note that these results do not rule out the possibility of stress levels affecting to what degree parents can make use of their EF capacity in caregiving situations in other samples, like parents experiencing a broader range of stress exposures and symptom levels than the participants included in the current thesis. As the interaction effects in Study III were in the expected direction but too weak to be significant, is it possible that a significant effect would be found among parents with greater stress symptom variance. Pending further research into this subject, health care professionals working with parenting interventions can consider that although distress symptoms experienced by general population mothers are not likely to affect to what degree mothers can utilize their EF capacity while caring for their toddlers, it is possible that higher stress levels among more disadvantaged parents could have a negative effect on parents' ability to utilize their EF capacity during childcare.

Importantly, although the thesis findings indicate that it is relevant to consider the EF/EA association even among general population mothers, the effect of EF on EA appears to be more pronounced among mothers experiencing higher levels of psychological distress than what is typically found among general population mothers. Exemplifying this, Porreca and colleagues (2018) reported maternal EF to predict 25.5% of the variation in maternal EA, which is a notably larger effect than the results in Study III, where maternal EF predicted only 3% of the maternal EA variation. Consequently, *accounting for the influence of parental EF on EA appears to be especially relevant when assessing parental caregiving resources among high-risk parents*.

The link between higher maternal EF and more EA caregiving behavior during early parenthood draws attention to the potential mechanisms through which EF might influence the degree of EA in caregiving behavior. Although the studies included in this thesis do not provide certain knowledge about how maternal EF influences caregiving behavior, an educated guess about these mechanisms can be formulated based on prior knowledge about EF, maternal EA, and children's caregiving needs during toddlerhood. Toddlerhood is characterized by an intense interest in exploring the physical world, and by rapid motor, cognitive, and language development (Payne & Isaacs, 2017; Madigan et al., 2019). Furthermore, toddlers exhibit frequent negative emotional reactivity as part of their normative socioemotional development (Alink et al., 2006). Hence, toddlers benefit from active and engaged parental caregiving, that supports and guides the children through their developmental tasks, while also allowing for sufficient independence. The observational framework that was employed in the current thesis (the EAS) reflects to what degree the mothers were emotionally available while interacting with their children, i.e., sensitive, structuring, non-intrusive and non-hostile. Hence, EF capacity appears to affect to what degree mothers of toddlers are able to have an authentic and positive emotional presence while appropriately interpreting and flexibly reacting to the child's emotional cues, to mentor the child's pursuits while simultaneously strengthening the child's sense of autonomy, and to be available to the child without being intrusive or hostile. Considering previous knowledge about the core EF components (which is described in more detail in the *Introduction*), it is plausible that the effect of EF on EA is rooted in the capacity to cognitively process caregiving interactions. Better working memory is likely to support parents' ability to keep information about their child/the caregiving situation in mind and process this information. Correspondingly, a better set-shifting capacity helps parents flexibly shift their attention between different stimuli in caregiving situations/between different mental interpretations of caregiving situations, while inhibitory control supports parents' ability to suppress prepotent automatic impulsive reactions and consider the child's needs. In other words, EF likely enables parents to pause and think before reacting, to suppress their own automatic reactions and instead consider the child's needs and situational factors, and to consider the consequences of different caregiving responses before reacting. During a free-play situation like the one studied in the present thesis, higher parental EF is likely to help the parent keep the purpose of the task at hand (i.e. playing with your child) in mind and focus on it, while flexibly shifting attention between different stimuli (e.g., the child's behavior and emotional reactions, as well as the parent's thoughts and emotional reactions), and inhibiting automatic responses to these stimuli which allows for the consideration of the consequences of different behavioral responses from both the parent's and the child's perspective.

Widening the perspective on the potential mechanisms behind the EF/EA association from cognitive to socioemotional dimensions, the effect of maternal EF on EA is also likely to be related to maternal emotion regulation capacity. Emotion regulation refers to the ability to influence emotional experience and expression, by processes like expressive suppression (i.e., reducing outward expressions of internal emotional states) and cognitive reappraisal (i.e., modifying one's thoughts about a situation in order to influence one's emotional response to the situation) (McRae & Gross, 2020). Although research on the influence of EF on emotion regulation capacity is scarce, a few studies have indicated that individual EF differences predict differences in emotion regulation. Inhibitory control and working memory updating have been suggested to facilitate both expressive suppression and cognitive reappraisal, by keeping in mind the intention to suppress emotions, and aiding to generate and maintain non-emotional appraisals of emotional events (Schmeichel & Tang, 2015). In a review of emotion regulation specifically in the context of parenthood, Rutherford et al. (2015) highlight that well-functioning emotion regulation is vital for parental caregiving, as it facilitates sensitive responding and caregiving behavior irrespective of the child's affective state. A common parenting challenge is maintaining a regulated emotional state while caring for a dysregulated and distressed child, in order to sensitively respond to the child's needs and facilitate the child's regulation (Rutherford et al., 2015). Although the link between parental emotion regulation ability and EA has not yet been widely studied, an association seems likely considering that emotion regulation is known to be central for sensitive parental caregiving behavior (Rutherford et al., 2015), and the EAS focuses on the parent-child dyad's capacity to share an emotionally healthy relationship (Biringen et al., 2014). In line with this expectation, Kim et al. (2012) found maternal affect dysregulation (more specifically, the tendency to use unhealthy externalizing behaviors to reduce tension and distress) to be associated with less EA caregiving behavior. To summarize, as individual EF differences predict differences in emotion regulation (Schmeilchel & Tang, 2015), and maternal emotion regulation is central both for caregiving behavior in general (Rutherford et al., 2015) and for EA specifically (Kim et al., 2012), the effect of maternal EF on EA could in part be related to maternal emotion regulation capacity.

Another potential mechanism in relation to the effect of EF on EA is parental reflective functioning, i.e., the capacity to relate to the child as someone with a mind of his/her own and to show interest in the child's thoughts and feelings. The basis for this interpretation lies in the results of Study IV, in which the association between maternal alexithymic traits and EA was driven by the alexithymia dimension EOT (Externally Oriented Thinking), and it was specifically on this higher EOT/lower EA link that maternal EF had a moderating effect. In other words, higher EOT levels were associated with less EA caregiving, but only among mothers with lower EF than the group mean level, indicating an interaction effect between maternal EOT and EF in relation to caregiving behavior during toddlerhood. EOT is characterized by an unemotional, non-introspective cognitive style. Considering that parents need to be interested in the child's thoughts and emotional experiences in order to be able to provide EA caregiving to active and sometimes oppositional toddlers, it seems plausible that parents with an externally oriented thinking style would have a lower EA capacity. Besides generally being associated with detached social behavior and empathy deficits (Grabe et al., 2004; Grynberg et al., 2010; Kajanoja, 2017; Kajanoja, 2019; Vanheule et al., 2011), the cognitive alexithymia dimension EOT has also been associated with lower parental reflective functioning among general population parents (Ahrnberg et al., 2020). Thus, the negative effect of EOT on parental caregiving behavior could at least partly be rooted in a restricted capacity for parental reflective functioning. As higher maternal EF has also been reported to be associated with better reflective functioning (Rutherford et al., 2018; Yatziv et al., 2020), it is possible that the that the joint effect of EOT and EF on EA is linked to parental reflective functioning. In other words, higher EF could buffer against the negative effect of EOT on EA by creating better conditions for parental reflective functioning.

Turning to parenting interventions, the higher EF/better EA association has several implications that are relevant to consider within this area. Generally, low EF parents could benefit from interventions that support their EF resources specifically in the context of caregiving situations. As the scientific field of parental EF is still emerging, the literature is scarce regarding suitable support for low EF parents. Johnston and colleagues (2012) offer some suggestions of psychosocial interventions that are likely to support positive caregiving behavior among parents with ADHD. Since EF deficits are a core feature of ADHD, low EF parents are likely to benefit from similar interventions, even if they do not fill the diagnostic requirements for ADHD. As described by Johnston and colleagues (2012), parents with ADHD/low EF are more likely to benefit from skill-based practice that allows for repetition in order to build new parenting habits, than from lecture style psycho-education about parenting. One reason for this is that caregiving challenges that are rooted in low EF/ADHD are neither related to deficient knowledge about what good parental caregiving is, nor caused by a low motivation to provide good caregiving for one's children, but is rather related with challenges to utilize this knowledge and motivation in day-to-day caregiving situations. Therefore, ADHD/low EF parents are likely to benefit, e.g., from explicit instruction in planning and organizational skills that are relevant to caregiving, and from the modification of community and home settings so as to help elicit positive caregiving behavior. Considering that the parenting challenges that low EF/ADHD parents experience can over time negatively affect their sense of competence as parents, it can also be relevant to target dysfunctional cognitions about parenting in order to support the acquisition of new parenting skills (Johnston et al., 2012). As the findings in Study III indicated that maternal EF plays a role specifically in the degree of EA caregiving behavior, interventions focusing particularly on parental EA could benefit from the inclusion of parental EF supporting elements. Parenting interventions that are based on dyadic EAS observations support the parent's ability to provide more EA caregiving by, e.g., offering information about EA and attachment, and by providing feedback on videotaped dyadic interactions through a strengths-based approach (Baker et al., 2015). These interventions might benefit from taking into account the role of parental EF in EA, by helping parents recognize how their EF capacity can reflect onto the degree of EA in their caregiving behavior, and by assisting parents to find strategies that support their EF capacity specifically with regards to their ability to provide EA caregiving.

4.6. Limitations and strengths

The current thesis has some limitations and strengths that are relevant to note. The most central limitations are related to study sample characteristics. Firstly, in line with a majority of the parental EF publications, only mothers were studied. This is a reasonable starting point for this line of research, as mothers are often more actively involved in childcare during early childhood. Although findings from maternal EF studies are likely to be applicable to fathers as well, it is also possible that the dynamics of parental EF to some degree function differently among fathers. Secondly, the study samples included in the present thesis included healthy, general population mothers. As described in section *2.1. Participants*, the participants in Studies I-IV were drawn from the FinnBrain Birth Cohort, which is fairly representative of the general Finnish population (Karlsson et al., 2018). As can be seen in *Table 1*, the sociodemographic characteristics of the four largely overlapping study samples are very similar. On a group level, the mothers were relatively highly educated, had a low rate of unemployment, and mainly reported being in a couple relationship. Compared to the whole FinnBrain Cohort, the participants in the present thesis were both older and had attained a higher level of education. As described in section *3.1. Initial Results, Study I-IV*, the mothers displayed normative levels of verbal intelligence and EF. Furthermore, they reported fairly low levels of anxiety and depression symptoms, as well as a low prevalence of alexithymic traits, and their caregiving behavior was mostly coded as emotionally available. Together with the comparatively higher levels of insomnia and poor couple relationship adjustment that can be expected among mothers of toddlers, these sample characteristics indicate that the results of the present thesis describe patterns that can be found among healthy, general population mothers during early parenthood. It is therefore important that results from this thesis are not generalized to more disadvantaged populations, as the dynamics of parental EF, psychological risk factors and caregiving behavior are likely to function differently in high stress contexts.

The present thesis also includes some study design limitations that are relevant to note. In Study II, the maternal EF and psychological distress data were collected at the same time point. As it is both theoretically plausible that psychological distress levels influence EF, and that EF levels influence psychological distress, it is important to note that this correlative study design does not allow for certainty about causal effects. However, the correlative study design is motivated as a first exploration into the dynamics between EF and psychological distress domains that are common among general population parents during early parenthood (especially as both directions of the potentially bi-directional association between parental EF and psychological distress are relevant from a clinical perspective). Although data on maternal EF and caregiving behavior were also collected at the same time points in Studies III and IV, these variables are not affected by a similar uncertainty concerning the direction of the associations, as it is not theoretically probable that maternal EA would have a causal effect on maternal EF levels. However, in Study III it would also have been theoretically plausible to alternatively examine the moderating effect of maternal EF on the association between psychological distress and caregiving behavior, especially as EF and psychological distress were measured at the same time point.

Additionally, some limitations related to the measurement methods employed in the current thesis should be noted. The Cogstate EF composite utilized in Studies II-IV primarily measures working memory updating and set-shifting capacity, and does not include inhibitory control tasks. The composite furthermore encompasses a notable visuospatial component, and incorporates substantial elements of learning. The results of Studies II-IV should thus be viewed specifically in the context of these EF dimensions, and it should be recognized that the results might have differed to some degree if other EF measures had been employed. Simultaneously, the combination of multiple tasks into an EF composite can be seen as a strength of the study, as it minimizes variability due to measurement errors. Concerning the EF assessments, it is also important to consider the ecological validity of the employed EF composite. The EF assessments were conducted in structured laboratory environments, that differed greatly from the real-life situations in which parents utilize their EF capacity during childcare. This entails some uncertainty regarding how well the employed EF composite reflects the EF resources that the participants can draw upon in day-to-day caregiving situations. Still, especially considering how time intensive EF task data collection is, the findings related to parental EF in Studies II-IV can be seen as valuable additions to the literature in this research field, paving the way for studies employing more nuanced and ecologically valid EF measurement methods. Turning to the assessment of psychological distress levels and alexithymic traits, these were measured with self-report questionnaires. Allowing for reporting biases, this can be considered a study limitation. However, health care providers assessing parental mental health during early parenthood often rely on the same or very similar questionnaires as the ones employed in Studies II-IV (i.e., EPDS, SCL-90, AIS and RDAS). The utilized self-reports thus encompass a central aspect of ecological validity, providing similar information about parental psychological distress as what is commonly available to health care providers. Concerning the RDAS questionnaire that was employed in Study II, it should be noted that the data on couple relationship adjustment was collected at two years after delivery, which is six months before the other main variables included in Study II (i.e., EPDS, SCL-90, AIS and Cogstate EF tasks). It is thus possible that the participants' couple relationship status or relationship quality had changed during this time, resulting in RDAS scores that inaccurately described the participants' couple relationship adjustment at 2.5 years after delivery. However, considering that adult couple relationships often change slowly, this is unlikely to be a major concern. Regarding the TAS-20, there have been some indications that the subscale EOT could have partly weak psychometric properties (Kooiman et al., 2002). EOT has furthermore been reported to have questionable internal consistency within the FinnBrain Birth Cohort (Kajanoja et al., 2017). However, EOT has been found to show good construct validity, showing negative correlations with empathy, mind mindedness, and emotional intelligence (Bagby et al, 1994b; Parker et al, 2001). Although these limitations are central to note, the TAS-20 was considered to be the most suitable option for the assessments of alexithymic traits in the present study, allowing for time efficient data collection from a large study population.

4.7. Future research suggestions

The limitations of the current thesis give rise to some suggestions concerning future parental EF research. Importantly, studies that elucidate the patterns of parental EF among fathers are called for. Expanding knowledge about paternal EF is central considering that the dynamics of parental EF might to some degree function differently among fathers. As fathers alongside mothers constitute a central influence on child development and well-being, detailed knowledge about the determinants of both parents' caregiving behavior is needed. As importantly, together with the related findings from prior parental EF studies described in the *Introduction*, the interplay between parental EF and psychological distress that was found in the present thesis points to the relevance of studying parental EF within both general population samples and high-risk samples. As the current literature indicates that the EF/caregiving behavior association might vary depending on the parents' level of stress exposure, it would be especially recommendable for future studies to include both high-risk and general population samples in their study designs, allowing for direct comparisons of results from the same assessment methods between samples. Concerning measurement methods, future parental EF studies would benefit from more extensive neurocognitive test batteries, that besides a general EF composite would offer more fine-grained insight into the role of separable EF core functions in parental caregiving behavior. Furthermore, the development of EF measures that would be more ecologically valid in the context of early parenthood would likely offer a more nuanced understanding for the dynamics of parental EF, as well as be a welcome addition to the clinical tools available to health care professionals working with parents and families. Importantly, future parental EF studies would also benefit from longitudinal study designs including repeated EF assessments. Baseline EF assessments conducted prior to, e.g., variation in psychological distress levels or EF supporting interventions, would allow for more robust conclusions about causal effects. Longitudinal study designs of the associations between parental EF and caregiving behavior would also allow for more insight into how the role of parental EF in the context of caregiving behavior might vary in different child developmental phases.

The consideration of what is currently known about parental EF gives rise to some additional suggestions for future studies. As the first decade of research in this area has shown, parental EF is one of determinants that shape parental caregiving behavior. Based on this knowledge, it is motivated to start exploring whether parental EF-supporting interventions could have a positive effect on parental caregiving capacity. The interplay between psychological risk factors and EF in the context of caregiving behavior that was found in the current thesis, along with the previous research in this area that is described in more detail in the *Introduction*, indicates that EF can have complex associations with other determinants of caregiving behavior. Consequently, future studies would benefit from open-minded, cross-disciplinary study designs including varied parenting determinants, in order to shed more light on the dynamics of parental EF. One future study topic that seems relevant in light of the results found in Study IV is the role of parental EF in the interplay between alexithymic traits, parental reflective functioning, and EA in caregiving situations.

4.8. Conclusions

The results of the present thesis indicate that alongside socioemotional factors, parental EF should be considered as one of the determinants that shape the capacity to provide EA caregiving during early parenthood. Furthermore, parental EF can buffer against the influence of other negative parenting determinants on caregiving behavior (like parental alexithymic traits), while lower EF levels can increase a parent's vulnerability in this context. Consequently, interventions supporting parental EF specifically in the context of early parenthood are likely to strengthen a parent's ability to be EA in caregiving situations. Parents experiencing psychological distress levels that are common among the general population during early parenthood do not seem to be at great risk for these distress levels depleting their EF capacity, nor for these distress levels affecting to what degree they can utilize their EF capacity in order to be EA during childcare. However, as a higher number of concurrent clinically elevated distress domains were linked to lower EF even among general population mothers, the negative influence of psychological distress is relevant to keep in mind when considering how parental EF might affect caregiving behavior. If distress levels deplete parental EF capacity, then interventions that relieve these symptoms are also likely to allow for recovered EF, enabling parents to make optimal use of their EF capacity in caregiving situations. Further research in the area of parental EF is called for, and future studies would benefit from exploring how the effects of parental EF on caregiving behavior might be linked to parental reflective functioning. The findings of the current thesis highlight the importance of cross-disciplinary study designs that combine perspectives from different clinical traditions/research fields in order to deepen the understanding for the complex dynamics that shape parental caregiving behavior.

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