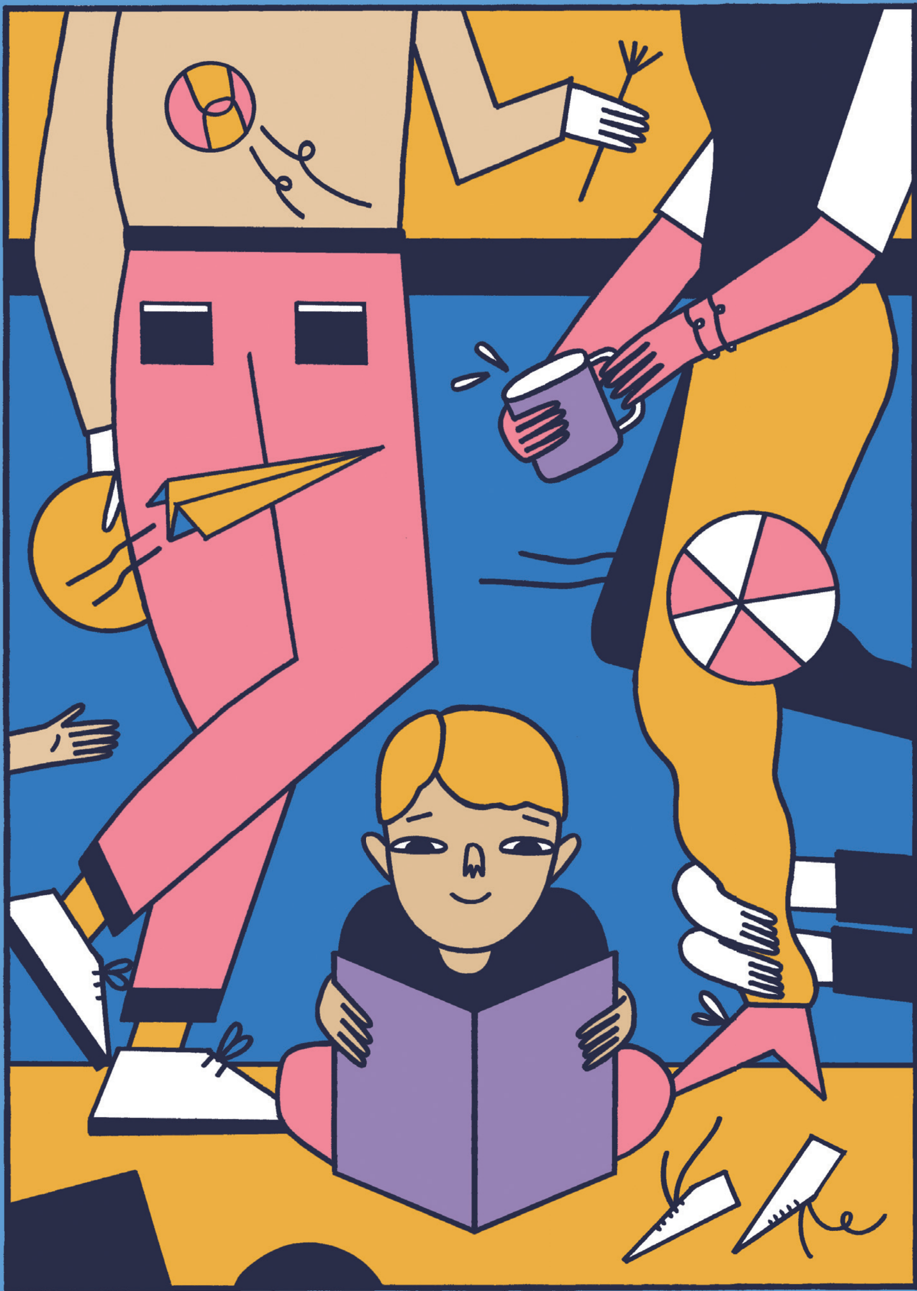
In Control

Early Precursors and Development of Self-Regulation



Sanne Geeraerts

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Early Precursors and Development of Self-Regulation

Sanne Barbara Geeraerts

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In Control

Early Precursors and Development of Self-Regulation

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(met een samenvatting in het Nederlands)

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Voor mijn ouders,

in herinnering aan mijn vader

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CHAPTER 1

General Introduction

At school entry, most children already show a remarkable ability for self-regulation. They can work relatively independently in crowded classrooms, wait when asked to do so, and control emotions such as anger and sadness to some extent. At the same time, there is already considerable variation in self-regulation at this age, which can be seen in differences in children's ability to focus on a task, the ease with which they comply to adult requests, and their ability to deal with emotions. These individual differences in self-regulation matter: higher levels of self-regulation are associated with adaptive outcomes in multiple domains, such as more school readiness (Blair & Razza, 2007), better social skills (Eisenberg, Fabes, Gurthrie, & Reiser, 2000), less substance abuse (Quinn & Fromme, 2010), and fewer externalizing symptoms (Olson, Sameroff, Kerr, Lopez, & Wellman, 2005). Understanding how individual differences in self-regulation emerge is the focus of this dissertation.

Given its importance for a broad range of developmental outcomes, self-regulation has been the object of much scientific endeavor. Broadly, self-regulation is defined as the automatic or deliberate modulation of affect, behavior, and cognition (Karoly, 1993). Studies have traditionally focused on self-regulation as a predictor of developmental outcomes such as those described above. In recent years, a shift has taken place, with more and more research focusing on questions regarding how self-regulation develops, and which early individual factors predict self-regulation (see for instance Hendry et al., 2016 for a recent review). However, although we know fairly well which developmental outcomes are predicted by self-regulation, the early antecedents and development of self-regulation itself are still less well understood. To further understand how individual differences in self-regulation emerge, longitudinal studies spanning the first years of life are needed.

In the current dissertation, the overarching aim was to increase knowledge on the early development of self-regulation and the factors that are associated with self-regulation in early childhood. To this end, the three aims of this dissertation are to (1) examine the mean-level development and early markers of self-regulation; (2) identify family factors that might play a role in the development of self-regulation, including parental characteristics, parenting practices, and features that define the broader rearing context; and (3) examine problem behavior related to self-regulation that manifest in the preschool years.

Conceptualizations and Measurement of Self-Regulation

Given the interest of researchers from various disciplines (developmental psychology, cognitive psychology, socialization research) in self-regulation, there is a wide array of conceptualizations of self-regulation in circulation. A commonality between most of these definitions is that they generally distinguish *regulation* from *targets of regulation* (i.e., a dual-process model, Nigg, 2017; Skinner & Zimmer-Gembeck, 2007). Targets of regulation, often being referred to as reactivity, are fast, automatic responses to a certain situation, which are generated without much conscious control. For instance, a stranger generates a reaction of fear, an attractive object triggers an impulse to grab it, a loud sound attracts attention, etcetera. Such automatic responses are adaptive, especially in moments when it is necessary to act fast. However, individuals also need regulatory processes and behaviors to be able to flexibly modulate automatic responses into more desirable ones. For example, regulatory behaviors such as thumb-sucking lessen the feeling of anxiety (Ekas, Lickenbrock, & Braungart-Rieker, 2013), and looking away from an attractive object helps in inhibiting the urge to grab it (Putnam, Spritz, & Stifter, 2002). In this dissertation, my primary focus is on these regulatory processes, conceptualized as effortful control, executive functioning, or compliance.

The first conceptualization that is used throughout this dissertation is *effortful control.* Effortful control stems from research focusing on temperament, i.e., constitutionally based individual differences, within the influential psychobiological model proposed by Rothbart, Posner and collaborators (e.g., Rothbart, Sheese, Rueda, & Posner, 2011). In this model, that is often used by developmental psychologists, effortful control and reactivity form the core of an individual's temperament. Reactivity refers to automatic responses to changes in the external and internal environment, i.e., the targets of regulation. Reactivity includes both negative (i.e., negative affect), and positive components (i.e., extraversion or surgency). In line with a dual-process model, the role of effortful control is to modulate reactivity. Effortful control concerns the ability to inhibit a dominant response in order to perform a subdominant response, to detect errors, and to engage in planning (Rothbart, Posner & Kieras, 2006). The concept of effortful control is used in Chapter 2 and 5. In Chapter 4, I focus on a subcomponent of effortful control: inhibitory control, i.e., the ability to plan and suppress responses (Rothbart, Ahadi, Hershey, & Fisher, 2001).

A second conceptualization of self-regulation used in this dissertation is *executive functioning*, which emanates from cognitive psychology. Executive functioning refers to a set of interrelated cognitive skills and often includes at least three components: working memory (the ability to memorize information and update/manipulate this information), inhibition (the ability to suppress a dominant response in favor of a subdominant response), and shifting/cognitive flexibility (the capacity to form a cognitive set and switch to new sets) (Miayke et al., 2000). These cognitive skills can support children in self-regulation, and thereby promote development. For instance, executive functioning is related to superior emotion regulation and emotion understanding in three-year-old children (Leerkes, Paradise, O'Brien, Calkins, & Lange, 2008). Executive functions are related to intelligence, but they are not the same. Whereas working memory is strongly correlated with intelligence (and is in fact often a part of what is tested with intelligence tests), inhibition and shifting/cognitive flexibility are not (Friedman et al., 2006). The concept of executive function is used in Chapter 3, 5, and 6.

Socialization researchers who focused on the development of self-regulation in toddlers and preschoolers have also considered *compliance* as a form of self-regulation (Denham, Warren-Khot, Bassett, Wyatt, & Perna, 2012). To a certain degree, compliance is an odd man out, because it is often not discussed in reviews on various operationalizations of self-regulation (e.g., Bridgett, Oddi, Laake, Murdock, & Bachmann, 2013; Nigg, 2017; Zhou, Chen, & Main, 2012). Yet, compliance can be seen as a first step in acquiring self-regulation, as it encompasses children's reactions to being regulated by others. Compliance is already visible in the first year of life and initially refers to behaviors that are closely tied to an adult's request (e.g., "don't touch"; Kopp, 1982). For instance, eight-month-old infants can refrain from touching a plant when their parent says "no" (Kochanska, Tjebkes, & Fortnan, 1998). Throughout development, compliance generally becomes more self-sustained, and control by adults is not constantly required (Kochanska, 2002). Although noncompliance can also be a sign of developing autonomy, compliance also increases over the first years of life (Sulik et al., 2012). I use compliance as a proxy for self-regulation in Chapter 2 and 3. In Chapter 5, I pay attention to parents' responses to toddlers' noncompliance.

Aim 1: Mean-Level Development and Early Markers of Self-Regulation

Various theoretical frameworks argue that the development of self-regulation builds upon simpler skills that are already developing during infancy (Garon, Bryson, & Smith, 2008; Kopp, 1982). In recent years, a small body of studies has emerged that focusses on predictors of self-regulation. These studies show that control over (visual) attention and negative reactivity are two early markers of self-regulation (see Hendry et al., 2013, for a review). In this dissertation, I focus on these two early individual markers of self-regulation in infancy. In addition, I study mean-level development of a subcomponent of effortful control: inhibitory control.

Visual attention. A variety of studies has demonstrated that visual attention in infancy predicts self-regulation later in development, for instance in the preschool years. As an example, so-called "short lookers" at 5 months of age are found to display superior

executive functioning in the preschool years (Cuevas & Bell, 2014). In addition, sustained attention measured after the second half year of life predicted better toddler and preschool self-regulation (Brandes-Aitken, Braren, Swingler, Voegtline, & Blair, 2019; Johansson, Marciszko, Gredebäck, Nyström, & Bohlin, 2015).

The seminal work by Posner, Rothbart, and collaborators (Posner, Rothbart, Sheese, & Voelker, 2012) focused on three attention networks; the alerting, orienting, and executive attention network. The alerting network is primarily responsible for achieving and maintaining attention, and the orienting network is involved in the overt (with eye movement) and covert (without eye movement) selection of input. Lastly, control over these attention networks is executed through the executive attention network (Posner & Rothbart, 2007). Across development, the relative importance of the orienting and executive attention network for self-regulation changes. Whereas the orienting network is most important for regulation in infancy, the executive attention network takes over at around 3 or 4 years of age (Posner et al., 2012).

Most studies thus far have used very coarse measures of attention that are obtained through video-coding. For instance, a well-known procedure for measuring attention is to manually code the peak duration of looking towards a stimulus (Cuevas & Bell, 2014). A more sophisticated way to look at visual attention is by using eye-tracking. Eye-tracking allows to examine attention behaviors that are inaccessible for video-coders, because they occur at a more detailed spatiotemporal scale. In eye-tracking studies, visual attention is measured by examining fixations and saccades. In contrast to looking time, which is measured in seconds, these measures are in the order of milliseconds. In this dissertation, I extended previous research by focusing on three microtemporal measures of visual attention: fixation duration, variation in fixation duration, and disengagement. Disengagement, the ability to remove attention from the point of fixations, is related to the orienting network. In contrast, fixation duration, which refers to the time the eyes are relatively stable with respect to the world, is most likely related to the executive attention network (Papageorgiou et al., 2014). Variation in fixation duration may indicate flexibility in attention style (Wass & Smith, 2014) but there are also indications that variation in fixation duration declines with age (Hunnius & Geuze, 2004), which means that low variation may signify cognitive maturity. Although fixation duration, variation in fixation duration, and disengagement are often used in visual attention research, their predictive utility for self-regulation has seldom been examined. In Chapter 2, I examine how these three visual attention measures are related to self-regulation in toddlerhood.

Negative reactivity. A second predictor of self-regulation is negative reactivity. Dual processes models postulate that self-regulation modulates targets of regulation such as negative reactivity (Skinner & Zimmer-Gembeck, 2007). However, reactivity can also modulate self-regulation in various ways, by triggering, modulating, and optimizing certain regulatory responses (Nigg, 2017). For instance, regulatory behavior that is initially reflexive when experiencing negative reactivity, such as looking away from distressing stimuli, can progress into purposefully used regulatory behavior when infants experience their effectiveness in down regulating negative reactivity. The modulating role of negative reactivity for self-regulation may be particularly pertinent in early childhood, because of the protracted development of self-regulation.

The optimal arousal perspective on the development of self-regulation states that the relation between indicators of negative reactivity and self-regulation is expected to be curvilinear, taking an inverted U-shape (Blair & Ursache, 2011). From this perspective, moderate and time-limited negative reactivity is associated with well-developed self-regulation, whereas both low and high chronic reactivity is related to poorly developed self-regulation. A similar argument has been made by Obradovic (2016), who argued that elevations in reactivity in response to exposure to adversity, accompanied by fast recovery, represents the most beneficial stress response. Such a response indicates that children are vigilant to threats but are not exposed to prolonged negative reactivity that may be harmful. A common way to express negative reactivity is through fussing and crying. Here, fussing can be seen as low-level negative reactivity, whereas crying can be seen as high-level negative reactivity. Such behaviors can be easily assessed with cry diaries. In Chapter 3, I examined whether negative reactivity (i.e., fussing and crying assessed through cry diaries) predict self-regulation in toddlerhood (18 months) and the preschool years (4.5 years).

Mean-level of development of inhibitory control. In Chapter 4, I examine mean-level development of a key-component of self-regulation: inhibitory control, that is the ability to plan and suppress responses (Rothbart et al., 2001). Early displays of inhibitory control are already seen during the first year of life (Garon, Bryson, & Smith, 2008), and inhibitory control develops rapidly from that time on (Dennis, Brotman, Huang, & Gouley, 2007; Klenberg, Korkman, & Lahti-Nuuttila, 2001; Schoemaker, Bunte, Espy, Deković, & Matthys, 2014). Thus far, the early development of inhibitory control has mainly been assessed with lab tasks. Although these studies are highly valuable, parent reports on acts of inhibitory control in real life may provide a more ecologically valid measure. The development of inhibitory control as expressed in daily life may be slower, for instance because the skills that are measured with lab tasks do not translate directly into everyday behavior, or faster, because children receive more support in regulation in daily life. It is therefore important to examine parent-reports of inhibitory control as well. I complemented previous research by examining measurement invariance and the mean-level development of inhibitory control as assessed through parent-reports between 2.5 and 6.5 years of age.

In sum, research into the early development of self-regulation and infant precursors of self-regulation later in development is still relatively scarce. Therefore, the first aim of this dissertation was to examine individual factors related to self-regulation. By focusing on (1) visual attention and (2) negative reactivity in infancy as predictors of self-regulation, as well as on (3) measurement invariance and mean-level development of inhibitory control across the preschool years, I aim to contribute to the growing body of research on the early development of self-regulation.

Aim 2: Family Factors Related to the Development of Self-Regulation

Various studies report familial resemblance in self-regulation (e.g., Bridgett et al., 2011; Cuevas et al., 2014; Jester et al., 2009; Valiente, Lemery-Chalfant, & Reiser, 2007). In addition, a recent meta-analysis on twin studies indicates that approximately 60 percent of the variance in self-regulation is attributable to genetic influences (Willems, Boesen, Li, Finkenauer, & Bartels, 2019). This means that at least 40 percent of the variance in self-regulation can be explained by environmental factors, as genetic and environmental influences are not necessarily mutually exclusive. In recent years, a burgeoning literature explored the environmental factors that predict the way in which self-regulation develops. Studies that examine how transmission of self-regulation occurs indicate that the family context is important to consider (see Bridgett, Burt, Edwards, & Deater-Deckard, 2015, and Deater-Deckard, 2014, for recent reviews). In this dissertation, I focus on parenting as a predictor of self-regulation (Chapter 4), and as a moderator that plays in role in the way in which individual predictors (fussing and crying) in infancy translate into self-regulation in early childhood (Chapter 3). In Chapter 5, I also examine whether parental self-regulation and household chaos interact in predicting parenting practices that are known to be important in the development of self-regulation.

That parenting plays an important role in the development of self-regulation has been broadly accepted (e.g., Rothbart, Sheese, Rueda, & Posner, 2011; Sroufe, 2000). An important theory in this regard is attachment theory (Ainsworth, 1969). Attachment refers to a strong and persistent bond between individuals, which is characterized by a tendency to pursue proximity and contact, especially within conditions that cause distress (Bowlby, 1982). For infants, who are highly immobile and dependent upon care, attachment to the primary caregiver is critical for survival. Therefore, infants form a bond with their primary caregiver regardless of the quality of care that is received. If all goes well, infants develop a secure attachment relationship with their primary caregivers. This secure attachment relationship is characterized by the confident expectation that caregivers will provide support when needed (Sroufe, 2000). Within this secure relationship, children can gradually learn the skills needed for autonomous self-regulation.

Sensitive and nonintrusive parenting promotes the development of a secure attachment relationship (Ainsworth, 1969). Sensitive parenting entails that parents notice the cues of their child, interpret these cues correctly, and respond promptly and appropriately (Ainsworth, 1969). Parental intrusiveness refers to being overdirecting or, overstimulating, or interfering with children's activities (Biringen, Robinson, & Emde, 2008). Nonintrusive parents are available to their child when needed: interactions are spacious and not overpowered by the parent. Sensitivity and nonintrusiveness may support children in their ability for self-regulation, but their function may differ depending upon the age of the child.

In Chapter 3, I focus on maternal sensitivity when infants are 6 months old. Although infants can already rely on a limited set of rudimentary regulatory behaviors, they often require help from their parents in regulation. This help is especially required during moments of negative reactivity. During these moments, parents can help their infant with maintaining negative reactivity at a controllable level, and also train and model effective regulatory skills that can be used in the future (Eisenberg, Cumberland, & Spinrad, 1998; Sroufe, 2000). In addition, if infants learn that moments of negative reactivity are followed by recovery, and that they will receive support when signaling distress, they may build confidence in their ability for regulation (Sroufe, 2000). Related to this issue is the finding that sensitivity during moments of negative reactivity, compared to sensitivity during moments in which infants are not experiencing negative reactivity, is more important for predicting developmental outcomes such as behavioral problems and social competence (Leerkes, Blankson, & O'Brien, 2009).

After infancy, parents continue to play an important role in the development of children's self-regulation, but their role also gradually changes (Sroufe, 2000). Toddlers already have a range of regulatory skills at their disposal, but they are also easily overwhelmed. A particular challenge for parents of toddlers lies in finding a balance between providing age-appropriate assistance when needed, for instance when tasks are too difficult or

when toddlers are overtaxed, but also by letting them find their own way to deal with situations (Sroufe, 2000). In Chapter 4, I focus on maternal and paternal sensitivity and nonintrusiveness when children were 2.5 to 3.5 years old (Biringen, Robinson, & Emde, 2008). I examined how maternal and paternal sensitivity and nonintrusiveness predict initial levels and growth of inhibitory control across the preschool years.

Chapter 4 also adds to literature by examining both maternal and paternal parenting practices. It is possible that fathers and mothers may play different roles in raising their children. For instance, it has been proposed that mothers generally provide more support to their children by comforting them, whereas fathers may help children with dealing with challenging and stimulating circumstances (Grossmann, Grossmann, Kindler, & Zimmermann, 2008; Paquette, 2004). Mothers may therefore support the development of inhibitory control by being sensitive to their children's cues, whereas fathers provide stimulation that may enhance inhibitory control. However, the majority of the research thus far has focused on the association of maternal parenting behavior and inhibitory control.

In Chapter 5 I extend existing research by examining household chaos and self-regulation of parents in relation to parenting practices. During the toddlerhood phase, or "terrible two's", most parents are from time to time faced with situations that put a strain on their ability to show sensitivity and nonintrusiveness. In Chapter 5, I focus on negative behaviors of parents in response to toddler's noncompliance. Such behaviors include amongst others grabbing toys out of children's hands, threatening with punishment, ignoring, or mocking the child.

Previous studies demonstrated that parental self-regulation helps to prevent negative parenting practices, especially in relatively calm households (e.g., Deater-Deckard, Wang, Chen, & Bell, 2012). A gap in the literature is that these studies were not designed to examine *responses* of parents to their children's behavior, as they used global measures of parent and child behavior. Whereas sensitivity and nonintrusiveness in Chapter 3 and 4 were coded using so-called global coding systems, I used a micro-coding system in Chapter 5. Micro-coding involves coding of behavior in small time epochs, e.g., one second, whereas macro coding systems are designed to capture global parenting constructs that are measured over a longer observational time. Micro-coding allows to examine contingencies in parent-child interactions. In this case, I was interested in instances in which the parent showed negative behavior after the child showed negative behavior. I labelled those instances reactive negative parenting. I expected that parents with higher self-regulation showed less instances of reactive negative parenting, because they can rely on their regulatory abilities.

In Chapter 5 I also took the broader household context into account. Household chaos refers to the level of background noise, crowding, and a lack of routine in a household (Matheny, Wachs, Ludwig, & Phillips, 1995). In households characterized by high levels of household chaos, parental self-regulation may be particularly needed to refrain from reactive negative parenting. However, chaos may also overwhelm parents' ability for self-regulation and promote reactive negative parenting irrespective of the level of parental self-regulation. I tested how household chaos and parental self-regulation interacted to predict reactive negative parenting.

Overall, the second aim of this dissertation was to examine family factors related to (the development of) self-regulation. To this end, I examined (1) whether maternal sensitivity at 6 months interacts with negative reactivity to predict later self-regulation; (2) whether maternal and paternal sensitivity and nonintrusiveness predict the initial level and development of inhibitory control; and (3) whether parental self-regulation and household chaos interact to predict parental responses to toddler's noncompliance (i.e., reactive negative parenting practices).

Aim 3: Problem Behavior Related to Deficits in Self-Regulation in Early Childhood

The final aim of this dissertation was to examine problems related to self-regulation. I focus on a phenotype that is characterized by disturbances in mood, attention, and behavior, measured through the Dysregulation Profile (DP). These problems are represented by elevated scores on the so-called AAA-scales of the Child Behavior Checklist and related ASEBA questionnaires: the Anxious/Depressed, Aggressive Behavior, and Attention Problems scales, but have also been measured with the Strengths and Difficulties Questionnaire (Deutz et al., 2018; Holtmann, Becker, Banaschewski, Rothenberger, & Roessner, 2011).

DP was introduced in 1995 by Biederman and colleagues as a proxy for juvenile bipolar disorder (Biederman et al., 1995), but subsequent research has demonstrated that it was not a good screener for this purpose. For instance, scores on the AAA-scales do not correspond well with semi-structured interviews to detect juvenile bipolar disorder (Volk & Todd, 2007). In more recent literature, it was established that children with elevated scores on all AAA-scales are at risk in their development, due to the breadth of their problems, and the long-term outcomes that are associated with this profile (e.g.,

Althoff, Verhulst, Rettew, Hudziak, & van der Ende, 2010). It has been proposed that the AAA-scales indicate problems in regulating affect (manifested through anxious and depressed behavior), behavior (i.e., aggressive behavior), and cognition (experienced through attention problems), the so-called ABC's of self-regulation (Althoff, 2010). As such, the profile was renamed as DP (Althoff, 2010).

There has been a lack of consensus on how DP is best conceptualized and measured. Previous research that focused on the CBCL operationalized DP with a cut-of approach, either with summed t-scores across three CBCL scales (e.g., a score higher than 180; Kim et al., 2012), or for each separate CBCL scale (e.g, a score higher than 70 for each scale; Jucksch et al., 2011), latent classes (Basten et al., 2013), or sum scores (Holtmann, Buchmann, et al., 2011). These differences complicate the integration of research, and indicate fundamental different perspectives on how DP should be conceptualized. A perspective in which dysregulation represents comorbidity fits better with a cut-of approach for each separate scale, whereas a perspective on dysregulation as representing a separate syndrome fits better with using a sum of the AAA-scales, latent classes, and sum scores.

Factor analyses can help to clarify the best conceptualization of DP. In Chapter 6, I focus on the conceptualization and operationalization of DP in a group of preschool children, of which most are referred to an outpatient clinic for their externalizing problem behaviors. To address a debate on how DP is best conceptualized, I conducted factor analyses and validated the best-fitting factor model.

Project

For this dissertation, I examined individual and family factors related to early self-regulation and dysregulation in four samples, using multiple measures and reporters. The characteristics of the samples and measurements can be found in Table 1.

Sample 1. Chapter 2 and 5 were based on a Dutch longitudinal study following infants into toddlerhood. The first wave of this study was part of a larger project aimed at studying test–retest reliability of measures for 10-month-old infants (YOUth cohort; Hessels, Andersson, Hooge, Nyström, & Kemner, 2015). A total of 80 infants between 9 and 11 months of age and one of their parents were recruited through local municipalities within the province of Utrecht, the Netherlands. Infants participated in two eye-tracking tasks that were used to measure visual attention: a visual search task and the gap-overlap paradigm.

A total of 65 children and one of their parents also participated during a second wave in toddlerhood. The second wave was a follow-up for which data was collected as part of this PhD project. It involved a house-visit, during which an assessment of parent-child interactions and toddler's effortful control took place, questionnaire administration, and an assessment of parental executive functioning through online testing.

Sample 2. Chapter 3 is based on the *Back to Baby Basics study*, conducted at Penn State University (Stifter & Moding, 2015). Infants and their parents took part in five assessments, when children were within two weeks of being 6 months, 12 months, 18 months, 4.5 years, and 5.5 years of age. Data from when infants were six months, 18 months, and 4.5 years of age were used for Chapter 3.

At six months, infant's negative reactivity was measured using a cry diary (Barr, Kramer, Boisjoly, McVey-White, & Pless, 1988), and maternal sensitivity was coded during a procedure in which mothers had to present three new toys to their infant. At 18 months, toddler's self-regulation was measured using three tasks: compliance during a clean-up task, a delay procedure, and rated by two experimenters during a laboratory visit. At 4.5 years, children participated in four lab-based tasks for self-regulation.

Sample 3. Chapter 4 is based on data from the *Boys will be Boys* dataset, collected at Leiden University (Endendijk et al., 2013). This four-wave longitudinal study was set up to examine gender-differentiated parenting and involved intact families with two children. During all waves, parents reported on their child's inhibitory control (Rothbart et al., 2001). During the first wave, mothers' and fathers' sensitivity and nonintrusiveness were observed and coded.

Sample 4. Chapter 6 is based on data from a predominantly clinically referred sample (Bunte, Laschen, et al., 2013; Schoemaker et al., 2012). This 18-month longitudinal study contains a sample of preschool children. Most of the children were referred for clinical assessment of their externalizing behavior problems to the Outpatient Clinic for Preschool Children with Behavioral Problems at University Medical Centre Utrecht. A group of typically developing children also participated in the study. During both waves, children participated in executive functioning tasks, and participated in an observational procedure. A semi-structured interview was conducted with parents, and parents and caregivers filled in questionnaires.

TABLE 1
Characteristics of Samples Used in This Dissertation, Split by Chapter

Ch.	Child age	Study characteristics	Country	Measures	Precursor/*outcome*	Child/parent self-regulation	Parenting	Broader context
2	9-11 months (w1)	Longitudinal Community sample	NL	Eye-tracking Questionnaires Observations Tasks	Fixation duration Variation in fixation duration Disengagement (E)	Toddler compliance (O, P) and effortful control (TB, P)	-	
3	6 months (w1) 18 months (w2) 4.5 years (w3)	Longitudinal Community sample	USA	Daily diaries Observations Tasks	Infant Fussing (P) Infant Crying (P) Parenting (O)	Toddler compliance, delay of gratification, experimenter rated self-regulation (composite score TB, O). Preschool executive functioning (composite score TB)	Maternal sensitivity (O)	
4	2.5 - 3.1 years (w1) 3.4 - 4.6 years (w2) 4.4 - 5.9 years (w3) 5.5 - 6.7 years (w4)	Longitudinal Community sample	NL	Questionnaires Observations	Parenting (O)	Preschoolers inhibitory control (M, F)	Maternal and paternal sensitivity and nonintrusiveness (O)	
5	26-31 months	Cross-sectional Time-series Community sample	NL	Observations Tasks Questionnaires	*Parenting* (O)	Parental executive functioning (TB) and effortful control (S)	Parents' reactive negative parenting (O)	Chaos (S)
6	3.5 - 5.5 years (w1)	Longitudinal Mainly clinically referred	NL	Questionnaires Observations Tasks	Dysregulation profile (P, T)	Child inhibitory control (TB)	-	

Note. M = mother-report, F = father-report, P = parent-report (either father or mother), T = teacher-report, S = self-report, TB= task-based, O = observational, E = eye-tracking.

Outline of this Dissertation

Figure 1 provides a schematic overview of the studies in this dissertation. In Chapter 2, I examined whether three visual attention measures (fixation duration, variation in fixation duration, and disengagement) in infancy predicted effortful control and compliance in toddlerhood. In Chapter 3, I examined the association of infant negative reactivity (i.e., fussing and crying) with self-regulation in toddlerhood and the preschool years, as well as the moderating role of maternal sensitivity herein. In Chapter 4, I examined measurement invariance of parent-reported inhibitory control between 2.5 and 6.5 years. I also examined the mean-level development of inhibitory control, and associations with maternal and paternal sensitivity and nonintrusiveness. In Chapter 5, I examined whether parental self-regulation and household chaos predicted reactive negative parenting for parents of toddlers. Lastly, in Chapter 6, I tested and validated the factor structure of the Dysregulation Profile in a group of predominantly clinically referred preschool children.

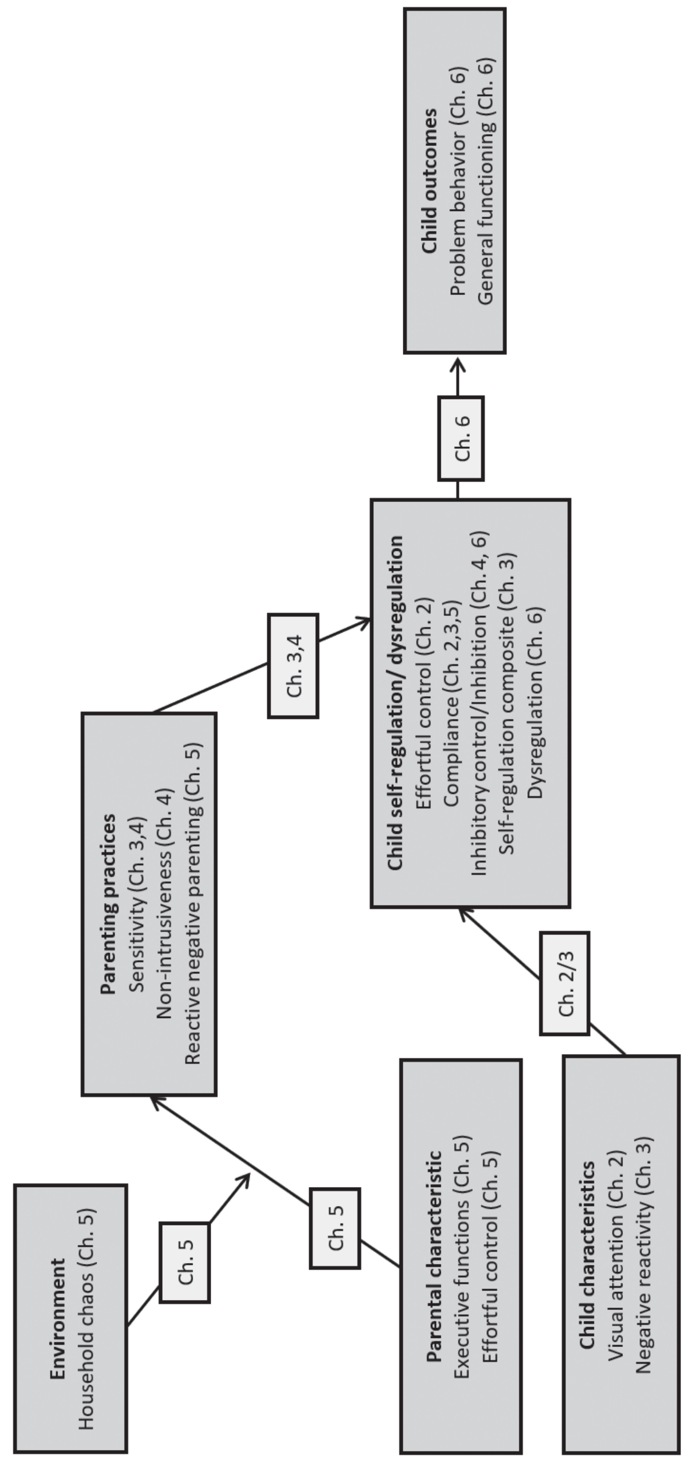

FIGURE 1. Overview of the concepts and tested associations per chapter.

CHAPTER 2

Individual Differences in Visual Attention and Self-regulation: A Multimethod Longitudinal Study from Infancy to Toddlerhood

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ABSTRACT

Given the importance of self-regulation for a broad range of developmental outcomes, identifying reliable precursors of self-regulation early in development is important for early prevention of developmental problems. The aim of this study was to examine whether three visual attention measures (fixation duration, variation in fixation duration, and disengagement) in infancy (9.10 - 11.43 months) predicted effortful control and compliance in toddlerhood (26.71 - 31.80 months). The sample consisted of 74 children (50% boys). In infancy, two eye-tracking tasks were conducted: a visual search task to assess fixation duration and variation in fixation duration (*n* = 58), and a gap-overlap task to assess disengagement (*n* = 49). In toddlerhood, children's effortful control (*n* = 65) and compliance (*n* = 65) were assessed by parent-reports and observed during respectively a delay of gratification task and a clean-up session together with the parent. Using Full Information Maximum Likelihood to account for missing data, multiple regression analyses revealed that, when all three measures of visual attention were taken into account, longer fixations and less variation in fixation duration in infancy predicted better effortful control. Disengagement did not predict effortful control. Compliance in toddlerhood was not predicted by any of the visual attention measures. These findings may indicate that visual attentional measures in infancy predict relatively independent forms of self-regulation in toddlerhood. Future studies are necessary to elucidate the mechanisms that underlie the association between (variation in) fixation duration in infancy and effortful control in toddlerhood.

Keywords
Visual attention, Disengagement, Fixation duration, Self-regulation, Early childhood, Longitudinal

Author contributions
SG, JH, and MD conceptualized the study. SG, RH, SdvdS, and CB were responsible for the collection of the data. SG analyzed the data, and wrote the manuscript. All authors provided feedback on the study.

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INTRODUCTION

Self-regulation, which is defined as the ability to automatically or deliberately modulate affect, behavior, and cognition (Karoly, 1993), plays an important role in human development. For instance, higher levels of self-regulation relate to better school performance (Bull, Espy, & Wiebe, 2008) and less problem behavior (Olson, Sameroff, Kerr, Lopez, & Wellman, 2005). Knowledge of early individual differences that may predict later self-regulation is important for early prevention of developmental problems. However, studies on early antecedents of self-regulation are relatively scarce. In this study, we focused on antecedents of emerging self-regulation in toddlerhood. Toddlerhood is a transitional phase during which the ability to inhibit dominant responses develops, and external regulation is still required (Kopp, 1982). This is exemplified by compliance, which indicates toddlers' ability to display desirable behavior in response to others. Compliance is related to effortful control, which refers to individuals' ability to inhibit prepotent behaviors and perform less salient behaviors, detect errors, and engage in planning (Rothbart, Sheese, Rueda, & Posner, 2011). Although compliance and effortful control are related, effortful control is more independent compared with compliance because the latter, per definition, occurs in response to others.

Various theoretical frameworks argue that the development of self-regulation builds on simpler cognitive skills, in particular visual attention (e.g., Kochanska et al., 2000, Rothbart et al., 2011). Visual attention refers to a set of cognitive operations by which the selection of relevant visual information, and the exclusion of irrelevant visual information, occurs. Posner, Rothbart, and colleagues proposed that attentional processes involve three neural networks that are closely related to self-regulation. The alerting network is involved in achieving and maintaining attention, the orienting network is involved in selecting input, and control over these networks is executed through the executive attention network (Posner, Rothbart, Sheese, & Voelker, 2012). Over development, the relative importance of these networks for self-regulation gradually shifts, with the orienting network being most important in infancy and the executive attention network taking over at around 3 or 4 years of age (Posner et al., 2012). This allows children to progressively exert more independent control.

In line with the notion that visual attention is an antecedent of self-regulation, relatively coarse attention measures indeed predict self-regulation later in development (see Hendry, Jones, & Charman, 2016, for a review). These measures generally capture a variety of processes that may be difficult to disentangle. For instance, habituation studies typically demonstrate that shorter dwell times in infancy, measured using video cameras, predict better self-regulation later in development (e.g., Cuevas & Bell, 2014; cf. Papageorgiou, Farroni, Johnson, Smith, & Ronald, 2015). These studies build on the notion that shorter lasting orienting responses reflect faster processing speed. Yet, these orienting responses relate to various attentional processes, including the ability to disengage attention (Colombo & Mitchell, 2009). A more detailed examination of attentional processes implicated in the development of self-regulation may be achieved with eye-tracking measures. In this study, we focused on the predictive value of three microtemporal measures of visual attention: fixation duration, variation in fixation duration, and disengagement.

In eye-tracking studies, visual attention is generally characterized in terms of fixations and saccades. During fixations, the eyes are relatively stable with respect to the world, which allows for inspection of different areas of the visual scene. Because only a small part of the retina, the fovea, allows for high-acuity vision, saccadic movements are made to allow light to fall on the fovea (Holmqvist et al., 2011). The duration of a fixation is often conceptualized as an indicator of the time needed to process the visual information available at the point of fixation (Nuthmann, Smith, Engbert, & Henderson, 2010). Individual differences in fixation duration are relatively stable across various viewing materials and show good test–retest reliability in infancy (Hessels et al., 2016, Wass and Smith, 2014). Although a cross-sectional study indicated that fixation durations were unrelated to concurrent cognitive control in infancy (Wass & Smith, 2014), the only longitudinal study found that longer fixations in infancy predicted better parent-reported effortful control in children between 19 and 58 months old (Papageorgiou et al., 2014). Papageorgiou et al. (2014) suggested that longer fixations indicate better executive attention because there is an enduring conflict between maintaining fixation and disengaging attention.

Variation in fixation duration is another relevant measure of visual attention in relation to self-regulation. In adults, saccades are made at a relatively constant rate independent of the current visual input. Yet, there is some moment-to-moment monitoring that determines the duration of a fixation (Henderson & Smith, 2009). It is possible that higher within-person variation of fixation duration indicates an enhanced ability to adjust attention duration when this is desired, for instance, because of increased interest (Wass & Smith, 2014). Conversely, individual distributions of fixation durations become narrower throughout the first year of life (Hunnius & Geuze, 2004), indicating that less variation may be an indicator of cognitive maturity. Diminished variation in fixation duration when watching dynamic (but not static) stimuli in infancy relates

to better concurrent cognitive control (Wass & Smith, 2014). No studies so far have examined whether variation in fixation duration in infancy predicts self-regulation.

Next to fixations, disengagement of attention (related to the orienting network) is a necessary requirement to attend to parts of the environment and for preventing or stopping overstimulation. Disengagement plays an important role in early state regulation (Rothbart et al., 2011). For instance, attentional disengagement is found to be an effective strategy for lowering negative affect in infancy (Stifter & Braungart, 1995). Prolonged disengagement is also found in infants at risk for autism, a finding that may be related to the deficits in self-regulation that have been reported for these children (Elsabbagh et al., 2013, Gliga et al., 2014). Moreover, two studies directly examined associations between disengagement and effortful control, or its forerunners. First, infants at 4 and 6 months of age who disengaged quicker were less distressed but not easier to soothe (McConnell & Bryson, 2005). The second study found a negative association between disengagement latencies and parent-reported orienting/regulation at 12 months of age but found no predictive association between disengagement latencies at 12 months and observed and parent-reported effortful control at 36 months (Nakagawa & Sukigara, 2013).

The aim of this longitudinal study was to simultaneously examine the predictive value of fixation duration, variation in fixation duration, and disengagement in infancy (9–11 months of age) for effortful control and compliance in toddlerhood (26–32 months). We hypothesized that longer fixation duration would predict better effortful control and compliance, whereas our analyses regarding the variation in fixation duration were exploratory. We also hypothesized that faster disengagement would predict better effortful control and compliance in toddlerhood.

METHOD

Participants

A total of 80 infants between 9 and 11 months of age and one of their parents were recruited through local municipalities within the province of Utrecht, the Netherlands. Infants were excluded if they were born before 37 weeks of pregnancy, had a significant uncorrected hearing or vision impairment, or had a significant developmental delay or condition. Of this sample, 65 children and one of their parents also participated during a second wave in toddlerhood.

The final sample consisted of 74 children who provided usable data during at least one wave. Infants (50% boys) ranged between 9.10 and 11.43 months of age (M = 10.04, SD = 0.38) during the first wave in infancy and between 26.71 and 31.80 months (M = 28.50, SD = 1.20) during the second wave in toddlerhood. Parents accompanying infants during the first wave were predominantly higher educated (77% reported having at least a college degree).

Apparatus

Infants' eye movements were recorded with a Tobii TX300 eye tracker (Tobii Technology, Stockholm, Sweden) running at 300 Hz. Stimuli were presented on an integrated 23-inch monitor at a resolution of 1920 × 1080 pixels and a refresh rate of 60 Hz. The eye tracker communicated with MATLAB (Version R2013a; The MathWorks, Natick, MA, USA) and the PsychToolbox (Version 3.0.11; Brainard, 1997) via the Tobii SDK and ran on a MacBook Pro (OS X 10.9).

Procedure

During both waves, parents provided written informed consent before participation and received a small financial compensation. Children received a small gift.

Wave 1. The first wave was part of a larger project aimed at studying test–retest reliability of infant measures (YOUth cohort; Hessels, Andersson, Hooge, Nyström, & Kemner, 2015). The study involved 2 testing days in a lab center within 2 weeks (M_{weeks} = 1.07, SD = 0.38; 2 children were tested within 3 weeks). The same procedure was followed on both testing days. A testing day lasted approximately 5 h, including breaks and approximately 90 min of assessments. Electroencephalography, eye-tracking tasks, parent–child interaction tasks, and a developmental assessment were administered. The protocol was approved by the ethical committee of the University Medical Center Utrecht.

For the eye-tracking tasks, familiarization and positioning of the infant was done as described in Hessels et al. (2016). Briefly, each infant was strapped into a baby chair placed on the parent's lap in front of the eye tracker. The eyes of the infant were at distance of 65 cm from the eye tracker and were at the same height as the center of the screen. The operator monitored the infant with a webcam and presented sounds or videos with sound in the center of the screen to keep the infant's attention on the screen during the task. If the infant was not attending to the screen, the operator could present sounds or videos with sound in the center of the screen to attract the infant's attention.

Wave 2. Two examiners visited toddlers and parents at their homes. Three tasks for children, questionnaires for parents, and parent–child interaction tasks were administered. This visit lasted approximately 90 min, allowing sufficient time for breaks. The protocol was approved by the ethical committee of the Faculty of Social and Behavioral Sciences of Utrecht University.

Measures

Fixation duration and variation in fixation duration. A total of 24 visual search displays were presented, each containing two rows of 14 lines (Hessels et al., 2016). These lines were jittered between −1.68° and 1.68° in a horizontal direction and between −6.38° and 6.38° in a vertical direction. All lines were vertically aligned except for one divergent line that was tilted 30°, 60°, or 90° clockwise. The divergent line appeared once on eight different locations in all three angles. Every trial lasted until the infant fixated on the divergent line within a range of 1.4° for at least 100 ms or until 4 s had passed. Calibration occurred at the start of the experiment and following every additional fifth display to determine accuracy (see Hessels et al., 2016, for a description of the calibration process and data preparation). The experiment lasted 10–15 min.

Originally, visual search data were available for 75 infants. Infants were included only when at least 12 fixations were recorded. Fixations were parsed using identification by two-means clustering (Hessels, Niehorster, Kemner, & Hooge, 2017). Only fixations that were not flanked by missing data were included to diminish the chance that fixations were shortened because the eye tracker could not report on data. This led to the exclusion of 17 infants. The median fixation duration (in milliseconds) and the pooled intraindividual standard deviation of fixation duration across testing days were used. Higher scores represented longer fixation duration and more variation in fixation durations, respectively.

Disengagement. The gap–overlap task was used to measure disengagement (Cousijn, Hessels, Van der Stigchel, & Kemner, 2017). After calibration (see Cousijn et al., 2017), 60 trials were presented in random order, evenly distributed over gap, overlap, and baseline conditions. All trials commenced by attracting the infant's attention with the central stimulus—an expanding and contracting (maximum size: 3.3° × 3.3°) central clock (2.1° × 2.1°). To maintain the infant's attention, the clock started spinning at 500°/s after fixation. The peripheral stimulus, which was either a sun, cloud, ball, star, or dog (2.5° × 2.5°, positioned 19° left or right from the central stimulus), appeared 600–700 ms after the infant fixated to the central stimulus. The 100-ms jitter was implemented to decrease anticipatory saccades. In the baseline condition, the onset of the peripheral stimulus directly followed the offset of the central stimulus. The peripheral stimulus stayed on-screen until the child fixated it or until 1500 ms elapsed. The peripheral stimulus contracted and expanded or spiraled out of view for 1000 ms after a first fixation. This feedback was combined with various sounds (e.g., a car horn, a bell). During the gap condition, the offset of the central stimulus was 222 ± 35 ms before the onset of the peripheral stimulus. During the overlap condition, the central and peripheral stimuli remained simultaneously and inanimately on-screen.

Data preparation is described in Cousijn et al. (2017). Data were originally available for 68 infants. Infants with fewer than 10 included trials for either the gap or overlap condition were excluded (*n* = 19). Saccadic reaction time was defined as the time between the target stimulus onset and the first fixation on this target. The difference in saccadic reaction time during the gap and overlap conditions across testing days was used, with higher scores representing slower disengagement.

Effortful control. Parent-reported effortful control was determined following the scoring procedure for the Early Childhood Behavior Questionnaire Short Form by averaging the attention focusing, attention shifting, cuddliness, inhibitory control, and low-intensity pleasure subscales (Putnam, Gartstein, & Rothbart, 2006). The 32 questions were answered on a scale from 1 (never) to 7 (always). Internal consistency was good (α = .86). Observed effortful control was assessed with a delay of gratification task (Kochanska et al., 2000). Toddlers were seated, and a bag with a gift inside was presented along with the instruction to wait until the experimenter returned with a bow. Parents were instructed to stay in the room but to remain as neutral as possible. The experimenter left the room and returned after 3 min. Toddlers were filmed, and latencies (in seconds) to touch the bag, open the bag, look in the bag, put a hand in the bag, pull the gift out of the bag, and leave the chair were coded afterward by two coders, with latency scores ranging from 0 (immediately) to 180 (never). Interrater reliability on 15 videos was good, with Intraclass correlations (ICCs) ranging from .91 to .99. A mean of all latency scores was used and had good internal consistency (α = .91). Observed effortful control and parent-reported effortful control were sufficiently correlated ($r = .39$, $p < .001$), and an average score was created. Higher scores represented better effortful control.

Compliance. Parent-reported compliance was measured with the compliance subscale of the Infant Toddler Social Emotional Assessment (Carter & Briggs-Gowan, 2006). All eight questions were answered on a scale from 0 (not true or seldom true) to 2 (completely or often true). Internal consistency was sufficient (α = .70). Observed

compliance was coded during a 3-min cleanup, which followed a 12-min play situation with one parent. Parents were cued to instruct their children to clean up toys in a transparent box. Child compliance was coded using an adapted version of the Dyadic Interaction Coding Manual (Lunkenheimer, 2009) by two trained coders. Coders coded three forms of noncompliance (dysregulation, passive noncompliance, and refusal), compliance, and other off-task behaviors (e.g., playing, talking). Time spent showing off-task behaviors was not taken into consideration. The percentage of time the child complied, relative to the overall time, was used. Interrater reliability was determined over the percentage compliance in 15 videos and was excellent (ICC = .99). Observed compliance and parent-reported compliance were sufficiently correlated ($r = .34$, $p = .009$), and an average score was created. Higher scores represented better compliance.

RESULTS

Preliminary Analyses

Table 1 displays descriptive statistics and bivariate correlations. There were medium-sized positive correlations between median fixation duration and variation in fixation duration, between disengagement and fixation duration, and between compliance and self-regulation in toddlerhood. There were no associations between the attention measures in infancy and compliance and self-regulation in toddlerhood. The Hawkins test of normality and homoscedasticity (Jamshidian, Jalal, & Jansen, 2014) indicated that data were missing completely at random ($p = .086$).

Primary Analyses

Two multiple regression analyses were performed to test whether infant fixation duration, variation in fixation duration, and disengagement predicted effortful control and compliance in toddlerhood. These models were estimated in the R package Lavaan (Rosseel, 2012) using maximum likelihood estimation with an asymptotical equivalent of the Yuan–Bentler adjusted chi-square test and robust (Huber–White) standard errors. Missing data were handled with full information maximum likelihood estimation, enabling the analyses to be conducted on the sample of 74 children.

Table 2 shows the results of both multiple regression analyses. For effortful control, chi-square testing against the baseline model indicated that the regression model fitted the data better than a baseline model with uncorrelated variables ($\chi2 = 17.42$, $df = 3$, $p = .001$). Longer fixations and less variation in fixation duration in infancy predicted better effortful control in toddlerhood. However, the individual bivariate correlations between effortful control and both fixation duration and variation in fixation duration were not significant (see Table 1). Thus, the visual attention measures strengthen each other's association with effortful control by accounting for their residuals. Disengagement was unrelated to toddler effortful control. For compliance, chi-square test against the baseline model indicated that the regression model fitted the data better than a baseline model ($\chi 2 = 8.24$, $df = 3$, $p = .041$). However, none of the visual attention measures predicted compliance. Results were similar when analyses were conducted while controlling for covariates (see online supplementary material).

TABLE 1

Correlations and Descriptive Values

	M (*SD*) Range	1.	2.	3.	4.	5.
1. Age in toddlerhood (*n* = 65)	28.50 (1.20) 26.71 - 31.80					
2. Fixation duration (*n* = 58)	314.23 (56.71) 114.99 - 441.59	-.08				
3. Variation in fixation duration (*n* = 58)	214.00 (78.93) 73.12 - 626.52	-.07	.36**			
4. Disengagement (*n* = 49)	157.01 (71.95) 13.28 - 321.30	.17	.29**	.13		
5. Effortful control (*n* = 65)	-0.04 (0.86) -1.77 - 1.71	.05	.22	-.21	-.09	
6. Compliance (*n* = 65)	0.00 (0.86) -1.55 - 1.77	.02	-.09	-.04	-.04	.30**

Note. The *n*s vary depending on missing data and range between 44 and 65. Values are based on bootstrapped confidence intervals. Parent-reported effortful control (*n* = 64) ranged from 3.89 to 6.30 (*M* = 4.98, *SD* = 0.50). Observed effortful control (*n* = 58) ranged from 4.33 to 180.00 (*M* = 108.76, *SD* = 60.64). Parent-reported compliance (*n* = 61) ranged from 1.00 to 2.00 (*M* = 1.52, *SD* = 0.27). Observed compliance (*n* = 62) ranged from 0.00 to 100.00 (*M* = 55.16, *SD* = 31.52). *$p < .05$. ** $p < .01$.

DISCUSSION

The current study is one of the first to examine whether microtemporal measures of visual attention (fixation duration, variation in fixation duration, and disengagement) predict two aspects of self-regulation (effortful control and compliance) in toddlerhood. The results showed that when all three measures of visual attention are taken into account, longer fixation durations and less variation in fixation duration predicted better effortful control but not compliance. Disengagement did not predict either effortful control or compliance.

TABLE 2

Multiple Regression of Visual Attention in Infancy on Effortful Control and Compliance in Toddlerhood

	Effortful control			Compliance		
	b (*SE*)	β	*p*	*b* (*SE*)	β	*p*
Fixation duration	0.37 (0.09)	.43	<.001	-0.03 (0.11)	-.04	.759
Variation in fixation duration	-0.29 (0.07)	-.34	<.001	-0.28 (0.16)	-.24	.075
Disengagement	-0.10 (0.13)	-.12	.432	0.12 (0.12)	.15	.315

Note. n = 74 with Full Information Maximum Likelihood. $R^2 = .18$ for effortful control, and $R^2 = .05$ for compliance. For compliance, one extreme influential case on the set of parameters was deleted (Generalized Cook's Distance (GCD) = 4.31[1]). All predictors were entered into the regression analyses simultaneously. Predictors were standardized to avoid problems related to large differences in variances.

Fixation duration and variation in fixation duration predicted effortful control when all variables were entered into the regression analyses simultaneously, indicating that these measures share information that is irrelevant for predicting later self-regulation. This may relate to shared-method variance, given that all measures were obtained through eye-tracking, and to the general observation that reaction time measures and their variances are positively related (e.g., Robinson & Tamir, 2005). The results of this study concord with previous work indicating that longer fixation duration in infancy predicts better parent-reported effortful control in preschool years (Papageorgiou et al., 2014) and that low variation in fixation duration (but not fixation duration) when watching dynamic stimuli is associated with better concurrent cognitive control (Wass & Smith, 2014). In contrast to Wass and Smith (2014), the results of the current study indicate that only the combination of multiple visual attention measures yields sufficiently accurate predictions for effortful control.

Disengagement, a measure that closely relates to the orienting network, was not predictive of toddlers' self-regulation. Interestingly, Nakagawa and Sukigara (2013) demonstrated that, whereas faster disengagement was associated with better concurrent parent-reported self-regulation at 12 months of age, the direction of this concurrent association reversed at 18 and 24 months and became nonsignificant

1 GCD's higher than 1.00 may indicate a problem (Cook & Weisberg, 1982). All other GCD values fell within a 0.00 - 0.75 range for the compliance model and within a 0.00 - 0.66 range for the effortful control model.

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at 36 months. This may relate to a shift in self-regulation, where control is first primarily executed through the orienting network and later is executed through the executive attention network (Posner et al., 2012). It is possible that indicators of the executive attention network are more appropriate predictors of later self-regulation than indicators of the orienting network. In contrast to effortful control, none of the visual attention measures predicted compliance. Because compliance per definition occurs within interactions with others, whereas effortful control also entails relatively independent forms of regulation (e.g., by including focused attention when playing alone and the ability to wait independently), this may indicate that measures of visual attention predict relatively independent forms of self-regulation.

This study has a couple of strengths. First, infant visual attention was measured on 2 testing days, allowing us to obtain robust estimates. Second, we used both objective measures of self-regulation (observations) and measures of self-regulation outside the laboratory context (parent reports). Third, fixation duration and disengagement were measured with commonly used paradigms (gap–overlap and visual search). A limitation of this study is that participants' high socioeconomic status may limit the generalizability of the study. In addition, test–retest reliability for visual search performance (i.e., time to hit target) was too low to examine whether individual differences on this measure predicted self-regulation (Hessels et al., 2016). By including more search trials, future studies could examine whether search performance also predicts self-regulation. Lastly, given the relatively small sample size of the current study, especially when considering the missing data for disengagement, studies with larger sample sizes are needed to confirm these conclusions.

Overall, the current study is one of the first longitudinal multimethod studies showing that microtemporal visual attention measures in infancy can predict effortful control, but not compliance, in toddlerhood. The finding that individual differences in microtemporal measures of visual attention hold information relevant for predicting self-regulation paves the way for new studies aimed at further understanding the nature of these individual differences.

SUPPLEMENTARY MATERIAL

Two additional multiple regression analyses were performed to test whether the results would be similar when controlling for covariates. In these models, we controlled for age in infancy and toddlerhood, sex, the number of fixations during visual search, and the number of successful trials during the gap-overlap task. Similar to the main analyses, these models were estimated in the R package Lavaan (Roseel, 2012), using maximum likelihood estimation with an asymptotical equivalent of the Yuan-Bentler adjusted chi-square test, and robust (Huber-White) standard errors. Missing data were handled with full information maximum likelihood estimation, enabling the analyses to be conducted on the sample of 74 children. All predictors were entered simultaneously in the model. Table S1 shows the results of both multiple regression analyses. For effortful control, chi-square testing against the baseline model indicated that the regression model fitted the data better than a baseline model with uncorrelated variables ($\chi 2 = 25.75$, $df = 8$, $p = .001$). After controlling for age in infancy, toddlerhood, sex, the number of fixations during visual search, and the number of successful trials during the gap-overlap task, fixation duration and the variation in fixation duration were still significant predictors of effortful control. Specifically, longer fixations, as well as less variation in fixation duration predicted better effortful control. Disengagement did not predict effortful control. Inspection of the covariates demonstrated that only age at wave 1 was a significant predictor of effortful control. For compliance, Chi-square test against the baseline model indicated that the regression model did not fit the data better than a baseline model ($\chi 2 = 11.11$, $df = 8$, $p = .196$).

TABLE S1

Multiple Regression of Visual Attention in Infancy on Effortful Control and Compliance in Toddlerhood with Covariates

	Effortful control			Compliance		
	b (*SE*)	β	*p*	*b* (*SE*)	β	*p*
Age wave 1	0.23 (0.11)	.27	.038	-0.14 (0.14)	-.16	.325
Age wave 2	0.06 (0.10)	.07	.538	0.02 (0.12)	.02	.886
Sex	0.01 (0.21)	.01	.950	-0.23 (0.23)	-.14	.312
N fixations visual search	-0.13 (0.10)	-.15	.223	0.14 (0.14)	.17	.307
N trials disengagement	0.06 (0.12)	.07	.630	0.15 (0.16)	.19	.349
Fixation duration	0.39 (0.11)	.46	<.001	-0.02 (0.12)	-.03	.856
Variation in fixation duration	-0.33 (0.08)	-.38	<.001	-0.42 (0.19)	-.36	.027
Disengagement	-0.08 (0.11)	-.09	.486	0.12 (0.10)	.16	.225

Note. $n = 74$. $R^2 = .33$ for effortful control, and $R^2 = .12$ for compliance. For both models, one extreme influential case on the set of parameters was deleted. Predictors were standardized to avoid problems related to large differences in variances.

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CHAPTER 3

It Takes Two: Infants' Moderate Reactivity and Maternal Sensitivity Predict Self-regulation in the Preschool Years

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Under review.

ABSTRACT

The aim of this longitudinal study was to examine the association of infant fussing and crying with self-regulation in toddlerhood and the preschool years, as well as the moderating role of maternal sensitivity therein. When children (*n* = 149, 53.69% boys) were six months old, parents reported on their fussing and crying using a cry diary, and maternal sensitivity was coded during a novel toy procedure. Children participated in various tasks to assess self-regulation in toddlerhood (18 months) and the preschool years (4.5 years). Results indicated that the relation between infant fussing and preschool self-regulation took the shape of an inverted U, but only for children of relatively sensitive mothers. Here, fussing was positively related to self-regulation at the lower end of the distribution of fussiness, and this association levelled off. At the higher end of the distribution of fussiness, there was a trend towards a negative association between fussiness and self-regulation, but only at very high amounts of fussiness. For infants of less sensitive mothers, fussing was not related to later self-regulation. Crying was unrelated to preschool self-regulation. Neither fussing, crying, nor maternal sensitivity predicted self-regulation in toddlerhood. The findings support the optimal arousal theory, by demonstrating that for infants of relatively sensitive mothers, moderate amounts of low intensity negative reactivity are associated with enhanced self-regulation in the preschool years.

Keywords

Reactivity, Self-regulation, Early childhood, Maternal Sensitivity, Optimal arousal, Bio-ecological model

Author contributions

SG and CS conceptualized the study, PB and CS were responsible for data collection, SG analyzed the data, and wrote the manuscript. All authors provided feedback on the study.

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INTRODUCTION

Self-regulation plays a crucial role in healthy child development, promoting a myriad of competencies including social skills (Eisenberg, Fabes, Guthrie, & Reiser, 2000) and school readiness (Blair & Razza, 2007). Together with reactivity, self-regulation forms the core of temperament, or constitutionally based individual differences (Rothbart, Sheese, Rueda, & Posner, 2011). Reactivity refers to emotional, motoric and attentional responses to changes in the external and internal environment and includes both negative (i.e., negative affect), and positive components (i.e., extraversion or surgency). Self-regulation serves to modulate these forms of reactivity and mainly depends on processes of executive attention (i.e., higher-order coordination of attention orienting and alerting) and effortful control (i.e., the capacities to withhold a dominant response and substitute a more appropriate subdominant response, to ascertain errors, and to plan) (Rothbart, 1989; Rothbart et al., 2011).

Self-regulation develops rapidly throughout the first years of life, and this development is characterized by a progression from involuntary forms of regulation in early infancy to purposeful and flexible self-regulation from the preschool years on (Kopp, 1982; Rothbart et al., 2011). Infants often rely on external support to regulate emotions such as frustration and fear; however, they also have some rudimentary regulatory behaviors at their disposal. These behaviors are primarily classified as automatic approach and withdrawal behaviors, as they are hardly planned or effortful (Kopp, 1982; Rothbart et al., 2011). For instance, infants can avert their gaze or use thumb sucking to alleviate distress (e.g., Ekas, Lickenbrock, & Braungart-Rieker, 2013). Such behaviors are reflexive at birth and progress to voluntary techniques in later infancy (Kopp, 1982). In toddlerhood, early forms of self-regulation are mainly manifested as compliance with parental demands and the inhibition of prohibited behaviors (Kochanska, Coy, & Murray, 2001; Kopp, 1982). Over time, toddlers learn to comply and delay an act in the absence of caregivers and, by approximately 36 months, they are generally capable of modulating their behaviors in a relatively flexible manner (Kopp, 1982). Due to the rapid development of self-regulation, the first years of life form a window of opportunity for interventions targeting self-regulation. In the current study, we examine longitudinal associations between infant negative reactivity, maternal sensitivity, and self-regulation in early childhood.

As the regulation of negative reactivity is an important early manifestation of self-regulation, negative reactivity plays a central role in the development of self-regulation (Blair, 2002). The optimal arousal perspective on the development of self-regulation states that the relation between negative reactivity and self-regulation is expected to be curvilinear, taking an inverted U-shape (Blair & Ursache, 2011). Moderate and time-limited negative reactivity is associated with well-developed self-regulation, whereas both extreme ends (i.e., chronically low and high levels of negative reactivity) are related to poorly developed self-regulation. The optimal arousal theory shows many similarities with the Yerkes-Dodson law: i.e., the finding that complex cognitive performances show an inverted U-shaped relation with concurrent levels of arousal (Yerkes & Dodson, 1908). The optimal arousal theory is based on research demonstrating that neural activity in the prefrontal cortex, a brain region closely associated with goal-directed behavior, is dependent upon moderate and time-limited increases in neuromodulators such as noradrenaline and dopamine, which are released when experiencing negative reactivity. If neuromodulator levels increase too much or too little, prefrontal cortex functioning and self-regulation are impaired (see Arnsten, 2009 for a review).

It may also be that experiences of negative reactivity teach infants that they can recover from negative reactivity, progressively promoting self-regulation in increasingly challenging situations (Kopp, 1982; Sroufe, 2000). Infants who rarely experience moments of negative reactivity may not get the opportunities to practice and improve skills needed for self-regulation. On the other end of the spectrum, persistent and excessive negative reactivity may override infant's ability to regulate themselves effectively or to be soothed by others, which could hamper the development of future regulatory capacities (Blair, 2002; Stifter & Braungart, 1995).

Prior animal studies indicate that short moments of increased negative reactivity (elicited by creating a controlled stressful event through a brief maternal separation) are related to enhanced self-regulation (e.g., Parker, Buckmaster, Justus, Schatzberg, & Lyons, 2005; Tang, Akers, Reeb, Romeo, & McEwen, 2006). This notion has also been referred to as stress inoculation, which proposes that controlled stressful experiences improve the development of regulation and resilience (Lyons, Parker, Katz, & Schatzberg, 2009). In human children, moderate fluctuations in cortisol (a physiological response associated with negative reactivity) between the ages of 7, 15, 24, and 48 months, combined with low cortisol levels, predict better preschool self-regulation. In contrast, both high cortisol levels and low cortisol levels that were highly stable or highly variable predicted lower levels of self-regulation (Blair, Berry, & FLP Investigators, 2017). This suggests that time-limited, low-level negative reactivity in early childhood promotes the development of self-regulation.

Although cortisol is a reasonably good peripheral indicator of negative reactivity (e.g., Ursache et al., 2014), few studies have examined whether the optimal arousal

perspective can be applied to observed indicators of negative reactivity. Most prior studies on the relation between behavioral observations of negative reactivity and self-regulation applied a linear perspective. A study with infants from 6 weeks to 10 months of age reported that excessively crying boys demonstrated the lowest levels of emotional self-regulation at ten months (Stifter & Spinrad, 2002). Similarly, longitudinal studies indicate that high levels of negative reactivity hamper the development of self-regulation (Bridgett et al., 2009; Raikes, Robinson, Bradley, Raikes, & Ayoub, 2007). On the other hand, another longitudinal study reported no predictive value of parent-reported negative reactivity for self-regulation (Gartstein, Bridgett, Young, Panksepp, & Power, 2013).

From the optimal arousal perspective, the linear approach applied in most studies is incomplete in capturing the full relation between negative reactivity and self-regulation. Related to this perspective, a small body of research demonstrates that the relation between observed negative reactivity in infancy and self-regulation later in development is moderated by early forms of emotion regulation. That is, infants displaying both high negative reactivity *and* behaviors to regulate this reactivity displayed better self-regulation later in development (Stifter, Spinrad, & Braungart-Rieker, 1999; Ursache, Blair, Stifter, & Voegtline, 2013). These infants experience negativity such as anger and fear, but they also display behaviors that could potentially maintain negative reactivity at a controllable level. A remaining question is whether observable indicators of negative reactivity show a curvilinear association with self-regulation, as the optimal arousal theory suggests. The goal of the current study is therefore to provide a direct examination of the optimal arousal theory using observable indicators of negative reactivity.

In order to develop more independent regulatory abilities, infants must receive support from their proximal environment. Sensitive mothers notice the cues of their infants in a timely manner, and provide responses that appropriately address the signaled needs of their infant (Ainsworth, 1969). Such responses may include adjusting the level of provided stimulation or mirroring the behavior of the infant (De Wolff & Van Ijzendoorn, 1997). In the moment, prompt and appropriate responses support the immediate modulation of infants' arousal. Over time, maternal behavior provides learning experiences on how to control arousal and emotional states in an autonomous manner (Beeghly & Tronick, 2011; Eisenberg, Cumberland, & Spinrad, 1998). For instance, prior research demonstrates that shifting attention away from a distressing stimulus is an important emotion regulation strategy in infancy (Ekas et al., 2013; Stifter & Braungart, 1995). At six months, this ability is still 'under construction', and contingency analyses demonstrate that infants benefit from their mothers' support in attention shifting (Crockenberg & Leerkes, 2004). Longitudinally, maternal support in attention shifting forms a buffer for infant reactivity to develop into anxious feelings (Crockenberg & Leerkes, 2006). Higher levels of maternal sensitivity in infancy also predict better self-regulation in toddlerhood (Bernier, Carlson, & Whipple, 2010), whereas negative parenting behaviors, including intrusive behaviors and negative reactivity, are related to diminished preschool self-regulation (Cuevas et al., 2014). Overall, these studies indicate that parental sensitivity can promote regulation in the moment, and also over time.

In addition, because resolving moments of negative reactivity is a key mechanism through which children internalize regulatory abilities (Beeghly & Tronick, 2011; Tronick, 2003), it is likely that infants who experience moments of negative reactivity profit most from maternal sensitivity. Such ideas have been posited before in bioecological models of development (e.g., Bronfenbrenner & Ceci, 1994). These models predict that an enriched environment will promote potentials to be actualized, whereas risky environments will mask such individual differences. A variety of studies indeed report that the combination of high negative reactivity and (indicators of) sensitive parenting are related to improved self-regulation (Feldman, Greenbaum, & Yirmiya, 1999; Kim & Kochanska, 2012; Poehlmann et al., 2011; Kim, Stifter, Philbrook & Teti, 2014). However, these studies may have captured an effect of negative reactivity that occurs at low to moderate levels, without considering that this effect decays when negative reactivity reaches a certain threshold. As both linear and curvilinear associations can be significant within the same model (Cohen, Cohen, West, & Aiken, 2003), previous results may have been interpreted as representing linear effects, without considering potential quadratic effects.

In the current multimethod longitudinal study, we examined whether daily reports of 6-month-old infants' negative reactivity predicted self-regulation in toddlerhood and the preschool years, in manner consistent with the optimal arousal perspective. Typical manifestations of negative reactivity in infancy are fussing and crying. While fussing and crying may be seen as similar behavioral states that merely differ in intensity, there are some indications that they, at least partly, reflect qualitatively different behavioral states. When parents are instructed to report on both fussing and crying behavior of their infant, the majority of the reported behavior is in fact fussing (e.g., Alvarez, 2004; James-Roberts, 2001). Infants who fuss a lot do not necessarily cry a lot, and vice versa (James-Roberts & Plewis, 1996). In addition, infants who fuss a lot are more likely to preserve this characteristic, whereas crying has proven to be more transient over development (James-Roberts & Plewis, 1996). It has also been suggested that fussing

signifies a behavioral state during which infants are not crying due to parents' extensive soothing efforts, but that these efforts are not fully effective (James-Roberts, 2001). Lastly, a small follow-up study with infants referred for excessive crying also indicated that hours of fussing, but not hours of crying, predicted a variety of maladaptive developmental outcomes, such as less efficient sensory processing and more attention and hyperactivity problems (DeSantis, Coster, Bigsby, & Lester, 2004). Overall, the small body of literature indicates that fussing may be a different, and perhaps more stable characteristic compared to crying. It should also be noted that fussing and crying during the first three months of life, also referred to as "colic", are not reliable indicators of problems later in development (Stifter & Braungart, 1992). It is only after the first two to three months of life that fussing and crying predict future psychosocial and cognitive problems (Hemmi, Wolke, & Schneider, 2011; Rao, Brenner, Schisterman, Vik, & Mills, 2004). By examining fussing and crying at six months, we focus on the developmental period after the so-called "colic" period.

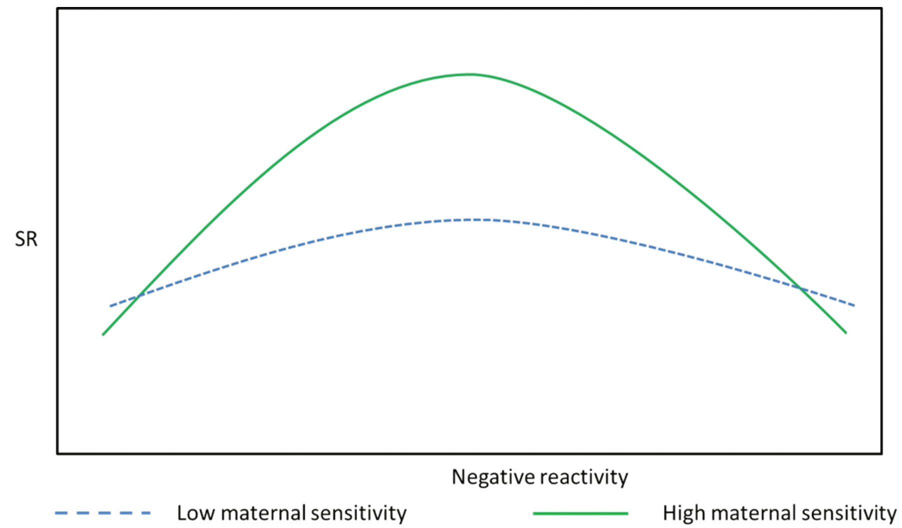

FIGURE 1. Hypothesized predictive value of negative reactivity in infancy for self-regulation in toddlerhood and the preschool years. These predictive values are conditional on maternal sensitivity, such that the quadratic association is stronger at higher levels of maternal sensitivity. *Note.* SR: self-regulation.

In line with the optimal arousal perspective, we hypothesized that parent-reported negative reactivity would be predictive of self-regulation in toddlerhood and in the preschool years in a nonlinear manner. Specifically, we expected a quadratic relation (inverted U-shaped curve; see Figure 1). We examined whether moderate amounts of negative reactivity in infancy, as opposed to low and high amounts of negative reactivity, predicted higher levels of self-regulation in toddlerhood and the preschool years. We mainly expected to find such a quadratic association for fussing, as opposed to crying, as fussing represents low level negative reactivity. In addition, fussing is found to better predict developmental outcomes compared to crying. Second, we hypothesized that maternal sensitivity in infancy would be positively related to self-regulation in toddlerhood and the preschool years. Third, combining the optimal arousal and the bioecological model, we expected maternal sensitivity to moderate the association between fussing and later self-regulation. Specifically, we expected the hypothesized quadratic relation between fussing and self-regulation to be most pronounced for children with relatively sensitive mothers (see Figure 1). Further, we examined whether these prospective relations were found in predicting self-regulation both in toddlerhood and the preschool years.

METHODS

Participants

Caregivers and infants (*N* =165) were recruited through birth announcements and a local community hospital in Central Pennsylvania. Inclusion criteria were full-term pregnancy, ability to speak and read English, and maternal age above 18. A total of 149 children (53.69% boys) provided data at six months and/or at follow-up waves (*n* = 149 at 6 months, *n* = 132 at 18 months and *n* = 111 at 4.5 years), and were included in this study. No significant differences in terms of maternal or paternal education were found between included and excluded children. Within the selected sample, maternal age ranged between 21.22 and 41.68 (*M* = 30.94, *SD* = 4.60). Years of education ranged between 12 and 20 (*M* = 15.0, *SD* = 2.0) and between 8 and 17 (*M* = 14.4, *SD* = 2.1) for mothers and fathers respectively. A total of 139 infants (93.29%) were described as white or Caucasian, three infants (2.01%) as black or African American, two infants (1.34%) as Hispanic or Latino, and two infants (1.34%) as Asian. One infants was described as Native Hawaiian/Pacific Islander, and one as American Indian/Alaskan Native. For one infant, a description of ethnicity was not provided. Annual family income varied between less than $10.000 and more than $100.000, with 55.03% having an income less than $60.000, and 44.30% more than $60.000. With the exception of two families, all families were intact when infants were six months of age. Parents provided written consent for their participation and the participation of their children in the study. All procedures in this study (Back to Baby Basics Project) were approved by the Pennsylvania State University Human Subjects Institutional Review Board, with approval number PRAMS00031155. A nonparametric test of homoscedasticity (Jamshidian, Jalal, & Jansen, 2014) indicated that data were missing completely at random. Attrition analyses indicated that families who did not participate when children were 18 months old (*m* = -0.37, *sd* = 0.88) on average had a lower socio-economic status (SES; a composite of maternal and paternal years of education and family income) than families who did participate (*m* = 0.06, *sd* = 0.83), *t*(37.83) = 2.30, *p* = .021. Similarly, families who did not participate when children were 4.5 years old also had a lower SES (*m* = -0.27, *sd* = 0.93) compared to families who did participate (*m* = 0.10, *sd* = 0.79), *t*(79.90) = 2.44, *p* = .017. Attrition was unrelated to children's sex, as well as to infant fussing and crying. SES was included in the final models, both to control for SES and to account for the missing data pattern related to SES.

Procedure

Data collection took place between December 2009 and January 2018. Infants and their parents took part in five assessments when children were within two weeks of being 6 months, 12 months, 18 months, 4.5 years, and 5.5 years of age. The present study includes data from when children were 6 months old, 18 months old and 4.5 years old, as the measures relevant for this study were obtained during these waves. Infant crying and fussing was assessed with a cry diary, whereas maternal sensitivity and children's self-regulation were observed and/or assessed during laboratory visits.

Measures

Crying and fussing. When infants were six months of age, primary caregivers (*n* = 149, 98.68% mothers) were asked to complete a 24-hour diary for three days (Barr, Kramer, Boisjoly, McVey-White, & Pless, 1988; St James-Roberts, Hurry, & Bowyer, 1993). Caregivers reported on the infants' state (awake and content, sleeping, feeding, fussing, and crying) on a ruler-like diary. The ruler had ticks specifying every five minutes. Parents received five colored pencils to specify the five states. To distinguish between crying and fussing, parents received the following descriptions: "Crying is generally loud and constant negative vocalizations that can be accompanied by breath holding and muscle tension. Fussing is low level negative vocalizations that are often accompanied by increased arm and leg movements." Parents were also requested to report whether a day was typical or not. Non-typical days (*n* = 78) were those days during which the infant was ill, teething, or participating in unusual events, such as travel. These days were removed, resulting in the exclusion of five infants with no available information on typical days. A total of 52 diaries were incomplete, of which 40 were incomplete due to deleting non-typical days. Data of incomplete diaries were still included in the analyses. Two measures were obtained from the diaries: percentage of time infants fussed and percentage of time infants cried over three (or fewer) days. Higher scores represented more fussing and crying. Previous studies have found that reports on a cry diary are related to audiotaped recordings, providing evidence for the validity of the cry diary (St. James-Roberts et al., 1993; Salisbury et al., 2001).

Maternal sensitivity. Mother-infant interaction was observed during a novel toy procedure (Crockenberg & Leerkes, 2004; Gunnar & Stone, 1984) in the laboratory when infants were six months of age. Mothers were asked to introduce one low-intensity toy (a stuffed octopus), one medium-intensity toy (a musical toy), and one high-intensity toy (a toy popper). Mothers and infants were seated on the floor and played with one toy at a time, each for one minute. Hence, the play session lasted three minutes. Maternal sensitivity was conceptualized as the level at which the mother contingently and appropriately responded to the infant's actions. Maternal sensitivity was coded every 10-seconds with a code that captured the frequency and intensity at which the mother responded to the baby's actions, with the scores 0 = "*None: no sensitive or contingent responses. The mother does not respond to the baby's actions*", 1 = "*Low: one instance of sensitivity. Mother shows minimal sensitivity or a minimal response to the baby's actions*", 2 = "*Moderate: more than one instance of the behaviors above or one prolonged instance. Clear evidence that the mother is more than minimally tuned into the baby*", and 3 = "*High: mother is very aware of the infant and contingently responsive to the baby's interests and affect. Behavior occurs at a very high level, is quite intense or prolonged, or occurs repeatedly*". The mean sensitivity level across the 10-second epochs was used, with higher scores representing more sensitivity. A team of coders was trained to reach a minimum inter-rater reliability of $\kappa = .75$. Drift reliability ranged between $\kappa = .81$- .95.

Toddler's self-regulation. During the 18-month laboratory visit, three age-appropriate measures of toddler's self-regulation were obtained. Compliance was coded during a *Clean-up task* (Kochanska, Tjebkes, & Fortnan, 1998). The instructor asked mothers to take out as many toys as possible, and to play with the child as they normally would. After five minutes, mothers were cued to instruct the child to clean up the toys. The clean-up task ended when all toys were put in the basket or three minutes had passed. Using an adapted coding scheme (e.g., Stifter et al., 1999), coders rated compliance and four forms of noncompliance in 10-second intervals. Codes were not mutually exclusive so that more than one code could be assigned. Compliance was coded when the child showed behaviors towards the goal of cleaning up, e.g., when the child was putting toys in the basket or otherwise following maternal instructions. In order for behavior to be coded as compliance, it had to be clear that the child was trying to comply with maternal requests, even if there were short pauses (e.g. looking briefly at the toy). Noncompliance was coded when the child ignored commands, verbally

refused to comply, showed defiance, or actively moved away to avoid having to comply. The proportion of compliance was calculated by summing the number of intervals that reflected compliance and dividing this by the total number compliance and noncompliance codes. Reliability was assessed over 24 videos, with an ICC of .932.

Toddlers also participated in a *Delay procedure* (Kochanska & Knaack, 2003). The experimenter presented the child with an attractive toy and instructed the child not to touch the toy until the experimenter allowed it, i.e., after five seconds. This procedure was then repeated with a delay of 10 seconds and 15 seconds. Latency to touch scores were coded (ICC = .996). Standardized latency scores across three trials were averaged into a mean score.

Self-regulation across the laboratory visit was also rated by two experimenters post visit (The visit lasted 1.5 hours overall and included various tasks designed to measure children's temperament and regulatory abilities, as well the quality of parent-child interactions). Three items from an adapted version of the *Infant Behavior Record* (IBR) were used: object orientation (degree of sustained interest in test materials), attention span (degree of continued interest in persons, toys, or activities), and compliance (degree of willingness to comply with requests from the experimenter or mother) (Stifter, Willoughby, & Towe-Goodman, 2008). Each item was scored on a 9-point scale with anchors specific to the range of behaviors, with ICC's ranging from .680 to .868. The rating of the two experimenters were averaged and a mean score of the three averaged scales were used, with higher scores indicating better self-regulation ($\alpha = .79$). For data reduction purposes, a principal component analysis of the three self-regulation scores indicated that the first principal component explained 45.55% of the variance ($\lambda = .54$-.79). Both compliance and latency to delay correlated modestly with self-regulation across the laboratory visit, with *r*'s of .27 ($p = .007$) and .20 ($p = .015$) respectively. Compliance and latency to delay were poorly correlated ($r = .06$, $p = .396$). The three scores were standardized and an average score was computed, with higher scores representing better self-regulation.

Preschool self-regulation. During the laboratory visit at 4.5 years, children completed four executive functions tasks that tapped response inhibition and attention shifting. During the *Tongue Task*, children were instructed to delay eating a small candy while holding it on their tongue with their mouth open (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996). After a ten-second practice trial, a two-minute test trial was administered. Each child's score was calculated as the proportion of the test trial during which they refrained from closing their mouth and eating the candy.

The *Day-Night Stroop Task* required children to say "day" when they saw a black card with a moon, and "night" when they saw a white card with a sun (Gerstadt, Hong, & Diamond, 1994). A maximum of three practice trials were administered, followed by 14 test trials. The proportion of correct responses during the test trials was used. Self-correction was allowed.

During the *Tapping Task*, children were directed to tap once when the experimenter tapped twice (50% of trials) and to tap twice when the experimenter tapped once (Diamond & Taylor, 1996; Luria, 1959). One practice trial for each rule was administered. If at least one of the child's responses was wrong, a second practice trial was administered. Only if children responded correctly to each rule at least once during the practice sets were the test trials administered. The proportion of correct responses on 14 trials, and on the additional 1 or 2 practice trials, were used as the final score.

The *Dimensional Card Sort Task* required children to sort cards depicting coloured shapes (Frye, Zelazo, & Palfai, 1995; Zelazo, 2006). During practice trials, children first sorted six cards by one dimension (colour or shape; counterbalanced across participants). During the test-trials, children had to sort six cards based on the other dimension. Performance was the proportion of correct responses during the test trials.

Principal component analysis over the four executive function scores indicated that the first principal component explained 33.99% of the variance (λ = .19 - .81). In addition, the measures did not all correlate well with each other. Specifically, scores on the tongue task correlated well with the tapping task (r = .36, p < .001), but the other tasks did not correlate well, with correlations ranging from -.01 to .20. The four scores were standardized and an average score was computed, with higher scores representing better self-regulation.

Data Analyses

Using the package Lavaan (Rosseel, 2012) in R (R Core team, 2019), four linear regression models were estimated using maximum likelihood estimation with robust (Huber-White) standard errors. An asymptotical equivalent of the Yuan-Bentler adjusted chi-square test was used to account for the non-normally distributed data. For both fussing and crying, a model predicting self-regulation at 18 months (toddlerhood model) and at 4.5 years (preschool model) was estimated. Missing data were handled with full information maximum likelihood estimation. For all analyses, an alpha level of .05 was used to determine the significance of parameters. We also inspected whether models contained influential cases, as indicated by Generalized Cook's Distances (GCD) higher than 1.00 (Cook & Weisberg, 1982).

For all models, SES was included as control variable. All four models included the percentage negative reactivity (either fussing or crying), maternal sensitivity, the quadratic terms of percentage negative reactivity (i.e., fussing^2, or crying^2), the interaction terms for fussing or crying with maternal sensitivity (i.e., a two-way interaction), and the interaction term between the quadratic terms of fussing or crying and maternal sensitivity (i.e., a quadratic-by-linear interaction). A quadratic-by-linear interaction indicates that the shape of a quadratic effect changes depending on the level of the moderator, in this case maternal sensitivity.

Whenever interactions proved to be significant, we visually inspected the association between fussing or crying and self-regulation at -1 and +1 *SD* from the mean level of maternal sensitivity. In addition, we tested whether the quadratic effect was significant within the range of our observed variables. That is, we examined whether there was a true u-shaped effect that both significantly increased and decreased, as opposed to either a positive or negative association that flattened out, using an extension of the Johnson-Neyman (J-N) technique for quadratic-by-linear interactions (Miller, Stromeyer, & Schwieterman, 2013). The J-N extension yields approximate values at which a slope is significantly different from zero at different levels of the moderator, and produces corresponding confidence bands to indicate the precision of the slope.

RESULTS

Preliminary Analyses

Descriptive statistics are reported in Table 1. Girls had higher self-regulation scores compared to boys at preschool age, $t(109) = -2.25$, p = .027, but not in toddlerhood, $t(134) = -1.35$, p = .181. No sex differences were found for percentage fussing, $t(130) = 0.72$, p = .473, and percentage crying, $t(130) = 0.89$, p = .374. Correlations for all parameters are depicted in Table 2 and indicate that higher SES was related to better self-regulation at both ages. Self-regulation was relatively stable from toddlerhood to preschool age. Fussing, crying, and maternal sensitivity in infancy were unrelated to self-regulation at either age.

Primary Analyses

Toddler self-regulation. Inspection of influential cases showed that GCD values fell within a 0.00-0.90 range for the toddlerhood model with fussing as predictor. For the toddlerhood model with crying as predictor, two influential cases appeared (GCD = 1.09 and 1.25). However, removing these influential cases resulted in new influential cases, which indicates a general poor model fit (Pek & MacCallum, 2011). We therefore did not remove any cases.

TABLE 1

Descriptive statistics

Measure	*n*	Mean (*SD*)	Range
Infancy			
Fussing: percentage	132	3.84 (2.52)	0.00-14.51
Crying: percentage	132	1.24 (1.19)	0.00-5.56
Maternal sensitivity	148	2.07 (0.14)	1.55-2.54
Toddlerhood			
Compliance	136	0.34 (0.24)	0.00-1.00
Experimenter-rated regulation	136	5.39 (0.82)	3.17-7.67
Delay of gratification	136	0.01 (0.91)	-1.40-1.07
Mean score	136	0.00 (0.67)	-1.67-1.80
Preschool years			
Day-Night task	109	0.71 (0.26)	0.00-1.00
Tongue task	108	0.77 (0.29)	0.03-1.00
Tapping task	96	0.71 (0.26)	0.06-1.00
Dimensional Change Card Sort	105	0.84 (0.33)	0.00-1.00
Mean score	111	-0.03 (0.63)	-2.43-0.89

For the model in which fussing predicted self-regulation in toddlerhood (Table 3), chi-square test against the baseline model was significant (χ2 = 22.27, *df* = 6, *p* = .001), indicating that the regression model was more meaningful compared to a baseline model in which all parameters are uncorrelated with each other. The predictors explained 12% of the variance in toddler's self-regulation. Only SES was a significant positive predictor. Neither fussing nor maternal sensitivity in infancy predicted self-regulation in toddlerhood. For the model in which crying predicted self-regulation in toddlerhood (Table 3), the chi-square test against the baseline model was not significant (χ2 = 12.33, *df* = 6, *p* = .055), indicating that the regression model was not more meaningful compared to a baseline model in which all parameters are uncorrelated with each other.

TABLE 2

Correlations matrix

	1.	2.	3.	4.	5.
1. SES					
2. Fussing: percentage – 6 months	-.10				
3. Crying: percentage– 6 months	-.08	.23**			
4. Maternal sensitivity– 6 months	.03	-.02	.01		
5. Self-regulation – 18 months	.21*	.14	-.09	.15	
6. Self-regulation – 4.5 years	.30**	.09	-.08	.14	.24*

*<.05. **<.01. *n* = 99–148, depending on missing data

Preschool self-regulation. For the preschool model with fussing as a predictor, two extreme influential cases on the set of parameters were deleted (GCD = 1.98 and 7.91). All other GCD values fell within a 0.00 - 0.71 range. For the preschool model with crying as a predictor, three influential cases were detected (GCD = 1.15, 2.00 and 8.12). All other GCD values fell within a 0.00 - 0.99 range.

TABLE 3

Multiple Regression of Fussing, Crying and Maternal Sensitivity in Infancy on Self-Regulation in Toddlerhood

	Fussiness			Crying		
	b (*SE*)	β	*p*	*b* (*SE*)	β	*p*
SES	0.19 (0.07)	.25	.006	0.16 (0.07)	.20	.022
Negative reactivity	0.02 (0.02)	.06	.460	-0.11 (0.07)	-.20	.088
Maternal sensitivity	0.58 (0.38)	.12	.122	0.67 (0.41)	.14	.106
Negative reactivity^2	0.01 (0.00)	.12	.076	0.04 (0.03)	.18	.128
Sensitivity* negative reactivity	-0.13 (0.16)	-.06	.420	0.39 (0.46)	.09	.390
Sensitivity*negative reactivity^2	-0.05 (0.04)	-.08	.293	-0.07 (0.22)	-.03	.749

Note. *n* = 149 with Full Information Maximum Likelihood. R^2 = .12 for the fussing model, and R^2=.21 for the crying model. Negative reactivity refers to percentage fussing in the fussiness model, and to percentage crying in the crying model.

For the model with fussing predicting preschool self-regulation, chi-square test against the baseline mAodel was significant (χ2 = 53.23, *df* = 6, *p* < .001). The quadratic term for fussing and the interaction between fussing and maternal sensitivity significantly predicted preschool self-regulation. The quadratic relation was subsumed by significant interactions between the quadratic term for fussing with maternal sensitivity (Table

4). Visual inspection of simple slopes indicated that the quadratic effect of fussing on preschool self-regulation was only evident for children of relatively sensitive mothers (see Figure 2). For this group, the quadratic effect was shaped as an inverted U, such that moderate levels of fussing in infancy were predictive of better preschool self-regulation. The initial positive linear effect reached its maximum point at a value of 1.38, then decayed. Given that fussing was centered before being entered in the equation, this means that the association between fussing and self-regulation reverses at a level of fussing that is higher than the grand mean. For children of low sensitive mothers, the effect of fussing on self-regulation took the shape of a slight (non-inverted) U-curve.

TABLE 4

Multiple Regression of Fussing, Crying and Maternal Sensitivity in Infancy on Self-Regulation in the Preschool Years

	Fussiness			Crying		
	b (*SE*)	β	*p*	*b* (*SE*)	β	*p*
SES	0.24 (0.06)	.35	<.001	0.25 (0.07)	.37	<.001
Negative reactivity	0.04 (0.03)	.19	.076	-0.00 (0.06)	-.02	.904
Maternal sensitivity	0.54 (0.33)	.13	.099	0.81 (0.33)	.25	.002
Negative reactivity^2	-0.02 (0.01)	-.35	.049	-0.06 (0.04)	-.26	.074
Sensitivity* negative reactivity	0.46 (0.19)	.24	.015	-0.03 (0.43)	-.01	.948
Sensitivity*negative reactivity^2	-0.18 (0.05)	-.34	<.001	-0.43 (0.26)	-.19	.104

Note. n = 149 with Full Information Maximum Likelihood. R^2 = .37 for the fussing model, and R^2 = .25 for the crying model. Negative reactivity refers to percentage fussing in the fussiness model, and to percentage crying in the crying model.

Using an extension of the J-N technique for quadratic-by-linear interactions, we examined how the quadratic effect of fussing on preschool self-regulation changed at different levels of maternal sensitivity. To do so, we fixed maternal sensitivity at -1 and +1 standard deviation from the mean and computed the simple slopes and accompanying regions of significance. The resulting plot, depicting the simple slope and regions of significance for fussing on preschool self-regulation when maternal sensitivity is high (+1 *SD*), is depicted in Figure 3a. The figure shows that, when maternal sensitivity was high, there was an initial positive effect at the lower end of the distribution of infant fussing. Here, higher levels of fussing related to better self-regulation in childhood. At the higher end of the distribution fussing, the effect of infant fussing on child self-regulation became significantly negative, such that higher levels of fussing were related to lower self-regulation. It should be noted that the slope was only significantly negative at very high levels of fussing (i.e., at a value of 3.81) and that inspection of bivariate

scatterplots indicated that these data points were not well represented in the data (see Figure S1). Still, for infants with relatively sensitive mothers, there was an inverted U-shaped predictive association between infant fussing and preschool self-regulation. When maternal sensitivity was low (-1 *SD*, Figure 3b), there was no significant association between fussing and self-regulation.

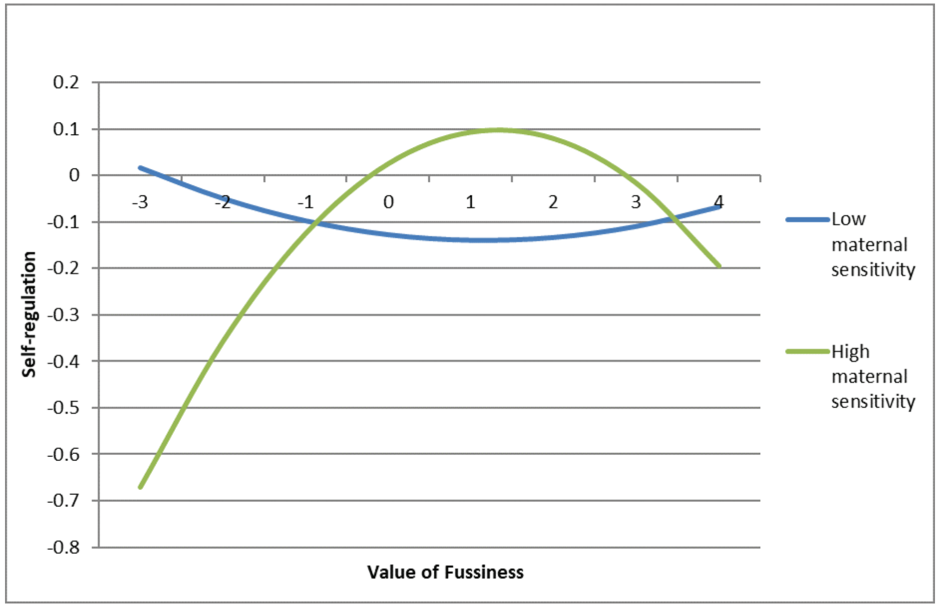

FIGURE 2. Simple Slope of Fussing on Self-Regulation Conditional on Maternal Sensitivity.

For the model with crying predicting preschool self-regulation, the chi-square test against the baseline model was also significant (χ2 = 34.41, *df* = 6, *p* < .001). The model explained 25% of the variance in preschool self-regulation. SES and maternal sensitivity predicted higher levels of self-regulation (Table 4). Specifically, higher SES and higher maternal sensitivity were associated with higher levels of preschool self-regulation. Crying was unrelated to preschool self-regulation.

DISCUSSION

The goal of the current multi-method longitudinal study was to examine whether infant negative reactivity, measured as fussing and crying, and maternal sensitivity predicted toddler and preschool self-regulation. To this end, we first tested the hypothesis that negative reactivity would predict later self-regulation in a manner consistent with the optimal arousal perspective. We examined whether moderate amounts of negative reactivity, as opposed to high and low amounts of negative reactivity, would predict

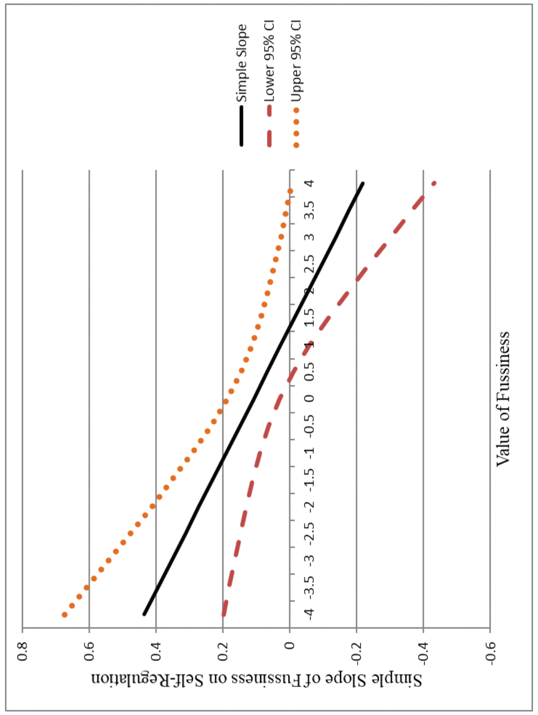

FIG. 3.A. J-N Plot for the Simple Slope of Fussing Across Values of Fussing when Maternal Sensitivity is Fixed at + 1 *SD*

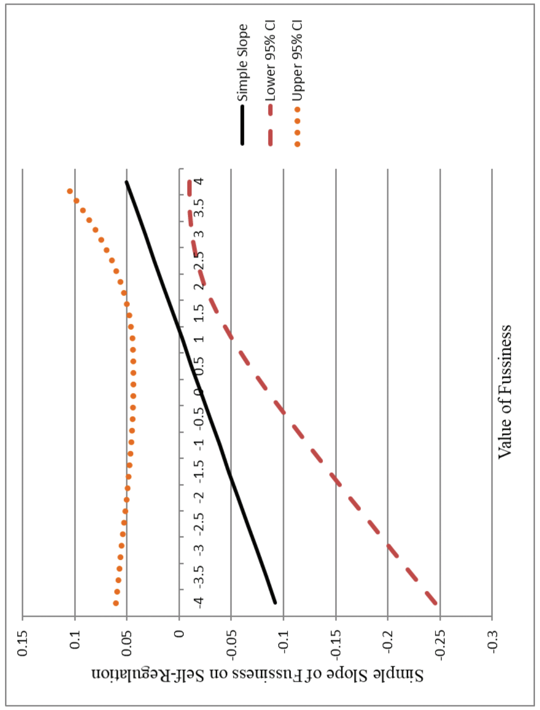

FIG. 3.B. J-N Plot for the Simple Slope of Fussing Across Values of Fussing when Maternal Sensitivity is Fixed at - 1 *SD*

higher levels of self-regulation in toddlerhood and the preschool years. We primarily expected to find such a quadratic association for fussing, as opposed to crying. Second, we tested the hypothesis that there was a positive predictive relation between maternal sensitivity in infancy and self-regulation in toddlerhood and the preschool years. Finally, we examined whether the predictive association between negative reactivity and self-regulation was conditional on levels of maternal sensitivity.

The results of this study indicated that self-regulation in the preschool years was predicted by fussing in a non-linear matter, and that this association was conditional on levels of maternal sensitivity. As hypothesized, the relation between infant fussing and preschool self-regulation was shaped as an inverted U. When maternal sensitivity was low, there was no association between fussing and self-regulation. Crying did not predict preschool self-regulation. Lastly, self-regulation in toddlerhood was neither predicted by fussing, crying, and sensitivity, nor by their interactions.

Informed by the theoretical notion that the relation between negative reactivity and self-regulation follows an inverted U shape (Blair & Ursache, 2011), the results of the current study indicate that moderate amounts of less intensive negative reactivity, expressed as fussing, predict better preschool self-regulation. Highly intensive negative reactivity, communicated through crying, did not predict self-regulation. The findings of this study are in keeping with prior animal studies indicating that experimentally induced short moments of negative reactivity are associated with enhanced performance on indicators of self-regulation (e.g., Parker et al., 2005; Tang et al., 2006), as well as with human studies demonstrating that infants with low levels and moderate fluctuations in cortisol levels showed better self-regulation in the preschool years (Blair et al., 2017), and that the combination of high reactivity and high regulation predicts more advanced self-regulation (Stifter et al., 1999; Ursache et al., 2013). Overall, the results indicate that both the level and amount of observed negative reactivity matter for the development of self-regulation.

The importance of distinguishing between infant fussing and crying is clearly demonstrated with this study. The results fit well with the optimal arousal theory, which focusses not only on the amount, but also on the level of negative reactivity (Blair & Ursache, 2011). Not only do relative low levels of negative reactivity support prefrontal cortex functioning (Arnsten, 2009), they may also provide a controlled practice opportunity for regulation. That is, during moments of fussing, six-month-old infants may be able to handle negative reactivity quite well, and thereby practice regulating their distress. Based on operant conditioning principles, it is likely that reductions in negative reactivity are an enjoyable experience, which increases the chance that infants will repeat regulatory behaviors associated with such reductions in the future. Tronick and Beeghly (2011) refer to this process as meaning-making: the process in which infants acquire information by engaging with their inner world, and the world around them. Infants who fuss a lot seem to benefit less from moments of negative reactivity, most likely because they often do not experience that their regulatory actions result in modulation of their reactivity. This relates to the finding that, within a sample of clinically referred infants with colic, the time spent in a fussing state was found to be a developmental risk marker (DeSantis et al., 2004). Moreover, during moments of crying, regulatory behaviors that would have been available to the infant if he or she would be less distressed may be disabled. There are indications that children use different regulatory behaviors depending on the level of negative reactivity (e.g., Ekas, Braungart-Rieker, Lickenbrock, Zentall, & Maxwell, 2011; Stifter & Braungart, 1995). Behaviors that are used at high levels of negative reactivity are generally more primitive, such as self-comforting behaviors (e.g., thumb-sucking), and these may be used at the expense of more mature attention-based regulatory behaviors (Stifter & Braungart, 1995). Hence, infants may not be able to practice and further refine more mature forms of emotion regulation during moments of highly intensive negative reactivity.

Maternal sensitivity was not consistently associated with preschool self-regulation, which is in contrast to previous work). However, maternal sensitivity did function as a moderator in the association between fussing and preschool self-regulation. In line with the bioecological model, individual differences in fussing were most important in predicting self-regulation in the context of high maternal sensitivity. Various studies have demonstrated that the combination of negative reactivity and parenting practices predicts later self-regulation (e.g., Feldman et al., 1999; Kim & Kochanska, 2012). Specifically, these studies demonstrated that the combination of high infant negative reactivity and high maternal sensitivity predicts higher levels of self-regulation. The current study shows that especially moderately fussy infants of relatively sensitive mothers show higher levels of self-regulation. Infants who experience moderate amounts of fussing create the opportunity for their mothers to help them learn how to regulate in the moment. Mothers can model and initiate regulatory behaviors, or support and encourage infants' own regulatory efforts. Infants who fuss a lot may not experience the modulating function of regulatory behaviors, and may therefore be less inclined to repeat modelled or encouraged regulatory behaviors. On the other hand, infants who do not experience moments of fussing do not have the opportunity to profit from the prompt and appropriate responses to negative reactivity from their mothers. This pattern is important, as maternal sensitivity to negative reactivity is found to be

particularly important for socioemotional adjustment (Leerkes, Blankson, & O'Brien, 2009; McElwain & Booth-LaForce, 2006). For mothers of infants who hardly fuss, there are few occasions for them to display sensitivity to negative reactivity.

The data also revealed that low amounts of infant fussing, combined with high levels of maternal sensitivity, were related to the poorest self-regulation in the preschool years. This indicates that behavior that may seem adaptive in the moment does not necessarily promote children's development (Beeghly & Tronick, 2011). Possibly, mothers who came across as highly sensitive during the novel toy procedure in the lab may in fact respond too promptly to their infants' signals in daily life, thereby preventing most instances of fussing. To some extent, six-month-old infants are capable of relatively independent regulation of distress (Crockenberg & Leerkes, 2004). Parents are found to wait longer before intervening when the degree of perceived negative reactivity of their infant is low (Wood & Gustafson, 2001), which gives infants the opportunity to solve moments low level negative reactivity independently. For infants of highly sensitive mothers, there may be less opportunity to develop and refine autonomous regulation strategies. Related to this finding is research demonstrating that children of parents who preemptively interfere, and thereby preclude children from conducting tasks by themselves, show higher levels of negative reactivity in frustrating events (Calkins & Johnson, 1998), and research demonstrating that high maternal sensitivity to distress predicts greater affect dysregulation amongst infants low on reactivity (Leerkes et al., 2009). Taken together, future research may want to examine whether the combination of high maternal sensitivity and low infant fussing functions as a risk-marker for poor self-regulation later in development.

In contrast to preschool self-regulation, self-regulation in toddlerhood was unrelated to any of the measures in infancy. Whereas we operationalized self-regulation in the preschool years with executive function tasks, our measure for self-regulation in toddlerhood predominantly tapped the ability to delay and comply with adults. Possibly, the optimal arousal perspective is not applicable to these forms of regulation. It should be noted that self-regulation in toddlerhood was modestly associated with self-regulation in the preschool years, supporting the predictive validity of our self-regulation measure in toddlerhood. In addition, as self-regulation is still 'under construction' in toddlerhood, individual differences at this age may be masked and difficult to predict. Previous longitudinal studies aimed at predicting self-regulation at various ages also found that self-regulation in toddlerhood was more difficult to predict than self-regulation in the preschool years (e.g., Cuevas et al., 2014; Johansson, Marciszko, Brocki, & Bohlin, 2016).

There are many strengths to the current study, including the use of cry diaries over multiple days and reliance of observational measures to assess both toddler and preschool self-regulation. Yet, the results of the study should also be considered alongside some limitations. First, the majority of the sample comprised high SES families. This may have affected the observed range of our variables. For instance, mothers were on average sensitive towards their infant, and there are indications that mothers from a high SES background are better capable of adjusting their parenting practices to difficult behavior (Paulussen-Hoogeboom, Stams, Hermanns, & Peetsma, 2007). As such, future studies should test whether our results hold in more diverse samples. This also allows to examine whether a differential susceptibility model would hold, claiming that individual differences are most important in both highly advantaged and highly disadvantages proximal environments (Belsky, 1997). In the current study, we were only able to contrast advantaged proximal environments against less advantaged proximal environments. Second, highly sensitive mothers may have been more reliable informants regarding infant fussing and crying, which could explain why fussing was mainly predictive for self-regulation in children of highly sensitive mothers. As such, future studies should examine whether our results hold for measures of fussing and crying that are independent of maternal reports, for instance by using auditory or video assessment procedures or by relying on different informants. On a similar note, it should also be noted that we did not control for maternal self-regulation. Possibly, genetic influences may play a role in associations between maternal sensitivity and children's self-regulation. Third, principal component analyses indicated that a relatively small proportion of the variance of the tasks used to measure self-regulation in toddlerhood and the preschool years was explained by a common factor. Future studies may want to incorporate a larger test-battery to measure self-regulation and include longer assessments for compliance and maternal sensitivity. Lastly, larger and more diverse samples are needed to further confirm the robustness of the relatively complex moderated quadratic models tested in this study. The association between high amounts of fussing and self-regulation especially requires further examination, in order to establish whether this association indeed becomes significantly negative at high levels of fussiness.

Overall, the current study is the first to demonstrate that the relation between fussing and self-regulation may take the shape of an inverted U, and that this association depends upon levels of maternal sensitivity. At six months, experiencing moments of fussing, and not crying, is integral to the development of self-regulation, provided that fussing is accompanied by prompt and appropriate maternal responses. Infants who rarely experience moments of fussing may not get the practice opportunities needed

to develop and enhance regulatory skills. Similarly, their mothers also have fewer opportunities to support their infant with regulating negative reactivity, and thereby teach and model regulatory strategies. Inconsolable or highly distressed infants, on the other hand, may not build upon the experience that certain regulatory behaviors are followed by a reduction in negative reactivity. Our findings underscore the importance of distinguishing between levels of negative reactivity, and the need to consider the social context of infants.

SUPPLEMENTARY MATERIAL

As can be seen in Figure S1, infants with a fussing score higher than 3.81, and with mothers who score 1 *SD* above the mean of maternal sensitivity are not well represented in the data.

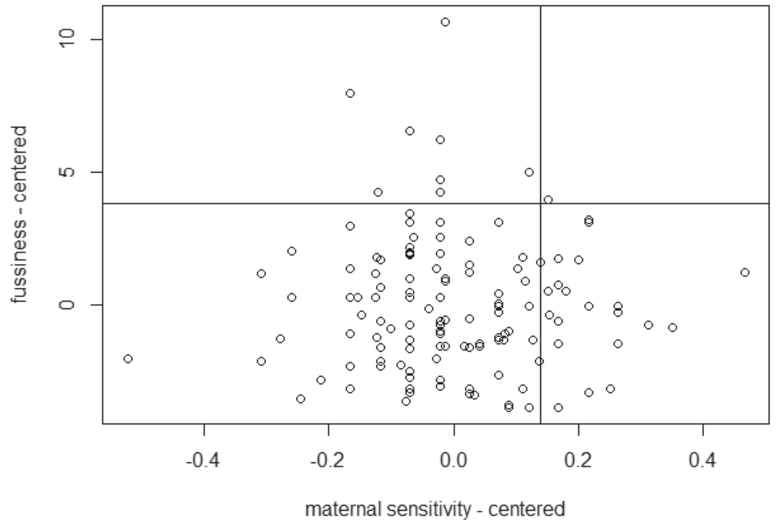

FIGURE S1. Scatterplot for Maternal Sensitivity and Infant Fussing. Lines represent value 1 sd above the mean for maternal sensitivity, and the value of fusiness at which the simple slope becomes significantly negative.

3

CHAPTER 4

Inhibitory Control across the Preschool Years: Developmental Changes and Associations with Parenting

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Under review.

ABSTRACT

The normative developmental course of inhibitory control between 2.5 and 6.5 years, and associations with maternal and paternal sensitivity and nonintrusiveness were tested. The sample consisted of 383 children (52.5% boys). During four annual waves, mothers and fathers reported on their children's inhibitory control using the Children's Behavior Questionnaire. During the first wave, mothers' and fathers' sensitivity and nonintrusiveness were observed and coded with the Emotional Availability Scales. Inhibitory control exhibited partial scalar invariance over time, and increased in a decelerating rate. For both mothers and fathers, higher levels of sensitivity and lower levels of nonintrusiveness were associated with a higher initial level of children's inhibitory control, whereas higher levels of nonintrusiveness predicted a steeper increase in children's inhibitory control.

Keywords
Inhibitory control, Development, Parenting

Author contributions
SG, JE, and MD conceptualized the study, JE and JM were responsible for data collection, SG analyzed data, and wrote the manuscript. All authors provided feedback on the study.

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INTRODUCTION

Developing the capacity for self-regulation, i.e., the ability to automatically or deliberately modulate affect, behavior, and cognition (Karoly, 1993), is an important task in childhood and adolescence. Higher levels of self-regulation are related to fewer mental health problems, and better academic performance (Bull, Espy, & Wiebe, 2008; Olson, Sameroff, Kerr, Lopez, & Wellman, 2005). One key-component of self-regulation is inhibitory control, i.e., the ability to plan and suppress responses (Rothbart et al., 2001). Understanding the normative developmental course of inhibitory control, and the factors that may predict this development, can help professionals in detecting developmental problems early on and identifying intervention targets with parents. Therefore, the aim of the current study is to model the development of inhibitory control in Dutch preschool children between the ages of 2.5 and 6.5 years, and to examine whether parental sensitivity and nonintrusiveness predict the course of development.

Development of Inhibitory Control

Early displays of inhibitory control are already seen during the first year of life (Garon et al., 2008). Even 8-month-old children can prevent or stop behaviors in response to their parents' requests (Kochanska et al., 1998). Over the preschool years, inhibitory control develops rapidly. Prior studies have tracked this development by looking at mean level changes across a variety of lab tasks (Dennis et al., 2007; Klenberg et al., 2001; Schoemaker et al., 2014). These studies indicate that inhibitory control develops especially fast during the early preschool years. Specifically, a study with a group of predominantly clinically referred preschool children with externalizing problems (age between 3.5 and 5.6 years at the first wave) demonstrated that inhibitory control improved over a course of 18 months, and that this development was the strongest between the age of 3.5 and 4.5 years (Schoemaker et al., 2014). Similarly, a study with 75 children at risk for conduct problems indicated that inhibitory control increased rapidly between four and five years, and that this increase leveled off between five and six years (Dennis et al., 2007). Another study found similar results for simple inhibition (suppressing a dominant response) in a sample with children who were not at risk in their development (Lengua et al., 2015). Lastly, a study with a normative sample between 3 and 12 years of age indicated that the ability for simple inhibition improved until the age of 6 years, and the ability for complex inhibition (suppressing a dominant response and activating a subdominant response) improved until the age of seven years (Klenberg et al., 2001).

Despite a handful of studies on the early development of inhibitory control as assessed with lab tasks, we know little about the development of inhibitory control as expressed in daily life. Although studies conducted with information obtained in lab-settings are highly valuable, data provided by parents on acts of inhibitory control in real world situations (e.g., are children capable of waiting in line, do they obey instructions) add to our knowledge by providing a more ecologically valid measure. The most widely used questionnaire for parents to report on inhibitory control is the Children's Behavior Questionnaire (CBQ; Rothbart et al., 2001). A meta-analysis on the usefulness of various inhibitory control measures across age, based on cross-sectional data, concluded that the CBQ inhibitory control subscale is useful to measure individual differences in inhibitory control within a six-year age range (i.e., from age 2 to 8 years), whereas lab tasks were on average only useful for detecting individual differences within a 2.49 year age range (Petersen, Hoyniak, McQuillan, Bates, & Staples, 2016).

Although useful across a wide age-range, in the meta-analysis on inhibitory control measures it appears that there is only a modest increase in scores on the CBQ inhibitory control scale across age (Petersen et al., 2016). For example, a cross-sectional study with children between 3 and 6 years of age found that age only modestly accounted for increases in parent-reported inhibitory control (Reck & Hund, 2011). Longitudinal research on the CBQ inhibitory control scale indicates a decelerating increase between 2 to 7.5 years (Chang, Shaw, Dishion, Gardner, & Wilson, 2014; Moilanen, Shaw, Dishion, Gardner, & Wilson, 2010). Overall, studies thus far indicate that findings on the development of inhibitory control measured with lab tasks are not necessarily generalizable to parent-reported inhibitory control, as parent-reported inhibitory control may increase less during the preschool years.

As the CBQ was developed to measure a temperament related construct, it may be argued that it is not designed to detect change. However, whereas earlier theories regarding temperament underscored the longitudinal stability of temperament, Rothbart and colleagues have argued against this conceptualization (see also Putnam & Stifter, 2008 for a review on this matter). Rothbart reasoned that temperament developmental changes are likely, due to the emergence of new skills, other expressions of behavior, and because temperament is an open system that is influenced by interactions with the environment (Rothbart & Putnam, 2002; Rothbart, 2012). Within this framework, inhibitory control and other aspects that relate to effortful control develop substantially in the preschool years (Rothbart & Rueda, 2005). It is therefore to be expected that inhibitory control measured through the CBQ also changes over time, but not necessarily in the same manner as inhibitory control as assessed through lab tasks. Development may for instance be slower, because children do not necessarily immediately implement the cognitive skills that are measured with lab tasks in their

daily life. Exclusively relying on lab tasks for measuring growth in inhibitory control may create unrealistic expectations regarding the development that children demonstrate in inhibitory control over the preschool years. It is therefore important to examine parent-reports of inhibitory control as well. Moreover, most studies on the development of inhibitory control (both parent-rated and lab-based) utilized at-risk samples. Less is known about how these results generalize to children who are not at risk in their development.

Another limitation of previous work on parent-reported inhibitory control concerns the absence of longitudinal measurement invariance testing. Younger children may not only show lower levels of inhibitory control (i.e., mean-level change), but may also show different behaviors that indicate their level of inhibitory control (i.e., conceptual change). Potential conceptual changes may be due to preschoolers significant development in multiple domains, such as language and motor development, that interact with the way in which inhibitory control is manifested (e.g., Hughes & Graham, 2002), as well as developmental changes in contexts. An important contextual milestone to consider is the transition to school, which happens at the age of four years in the Netherlands. This transition brings a variety of changes in children's environments, including different expectations when it comes to following instructions, remaining seated, and inhibiting unwanted behaviors. As a result, observed changes in inhibitory control can be confounded with other developmental processes.

Conceptual changes in inhibitory control can hinder interpretations regarding mean-level developmental changes in inhibitory control. To test for possible conceptual changes in inhibitory control, longitudinal measurement invariance should be examined. Measurement invariance ensures that means, variances and correlations (with other variables) can be reliably compared across age, because the indicators are measuring the same thing at different ages. Thus far, a few studies using lab-based tasks to measure inhibitory control in the preschool years have reported evidence for longitudinal measurement invariance (Hughes, Ensor, Wilson, & Graham, 2009; Wiebe et al., 2008), or partial (i.e., incomplete) measurement invariance (Willoughby, Wirth, & Blair, 2012). Whether parent-reports of inhibitory control show longitudinal measurement invariance is still unclear. In the only study we known of that tested measurement invariance of the CBQ across age, Frohn (2017) reported that eight out of 13 items of the inhibitory control scale were either deemed not applicable by a large proportion of parents, or not invariant when comparing a group of 3 to 4 year old children with a group of 6 to 7 year old children. These items involved: (1) ability for games like "Simon Says," "Mother, May I?" and "Red Light, Green Light.", (2) lowering voice upon request,

(3) resisting temptation upon request, (4) preparation for trips and outing by planning, (5) difficulty with waiting in line, (6) difficulty with sitting still upon request, (7) ability for resisting to laugh or smile when this is inappropriate, (8) difficulty in being careful and cautious when crossing a street. These cross-sectional results should be replicated in studies with a longitudinal design, to examine whether parent-reported inhibitory control conceptually changes across development within the same children.

Parenting and the Development of Inhibitory Control

Various theories emphasize the importance of parenting in the development of higher order skills, including inhibitory control (Deci & Ryan, 1985; Rothbart, Sheese, Rueda, & Posner, 2011; Sroufe, 2000). An important theory in this regard is attachment theory. Attachment theory underscores the importance of sensitive and nonintrusive parenting. Sensitive parenting entails that parents notice the cues of their child, interpret these cues correctly, and respond promptly and appropriately (Ainsworth, 1969). Such prompt and appropriate responses support children in staying well-regulated in the moment, but they also provide an example of appropriate regulatory strategies which can be internalized (Sroufe, 2000). Intrusiveness entails parental behaviors that are overdirecting, overstimulating, or that interfere with children's own activities (Biringen et al., 2008). These intrusive behaviors relate to increased stress in young children. For instance, higher levels of intrusive parenting are associated with increased levels of cortisol and alpha amylase (Taylor et al., 2013).

The attachment relationship with caregivers is considered to be the model for learning self-regulation at a physiological level (Perry, Blair, & Sullivan, 2017) and at a behavioral level (e.g., Sroufe, 2000). Although the foundation for this model is laid in infancy, the attachment relationship continues to play an important role in self-regulation throughout childhood (Sroufe, 2000) and adolescence (Zimmermann, Mohr, & Spangler, 2009). Considering the preschool years, when self-regulation is still developing, caregivers must give their child the opportunity to master difficult circumstances, but also provide support when needed (Sroufe, 2000). The preschool years form a sensitive period for maternal support to affect developmental trajectories of hippocampal volume, a region that has an important function in physiological stress responses (Luby, Belden, Harms, Tillman, & Barch, 2016). Additionally, children from parents who are sensitive and nonintrusive may benefit more from socialization efforts, which may in turn further enhance their inhibitory control. A secure attachment with caregivers is found to amplify positive effects of children's receptive stance towards parental rules, and has been marked as a catalyst for future positive socialization processes (Kochanska et al., 2010). On top of that, children with poor inhibitory control may also

tax parents' ability to remain sensitive and nonintrusive, for instance because they show higher levels of noncompliance (Gauvain & Perez, 2008; Morasch & Bell, 2011). This can result in back-and-forth processes between parents and children that accumulate over time, also known as developmental cascades (Masten & Cicchetti, 2010). Therefore, children of sensitive and nonintrusive parents are expected to demonstrate more growth in inhibitory control.

A meta-analysis published 13 years ago reported that there was no concurrent association between parental responsiveness, which included measures of parental sensitivity, and inhibitory control (Karreman, Van Tuijl, van Aken, & Deković, 2006). This conclusion was based on a few studies ($N_{studies}$ = 7) that examined concurrent associations between responsiveness and a slightly broader inhibitory control construct that also included anxiety related behavioral inhibition. Karreman et al. (2006) also reported that negative control, including intrusive behavior, was not associated with inhibitory control ($N_{studies}$ = 7). Although the authors tentatively concluded that responsiveness and negative control may not be that important for the development of inhibitory control, a growing body of research since then indicates that this conclusion cannot yet be made. For instance, Bernier et al. (2010) reported that maternal sensitivity and autonomy support, which can be seen as the opposite of intrusive behavior, at 12 to 15 months were related to lab-performance on inhibitory control tasks at 26 months—although these parenting measures were not found to predict longitudinal change in inhibitory control. Restricting infants' behavior at eight months, for instance by taking objects away and prohibiting, was found to predict lower levels of (lab-based) inhibitory control at eight years (Olson, Bates, Sandy, & Schilling, 2002). Most studies on parenting and inhibitory control are based on only one or two assessments of inhibitory control. An exception is a longitudinal three-wave study, demonstrating that positive behavior support (e.g., providing structure and positive reinforcement) was linked to faster growth in parent-reported inhibitory control from two to four years of age, but not to initial levels of inhibitory control. Harsh intrusive parenting was linked to lower initial levels of parent-reported inhibitory control, but not to change in inhibitory control (Moilanen et al., 2010).

In addition, studies on broader self-regulation constructs, which generally include inhibitory control, demonstrated that higher parental sensitivity predicts higher levels of self-regulation in toddlers and preschoolers, even when controlling for prior levels of self-regulation (Blair, Raver, & Berry, 2014; Spinrad et al., 2007). In a longitudinal study following children from 2.5 to 4.5 years of age, intrusive parenting longitudinally predicted effortful control, again even when controlling for prior levels of effortful control (Eisenberg, Taylor, Widaman, & Spinrad, 2015). On the other hand, Eisenberg et al. (2010) reported that supportive parenting was important for effortful control between 18 and 30 months, but not for 42 month old children's effortful control. Overall, the available evidence indicates that sensitive and nonintrusive parenting may bolster the development of inhibitory control, but there are only a few studies to date that have related parenting to developmental changes of inhibitory control over more than two measurement occasions.

Fathers and Mothers

Traditionally, most research into the association of parenting behavior and inhibitory control has focused on mothers. However, a variety of theorists claim that fathers and mothers may play different roles in raising their children, and argue that, whereas mothers typically provide support to their children by comforting them (i.e., the traditional attachment relationship), fathers offer security in situations that are challenging and stimulating (Grossmann, Grossmann, Kindler, & Zimmermann, 2008; Paquette, 2004). These differences in roles imply different ways in which mothers and fathers promote the development of their children's inhibitory control. Mothers may typically stimulate the development of autonomous regulation by providing support during moment of child distress, whereas the interactions with fathers generally come with a broader range of arousal intensities to practice regulation (Parke et al., 2004). More broadly, as mothers on average still spend two to three times more time on child care than fathers in most Western countries (Huerta et al., 2013), maternal parenting may also have more impact on children's development compared to fathering.

Supporting this line of reasoning are studies reporting that the parenting behaviors of mothers and fathers that are associated with children's self-regulation (parent reports and lab tasks) differ on average (Karreman, Van Tuijl, Van Aken, & Deković, 2008; Tiberio et al., 2016) and studies reporting that parenting practices of mothers are more strongly or consistently associated with children's self-regulation, measured with questionnaires or lab-tasks (e.g., S. Kim & Kochanska, 2012; Towe-Goodman et al., 2014). Notably, in one of the few studies to consider both mothers and fathers, higher maternal positive control, including sensitivity, and lower paternal negative control were found to promote self-regulation in preschoolers (Karreman et al., 2008). Hence, whereas maternal sensitivity may be particularly important for the development of children's self-regulation, the most important task for fathers when promoting their children's self-regulation may be to avoid intrusive behaviors. However, it should also be noted that roles of comforting and activating are not necessarily bound to be fulfilled by mothers and fathers respectively (e.g., Roggman, 2004). In fact, other studies indicate

that parenting practices of mothers and fathers are quite similarly related to their preschooler's self-regulation (Bridgett et al., 2018; Kochanska, Aksan, Prisco, & Adams, 2008).

Current Study

The first objective of the current study was to model the development of inhibitory control between the ages of 2.5 to 6.5. As a prerequisite, we first examined longitudinal measurement invariance, in order to test the conceptually similarity of the inhibitory control concept across age. With regard to the development of inhibitory control, we expected to find a decelerating increase in inhibitory control over the preschool years. We also explored sex differences in the development of inhibitory control, as girls are generally found to have higher scores on the CBQ inhibitory control scale (Else-Quest, Hyde, Goldsmith, & Van Hulle, 2006), but growth rates may be similar across sexes (Moilanen et al., 2010). The second objective was to examine whether maternal and paternal sensitivity and nonintrusiveness at 2.5-3.5 years predicted the initial level and growth of inhibitory control. We expected parental sensitivity and nonintrusiveness to be positively related to the initial levels and growth of inhibitory control. Lastly, we explored whether mothers' and fathers' sensitivity and nonintrusiveness were similarly, or differently, related to initial levels and growth in inhibitory control, and whether this differed for boys and girls.

METHODS

Sample

This study makes use of data from the longitudinal study Boys will be Boys, focused on gender-differentiated socialization in the first years of life (see Endendijk et al., 2013). Between April 2010 and May 2011, families were selected from municipality records, and invited by mail to participate in the study. For this study, families with two children in the Netherlands of which the firstborn child was between 2.5 and 3.5 years old and their sibling was around 12 months of age old were eligible. Only data considering the firstborn child was used, as inhibitory control in the younger sibling was measured with differing age-appropriate questionnaires across waves.

Single parents, families in which either a child or parent had a severe physical or intellectual handicap, and parents born outside the Netherlands or not speaking the Dutch language were excluded from participation. In total, 390 (31%) of the 1,249 contacted families agreed to participate. These families did not differ from the non-participating families on age, educational level of both parents, and degree of urbanization of the place of residence (all *p*s>.10). A total of 383 families provided data on their children's inhibitory control during at least one wave and therefore were included in the current study. A total of 373 parents reported on their child's inhibitory control at wave 1, whereas 329 (88.20%) parents did so during wave 4. Little's MCAR test indicated that data were missing completely at random, $\chi^2(104) = 107.57$, $p = .385$. Follow-up analyses indicated that the number of missings on inhibitory control was unrelated to parental sensitivity and nonintrusiveness, age and sex of the child, and maternal and paternal education.

Children (52.5% boys) were on average 3.01 years old ($n = 383$, $SD = 0.30$, range = 2.46-3.61) during the first wave, 4.01 years ($n = 384$, $SD = .30$, range = 3.43 - 4.64) during the second wave, 5.04 years ($n = 372$, $SD = .30$, range = 4.44-5.85) during the third wave, and 6.03 years ($n = 370$, $SD = .30$, range = 5.50 - 6.66) during the fourth measurement wave. Mothers were aged between 23.64 and 45.62 years ($M = 33.95$, $SD = 3.93$) and fathers were between 25.84 and 62.97 years of age ($M = 36.79$, $SD = 5.03$). Most participating parents were married, had a cohabitation agreement or registered partnership (93.00%), and the remaining 7.00% lived together without any kind of registered agreement. With regard to educational level, most of the mothers (79.40%) and fathers (76.80%) had a high educational level (academic or higher vocational schooling). This is higher than the national average (i.e., 41.2% of the Dutch population between the age of 25 to 55 was higher educated in 2018; CBS-statline, 2019).

Procedure

During four annual measurement waves, each family was visited twice at home, separated by a period of approximately two weeks: once with the father, the target child and the younger sibling, and once with the mother and both children. The order in which parents were visited and the order in which they interacted with the firstborn child and the younger sibling was counterbalanced. Both parents were requested to individually complete questionnaires before the first home visit of each wave. During the home visits, parent– child interactions and sibling interactions were video recorded, and the children and both parents completed computerized tasks. The home visits were conducted by pairs of trained undergraduate and graduate students. Informed consent was obtained from all participating families. Families received a payment of 30 Euros and small presents for the children. Ethical approval for this study was provided by the Commission Research Ethics Code of the Leiden Institute of Education and Child Studies.

Measures

Inhibitory control. The Inhibitory Control subscale of the CBQ (Rothbart et al., 2001) was administered during all four waves. The original subscale contained 13 items, which parents had to answer on a scale from 1 (*never*) to 7 (*always*). This is in contrast to the original rating scale, which ranges from 1 = "*extremely untrue of your child*" to 7 = "*extremely true of your child*". Parents could also indicate that an item was not applicable. The scale used in the current study aligns with some of the other questionnaires based on Rothbart's work, such as the Early Childhood Behavior Questionnaire (Putnam, Gartstein, & Rothbart, 2006). This rating is also preferred because it focuses on the quantity of behavior, which may be easier to answer for parents, and more suitable to track mean-level differences than the original rating scale. Adjusting the rating scale of the CBQ has been proposed before (Frohn, 2017). One item was removed because more than 20% of parents indicated that this item was not applicable across all waves: "My child is able to resist laughing or smiling when it isn't appropriate.". Although a part of the sample ($n = 200$) was younger than the intended age range of the CQB, i.e., 3 years of age, this could not explain these high percentages: a high percentage of parents of children older than 3 years also indicated that this item was not applicable (See Table S1 in the supplementary results). Across all four waves, mean scores of father and mother reported inhibitory control were sufficiently correlated ($r = .46 - .53$). Items were generally also sufficiently correlated ($r = .15 - .40$). To create more robust scores for inhibitory control, father and mother reports were averaged at the item-level for subsequent factor analyses as described in the results section. Cronbach's alpha using these averaged items indicated that the internal consistency of the scale was good, ranging from .77 to .85 across waves.

Parenting. Parents and children were videotaped after they were asked to play with a bag with toys for 8 minutes. Parental sensitivity and nonintrusiveness were coded by a team of seven coders using the fourth edition of the Emotional Availability Scales (EAS; Biringen, 2008). Sensitivity refers to the parent's ability to be warm and appropriately responsive to the child, whereas nonintrusiveness indicates the parent's ability to give the child space to explore and to refrain from intrusions on the child's activities. Both dimensions were divided into seven subscales, in which the first two subscales were coded on a 7-point Likert scale and the other subscales are coded using a 3-point Likert scale (potential score range 7 - 29). Fathers and mothers received a global rating score for both sensitivity and nonintrusiveness based on their behavior during the entire 8-minute free play session. For the nonintrusiveness scale, one subscale (the adult is made to "feel" or "seem" intrusive) was excluded because it refers to child behavior rather than parental behavior, which resulted in a potential score range of 7 - 26 (see

Hallers-Haalboom et al., 2014 for more details about coding). Interrater reliability, determined on 15% of the participating families, was sufficient, with a mean intraclass correlation coefficient for sensitivity of .81 (range: .73 to .92) and .84 (range: .76 to .93) for nonintrusiveness. In addition, the first 100 videotapes were coded twice by separate coders, and regular meetings were organized to prevent coder drift.

Plan of Analyses

Measurement invariance. Using M*plus* 8.0 (Muthén & Muthén, 1998–2012), we first fitted a one-factor model on the data of the first wave, to test whether all items of the inhibitory control scale loaded on a single factor for parent reports (mother and father reports collapsed for each item). Next, we tested for measurement invariance. We first constrained factor loadings over time (i.e., metric invariance), followed by the intercepts (i.e., scalar invariance), and the residuals (i.e., error variance invariance). Potential sources of invariance were detected by inspecting the Modification Indices (MI) in M*plus*. Partial scalar invariance is required to compare means over time (Little, 2013).

Next, we reran the factor analysis using the effect coding method as proposed by Little, Slegers, and Card (2006). In this method, the set of loadings are constrained to average 1, and the set of indicator intercepts are constrained to sum up to 0. This method results in estimated latent means and variances that reflect the observed metric of the underlying items. As such, this method provides meaningful latent means and variances, and is therefore particularly useful for analyses in which the means of latent constructs are of interest. The resulting scores from this analysis were saved for subsequent analyses.

Development of inhibitory control and associations with parenting. Because we were interested in sex differences in growth of inhibitory control, we fitted univariate growth models on the saved factor scores of inhibitory control for boys and girls separately, to determine whether the shape of the growth was similar for boys and girls (Duncan, Duncan, & Strycker, 2006). We compared a latent intercept model, a linear growth model, and a quadratic growth model. If the models for boys and girls resulted in a similar growth shape, we conducted a multi-group growth model with sex as grouping variable. We compared a model in which parameters were restricted across sex with a freely estimated model. If the restricted model fitted the data better, we also consulted MI's to determine if single parameters could be released. If the shape of growth differed between boys and girls, we conducted separate growth models for boys and girls.

Because children varied substantially in age within the measurement waves, we estimated growth models with individual varying times of observation (i.e., the TSCORES option in M*plus*). This approach avoids biases in growth factor variances that could potentially occur when fixed time intervals are applied to age heterogeneous samples (Mehta & West, 2000). Lastly, we included maternal and paternal sensitivity and nonintrusiveness as predictors in the final growth model(s). Both maternal and paternal sensitivity were added in the model simultaneously. We examined whether maternal and paternal sensitivity and nonintrusiveness were similarly related to the development of inhibitory control for both boys and girls. Specifically, we tested four models: children's sex unconstrained parents' sex unconstrained, children's sex unconstrained parents' sex constrained, children's sex constrained parents' sex unconstrained, and children's sex constrained parents constrained. Due to the multilevel structure that defines the TSCORES option in M*plus*, standardized coefficients were not available. For all models, we therefore reported the unstandardized coefficients.

Model fit indices. All models were estimated using the robust MLR estimator, and Full Information Maximum Likelihood to account for missing data. Model fit was evaluated through the Comparative Fit Index (*CFI*), Tucker-Lewis Index (*TLI*), and Root Mean Square Error of Approximation (*RMSEA*). *CFI* and *TLI* values above .90 and RMSEA values below .08 indicate a sufficient fit. To compare factor models, we used a corrected chi-square difference test implemented in M*plus*, the *CFI*, Bayesian Information Criterion (*BIC*) and Akaike Information Criterium (*AIC*). For the growth models, common fit indices are not provided when using the TSCORES option. Therefore, only the *AIC* and *BIC* were used to compare model fit. Significant differences in chi-square values, a ΔCFI of more than .01 (Little, 2013), and higher *BIC* and *AIC* values indicate a worse model fit for the restricted model. As the *BIC* more strongly penalizes model complexity, this fit index was considered superior to the *AIC*. Decreases in *BIC* values larger than 10 indicate serious model improvements (Raftery, 1995).

RESULTS

Measurement Invariance

At the first wave, a one-factor model showed near sufficient fit to the data ($\chi 2(35) = 150.668$, $p < .001$, $RMSEA = .069$, $CFI = .906$, $TLI = .885$). Based on the largest MI, we allowed for covariance between the residuals of two highly similar items ("Has a hard time following instructions" and " Is good at following instructions"). This model fitted the data sufficiently ($\chi 2(53) = 119.116$, $p < .001$, $RMSEA = .058$, $CFI = .936$, $TLI = .920$). Standardized factor loadings ranged from .10 to .74.

TABLE 1
Fit Indices for the Models Testing Measurement Invariance

	χ^2	*df*	*p*	*CFI*	*TLI*	*RMSEA*	$\Delta\chi^2$	*BIC*	*AIC*
1. Configural model	1529.016	998	<.001	.922	.912	.037		43005.708	42112.863
2. Metric invariance	1577.929	1031	<.001	.919	.912	.037	2 vs 1 (33): 48.92 *p* = .037	42861.374	42098.900
3. Scalar invariance	1907.290	1064	<.001	.876	.868	.045	3 vs 2 (33): 338.56 *p* < .001	43011.524	42379.421
4. Adjusted scalar invariance	1664.400	1058	<.001	.911	.905	.039	4 vs 2 (27): 88.88, *p* < .001	42789.704	42133.898
5. Residual invariance	1730.072	1088	<.001	.905	.902	.039	5 vs. 4 (30): 61.39, *p* = .001	42696.081	42158.794

Table 1 shows the fit indices of the tested models for measurement invariance. The configural model, in which both factor loadings and intercept were freely estimated across waves, showed a sufficient fit to the data. The chi-square difference test, *CFI*, *BIC*, and *AIC* indicated that metric invariance (i.e., similar factor loadings across waves) held, as the model did not fit the data significantly worse compared to the configural model, *BIC* and *AIC* values were lower for the model testing metric invariance, and Δ*CFI* was less than .01. For the model testing scalar invariance, the chi-square difference test, *CFI*, *BIC*, and *AIC* indicated that imposing scalar invariance (i.e., similar intercepts across waves) resulted in a worse model fit.

MI's indicated that the model could be substantially improved by releasing various intercepts. We released parameters with the highest MI one by one until the model had a sufficient fit. A model in which six intercepts of five items were released showed a sufficient fit to the data, see Table 1. Lastly, we tested whether the items that were scalar invariant were also invariant with respect to their residuals. As can be seen in Table 1, imposing residual invariance resulted in a sufficient model fit. Thus, the inhibitory control scale was found to be partially invariant over time. Table 2 lists an overview of the items with their factor loadings, intercepts and psychometric concerns. We reran the factor analyses using the effect coding method as proposed by Little, Slegers, and Card (2006), and saved the factor scores for subsequent analyses. The resulting descriptive information and correlations can be found in Table 3.

Development of Inhibitory Control

Separate growth models for boys and girls indicated that both boys and girls exhibited change in inhibitory control (see fit indices in Table 4), as a linear model fitted the data better than a model with only an intercept for both groups. In addition, for both boys and girls, *BIC* and *AIC* values indicated that a quadratic growth model fitted the data better than a linear model. In these models, there was no significant variance around the intercept, linear slope, and quadratic slope. We restricted the variance of the quadratic factor to zero, which is a common procedure as the variance of the quadratic slope can rarely be estimated (Tofighi & Enders, 2008). The adjusted quadratic models showed a relatively similar fit to the data compared to the initial quadratic models.

TABLE 2

Overview of Items and Psychometric Concerns

Item	W1	W2	W3	W4	Factor loading	Intercept	Intercept Wave 1/ Wave 2
Can lower voice					.56	4.84	
Good at games like "Simon Says"	1,2,	1[a],2			.19	5.63	4.73/5.22[c]
Hard time following instructions (R)					.62	5.07	
Prepares for trips and outings by planning	1,2	1			.25	3.98	3.41/-
Can wait before entering into new activities					.65	4.64	
Difficulty waiting in line (R)					.59	4.43	
Trouble sitting still (R)	2				.37	5.40	4.93/-
Able to resist laughing while inappropriate [b]	1	1	1	1	-	-	-
Good at following instructions					.61	5.08	
Approaches dangerous places slowly and cautiously					.33	5.70	
Not careful and cautious in crossing streets (R)	2				.28	5.26	4.80/-
Can easily stop an activity					.74	4.81	
Able to resist temptation	2				.63	4.77	4.51/-

Note. 1 = more than 20% not applicable (NA) response, 2 = not scalar invariant, a = only mother reports had more than 20% NA responses, b = item was removed, c = wave 2, W = wave

TABLE 3

Correlations and Descriptive Information

	N	*M (SD)*	Range	1	2	3	4	5	6	7
1. Maternal sensitivity	389	24.92 (2.77)	11.00-29.00							
2. Maternal nonintrusiveness	389	20.36 (3.40)	9.00-26.00	.56**						
3. Paternal sensitivity	390	24.04 (2.30)	11.00-29.00	.19**	.14**					
4. Paternal nonintrusiveness	390	19.66 (3.46)	9.00-26.00	.11*	.13*	.52**				
5. Inhibitory control wave 1	373	4.74 (0.46)	3.01-5.75	.16**	.00	.11*	.10*			
6. Inhibitory control wave 2	350	5.01 (0.52)	2.63-6.15	.07	-.02	.07	.10	.85**		
7. Inhibitory control wave 3	334	5.10 (0.55)	2.61-6.40	.08	.03	.07	.12*	.78**	.82**	
8. Inhibitory control wave 4	329	5.09 (0.55)	3.06-6.44	.05	-.02	.14*	.15**	.76**	.81**	.87**

Note. ** $p < .01$, * $p < .05$. Factor scores were calculated using the effect coding method as proposed by Little, Slegers, and Card (2006)

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TABLE 4

Fit Indices for the Growth Models

	Girls		Boys		Total	
	BIC	*AIC*	*BIC*	*AIC*	*BIC*	*AIC*
Intercept	538.629	519.405	738.596	718.776	1268.646	1244.958
Linear model	348.690	319.854	617.813	588.083	960.612	925.080
Quadratic model	323.955	282.303	566.711	523.768	868.444	817.119
Adjusted quadratic model	315.170	283.130	555.613	522.580	859.153	819.673

After determining the shape of growth, multi-group analyses showed that a model in which the intercepts, means, variances and covariances of the growth factors were constrained across sex (*BIC*: 859.153, *AIC*: 819.673) showed lower *BIC* values and higher *AIC* values than a model in which all parameters were released (*BIC*: 906.413, *AIC*: 803.901). In addition, there were no MI's that resulted in a better fit of the model. We therefore concluded that the development of inhibitory control was not only similar in shape, but also in initial level, rate, and direction of development for boys and girls. Inhibitory control showed an average linear increase that decelerated over time, with variance around the intercept and linear slope (intercept = 3.50, $p < .001$, σ = 0.26, $p < .001$, linear slope = 0.57, $p < .001$, σ = 0.00, $p = .044$, quadratic slope = -0.05, $p < .001$). The intercept and slope were negatively correlated, -0.02, $p < .019$, indicating that a high initial level was associated with a slower increase in inhibitory control.

Associations with Parenting

We next examined associations between the intercept and linear slope of inhibitory control and parenting (associations between parenting and the quadratic slope were not estimated as we fixed the variance of this slope to zero). A model in which maternal and paternal sensitivity and nonintrusiveness were similarly associated with boys' and girls' initial level and slope of inhibitory control showed the best fit to the data (see Table 5). There were no MI's indicating that releasing any of the parameters would result in a better fit. Thus, parenting practices of mothers and fathers are similarly related to the initial level and growth of inhibitory control for both boys and girls.

Higher parental sensitivity (0.025, *SE* = 0.008, $p = .001$) and lower nonintrusiveness (-0.015, *SE* = 0.007, $p = .023$) were related to higher initial levels of inhibitory control. In addition, lower parental nonintrusiveness predicted slower growth in inhibitory control (0.004, *SE* = 0.001, $p = .006$). Parental sensitivity was unrelated to growth in inhibitory control (-0.002 *SE* = 0.001, $p = .120$). Figure 1 illustrates that children with relatively sensitive parents consistently showed higher levels of inhibitory control than children

with relatively insensitive parents, but the rate of change did not differ. On the other hand, children of relatively nonintrusive parents showed a slightly lower initial level of inhibitory control, but a faster rate of development compared to children of parents who scored low on nonintrusiveness.

TABLE 5

Fit Indices for the Growth Models with Parenting

	Total	
	BIC	*AIC*
Children unconstrained parents unconstrained	948.251	806.216
Children unconstrained parents constrained	916.480	806.008
Children constrained parents unconstrained	906.051	795.579
Children constrained parents constrained	894.185	799.495

DISCUSSION

In the current longitudinal multi-method study we examined the development of parent-reported inhibitory control between 2.5 and 6.5 years of age, and tested associations with both maternal and paternal sensitivity and nonintrusiveness. We found that the inhibitory control scale demonstrated partial longitudinal measurement invariance. As expected, inhibitory control showed an increase that decelerated over time. This development was similar for boys and girls. Parental sensitivity was related to the initial level of inhibitory control, and nonintrusiveness was related to both the initial level and development of inhibitory control. Interestingly, whereas lower levels of nonintrusiveness related to higher initial levels of inhibitory control, it was also related to a slower rate of development. These associations were similar for mothers and fathers.

Longitudinal Measurement Invariance and Development

Knowledge regarding longitudinal measurement invariance of inhibitory control, i.e., whether a scale functions similarly across age, is a critical first step before mean-level development can be modelled. When a scale is not invariant across time, observed longitudinal changes are likely confounded by properties that are not the construct of interest. Despite the popularity of the CBQ, longitudinal measurement invariance has rarely been tested for this questionnaire. We tested whether the CBQ inhibitory control scale was invariant between the ages of 2.5 to 6.5 years. The results of the current

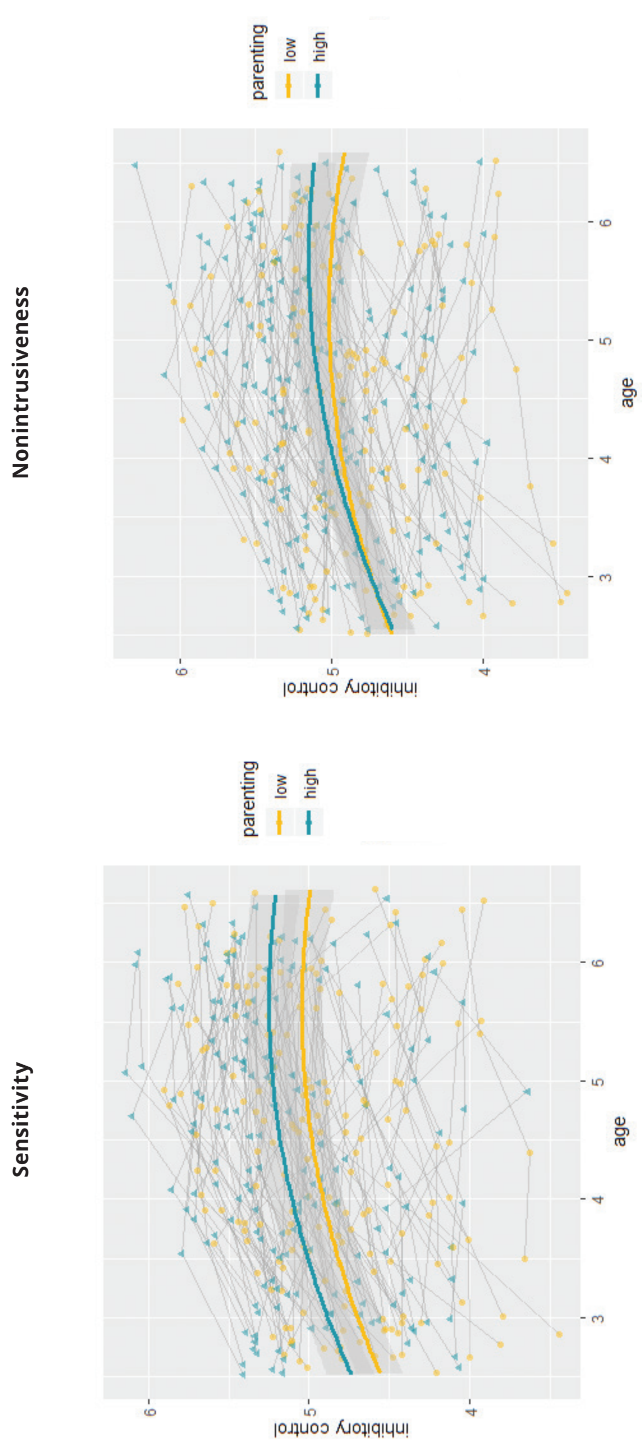

FIGURE 1. Observed and estimated trajectories of inhibitory control for children with parents scoring 1 *SD* above and below the mean levels of sensitivity and nonintrusiveness. Shaded areas represent 95% confidence intervals.

study show that all items of the inhibitory control scale were metric invariant. This indicates that the quality of the items as a reflection of inhibitory control does not change over time (Little, 2013). Items that were a good indicator of inhibitory control (i.e., with a high factor loading) were generally those that addressed children's compliance to requests. For instance, "can stop an activity when s/he is told "no."" had the highest factor loading. Items that were a poor indicator of inhibitory control were those that addressed relatively mature and independent behavior, such as crossing streets carefully. It should be noted that one item (i.e., able to resist laughing while inappropriate) was removed prior to invariance testing, because a high percentage of parents noted that this question was not applicable to their child. Although our sample contained children who were up to half a year younger than the intended age range of the scale (i.e., 3 - 7 years), this could not explain the high percentage of NA responses. Situations in which children are not supposed to laugh apparently happen too infrequently to assess inhibitory control.

Five items of the inhibitory control scale did not demonstrate scalar invariance across time. Longitudinal scalar invariance indicates that children with the same level of inhibitory control have the same scores on the underlying item, irrespective of their age (Little, 2013). For most items of the inhibitory control scale, this appeared to be the case. However, in order to have the same level of inhibitory control as children in wave 2, 3, and 4, children in wave 1 had to be less well capable of preparing for trips, sitting still, carefully crossing streets, and resisting temptation. In addition, in wave 1 and 2, children had to be less good at games such as Simon says in order to receive the same score on inhibitory control, compared to wave 3 and 4. With one exception (able to resist temptations) these items also contributed quite poorly to inhibitory control, i.e., they also had a low factor loading, indicating that these items are not a strong and stable indicator of inhibitory control. The items that demonstrated scalar invariance were also invariant with respect to their residuals. Although this is not a requirement for comparing means (Little, 2013), it does demonstrate that the questions used to assess inhibitory control are equally reliable across age.

The results of this study are in line with a previous study comparing younger and older children on various CBQ scales, reporting that eight of the 13 inhibitory control items were either deemed not applicable by a large proportion of parents, or did not show metric or scalar invariance (Frohn, 2017). The same items were flagged as problematic in the current study, except for two (assessing difficulty waiting in line and lowering voice when asked to do so) which were invariant in the current study, but not in the study by Frohn (Frohn, 2017). The overlap in results shows that there may be a consistent set of problematic items in the inhibitory control scale. Yet, although various guidelines have been proposed to determine adequate measurement invariance, Little (2013) proposed that at least partial scalar invariance is required to examine mean-level changes. Therefore, there was sufficient ground to examine mean-level development of inhibitory control.

We found a modest increase in inhibitory control between the ages of 2.5 and 6.5 years. In agreement with previous research, this increase decelerated over time (Chang et al., 2014). We found no evidence for differences between boys and girls in initial level of inhibitory control. This is contrast to previous research findings that girls score higher than boys on inhibitory control (Else-Quest, Hyde, Goldsmith, & Van Hulle, 2006; Moilanen et al., 2010). This divergent result may be explained by the relatively high educational level that characterizes most participants in the current study. Educational level has been associated with less traditional views on gender roles of parents (e.g., Jan & Janssens, 1998), which can subsequently result in smaller gender differences. In alliance with previous research, children's sex was not related to growth rates in inhibitory control (Moilanen et al., 2010). A remaining question concerns how development of inhibitory control on lab tasks and parent reports are related to each other. Future studies could therefore examine the development of inhibitory control using both lab tasks and parent-reports.

Parenting and the Development of Inhibitory Control

In keeping with theoretical work (Ainsworth, 1969; Rothbart et al., 2011; Sroufe, 2000), parental sensitivity was associated with a higher initial level of inhibitory control. Interestingly, parental sensitivity was not related to growth in inhibitory control. Hence, this study demonstrates that prompt and appropriate responses predict the level of inhibitory control at age 2.5 - 3.5 (i.e., the age of the first assessment), but does not support the premise that sensitivity enhances the development of inhibitory control after the age of the first assessment. These results are in contrast to previous work (Moilanen et al., 2010), reporting that positive behavior support, including sensitivity, did promote the development of inhibitory control. A possible explanation for these discrepant findings is that Moilanen et al. (2010) examined positive behavior support, which also involved providing structure. This aspect of parenting may be more important in the development of self-regulation than sensitivity (Karreman et al., 2006).

Lower levels of parental nonintrusiveness were associated with a higher initial level of inhibitory control, but a slower increase. This lends support to the notion that parental behavior that maximizes adaptation in the moment does not necessarily bolster development over time (Tronick & Beeghly, 2011). Parents who show high levels of intrusive behaviors may control their children's behavior in the moment, yet at the same time deprive their children of opportunities to practice and improve autonomous regulation skills. The findings of this study are in line with research demonstrating that high levels of parental directiveness when children are 3.5 years old are concurrently associated with increased cognitive functioning, but negatively predict cognitive functioning at 4.5 years (Landry, Smith, Swank, & Miller-Loncar, 2000). Overall, intrusive parenting may seem appropriate for young children, who have limited skills for self-regulation, but may also leave children ill-equipped for showing independent self-regulation later in development.

In line with previous work (Karreman et al., 2006; Moilanen et al., 2010), the associations between parenting and (growth in) inhibitory control was modest. Without question, the development of inhibitory control is affected by other processes on various levels, such as brain maturation and language development (e.g., Wolfe & Bell, 2007). Yet, whereas the current study demonstrated how parenting predicts children's development, other studies have demonstrated that the behaviors that come with poor child inhibitory control, such as noncompliance, also tax parent's ability to remain sensitive and nonintrusive (e.g., Gauvain & Perez, 2008). This can result in back-and-forth processes that accumulate over time (Masten & Cicchetti, 2010). Such cascading processes may be prevented by intervening on parenting behavior early on.

Differences between Mothers and Fathers

The associations between sensitivity and nonintrusiveness on the one hand, and both the initial level and development in inhibitory control on the other hand, were similar in strength for mothers and fathers. This was also irrespective of children's sex. The results indicate that fathers and mothers equally contribute to the development of their children's inhibitory control, which is in line with a variety of previous studies focused on concurrent associations between parenting and inhibitory control (Bridgett et al., 2018; Towe-Goodman et al., 2014), but in contrast to other studies (Karreman et al., 2008; Kochanska et al., 2008; Tiberio et al., 2016). Thus far, only a few studies have considered the contribution of both mothers and fathers on children's self-regulation. It is possible that unique influences of fathers are not easily detected with measures that have been developed from primarily mother-focused research, like the EAS that was used in the current study. For instance, although a qualitative study demonstrated that mothers and fathers differed on a variety of parenting behaviors (e.g., mothers tended to be more directive, and engaged in empathic conversations, whereas fathers followed the children's lead, engaged in physical play, and challenged children), fathers and mothers did not differ on the EAS sensitivity and nonintrusiveness scales (John, Halliburton, & Humphrey, 2013). Future studies on the role of mothers and fathers in the development of inhibitory control may benefit from including a broader array of parenting behaviors, such as challenging parenting behavior that playfully encourages children to push their limits (Majdandžić, Möller, de Vente, Bögels, & van den Boom, 2014).

Limitations and Future Directions

Despite various strengths, such as the use of multiple informants to assess inhibitory control, the rigorous testing of measurement invariance, and the usage of observed parenting measures, this study also has some limitations. First, participating families generally had a high socio-economic status, and consisted of a traditional family constellation (i.e., two parents and two children). The current study therefore adds to the literature on the development of inhibitory control, which has primarily focused on children at risk. However, future studies should examine the development of inhibitory control, and the role of parents in this development, in a more representative sample and in less traditional family compositions (single-parents, same-gender parents). Second, we could not examine associations between growth in parenting behaviors and development in inhibitory control, as parenting was not assessed during all four waves. Future studies should examine whether parents who show high initial levels of nonintrusiveness, but accompanied by a decrease over time, do support their children's inhibitory control development. Third, although a major strength of the current study is the inclusion of both mothers and fathers, we did not observe mothers and fathers simultaneously. Previous work has shown that co-parenting is related to children's effortful control over and above maternal and paternal parenting (Karreman et al., 2008). A next step for future research to take is to examine how co-parenting relates to the development of inhibitory control. Fourth, the design of this study did not permit us to examine genetic and biological factors that most likely play a role in the association between parenting and (growth of) inhibitory control. It is very well possible that the link between parenting and inhibitory control is at least partially explained by shared genes and/or shared environment. Lastly, we were not able to control for the involvement of mothers and fathers in the caregiving of their children, whereas this factor may be more important than parental sex in predicting the development of inhibitory control.

Conclusion

Overall, the present study involved a thorough longitudinal examination of the development of inhibitory control. We found parent reported inhibitory control to be subjected to conceptual changes in the preschool years, emphasizing the need for researchers to test for longitudinal measurement invariance prior to modeling mean-

level changes. In the current general population study, parent-reported inhibitory control for both boys and girls showed a decelerating increase in the preschool years. Importantly, parenting behaviors that are related to higher levels of inhibitory control during the first assessment are not predictive for faster increases in inhibitory control. The findings emphasize that, in order to bolster the development of inhibitory control, parents have to give their children space to explore, and interfere sparingly. This may feel counterintuitive to parents, as the results of the current study demonstrate that such a nonintrusive style does not immediately pay off. However, nonintrusive parenting does support inhibitory control development over time. Mothers and fathers parenting practices were of similar importance to the development of inhibitory control, suggesting that interventions designed to bolster the development of inhibitory control should target both parents.

SUPPLEMENTARY MATERIAL

TABLE S1

Number of Parents Answering Non-Applicable during Four Waves

	F W1	M W1	F W2	M W2	F W3	M W3	F W4	M W4
Able to resist temptation	1	0	0	0	0	1	0	0
Hard time following instructions (R)	2	0	0	0	0	0	0	1
Good at following instructions	0	0	1	0	0	0	0	2
Difficulty waiting in line (R)	4	1	0	0	0	0	1	1
Can easily stop an activity	0	0	1	1	0	0	0	0
Good at games like "Simon Says"	146 (85)	181 (111)	71	101	26	24	24	17
Prepares for trips and outings by planning	119 (68)	121 (78)	47	49	17	17	12	7
Can wait before entering into new activities	5	6	3	3	0	1	0	4
Can lower voice	3	5	2	5	1	1	1	2
Not careful and cautious in crossing streets (R)	26	21	9	4	2	2	2	1
Able to resist laughing inappropriate	**259 (149)**	**287 (153)**	**165**	**191**	**126**	**135**	**89**	**92**
Trouble sitting still (R)	29	24	11	8	7	6	5	2
Approaches dangerous places slowly and cautiously	9	16	6	4	2	2	5	1

Note. F = Father, M = Mother, W = wave. Values in parentheses represent the number of parents for children under 3 years. Bold item was excluded from subsequent analyses.

CHAPTER 5

The Role of Parental Self-Regulation and Household Chaos in Parent-Toddler Interactions: A Time-Series Study

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ABSTRACT

Various studies report that parental self-regulation is inversely related to negative parenting practices, especially in relatively calm households. These studies have focused on general tendencies of parents over longer periods of time. In the current time-series study, we extended previous work by focusing on the moment-to-moment processes in parent-child interactions that may explain associations between parental self-regulation, household chaos, and negative parenting practices. In a sample of 62 parent-toddler dyads (83.87% mothers), we tested whether observed contingent negative responses to child noncompliance (i.e., reactive negative parenting) could be predicted by the interaction between parental self-regulation and household chaos. Additionally, we examined whether two indicators of parental self-regulation, self-reported effortful control and task-based executive functioning, had similar associations with reactive negative parenting. Reactive negative parenting was assessed during clean-up, and was calculated as parents' propensity to show negative parenting practices immediately after their child showed noncompliance. We found that lower parental self-regulation predicted more reactive negative parenting practices in relatively chaotic households. In low chaotic households, parents showed relatively low levels of reactive negative parenting practices, independent of their ability for self-regulation. Associations were similar regardless of whether self-regulation was operationalized as effortful control or executive functioning. The findings show that parents with both a high level of self-regulation and a low level of household chaos were less likely to respond to toddler's noncompliance with negative parenting behaviors. Interventions should consider ways to reduce household chaos, in order to increase the likelihood of lasting change for parents with poor self-regulation.

Keywords

Parental self-regulation, Household chaos, Parenting, Time-series, Toddlerhood

Author contributions

SG, MD, KD, and JH conceptualized the study, SG and CB were responsible for data collection, SG analyzed data, and wrote the manuscript. All authors provided feedback on the study.

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INTRODUCTION

Parenting toddlers can be a daunting task, as the occurrence of defiance and aggression peaks in toddlerhood (Alink et al., 2006; Sulik et al., 2012). At the same time, toddlerhood is a time during which parents play an important role in supporting the development of their children's autonomous self-regulation (Sroufe, 2000). According to self-determination theory, children learn most from their environment when parents support them in their capacity for autonomous behavior, provide structure, and demonstrate involvement (Deci & Ryan, 1985; Grolnick, Deci, & Ryan, 1997). Yet, when children show hard-to-manage behaviors, parents tend to show more negativity and less supportive behaviors (Gauvain & Perez, 2008). This can result in back-and-forth processes that draw parents and children into a vicious circle of mutual negativity (Granic & Patterson, 2006). Hence, it is important to identify factors that prevent or amplify parental negativity in response to challenging child behavior.

Previous studies reported that parental self-regulation helps to prevent negative parenting practices, especially in relatively calm households (Deater-Deckard, Wang, Chen, & Bell, 2012; Valiente et al., 2007). These studies have focused on associations between general tendencies or frequency measures of parent and child behaviors across situations. In the current study, we extended previous work by focusing on the moment-to-moment processes in parent-child interactions that underly previously reported associations between parental self-regulation, household chaos, and negative parenting practices. Specifically, we performed a time-series study aimed at examining how parental self-regulation and household chaos interact to predict parental responses to child behavior in real time.

Parental Self-Regulation

Broadly, self-regulation is the ability to either automatically or deliberately modulate affect, behavior, and cognition (Karoly, 1993). Parents need their ability for self-regulation during a broad range of parenting situations. For instance, parents need to be able to manage multiple demands at the same time, plan ahead, and control their anger and frustration when interacting with their child. A wide range of studies quite consistently demonstrate that higher levels of parental self-regulation relate to lower levels of negative parenting practices, such as physical and verbal punishment (Cumberland-Li, Eisenberg, Champion, Gershoff, & Fabes, 2003; Deater-Deckard, Sewell, Petrill, & Thompson, 2010; Verhoeven, Junger, Van Aken, Deković, & Van Aken, 2007) and higher levels of positive parenting practices such as warmth and time spent with children in interacting caregiving activities (reading, feeding, bathing, changing/dressing, and holding infants) (Bridgett et al., 2011; Cumberland-Li et al., 2003; Verhoeven et al., 2007).

Parental self-regulation is expected to be particularly important for modulating responses in difficult situations, such as those characterized by child noncompliance (e.g., Deater-Deckard, 2014). When children show noncompliance, acting in line with long-term socialization goals parents have for their children can be an effortful act that requires parental self-regulation. It is during those challenging moments that differences between parents with high and low levels of self-regulation are expected to be most pronounced. Previous work has already demonstrated that parental self-regulation is negatively associated with a tendency towards negative parenting in the face of challenging child behavior (Deater-Deckard et al., 2010; Deater-Deckard et al., 2012; Valiente et al., 2007). Specifically, parents with poor self-regulation tend to show more harsh and controlling parenting practices and more negative affect towards children who generally show more hard-to-manage behavior (Deater-Deckard et al., 2010; Deater-Deckard et al., 2012). In addition, parents with poor self-regulation tend to describe less positive responses (e.g., less encouragement) and more negative responses (e.g., more punishment) in hypothetical scenarios involving children's negative emotions (Valiente et al., 2007).

An important gap in the literature is that previous studies did not examine how observed *contingent* responses of parents to their children's behavior vary depending upon parental self-regulation. By definition, reactive parenting is something that occurs in response to a cue from the child's behavior. Measures that assess general tendencies or frequencies of behavior across longer periods may obscure such response patterns because they also include negative behaviors that precede or are not contingent upon children's behavior. Contingency measures differ from general tendency or frequency measures in that contingency measures capture the likelihood of specific behavior-response sequences. For instance, contingency measures can represent the likelihood of the parent to respond punitively to child noncompliance. Contingency measures have unique, and sometimes even stronger, predictive utility for child outcomes than general measures of parenting practices (Lunkenheimer, Kemp, & Albrecht, 2013; Scaramella, Sohr-Preston, Mirabile, Robison, & Callahan, 2008). For instance, whereas harsh parenting per se does not predict child distress reactivity a year later, harsh parenting that is contingently linked to child noncompliance does (Scaramella et al., 2008). Moreover, moment-to-moment processes are an accessible target of interventions, because they are easier to monitor and change than general parenting dimensions such

as sensitivity. It may therefore be especially important to know which factors predict reactive negative parenting as operationalized using contingency measures.

Additionally, previous studies on the role of parental self-regulation in parenting practices focused on children in middle childhood and/or included children with a broad age range (Deater-Deckard et al., 2010; Deater-Deckard et al., 2012; Valiente et al., 2007). Research into the factors that affect parenting practices during toddlerhood is pivotal. The "terrible two's" are known to tax parents' ability for self-regulation, and form an important developmental period in which parents play an important role in their child's socio-emotional development (Sroufe, 2000).

Regulating in Chaotic Households

The modulation of parental responses to their toddler's behavior by parental self-regulation depends upon characteristics that define the broader family context, like household chaos. Household chaos refers to the level of background noise, crowding, and lack of routine in a household (Matheny, Wachs, Ludwig, & Phillips, 1995). Several studies examining adolescent functioning and parenting across a wide range of family socioeconomic statuses and cultures suggest that higher levels of chaos promote harsher and less supportive parenting, and strengthens the intergenerational transmission of self-regulation deficits (Brieant, Holmes, Deater-Deckard, King-Casas, & Kim-Spoon, 2017; Deater-Deckard et al., 2019; Lauharatanahirun et al., 2018; Peviani et al., 2019).

Two competing hypotheses have been formulated regarding the role of parental self-regulation in modulating parenting behavior at different levels of household chaos. First, in households characterized by high levels of household chaos, higher parental self-regulation may be particularly important to refrain from reactive parenting in response to challenging child behavior. Thus, an association between self-regulation and reactive parenting might be stronger at high levels of household chaos. Although this has been proposed in various studies (e.g., Deater-Deckard et al., 2012; Mokrova et al., 2010), and is broadly aligned with cumulative risk and family stress theories (Gerard & Buehler, 2004; Patterson, 2002), there is no empirical support for this hypothesis in literature.

In contrast, a second hypothesis states that high levels of household chaos may overwhelm parent's ability for self-regulation and promote reactive negative parenting in response to noncompliance, regardless of the level of parental self-regulation. Thus, in situations characterized by high levels of household chaos, little to no association would be expected between parental self-regulation and reactive parenting. Indeed, in highly chaotic households parenting practices are often found to be more strongly tied to non-effortful and automatic processes, such as attribution biases and ADHD symptoms, and less strongly to controlled and effortful processes such as executive functions (Deater-Deckard et al., 2012; Wang, Deater-Deckard, & Bell, 2013; Mokrova, O'Brien, Calkins, & Keane, 2010). In fact, associations between parental self-regulation and harsh parenting were not present at all when parents reported to be living in a chaotic household (Deater-Deckard et al., 2012).

Present Study

The purpose of the present study was to examine whether parents' responses to children's noncompliance are modulated by parental self-regulation and household chaos. Because this study comprised fine-grained moment-to-moment tracking of parent and child behavior over time, we could examine negative controlling parenting that *followed* child noncompliance in real time. We focused on negative directive responses of parents to children's noncompliance, that is, those responses that are intrusive, threatening, criticizing, or verbally or physically aggressive. These behaviors may curb the development of autonomous behavior in children (e.g., Valiente et al., 2007).

Regarding parental self-regulation, we focused on effortful control and executive functioning. Effortful control concerns the ability to inhibit a dominant response in order to perform a subdominant response, to detect errors, and to engage in planning (Rothbart, Posner, & Kieras, 2006). Executive functioning refers to a set of interrelated cognitive skills that support an individual's self-regulation, and often includes at least three components: working memory (the ability to memorize information and update/manipulate this information), inhibition (the ability to suppress a dominant response in favor of a subdominant response), and shifting/cognitive flexibility (the capacity to form a cognitive set and switch to new sets) (Miyake et al., 2000). Conceptually, these two ways of operationalizing self-regulation have a range of communalities, with the most important ones being that both approaches encompass inhibitory control and executive attention (Zhou et al., 2012). In practice, effortful control is typically measured with questionnaires, and executive functioning is typically measured through tasks. Measures of effortful control therefore often indicate a reflection on one's own ability to self-regulate, which is only moderately related to assessments that indicate individual's level of executive functioning (Bridgett et al., 2013). Another differentiating view explaining the modest association between self-reported effortful control and executive function proposes that executive control is a measure for the *ability* for

self-regulation, whereas self-reported effortful control might also tap an individual's *motivation* to use self-regulation (Blair & Razza, 2007).

Overall, we hypothesized that higher levels of parental self-regulation would be associated with lower levels of reactive negative parenting. In addition, we explored whether household chaos strengthened or dampened these associations, and whether associations between parental self-regulation, household chaos, and reactive negative parenting differed depending upon whether parental self-regulation was operationalized as self-reported effortful control, or as task-based executive functioning.

METHODS

Participants

A total of 62 Dutch toddlers (46.8% boys; age: M = 28.45, SD = 1.16, range: 26.71 - 31.80 months) and their parents (83.87% mothers) participated in the current study. Toddlers were excluded if they were born before 37 weeks of pregnancy, had a known significant uncorrected hearing or vision impairment, or a significant developmental delay or condition that was likely to affect brain development or the ability to participate in the study. Parents were between 27 and 46 years old (M = 36.1, SD = 4.04). Most of the parents (88.71%) had a high educational level (academic or higher vocational schooling).

Procedure

This study utilized data from the second wave of a two-wave longitudinal study. Toddlers and parents were visited at home by two examiners. During the home-visit, three tasks for children were administered, parent-child interaction was videotaped, and parents filled in an online questionnaire. This home visit lasted approximately 90 minutes, with enough time for breaks. After the home visit, parents conducted four computer-based tasks that assessed their level of executive functioning on a computer in their own home using the web-based version of Inquisit. Prior to the administration of these tasks, the test leader called parents on their phone to give instructions. Parents could call the test leader at any time to ask questions about the tasks. They could not quit the program without calling the test leader, and all parents finished the four tasks in one session. The protocol was approved by the Ethical Committee of the Faculty of Social and Behavioral Sciences of Utrecht University. Parents received a gift voucher as compensation for their participation, and children received a small gift.

Parent and child behaviors were coded during a 3-minute clean-up situation. Parents were cued to instruct the child to clean up toys in a transparent box. Parent and child behavior was coded using an adapted version of the Dyadic Interaction Coding Manual (Lunkenheimer, 2009). Coding was done on a second-by-second basis and codes were mutually exclusive and exhaustive. The behavior of parents and children was coded by two independent sets of two coders, and the combinations of child and parent coders were counterbalanced.

Measures

Parental executive functioning. Four computerized tasks were used to assess parental executive function. The Tower of London was administered to assess parents' spatial planning and problem-solving abilities (Krikorian, Bartok, & Gay, 1994). After a written instruction and practice trial, 12 test trials were administered. During each test trial, parents were presented with three pegs of varying lengths: the left, middle, and right peg could accommodate up to three, two, and one ball respectively. In addition, three balls with different colors (red, green, blue) were presented. Each test trial consisted of a start and a goal state. The instructions were that only one ball was allowed to be moved at a time, and that balls could not be placed next to the pegs. The computer program did not allow breaking these rules. In addition, parents received the instruction that they had to act as fast as possible, and with as little moves as possible. A trial was successfully completed when the goal state was achieved with the minimum number of necessary moves. Each test trial had three attempts. If parents completed a trial in one attempt, they received the maximum score of 3. Every extra attempt resulted in one penalty point. A maximum score of 36 could be obtained, with higher scores representing better planning and problem-solving ability.

A visual backward digit span task was administered to assess parents' working memory (Woods et al., 2011). In this task 14 trials with random series of digits (1-9) were presented, which parents had to type in the reversed sequence. Following instruction and a practice trial, the task commenced with a trial of two digits, and one more digit was added in each subsequent trial. If the parent answered incorrectly during a given trial, the same number of digits was presented a second time. After a consecutive error, one digit was subtracted in the subsequent trial. This procedure was followed until 14 trials were administered. The maximum number of correctly recalled digits in reversed order was used. Parents could receive a maximum score of 15.

The Wisconsin Card Sorting task assessed parents' shifting ability (Grant & Berg, 1948). Parents had to stack a maximum of 128 cards with differing quantities, colors, and shapes, according to a rule. This rule (i.e., either by quantity, color or shape) was not explicitly formulated, but could be derived from feedback on parents' choice (correct

vs. incorrect). After 10 consecutive correct responses for a category, the rule changed without notice, and the parent had to infer the new rule based on the feedback. The task was completed when either the maximum number of cards was reached, or the participant successfully completed two sequences of all three rules. The number of perseveration errors was used, which represents the number of errors caused by the parent applying an old rule despite feedback indicating that the rule was no longer correct.

The Stroop task assessed parents' complex inhibition. Using the keyboard on their computer, parents had to indicate as fast and accurate as possible the color ink of a word or a control stimulus (a square). The stimulus on the screen could be a consistent word (e.g., the word blue in blue), an inconsistent word (e.g., de word blue in red), or a square (e.g., a blue square). For each stimulus, parents had to indicate the color using four letters on their keyboard ("d" for red, "f" for green, "j" for blue, and "k" for black). A reminder of these letter-color combinations remained on the screen during the trials. The stimuli appeared in a random order in the middle of the screen. We used the D scoring algorithm, originally proposed for Implicit Association Tests (Greenwald, Nosek, & Banaji, 2003), but applicable to scores that involve latency contrasts (e.g., Ebersole et al., 2016), to contrast the reaction time for inconsistent words with the reaction time for consistent words. A high positive score represents more inhibition problems. A mean score for parental executive functioning was created by averaging the z-scores of the four tasks. Higher scores indicate better parental executive function.

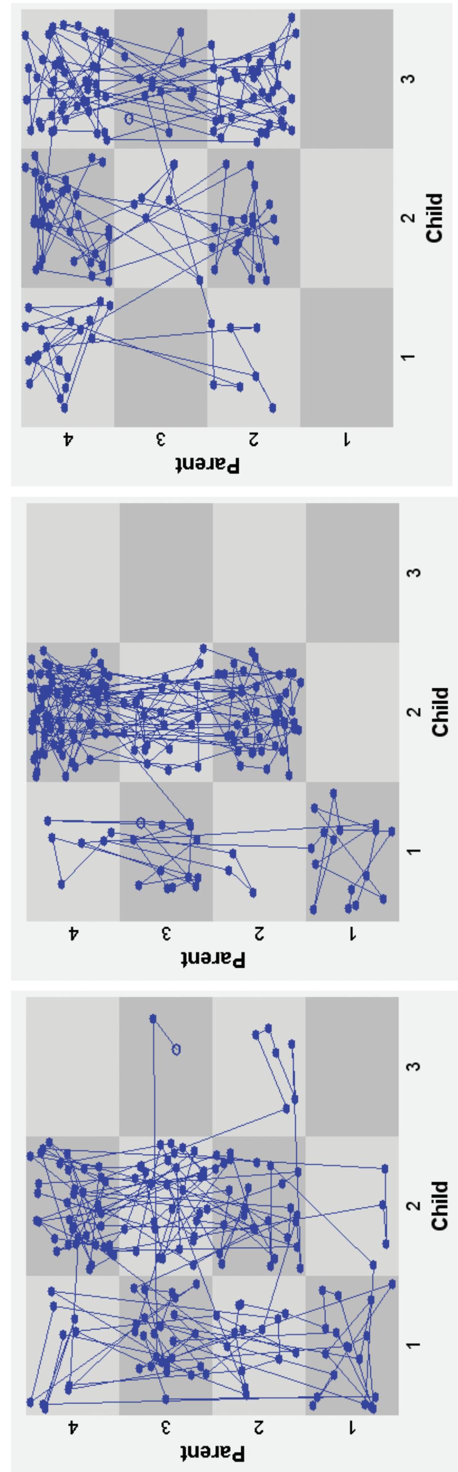
Parental effortful control. Parental self-reported effortful control was assessed by averaging the subscales Activation Control, Attention Control, and Inhibitory Control of the Effortful Control scale of the Adult Temperament Questionnaire-Short Form (D. E. Evans & Rothbart, 2007). Internal consistency was sufficient ($\alpha = .71$). The 19 questions were answered on a scale ranging from 1 = *extremely untrue of you* to 7 = *extremely true of you*. Higher average scores reflect better effortful control.

Household chaos. Household chaos was assessed with the Confusion, Hubbub, and Order Scale (CHAOS; Matheny et al., 1995). A total of 17 questions (e.g., 'You can't hear yourself think in our home') with a 5-point Likert-type scale was used, ranging from 1 = *completely true* to 5 = *completely untrue*. One item was removed from the scale, because it was inversely related to the total scale ("The telephone takes up a lot of our time at home."), after which the internal consistency of the scale was excellent ($\alpha = .81$). Higher average scores reflect higher levels of parent-reported chaos.

Parental behavior. Five categories of parental behaviors were coded. *Negative directive behavior* included moments when parents showed negative behavior and/or forced their agenda on their child. *Disengaged behavior* was coded when the parent showed lack of interaction with the child. *Neutral directive behaviors* were goal-directed behaviors that were clear commands or questions. *Autonomy supporting behaviors* reflected behaviors intended to maximize children's participation and independent efforts towards a task (e.g., giving feedback, making the task more enjoyable). *Warmth and involvement* involved all moments during which the parent did not show goal-directed behavior, but instead was engaged or providing emotional support. Interrater reliability, calculated over 15 videos, was sufficient (κ = .63). Negative directive behavior and disengaged behavior were aggregated as negative parent behavior.

Child behavior. Coders coded three forms of *Noncompliance*, which entailed ignoring of parental requests, verbal or non-verbal refusal or negotiation, and defiant resistance (e.g., throwing a tantrum). These three forms of noncompliance were aggregated into general noncompliance. *Compliance* was coded when the child clearly responded to the parent's bid for behavior change, or when the child continued to clean up without parental instructions. *Off-task behaviors* were other behaviors that were not compliance or noncompliance (e.g., playing or talking). Interrater reliability, calculated over 15 videos, was sufficient (κ = .66).

Data preprocessing. To derive the measures that captured reactive negative parenting, we applied State Space Grids (SSG; Lamey, Hollenstein, Lewis, & Granic, 2004) to compute transitional propensities (See Figure 1 for three examples of SSGs). Transitional propensities were calculated as the number of transitions from the start region to the destination region divided by the duration of time spent in the start region. *Reactive negative parenting* was calculated as the transitional propensity for the dyad to move from a state in which the child showed noncompliance and the parent did not show negative directive or disengaged behavior to a state in which the parent showed negative directive or disengaged behavior. The scores used in the analyses therefore captured those moments in which parents reacted negatively after their child showed noncompliance. One extreme value on this score was winsorized to the next highest value.



1.a 1.b 1.c

FIGURE 1. Examples of State Space Grids representing three different dyads during clean-up. Code 1 represents negative behavior for both parent and toddler. For parents: 2 = Autonomy supporting behaviors 3 = Neutral directive behaviors, 4 = Warmth and involvement. For children, 2 = compliance, 3 = off-task behavior. Figure 1.a. Both parent and child show negative behavior. Figure 1.b. Both parent and child show negative behavior. The parent shows only reactive negative parenting, as all instances of negative parenting follow child negative behavior in time. Figure 1.c. The parent does not show any negative behavior. The child does show negative behavior.

RESULTS

Preliminary Analyses

Descriptive information and correlations can be found in Table 1. As can be seen, reactive negative parenting was skewed (i.e., with an absolute skewness value higher than 1)[2]. We therefore used bootstrapping to obtain more reliable confidence intervals. Higher levels of parent-reported household chaos was correlated with lower levels of self-reported effortful control. None of the other correlations was significant.

TABLE 1

Correlations and Descriptive Statistics of Study Variables

	M (*SD*)	Range	Skewness	1.	2.	3.
1. Reactive negative parenting	0.02 (0.04)	0.00-0.25	3.22			
2. Effortful control	5.11 (0.59)	3.56-6.34	-0.19	-.29		
3. Executive functioning	0.00 (0.59)	-2.39-1.31	-1.12	-.18	.01	
4. Household chaos	1.99 (0.38)	1.38-3.12	0.70	.28	-.44**	.19

Note. ** $p < .01$, * $p < .05$. p-values are based on bootstrapped confidence intervals.

Primary Analyses

We conducted ordinary least squares regression analyses in R (https://www.r-project.org/). Because the outcome variables were skewed, we used bootstrapping to obtain more reliable confidence intervals. The results can be found in Table 2. Higher levels of effortful control and executive functioning were predictive of less reactive negative parenting. These additive effects were subsumed by significant two-way interaction effects. Figure 2 shows the simple slopes and region of significance plot for effortful control and household chaos predicting reactive negative parenting. There was only a negative association between parental effortful control and reactive negative parenting at high levels of household chaos. Specifically, the association between parental effortful control and reactive negative parenting was significant when household chaos had a value of -0.06 or higher. As household chaos was centered prior to being entered into the regression analyses, this means that the association between parental effortful control and reactive negative parenting practices was significant at values higher than the approximate mean level of household chaos.

Figure 3 shows the simple slopes and region of significance plot for executive functioning and household chaos predicting reactive negative parenting. Like the analyses with

2 One child did not show noncompliance during the 3-minute clean-up. We repeated the analyses without this participant, and the results were similar.

effortful control, the association between executive functioning and reactive negative parenting was only significant at relatively high levels of household chaos. Specifically, the association between parental executive functioning and reactive negative parenting was significant when household chaos had a value of -0.16.

TABLE 2

Parameter Coefficients of Regression Analyses

	b	β	Bootstrapped CI
Model 1: Effortful Control			
Effortful control	-0.02	-.33	-0.03 - -0.00
Household chaos	-0.00	-.02	-0.03 - 0.02
Effortful control * chaos	-0.06	-.40	-0.11 - -0.01
Model 2: Executive Functioning			
Executive functioning	-0.02	-.41	-0.04 - -0.01
Household chaos	0.01	.06	-0.01 - 0.03
Executive functioning * chaos	-0.05	-.44	-0.10 - -0.01

Note. CI = confidence interval.

DISCUSSION

The goal of the current study was to examine the predictive value of parental self-regulation and household chaos for reactive negative parenting practices, by conducting fine-grained moment-to-moment tracking of parent and child behavior. In general, higher parental self-regulation predicted less reactive negative parenting practices for parents living in relatively chaotic households. In households characterized by low levels of household chaos, parents showed few reactive negative parenting practices, and this was independent of their level of self-regulation. The results were the same regardless of whether parental self-regulation was operationalized as effortful control or executive functioning.

In accordance with our hypotheses, the findings of this study indicate that higher levels of self-regulation support parents in refraining from negative responses towards their child's noncompliance. Previous research already showed that parents with poor self-regulation show more negative behavior (Cumberland-Li, Eisenberg, Champion, Gershoff, & Fabes, 2003; Verhoeven, Junger, Van Aken, Deković, & Van Aken, 2007),

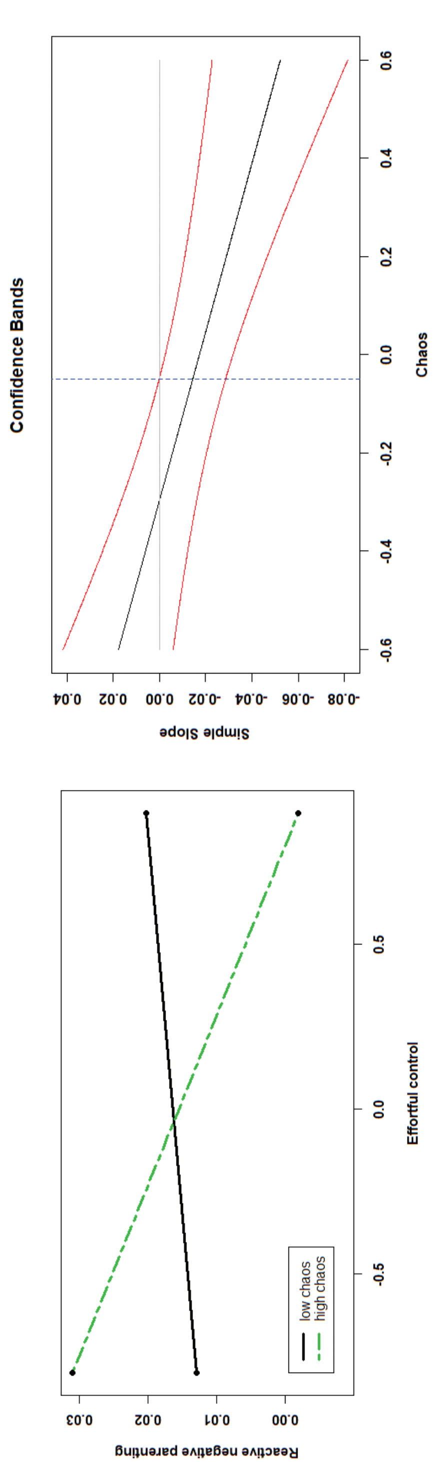


FIGURE 2. Simple slopes and region of significance analyses for parental effortful control and household chaos predicting reactive negative parenting

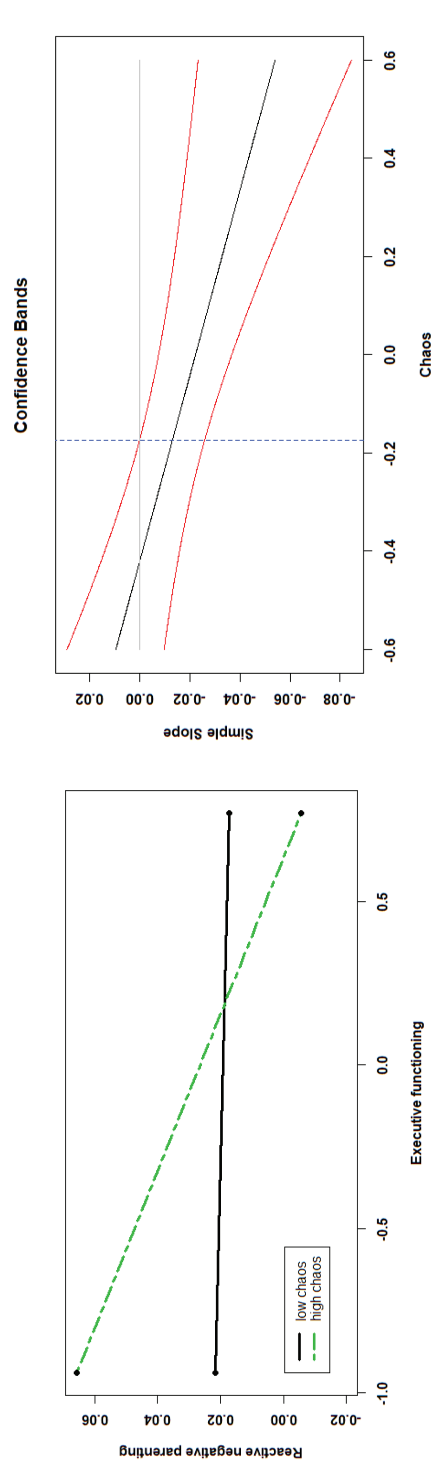


FIGURE 3. Simple slopes and region of significance analyses for parental executive functioning and household chaos predicting reactive negative parenting

respond more negatively in hypothetical scenarios involving children's negative emotions (Valiente et al., 2007), and are more inclined towards harsh and controlling parenting practices and negative affect towards children who generally show more hard-to-manage behavior (Deater-Deckard et al., 2012). The current study adds to this body of literature by demonstrating that parents with poor self-regulation are more likely to contingently respond negatively to noncompliance. By examining moment-to-moment interactions between parents and toddlers, instead of focusing on general tendencies of parents and toddlers, we could examine whether parents differed in response patterns depending upon their level of self-regulation. Such response patterns are accessible targets for interventions, because they can be monitored. In addition, parents with poor self-regulation are at higher risk for negative back-and-forth processes between child noncompliance and negative parenting, as negative directive parenting practices that are contingent upon toddler's noncompliance are related to subsequent increases in child distress (Scaramella & Leve, 2004).

Importantly, we found that parental self-regulation only helps to modulate negative responses to child noncompliance in relatively chaotic households. Although this has been proposed before, empirical studies thus far found that parental self-regulation is only effective in relatively calm households, such that chaos typically overwhelms parents' ability for self-regulation (Deater-Deckard et al., 2012; Mokrova, O'Brien, Calkins, & Keane, 2010). It should be noted that the mean level of household chaos in the current study was quite low, and that most parents had a high socioeconomic status. Consistent with cumulative risk theory, the number of risk factors may be a key factor in this regard (Gerard & Buehler, 2004; Trentacosta et al., 2008). Families with a lower socioeconomic status often have to deal with more risk factors, such as living in poor neighborhoods and having financial concerns. It is quite likely that parents profit from their ability for self-regulation in slightly chaotic households or in situations in which household chaos is one of the few stressors that parents must face. However, when household chaos is too severe, or when additional stressors mount on to household chaos, this may overrule any inherent ability for regulation. Studies that include families with a broader range of socio-economic status and levels of household chaos may further clarify whether parental self-regulation also supports parents in refraining from negative responses to child noncompliance in very chaotic households and in situations in which multiple stressors are present.

The results of the current study also demonstrate that living in a more calm and organized household may help parents in refraining from responding negatively towards their child's noncompliance, even when they have relatively limited levels of

self-regulation. Yet at the same time parents with poor self-regulation have trouble with creating routine and keeping their house tidy and calm (Bridgett, Burke, Laake & Oddi, 2013). Unsurprisingly, therefore, we found that parents with higher levels of self-reported effortful control also reported to live in less chaotic houses. Executive functioning was unrelated to household chaos, which is consistent with research showing that for low-risk parents, there is no association between household chaos and their level of executive functioning (Deater-Deckard, Chen, Wang, & Bell, 2012). Parents with low levels of effortful control and executive functioning benefit from living in low chaotic households, but especially parents with low levels of effortful control may require support to establish such a situation.

We found similar associations regardless of whether self-regulation was operationalized as effortful control or executive functioning: both parental effortful control and executive functioning predicted reactive negative parenting practices, even though the two constructs were not related to each other. Although the conceptual overlap between effortful control and executive control is quite substantial (e.g., Zhou et al., 2012), researchers have also noted that self-reported self-regulation is poorly related to measures that assess cognitive ability for self-regulation (e.g., Toplak, West, & Stanovich, 2013). For instance, the association between executive functioning and effortful control is quite modest when executive functioning is assessed with lab-tasks, but very high when both constructs are measured with a questionnaire (Bridgett et al., 2013). The current study adds to the literature by indicating that effortful control and executive functioning are overlapping constructs when it comes to their association with reactive negative parenting, despite a lack of association with each other. The sample size of the current study precluded us from simultaneously testing the effects of parental effortful control and executive functioning on negative directive parenting. Although we show that, when considered on their own, both measures of self-regulation have similar associations with negative directive parenting practices, it is also possible that they can complement each other or are both required for appropriate responses to toddler's noncompliance.

When it comes to implications for practice, creating a home situation that is tidy, calm, and that is characterized by routine may help poorly regulated parents with remaining neutral in situations in which their toddler is noncompliant. This is important as a range of studies have showed that interventions that are aimed at improving self-regulation are limited in their success, among others because the obtained gains do not generalize into broader self-regulation skills (Diamond & Ling, 2016). On the contrary, a growing body of research shows that creating routines is very effective in supporting individuals to display desired behavior in an effortless manner (see De Ridder & Gillebaart, 2017, for a recent review). Supporting parents in establishing routines that do not require self-regulation may be a fruitful avenue towards preventing reactive negative parenting practices. Importantly, children generally show less negative behavior in less chaotic households (e.g., Deater-Deckard et al., 2009; Price, Chiapa, & Walsh, 2013), which in turn makes it easier for parents to remain sensitive and nonnegative.

Despite the various strengths of this study, including its reliance on moment-to-moment assessments of parent-child interactions, and the multi-method approach to parental self-regulation, this study also comes with various limitations. First, most parents in the sample had a higher vocational or university degree, indicating a high socio-economic status. It is difficult to say how the results of the current study generalize to less affluential families, and this should be tested. As suggested before, parents who are faced with multiple risk factors may not profit from their regulatory ability in preventing reactive negative parenting practices. Second, we only tested concurrent associations between parental self-regulation, household chaos and reactive negative parenting practices. Future studies using longitudinal or experimental designs may further explain how parental self-regulation household chaos and reactive negative parenting practices are associated with each other.

Conclusion

Overall, the current study demonstrates that parents' self-regulation and the level of household chaos interact to predict the way in which parents respond to noncompliance of their toddlers. Low levels of parental self-regulation combined with higher levels of chaos in the household form a risk factor for parents to show reactive negative parenting practices that are contingent upon their child's noncompliance. Parents living in low chaotic households, and parents with high levels of self-regulation are on average less inclined to respond to their toddler's noncompliance with intrusive, disapproving, or other negative behaviors. A calm and routines-based household may therefore form a buffer for parents who are low in self-regulation. This may therefore be an interesting target for interventions, as low chaos may increase the likelihood of lasting changes in parenting behavior for parents with poor self-regulation. Parents with low levels of effortful control may especially benefit from support in creating a non-chaotic household.

CHAPTER 6

The Child Behavior Checklist Dysregulation Profile in Preschool Children: A Broad Dysregulation Syndrome

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ABSTRACT

Objective: Children with concurrent impairments in regulating affect, behavior, and cognition can be identified with the Anxious/Depressed, Aggressive Behavior, and Attention Problems scales (or AAA scales) of the Child Behavior Checklist (CBCL). Jointly, these scales form the Dysregulation Profile (DP). Despite persuasive evidence that DP is a marker for severe developmental problems, no consensus exists on the preferred conceptualization and operationalization of DP in preschool years. We addressed this concern by testing and validating the factor structure of DP in a group of predominantly clinically referred preschool children. **Method**: Participants were 247 children (195 boys and 52 girls), aged 3.5 to 5.5 years. Children were assessed at baseline and 18 months later, using parent and teacher reports, a clinical interview with parents, behavioral observations, and neuropsychological tasks. **Results**: Confirmatory factor analysis showed that a bifactor model, with a general DP factor and 3 specific factors representing the AAA scales, fitted the data better than a second-order model and a one-factor model for both parent-reported and teacher-reported child problem behavior. Criterion validity analyses showed that the DP factor was concurrently and longitudinally associated with markers of dysregulation and clinically relevant criteria, whereas the specific factors representing the AAA scales were more differentially related to those criteria. **Conclusion**: DP is best conceptualized as a broad syndrome of dysregulation that exists in addition to the specific syndromes as represented by the AAA scales. Implications for researchers and clinicians are discussed.

Key Words

Child Behavior Checklist, Dysregulation profile, Preschool, Factor analyses, Clinical sample

Author contributions

SG, MHFD, and MD conceptualized the study, TB, KS, and WM collected the data. SG analyzed data and wrote the manuscript. All authors provided feedback on the study.

INTRODUCTION

A relatively large group of children who are referred for problem behavior experience mood instabilities, hyperarousal, and irritability (Holtmann et al., 2007). Serious concerns have been expressed about these children, who show deficits across all domains of self-regulation. Their concurrent impairments in regulating affect, behavior, and cognition pose challenges to diagnostic classification systems, which do not accurately capture this behavioral phenotype (Althoff, 2010). Problems of dysregulation might be identified by elevated scores on the so-called AAA scales: the Anxious/Depressed (affect), Aggressive Behavior (behavior), and Attention Problems (cognition) scales of the Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2000; Ayer et al., 2009). This well-established parental report of child problems allows researchers to communicate about a similar manifestation of dysregulation, which is referred to as the Dysregulation Profile (DP; Althoff, 2010).

DP was recently signified as a potential developmental profile for major psychopathology (Bellani, Negri, & Brambilla, 2012). In middle childhood and adolescence, DP is related to various adjustment problems later in life, including a range of psychological disorders, suicidality, and substance abuse (Althoff et al., 2010; Holtmann, Buchmann, et al., 2011). Therefore, understanding the early-life manifestations of DP is warranted, as this might help to explain the etiology and development of dysregulation, resulting in valuable venues for prevention and treatment. The preschool years especially provide a window of opportunity for treatment because of the significant development in executive functioning and accompanied plasticity that marks this period (Zelazo & Carlson, 2012).

Although most research has been conducted on DP in middle childhood and adolescence, DP is also valuable for identifying younger children with concurrent psychosocial impairments. A community study with preschoolers (mean age: 3.5 years) showed that preschoolers with DP had more concurrent depressive and oppositional defiant disorder (ODD) symptoms, a temperamental profile characterized by high negativity and low effortful control, more authoritarian mothers and permissive fathers, and more functional impairment in age-appropriate activities, school functioning, and social relationships (Kim et al., 2012). Moreover, in a community sample of relatively young children (mean age, 6 years), a group of children scoring high on all CBCL scales and a group of children scoring high on externalizing problem behavior and emotional reactivity were identified using latent profile analysis (Basten et al., 2013). Especially the highly problematic class was associated with more maternal and paternal psychological problems (Basten et al., 2013) and child lower nonverbal intelligence (Basten et al., 2014) and was therefore proposed to resemble DP.

There are also some salient gaps in our knowledge considering DP. Foremost, no consensus exists on how to theoretically and methodologically conceptualize DP. Although factor analysis could enhance consensus, the factor structure of DP in preschool years has not yet been examined. Second, no longitudinal research has been conducted on DP in preschool years, although this can clarify whether DP in preschoolers forms a valid developmental risk marker. Third, no research has been conducted on DP in clinically referred preschool children, although the CBCL was developed for purposes of screening within clinical practice.

Factorial Structure of DP

DP was originally proposed as a proxy for juvenile bipolar disorder (Biederman et al., 1995); however, subsequent research has indicated that the profile does not serve well as an indicator for this disorder (Diler et al., 2009). Currently, there is an ongoing debate on how DP is best conceptualized. Some argue that DP represents a single syndrome of dysregulation that is not included in dominant nosologies of child problem behavior (Ayer et al., 2009; Holtmann, Buchmann, et al., 2011). Others postulate that phenotypic manifestations of dysregulation represent comorbid disorders (Carlson, 2007).

Researchers have also operationalized DP in varying ways. These operationalizations suggest different underlying assumptions concerning the conceptualization of DP. Conceptualizing DP as a syndrome fits well with using the sum of the AAA scales (Kim et al., 2012), or latent classes/profiles (Basten et al., 2013). Assuming DP to represent comorbidity is best accompanied by cut-off approaches for each separate AAA scale (Holtmann et al., 2007).

Factor analysis could indicate the best conceptualization and operationalization of DP, which enhances integration of research on this topic. If a single factor (Figure S1a, available online) adequately represents the items of AAA scales, this indicates that DP represents a unidimensional syndrome. In this case, it would not be necessary to make distinctions between the AAA scales, as all symptoms are manifestations of DP only. Researchers could just use the sum-score of all three scales. Ayer et al. (2009) concluded that one factor adequately represented the items of the AAA scales, although it was not the main goal of this study, and comparisons with competing plausible factorial models were not conducted.

In contrast, if a second-order factor model (Figure S1b, available online) fits best, this indicates that DP is better conceptualized as comorbidity between the distinct problems of the AAA scales. Here, specific first-order factors represent distinct problems of Anxious/Depressed, Aggressive Behavior, and Attention Problems scales. A higher-order DP factor accounts for the communalities, or comorbidity, among the three specific syndromes.

Behavioral–genetic studies and studies with latent class analyses have indicated that DP is distinct from its specific components, that is the Anxious/Depressed, Aggressive Behavior, and Attention Problems scales (Althoff, Rettew, Faraone, Boomsma, & Hudziak, 2006; Boomsma et al., 2006). Therefore, conceptualizing DP as a separate syndrome is much more probable, although this syndrome would exist in addition to three specific syndromes as represented by the AAA scales. A bifactor model (Figure S1c, available online) accounts for this structure. Similar to a one-factor model, a general factor acknowledges the existence of a single syndrome, but additional specific factors explain the unique coherence among symptoms within the same scale.

Present Study

In this study, we examined the factor structure of DP in a sample of predominantly clinically referred preschool children with externalizing problem behavior, both for parent- and teacher-reported problem behavior. In a study on DP in a community sample of school-aged children and adolescents, we demonstrated that this bifactor model was preferred above a second-order and one-factor model (Deutz, Geeraerts, van Baar, Deković, & Prinzie, 2016). We hypothesized that a bifactor model would show the best fit, indicating that DP is best conceptualized as a broad syndrome that exists in addition to specific syndromes.

Moreover, as reporter bias in particular can be a viable alternative explanation for correlations between the AAA scales, the structure should be thoroughly validated (Lahey et al., 2015). We evaluated the concurrent and longitudinal criterion validity of the best-fitting factor structure using a multi-method and multi-informant approach. We examined associations between the best-fitting factor structure of the AAA scales on one hand, and external criteria that indicate dysregulation and maladjustment, both concurrently and 18 months later, on the other hand. Given the broad impairments that characterize DP, together with the wide range of concurrent and longitudinal associations that have been previously reported, we expected DP to be widely associated with the external criteria, both concurrently and longitudinally. This would further validate DP as a real phenotypic manifestation.

As we hypothesized the bifactor model to fit best, we also examined whether the three specific syndromes would predict external criteria over and above DP. We expected specific syndromes to be more differentially and selectively associated with these criteria (e.g., attention problems would be especially associated with impairments in attention and hyperactivity). This pattern of associations would support the conceptualization of DP as a broad syndrome of dysregulation that exists in addition to three specific syndromes as specified through the hypothesized bifactor model.

METHOD

Participants

General practitioners, pediatricians, and well-baby clinics in the province of Utrecht, the Netherlands, were invited to refer children 3.5 to 5.5 years of age with externalizing behavior problems for clinical assessment at the Outpatient Clinic for Preschool Children with Behavioral Problems, Department of Child and Adolescent Psychiatry, University Medical Centre Utrecht. Clinically referred children (*n* = 189) were included when they scored at or above the 90th percentile on the Attention Problems or Aggressive Behavior scales of the CBCL1.5-5 or Caregiver–Teacher Report Form (C-TRF). Typically developing children (*n* = 58) were recruited from elementary schools and daycare centers and were excluded if they scored at or above the 90th percentile of either the Attention Problems scale or the Aggressive Behavior scale of the CBCL1.5-5 or C-TRF1.5-5. The total sample included 247 children (195 boys and 52 girls). In both groups, children were excluded if their IQ, as assessed by the average score of the Raven Color Progressive Matrices (Raven, Court, & Raven, 1998) and Peabody Picture Vocabulary Test–III-NL (Schlichting, 2005) was below 70 and/or if they had a pervasive developmental disorder.

Children were assessed at baseline and at 18-month follow-up. At baseline, children's age was between 42 and 66 months (*M* = 54.5, *SD* = 7.6). Children's IQ ranged between 77 and 135 (*M* = 103.9, *SD* = 12.2). Parental educational level, for fathers and mothers respectively, was as follows: 6.9% and 0.8% unknown, 4.0% and 5.2% no high school diploma, 30.4% and 33.7% high school diploma, 24.7% and 24.7% vocational school diploma, and 34.0% and 35.6% college degree. Retention was high: 235 children (95%) were seen both at baseline and at follow-up. No significant differences were found between participants who did or did not attend the 18-month follow-up on age, sex, and measures at baseline.

None of the children received medication for their behavioral problems at baseline. After baseline, 74 of the clinically referred children (39.2%) received psychopharmacotherapy, mainly methylphenidate (*n* = 70) but also atomoxetine (*n* = 3) and risperidone (*n* = 1). If children received methylphenidate, parents were asked to withhold medication for 48 hours before the follow-up assessment. In addition, 108 families of clinically referred children (57.1%) received psychological interventions after the baseline measurement, that is, individual parent counseling at home (*n* = 32, 16.9%), at the outpatient clinic (n = 87, 46.0%), and/or participation in the Incredible Years Parent Program (Webster-Stratton, 2001); *n* = 8, 4.2%).

Procedure

At baseline and at 18-month follow-up, children were assessed during a single morning session, consisting of an intellectual and executive functioning assessment (Schoemaker et al., 2012) observations during the Disruptive Behavior Diagnostic Observation Schedule (DB-DOS; Bunte, Laschen, et al., 2013; Wakschlag et al., 2008), and administration of the Kiddie–Disruptive Behavior Disorder Schedule (K-DBDS; Bunte, Schoemaker, Hessen, van der Heijden, & Matthys, 2013; Keenan et al., 2007). The intellectual assessment was administered only during the baseline session. Questionnaires were answered by parents and teachers and sent to the medical center. Parents were asked to complete questionnaires together.

Parents provided written informed consent before participation and received a small amount of financial compensation. Children received two small gifts. The project was approved by the Medical Centre's ethical review committee.

Measures

Child problem behavior. Using the CBCL1.5-5 (parents) and C-TRF3 (teachers/caregivers), children's problem behaviors were rated on a 3-point scale (0 = not true, 1 = somewhat/sometimes true, 2 = very/often true; Achenbach & Rescorla, 2000). Items on the Anxious/Depressed (n_{CBCL} = 8, n_{TRF} = 8), Aggressive Behavior (n_{CBCL} = 19, n_{TRF} = 25), and Attention Problems (n_{CBCL} = 5, n_{TRF} = 9) scales were used. T scores of the Emotionally Reactive (n_{CBCL} = 9, n_{TRF} = 7) and CBCL Sleep Problems (*n* = 7) scales at baseline and 18-month follow-up were used for the purpose of validation. Cronbach's α values across waves and informants ranged between 0.71 and 0.96 (*M* = 0.82). CBCL data were available for all children, and C-TRF data were available for 236 children (95.5%). No significant differences between participants with and without C-TRF data were found on age, sex, and measures at baseline.

DSM behavioral disorder symptoms. The K-DBDS, a semi-structured clinical interview with parents, assessing DSM-IV-TR attention-deficit/hyperactivity disorder (ADHD), ODD, and conduct disorder (CD) symptoms was administered (Bunte et al., 2013; Keenan et al., 2007). Sum scores for each symptom cluster were used. The ODD cluster contained 11 questions assessing eight symptoms (e.g., often loses temper), with answer categories ranging from "never" (0) to "many times a day" (5). The cluster was divided into irritable and headstrong clusters. Confirmatory factor analysis (CFA) showed that this distinction fit the data well ($\chi2$ [43] = 71.254, *p* = .004, *RMSEA* = .052 [90% CI = 0.029 – 0.072], *CFI* = 0.978, *TLI* = 0.971), and better than a model without distinction ($\Delta\chi2$ [1] = 9.946, *p* = .002). The CD cluster contained 13 questions, assessing 12 symptoms (e.g., physically cruel to people), with answer categories ranging from "never" (0) to "more than once a day" (5). The ADHD cluster contained 19 questions assessing 18 ADHD symptoms (e.g., always "on the go"), with answer categories ranging from "never" (0) to "often" (3).

Observed externalizing behavior. Observed behaviors were coded with the DB-DOS and divided into 5 categories (Bunte, Laschen, et al., 2013; Wakschlag et al., 2008). Behavior regulation problems (*n* = 15) encompassed behaviors resulting from difficulties in the ability to keep with social rules and norms. Anger modulation problems (*n* = 6) incorporated behaviors reflecting irritable, sullen mood, and deregulated expressions of anger (e.g., often loses temper). Competence (*n* = 6) covered positive affect, social engagement, and assertiveness. Inattentiveness (*n* = 4) covered symptoms of ADHD inattentive subtype, such as being easily distracted. Hyperactivity/impulsivity (*n* = 6) covered symptoms of ADHD hyperactivity subtype, such as talking excessively. Behaviors were rated on a scale ranging from typical (0) to atypical (3) and were summed, with higher scores indicating more atypical behavior. For the competence cluster, higher scores indicated more competence. The mean score across the different conditions of the DB-DOS was used. Coded behaviors were available only for the baseline session.

General level of functioning. Parents and teachers answered the nonclinical version of the Child Global Assessment Schedule, which ranges from 0 to 100. Lower scores indicate greater impairment in general level of functioning (Shaffer et al., 1983).

Inhibition. To measure inhibition, three tasks were used (detailed in Schoemaker et al., 2012). The Go–No-Go Task is a computerized task in which children receive the instruction to press a button when an ordinary fish appears ("Go" stimuli, 75%) but to withhold pressing when a shark appears ("No-Go" stimuli, 25%). Correct Go trials minus incorrect No-Go trials were calculated. During the Modified Snack Delay, children needed to stand still and place their hands on a mat without talking. A bell and a glass with a treat underneath were placed in front of each of the children. Children were told that they could move and eat the treat when an examiner rang the bell. The examiner

progressively tried to distract the children, with activities such as dropping a pencil or leaving the room. Hand movement was coded every five seconds, and a total score of hand movement was calculated. The Shape School Task is a computerized task with cartoon figures in varying colors, shapes, and expressions. The naming rule varied in the different conditions. In the inhibition condition, children needed to name the color of the figures with happy faces and to suppress this response when the cartoon showed a sad or frustrated face. The number of correct responses was calculated and divided by the total number of trials. The mean of the three standardized scores was used, with higher scores indicating better inhibition.

Data Analyses

CFA was conducted in M*plus* 7.11 (Múthen & Múthen, 2012) using weighted least-squares means and variances adjusted (WLSMV) estimator with delta-parameterization because of categorical indicators. Three competing models were examined for both parent- and teacher-reported problem behavior: a bifactor, second-order, and one-factor model. Another possible model is a correlated three-factor model; however, this model is statistically indistinguishable from a second-order model, as the models are the same in degrees of freedom and fit. First, it was examined whether the bifactor model, which is the least constrained model, appropriately fitted the data. In this model, items load on orthogonal specific factors, representing the AAA scales, and on a general factor. Subsequently, it was examined whether the second-order model and, consequently, the one-factor model, significantly degraded this fit. In the second-order model, all items loaded on a factor representing their original AAA scale, which loaded on a second-order factor. In the one-factor model, all items loaded on one factor.

Model fit was evaluated through the Comparative Fit Index (*CFI*), Tucker-Lewis Index (*TLI*), and Root Mean Square Error of Approximation (*RMSEA*). *CFI* and *TLI* values above 0.95 and *RMSEA* values below 0.05 indicate a good fit (Byrne, 2012). $\chi2$ Difference tests for WLSMV estimator were conducted for model comparisons, with significant $\chi2$ values indicating a degrade in fit. To examine the validity of the best-fitting factor structure, we successively entered external criteria into the model and computed regression paths. For longitudinal validity analyses, we controlled for received medication (yes/no) and psychosocial treatment (yes/no). For all analyses, an α level of 0.01 was adopted to correct for multiple testing.

RESULTS

Correlations and Factorial Structure of DP

Correlations between the AAA scales were 0.619 and 0.679 (Aggressive Behavior and Attention Problems), 0.501 and 0.388 (Aggressive Behavior and Anxious/Depressed), and 0.371 and 0.324 (Anxious/Depressed and Attention Problems) for parent- and teacher-reported problem behavior, respectively. The results of the factor analyses are shown in Table 1. The results were similar for parent- and teacher-reported problem behavior. The model showed a very good fit to the data, and the fit significantly degraded when the model was restricted into a second-order model. It was therefore concluded that the bifactor model best fits the data.

Standardized factor-loadings in the bifactor model of parent data are reported in Table S1 (available online). Generally, factor loadings on DP were stronger than scale-specific loadings, although most scale-specific factor loadings were above 0.30. Scale-specific factor loadings were relatively low for the Aggressive Behavior scale, and 10 of 19 were not significant. Scale-specific factor loadings on the Attention Problems and Anxious/Depressed scales were, with 1 exception, all significant. Standardized factor loadings for teacher-reported problem behavior showed a fairly similar pattern (these can be obtained from the first author).

Criterion Validation

Concurrent and longitudinal associations of DP and three specific factors (Anxious/Depressed, Aggressive Behavior, and Attention Problems) with external criteria are reported in Table 2. With regard to parent-reported data, the DP factor was concurrently related to all criteria except observed competence. Notably, these associations were observed regardless of the source of information (i.e., parent or teacher reports, clinical interview, behavioral observations, and neuropsychological tasks).

The specific factors, representing the 3 problem areas, showed more differentiated concurrent associations with external criteria. The Anxious/Depressed factor was positively associated with parent-reported emotional reactivity and ODD irritable symptoms and negatively with observed anger modulation problems, behavior regulation problems, hyperactivity/impulsivity, and inattentiveness. Aggressive behavior was positively associated with more ODD headstrong and CD symptom clusters. Finally, attention problems were associated with a reduced general level of functioning and more ADHD symptoms, both observed and reported, and with fewer observed anger modulation problems and reported ODD irritable symptoms.

To a certain extent, factors of the teacher-reported data showed similar concurrent associations when compared to parent-reported factors. DP was concurrently related to external criteria, with 3 exceptions (i.e., parent-reported emotional reactivity, sleep problems, and observed competence). The associations with parent-reported criteria were generally weaker than for parent-reported DP, whereas associations with teacher-reported and observed criteria were larger. The Anxious/Depressed factor was concurrently related to emotional reactivity and sleep problems, less observed hyperactivity/impulsivity, and less observed competence. Aggressive behavior was poorly related to concurrent criteria, with only 1 negative association with teacher-reported emotional reactivity. Finally, attention problems were associated with lower level of general functioning, poor inhibition, more ADHD symptoms, and observed inattentiveness, hyperactivity/impulsivity, and behavior regulation problems. Parent-reported DP was also widely associated with criteria 18 months later when controlling for medication use and psychosocial treatment. These longitudinal associations were found across types of informants and methods and were still relatively strong.

Again, the specific factors were more selectively associated with external criteria 18 months later. Over time, anxious/depressed behavior was associated with parent-reported emotional reactivity and ODD irritable symptoms. Aggressive behavior was associated with poor inhibition and more ODD headstrong and CD symptoms, whereas attention problems were associated with impaired teacher-reported general level of functioning, more ADHD symptoms, and poor inhibition at follow-up.

For teacher reports, the DP factor was associated with a lower level of general functioning, more teacher-reported emotional reactivity, and less inhibition 18 months later, but was not related to the DSM symptom clusters and parent-reported emotional reactivity and sleep problems. Anxious/depressed behavior was associated with more emotional reactivity, sleep problems, and ODD irritable symptoms 18 months later. Aggressive behavior was longitudinally associated with less teacher-reported emotional reactivity and fewer ODD irritable symptoms. Attention problems were associated with lower teacher-reported general level of functioning, more ADHD symptoms, and poorer inhibition at follow-up.

Overall, DP was both concurrently and longitudinally related to a wide range of external criteria, whereas specific factors showed selective associations. These associations indicate the usefulness of the specific factors in addition to the general factor. Although fewer longitudinal associations for teacher-reported DP were found, this pattern of associations was generally found for both parent- and teacher-reported problem behavior.

TABLE 1
Fit Indices for the Bifactor, Second-Order, and One-Factor Models for Parent and Teacher Data

	Model	χ^2	*Df*	*RMSEA*	*RMSEA* 90% CI	*CFI*	*TLI*	$\Delta\chi^2$
	1.Bifactor	658.559*	432	.046	[.039 - .053]	.984	.982	
Parent	2.Second-order[a]	886.530*	461	.061	[.055 - .067]	.970	.967	2 vs. 1 (29) = 190.192, *p* <.001
	3.One-factor	1184.037*	464	.079	[.074 - .085]	.949	.945	3 vs. 2 (3) = 100.932, *p* <.001
	1.Bifactor	1242.580*	777	.050	[.045 - .056]	.971	.968	
Teacher	2.Second-order[a]	1519.277*	816	.060	[.056 - .065]	.956	.953	2 vs. 1 (39) = 232.434, *p* <.001
	3.One-factor	1916.101*	819	.075	[.071 - .080]	.931	.927	3 vs. 2 (3) = 137.577, *p* <.001

Note. * = *p* <.001.
[a] Latent variable covariance matrix was not positive definite.

TABLE 2
Fully Standardized Regression Coefficients for Concurrent and Longitudinal Associations with External Criteria

		Parent-reports				Teacher-reports			
		DP	Anxious/ Depressed	Aggressive Behavior	Attention Problems	DP	Anxious/ Depressed	Aggressive Behavior	Attention Problems
Parent-reported criteria									
Emotional reactivity	Baseline	.812**	.290**	-.067	-.069	.165	.275**	-.106	.106
	Follow-up	.477**	.190*	-.011	-.010	-.037	.308**	-.014	-.005
Sleep Problems	Baseline	.528**	.123	-.147	-.058	.012	.222*	-.054	.015
	Follow-up	.275**	.078	-.125	-.128	.075	.290**	-.135	-.001
General level of functioning	Baseline	-.715**	-.091	-.144	-.307**	-.570**	-.128	.060	-.218**
	Follow-up	-.398**	-.078	-.008	-.176	-.166*	-.270**	.140	-.080
Teacher-reported criteria									
Emotional reactivity	Baseline	.328**	.045	-.014	.066	.698**	.407**	-.285**	.016
	Follow-up	.131	.029	.015	.050	.365**	.183*	-.261**	.044
General level of functioning	Baseline	-.374**	.185	-.144	-.361**	-.685**	-.030	-.067	-.293**
	Follow-up	-.221*	.131	-.164	-.251*	-.425**	-.072	.069	-.206*
Symptom clusters									
ODD Headstrong	Baseline	.673**	.010	.181*	.000	.277**	.038	.074	-.034
	Follow-up	.396**	.025	.212*	-.041	.020	.081	-.080	-.142
ODD Irritable	Baseline	.648**	.179*	.039	-.235**	.200*	.191	-.070	.005
	Follow-up	.414**	.195*	-.075	-.103	-.085	.292**	-.190*	-.047
CD	Baseline	.491**	-.088	.305**	.000	.248**	-.085	.137	-.018
	Follow-up	.364**	.014	.234*	-.068	.053	.133	-.003	-.135

TABLE 2
Continued.

		Parent-reports				Teacher-reports			
		DP	Anxious/ Depressed	Aggressive Behavior	Attention Problems	DP	Anxious/ Depressed	Aggressive Behavior	Attention Problems
ADHD	Baseline	.600**	-.006	.013	.531**	.354**	-.093	.016	.426**
	Follow-up	.295**	.052	-.035	.320**	.044	.023	-.012	.263**
Inhibition	Baseline	-.352**	.163	.024	-.152	-.248**	.102	-.006	-.263*
	Follow-up	-.194**	.092	-.192*	-.336**	-.222**	.112	-.063	-.245**
Observed behavior									
Anger Modulation problems	Baseline	.323**	-.239*	-.037	-.267*	.358**	.107	-.114	.012
Behavior Regulation problems	Baseline	.374**	-.342**	.084	.147	.436**	-.149	.081	.198*
Inattentive	Baseline	.363**	-.358**	.002	.310**	.308**	-.175	.036	.305**
Hyperactivity/Impulsivity	Baseline	.315**	-.304*	.005	.381**	.420**	-.209*	.009	.200*
Competence	Baseline	-.041	-.005	-.004	.139	.044	-.251**	.103	-.069

Note. * <.01, **<.001

DISCUSSION

Previous research has provided compelling evidence indicating that DP is valuable in identifying children who are seriously at risk in their development (Althoff et al., 2010; Holtmann, Buchmann, et al., 2011). Yet, to date, there is no consensus on the conceptual meaning and preferred operationalization of DP, although this could substantially increase its clinical and scientific usefulness. We addressed this concern by testing and validating the factor structure of parent- and teacher-reported DP in a sample of predominantly clinically referred preschool children with externalizing problem behavior.

The first question was whether DP represents comorbidity among anxiety/ depression, aggressive behavior, and attention problems (i.e., second-order model) or a syndrome of dysregulation, either entirely (i.e., one-factor model) or in addition to the specific syndromes of anxiety/depression, aggressive behavior, and attention problems (i.e., bifactor model). Our findings convincingly support the hypothesized conceptualization of DP as a syndrome, which exists in addition to specific syndromes of anxiety/depression, aggressive behavior, and attention problems. This preferred conceptualization, accounted for by a bifactor model, was consistently found for both parent- and teacher-reported problem behavior and is in line with our results from research with older children, in which a bifactor model also fits best (Deutz et al., 2016).

Examination of factor loadings further demonstrated the appropriateness of differentiating between DP and specific syndromes, as most items contributed to both DP and the specific syndromes. However, a limited number of items loaded appropriately on the Aggressive Behavior factor. It has been noted before that the Aggressive Behavior scale covers a range of behaviors that cause discomfort to others, instead of merely aggression (Tremblay, 2000). Although a large cross-national study did find support for the existence of the Aggressive Behavior scale (Ivanova et al., 2010), it did not account for an underlying dysregulation syndrome. Replication studies should further examine the structure of this scale when accounting for DP.

The second aim was to examine the concurrent and longitudinal criterion validity of DP and specific syndromes. As expected, DP was related to poor inhibition, poor general level of functioning, and more emotional reactivity, sleep problems, observed externalizing behavior, and DSM externalizing behavior symptoms, both concurrently and 18 months later. These broad associations were especially convincing for parent-reported problem behavior. An important strength of the current study is our reliance on several methods and informants, including behavioral observations and neuropsychological tasks, which minimizes the chance that DP merely represents reporter bias. Moreover, the three specific syndromes, namely, anxiety/depression, aggressive behavior, and attention problems, were more differentially associated with external criteria. For example, attention problems were associated mainly with concurrent and longitudinal ADHD symptoms and poor general level of functioning. This underlines the usefulness of differentiating between specific syndromes and DP, as these syndromes have their unique associations over and above the associations of DP.

Our results are in line with research showing that DP is related to concurrent impairments in young children (Basten et al., 2013; Basten et al., 2014; Kim et al., 2012). Furthermore, the widespread associations between DP and impairments 18 months later are in line with findings in longitudinal studies with older children (Althoff et al., 2010; Holtmann, Buchmann, et al., 2011), and add to existing knowledge by indicating that DP in preschool years forms a valid marker for developmental risks.

Our findings provide compelling support for conceptualizing DP as a broad dysregulation syndrome (Althoff, 2010; Ayer et al., 2009). Given the associations with a range of clinical criteria, this syndrome is probably closely related to the general psychopathology factor, which was recently identified in (young) adults and preschoolers (Caspi et al., 2014; Olino, Dougherty, Bufferd, Carlson, & Klein, 2014). This psychopathology factor summarizes an individual's propensity toward developing many forms of psychopathology. Notably, dysregulation is suggested to form the core of this psychopathology factor (Caspi et al., 2014; Olino, Dougherty, Bufferd, Carlson, & Klein, 2014). The findings are also in line with recent efforts to capture underlying mechanisms that cut across existing disorders (e.g., the Research Domain Criteria [RDoC] framework).

Our results imply that preschool children differ in their liability for developing DP and for developing specific syndromes. Whereas some preschoolers have a liability for one form of problem behavior, others show a more generic deficit in self-regulation that can set the stage for broad maladjustment. Children who score high on DP seem severely impaired and developmentally at risk. These children may possibly require different forms of prevention and treatment than children with more specific problem behaviors. Bifactor models may support researchers in examining such hypotheses, as they are well suited for disentangling DP from specific problems. Because of the small number of girls in our sample, we could not examine measurement invariance across sexes. Results of the current study should also be replicated with larger samples, as this study might be underpowered according to some guidelines (Everitt, 1975), although it has sufficient participants according to others (Gorsuch, 1983).

In addition, Berkson bias (Berkson, 1946) is a relevant concern when examining the associations between syndromes within clinically referred samples. Berkson bias could occur because of a higher probability for children with more than one type of problem behavior to be referred than for children with only one type of problem behavior, which can lead to spurious associations among syndromes. However, the current sample contains typically developing children, which lowers the risk of Berkson bias. Moreover, differences between the correlations between AAA scales within our sample and within a nonreferred sample (Achenbach & Rescorla, 2000) were small. Hence, there are no indications for spuriously high associations between scales. Nonetheless, future research could examine whether our conclusions still hold in a general population sample.

Moreover, clinically referred children in our sample were referred for externalizing behavior problems, and the instruments used for validation were especially suited for these problems. As externalizing problem behavior is the most common reason for referring young children (Wilens et al., 2002), our results are applicable to a large share of clinically referred preschoolers. Still, future research should be conducted in a sample with a greater variation in problems and with a broader variety of instruments to further establish the validity of the Anxious/Depressed factor, although our study more likely underestimated instead of overestimated the validity of this factor. Finally, future research should incorporate even longer-term follow-up measures to further establish whether DP in preschool years can be considered a developmental risk marker.

To conclude, DP is best conceptualized as a broad syndrome of dysregulation that exists in addition to specific anxious/depressed, aggressive behavior, and attention problem syndromes. Preschoolers with these regulation problems deserve researchers' and clinicians' attention, as their problems are accompanied with impairments, and as they may be developmentally at risk. In clinical practice, the CBCL and C-TRF are often filled in before clinicians meet their patients and can inform clinicians whether children have elevated scores on all AAA scales. The profile is therefore a low-effort method of attending clinicians, in the early stage of the diagnostic procedure, to identify possible regulation problems. More research is needed to further deepen our knowledge of DP in preschool children.

SUPPLEMENTARY MATERIAL

TABLE S1

Standardized Factor Loadings for Parent-Reported Problem Behavior

Item	Description	Scale-specific loading	DP loading
	Anxious/Depressed		
I10	Clings	.370**	.557**
I33	Feelings hurt	.235*	.667**
I37	Upset by separation	.393**	.403**
I43	Looks unhappy	.628**	.625**
I47	Nervous	.318**	.619**
I68	Self-conscious	.611**	.407**
I87	Fearful	.596**	.435**
I90	Sad	.759**	.554**
	Aggressive Behavior		
I8	Can't stand waiting	.058	.912**
I15	Defiant	.313**	.801**
I16	Demands met	.082	.932**
I18	Destroys others	.282**	.690**
I20	Disobedient	.279**	.846**
I27	Lacks guilt	.284**	.778**
I29	Easily frustrated	-.200	.801**
I35	Fights	.559**	.559**
I40	Hits others	.703**	.631**
I42	Hurts accidently	.551**	.574**
I44	Angry moods	.072	.886**
I53	Attacks people	.548**	.585**
I58	Punishment doesn't change	.228*	.825**
I66	Screams	.170	.863**
I69	Selfish	.078	.596**
I81	Stubborn/sullen/irritable	-.089	.791**
I85	Temper	.083	.897**
I88	Uncooperative	.144	.779**
I96	Wants attention	.027	.876**
	Attention Problems		
I5	Can't concentrate	.660**	.703**
I6	Can't sit still	.455**	.829**
I56	Clumsy	.353**	.469**
I59	Quickly shifts	.534**	.764**
I95	Wanders away	.018	.590**

Note: * <.01, **<.001

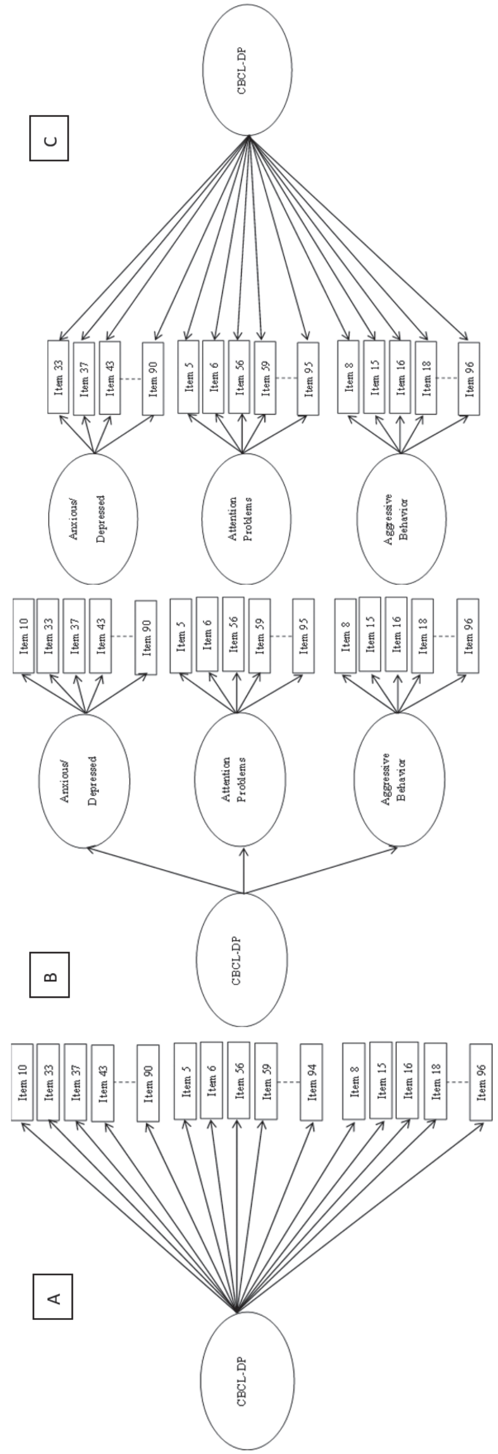

FIGURE S1. A: One-factor model, B: Second-order factor model, C: Bifactor model

CHAPTER 7

General Discussion

The aim of this dissertation was to increase knowledge on the early development of self-regulation, by (1) examining mean-level development, as well as early markers of self-regulation; (2) identifying family factors that might play a role in the development of self-regulation, including parental characteristics, parenting practices, and household chaos; and (3) examining problem behavior related to deficits in self-regulation in early childhood. This chapter contains a summary and discussion of the main findings, theoretical and clinical implications, as well as strengths, limitations, and future directions. Table 1 also shows a summary of the results presented in Chapter 2 to 6.

Aim 1: Mean-Level Development and Early Markers of Self-Regulation

Self-regulation develops fast in the first years of life and is expected to build upon more basic abilities that are already present in infancy (e.g., Garon et al., 2008). The first aim in this dissertation was to identify individual predictors of self-regulation. I focused on two individual factors in infancy that are important for self-regulation: visual attention and negative reactivity (Hendry, Jones, & Charman, 2016). In addition, I examined measurement invariance and mean-level development of inhibitory control across the preschool years.

Visual attention. The results in Chapter 2 demonstrate that microtemporal measures of visual attention at 10 months of age predict self-regulation in toddlerhood (i.e., at 2.5 years of age). This study is one of the first studies to find that visual attention measures that are obtained through eye-tracking are relevant for self-regulation later in development. Longer fixations, as well as less variation in fixation durations, predicted higher levels of effortful control, but not compliance. Fixation duration and variation in fixation duration only predicted effortful control when all three attention measures (i.e., fixation duration, variation in fixation duration and disengagement) were entered in the regression analysis simultaneously. This indicates that visual attention measures share information, such as shared-measurement variance, that is irrelevant for predicting later self-regulation. Surprisingly, disengagement was unrelated to both effortful control and compliance. The results indicate that early marker of the orienting network, the dominant network in self-regulation during infancy (Rothbart et al., 2011), may not form a good predictors for later self-regulation. Instead, a superior executive attention network, measured by long and steady fixations, seems to predict better effortful control in toddlerhood. This attentional network is dominant in self-regulation at 3 to 4 years of age (Posner et al., 2012).

The results described in Chapter 2 concord with a small body of literature showing that faster disengagement is only concurrently related to better self-regulation in infancy, and could even be inversely related to self-regulation in toddlerhood (Nakagawa & Sukigara, 2013). In addition, a recent study also found that disengagement (measured at 4 months) was unrelated to rudimentary inhibitory control (measured at 6 months) (Holmboe, Bonneville-Roussy, Csibra, & Johnson, 2018). Whereas previous studies on disengagement have been extremely underpowered (with *N*'s between 21 and 25; Nakagawa & Sikigara, 2014; McConnell & Bryson, 2005), Chapter 2 and the study by Holmboe et al (2018) demonstrate that associations between disengagement and self-regulation are not present when relying on larger sample sizes. Instead, longer fixations and less variation in fixation duration signify those infants who will be better in self-regulation, which is also in agreement with previous work (Papageorgiou et al., 2014; Wass & Smith, 2014).

A next step forward would be to examine whether parents can stimulate the development of executive attention at an early age. Rothbart et al. (2011) suggested that parents might be able to train the executive network of infants by presenting novel objects. In addition, Bono and Stifter (2003) showed that mothers' support in maintaining attention in infancy promotes the development of focused attention. Future studies may want to include parental attention supporting behavior as a moderator when examining the prospective relation between infant attention and later self-regulation.

Negative reactivity. The results described in Chapter 3 show that moderate amounts of low intensive negative reactivity at 6 months of age, operationalized as fussing, predict later self-regulation in the preschool years (4.5 years of age), but not in toddlerhood (18 months of age). In a context characterized by high levels of maternal sensitivity, a moderate amount of fussing, but not crying, was predictive of higher levels of self-regulation at 4.5 years of age.

The results of Chapter 3 align well with the optimal arousal perspective on the development of self-regulation (Blair & Ursache, 2011). This perspective states that moderate and time limited negative reactivity promotes the development of self-regulation. Previous studies already noted that infants who display a combination of high levels of negative reactivity *and* regulatory skills perform better with regard to self-regulation later in their development (Stifter, Spinrad, & Braungart-Rieker, 1999; Ursache, Blair, Stifter, & Voegtline, 2013). The results in Chapter 3 add to this body of literature by showing that fussing has a curvilinear association with self-regulation, but only when mothers show relatively high levels of sensitivity (for a discussion on this matter; see Aim 2). The association does not follow an entirely symmetric U shape: the right tail of the curve is only significant at levels of fussing that were hardly present in the sample. As such, the results should be replicated in samples with a larger variety of fussing. The results of this study are also most likely specific to the period after the first three months in infancy. During these first three months, the so-called 'colic' phase, fussing and crying are not predictive of later developmental outcomes (Hemmi et al., 2011; Rao et al., 2004).

Development of inhibitory control. In Chapter 4, I thoroughly examined parent-reported inhibitory control across four moments during the preschool years (2.5-6.5 years). I examined measurement invariance, mean-level development, and associations with parenting. When a scale is not invariant over time, this indicates that the meaning of the construct has changed. I found that parent-reported inhibitory control was metric invariant over time, i.e., the quality of the items as an indicator of inhibitory control did not change. However, five items were not invariant with respect to their intercept levels. Older children required a higher score on these items (such as "prepares for trips and outings by planning"), to obtain a similar score on the inhibitory control scale compared to younger children. The items that were invariant with respect to their intercepts also showed strict invariance. This is not a requirement for comparing means across development (Little, 2013), but it does show that most items used to assess inhibitory control are equally reliable across development. The results of this study demonstrate that there are conceptual changes in parent-reported inhibitory control over time, but that there is also sufficient conceptual continuity to model longitudinal mean-level changes. As expected, parent-reported inhibitory control improved with age. This increase decelerated over time, which has also been reported in previous research (e.g., Chang et al., 2014).

The results of this study are in line with the notion that the behavioral manifestation of self-regulation changes during the first years of life. This phenomenon has been labelled heterotypic continuity, i.e., "the manifestation of the same underlying process through different behavioral presentations at different developmental periods" (Cicchetti & Rogosch, 2002, p.13). In longitudinal research, this phenomenon requires careful consideration of the appropriateness of the measures. It is therefore not always feasible to rely on the same type of measurement across age. For instance, lab tasks to measure inhibitory control are on average only useful in detecting developmental changes within a timespan of less than 3 years (Petersen et al., 2016). Parent-reports of inhibitory control, as used in Chapter 4, can be used over longer timespans, but do seem to capture less growth. This could be because the questionnaire that was used to assess inhibitory, i.e., the Child Behavior Questionnaire (Rothbart et al., 2001), may

not be designed to detect growth, as it measures temperament. At the same time, Rothbart and colleagues argued that temperament also develops over time (Rothbart & Putnam, 2002; Rothbart, 2012).

Another option to model the development of self-regulation would be to use different measures of inhibitory control at different time points. By using an item response theory approach to vertical scaling, it is possible to assess both heterotypic continuity and mean-level development. For instance, Petersen et al. (2018) relied on a set of symptoms that changed over time to show that internalizing problems peak in mid-to-late adolescence, while at the same time accounting for the fact that somatic complaints are more strongly associated with internalizing problems in early adolescence compared to young adulthood. Given the rapid development of self-regulation during the first years of life, this could also be an interesting approach for modelling mean-level development of self-regulation.

In general, the findings in this dissertation demonstrate that early markers of self-regulation are already notable in infancy, which aligns with theories that postulate that the ability for self-regulation builds upon simpler skills that are already present in infancy (Garon, Bryson, & Smith, 2008; Kopp,1982). Although infants are not capable of independent self-regulation, they are capable of some control over their attention and emotion, especially during the second half year of life. As an example, infants can avert their gaze or suck on their thumb to alleviate negative reactivity (e.g., Ekas, Lickenbrock, & Braungart-Rieker, 2013). These rudimentary skills are expected to set the stage for complex forms of self-regulation that emerge later in development. The results presented in Chapter 2 and 3 fit well within this perspective on the development of self-regulation: Those infants who have better control over their attention also show higher levels of self-regulation in toddlerhood, and infants who experience negative reactivity, but only a moderate amount of low intensive negative reactivity, also show better self-regulation at 4.5 years. The results of this dissertation also show that self-regulation develops especially fast in the first years of life, as the increase in parent reported inhibitory control decelerates between 2.5 and 6.5 years of age.

Aim 2: Family Factors Related to the Development of Self-Regulation

The second aim in this dissertation was to identify family factors that might play a role in the early development of self-regulation. I focused on parenting practices (parental sensitivity and nonintrusiveness), parental characteristics (i.e., self-regulation), and factors that define the home environment (i.e., household chaos). Chapter 3 demonstrates that maternal sensitivity interacts with infant fussing to predict self-regulation at 4.5 years. Chapter 4 shows that mothers' and fathers' sensitivity and nonintrusiveness predict inhibitory control at 2.5-3.5 years of age. However, only nonintrusiveness predicts the development of inhibitory control during the preschool years. Lastly, Chapter 5 shows that parental self-regulation and household chaos interact in predicting the way that parents respond to toddler's noncompliance.

With regard to parenting practices that may predict children's self-regulation, my focus has been on sensitivity and nonintrusiveness. Both sensitivity and nonintrusiveness support children in their ability for self-regulation, but their function differs depending upon the developmental timing. In Chapter 3, I focused on maternal sensitivity when infants were 6 months old. Moderate amounts of infant fussing were predictive of self-regulation in the preschool years when maternal sensitivity was relatively high. This indicates that infants are more likely to learn from moments of distress when mothers are attentive to their cues and respond timely and appropriately. Mothers of infants who hardly fuss do not have the opportunity to respond timely and appropriately to negative reactivity. Infants who fuss a lot also benefit less from maternal sensitivity, perhaps because they have less experience with the positive effects of intervening during moments of negative reactivity. Interestingly, crying and maternal sensitivity did not interact to predict later self-regulation. This may relate to the fact that infants are less attentive to their environment when they are highly distressed (e.g., they squint their eyes). Overall, the results presented in Chapter 3 show that parental sensitivity interacts with infant negative reactivity to predict self-regulation. That is, infants who show controllable levels of low intensive negative reactivity seem to learn from their parents how to regulate themselves. These regulation skills in turn form the basis on which more complex regulatory abilities can build (Ursache et al., 2014).

After infancy, parents continue to play an important role in the development of children's self-regulation, but their role changes (Sroufe, 2000). In toddlerhood, parents have to find a balance between providing assistance and granting autonomy in regulation (Sroufe, 2000). In Chapter 4, I examined maternal and paternal sensitivity and nonintrusiveness when children were 2.5 to 3.5 years old as predictor of (the development of) inhibitory control during the preschool years. I found that higher levels of both paternal and maternal sensitivity and intrusiveness were associated with higher levels of children's inhibitory control at 2.5 to 3.5 years of age (i.e., the age during the first of four assessments). However, higher levels of nonintrusiveness were predictive of faster growth in inhibitory control. This indicates that behaviors that were adaptive in toddlerhood either do not further stimulate the development of self-regulation (for sensitivity) or even hamper the development of self-regulation (for intrusiveness). At first glance, some aspects of intrusive parenting (e.g., highly controlling parenting) may come across as an appropriate strategy for young children, who generally have limited skills for self-regulation. However, intrusive parenting also leaves children ill-equipped for independent self-regulation later in development. The results presented in Chapter 4 were similar for fathers and mothers, and independent of children's sex.

The results of Chapter 3 and 4 demonstrate the importance of parents for the development of self-regulation, but also suggests that their role changes over the course of development. Infants benefit from sensitive parenting practices, especially during moments of low distress, but after infancy it may be particularly important for parents to refrain from intrusive behavior when they want to support the development of self-regulation. In Chapter 5, I continued by examining whether parental self-regulation and household chaos predicted one aspect of nonintrusive parenting during toddlerhood: the ability to refrain from responding negatively to negative child behavior. In accordance with previous research (Deater-Deckard et al., 2010), I labelled this parenting dimension reactive negative parenting.

The results of Chapter 5 show that parental self-regulation and household chaos interact to predict reactive negative parenting. Specifically, lower parental self-regulation predicted more reactive negative parenting practices in more chaotic households. When household chaos was low, parents showed relatively low levels of reactive negative parenting practices independently of their ability for self-regulation.

While sensitivity and nonintrusiveness in Chapter 3 and 4 were assessed using global coding systems, I used a micro-coding system in Chapter 5. Micro-coding allows to examine contingencies in parent-child interactions. By examining moment-to-moment interactions between parents and toddlers, instead of focusing on general tendencies of parents and toddlers, I showed that parents differed in their response to noncompliance, and that this depended upon their ability for self-regulation and the chaos in their house. Previous studies have shown that these contingent responses to toddlers' noncompliance are related to subsequent increases in child distress (Scaramella & Leve, 2004), which leaves parents with poor self-regulation and living in a chaotic house, at higher risk for experiencing negative back-and-forth processes with their toddlers that accumulate over time. The micro-approach used in Chapter 5 points to very specific parenting practices that may require attention from professionals to avoid such cascading processes.

Overall, the results in this dissertation point towards the importance of sensitive and nonintrusive parenting, and indicate that the intergenerational transmission of self-regulation is partly explained by reactive negative parenting. Parents who are low on self-regulation tend to respond more negative towards toddlers' noncompliance. As the results of Chapter 4 demonstrated, such behaviors can curb the development of self-regulation. Reducing household chaos may help parents with low self-regulation to respond less often to toddlers' noncompliance with negative behaviors.

Aim 3: Problem Behavior Related to Deficits in Self-Regulation in Early Childhood

In Chapter 6, I focused on concurrent impairments in regulating affect, behavior, and cognition in preschool children. Previous work already provided compelling evidence that children exhibiting these problems may be identified with the Anxious/Depressed, Aggressive Behavior, and Attention Problems scales (AAA scales or Dysregulation Profile; DP) of the Child Behavior Checklist (CBCL) (Althoff, 2010). I tested whether DP represents comorbidity between anxiety/depression, aggressive behavior, and attention problems (i.e., second-order model), or was better conceptualized as a syndrome, either entirely (i.e., one-factor model) or next to anxiety/depression, aggressive behavior, and attention problems (i.e., bifactor model). Utilizing a sample of predominantly clinically referred preschool children with externalizing behavior problems, I concluded that a bifactor model described the AAA-scales best. This bifactor model comprised a general factor, i.e., dysregulation, and three specific factors that related to anxiety/depression, aggressive behavior, and attention problems.

The hierarchical structure that characterizes the bifactor model has gained momentum in social sciences. Bifactor models are found to hold for executive functioning (Friedman & Miyake, 2017), personality (Sharp et al., 2015), and for specific disorders such as ADHD (Martel, Von Eye, & Nigg, 2010). A related field of research has focused on applying the bifactor model on a broad range of psychopathological symptoms (Caspi et al., 2014). Here, the general factor is labelled 'general psychopathology' or the 'p-factor'. In a study that was not included in this dissertation, we found great resemblance between the dysregulation factor and the general psychopathology factor (Deutz et al., 2019). This strengthens the notion that DP represents a general liability for psychopathology.

A common critique to bifactor models is that they tend to show superior fit to the data due to overfitting: they also model irrelevant noise (Bonifay, Lane, & Reise, 2017). I therefore also thoroughly validated the bifactor model. Criterion validity analyses showed that the dysregulation factor was associated with almost all markers of

dysregulation and clinically relevant criteria (such as observed anger and behavior regulation, and DSM criteria assessed through an interview), both concurrently and longitudinally. This was especially the case for parent-reported problem behavior, and to a lesser extent for teacher/caregiver-reported problem behavior. In contrast, the specific factors were more differentially related to these criteria. For instance, the specific aggression factor was associated with parent-reported conduct disorder symptoms and oppositional defiant type headstrong symptoms but not with oppositional defiant type irritable symptoms. Headstrong symptoms capture rule breaking, argumentativeness, and noncompliance, which differ from the oppositional defiant irritable symptoms, that tap on deficient emotion regulation. In agreement with earlier research, these irritable symptoms were only related to the specific anxious/depressed factor (Stringaris & Goodman, 2009). A higher level of task-based inhibition predicted lower levels of dysregulation and was related to the specific factor attention problems. This strengthens the idea that DP taps problems related to self-regulation, and is in line with other research that demonstrates that deficits in self-regulation are related to a broad variety of problem behaviors (Martel et al., 2017).

Overall, the results presented in this dissertation indicate that DP is best conceptualized as a broad syndrome of dysregulation that exists next to specific problem behavior. This syndrome most likely indicates a general liability for developing psychopathology, and may be caused by breakdowns in self-regulation.

Conceptualization and Measurement of Self-Regulation

Throughout this dissertation, I relied on various conceptualizations of self-regulation, i.e., effortful control, executive functions, and compliance. Various researchers have noted that measures of self-regulation essentially cover the same construct, and that most differences between constructs are mostly due to diverging science traditions (e.g., Bridgett et al., 2013; Nigg, 2017; Zhou et al., 2012). At the same time, the concept self-regulation is at times too broad, especially considering the fact that various measures of self-regulation do not always correlate well (Bridgett et al., 2013; Toplak et al., 2013). In Chapter 5, I noted that parents' effortful control and executive functioning were not significantly related. In addition, the measures used to assess self-regulation were only moderately related with each other in Chapter 3 and 4. Some researchers have therefore argued for a limited set of key concepts that conceptualize self-regulation (Nigg, 2017). Instead of distinguishing between concepts such as effortful control and executive functions, there may be more useful key dimensions that help to differentiate between forms of self-regulation. The findings in this dissertation point towards two key dimensions that can be helpful in this regard, namely the degree of independence under which the child is showing regulation, and the types of measurements. I will discuss how the measures that are used the current dissertation map onto these two key dimensions, and how this may help our understanding of de development of self-regulation.

Degree of independence in regulation. Particularly in young children, when self-regulation is just emerging and still supported by parents, the degree of independence in regulation is an important dimension that should be taken into consideration when evaluating measures of self-regulation. Various theories on the early development of self-regulation postulate that a key feature of the development of self-regulation is a progression from externally imposed regulation to independent self-regulation (Kopp, 1982; Rothbart, Sheese, Rueda, & Posner, 2011). Most conceptualizations of self-regulation in toddlerhood include, to a certain degree, how well children are capable to modulate their behavior in response to request. For instance, compliance with parental and experimenter's requests during clean-up are used as a proxy for self-regulation (Denham, Warren-Khot, Bassett, Wyatt, & Perna, 2012). More formal tasks also measure children's compliance, either with the experimenter still being present (for instance during inhibition tasks in which children are not allowed to touch a toy, or have to keep a treat on their tongue without swallowing, used in Chapter 3), or with the experimenter leaving the room (for instance during the gift delay used in Chapter 2). So, measures of self-regulation in toddlerhood show considerable variation in the degree to which they call upon independent versus externally imposed regulation.

Differences in the degree of required independence are important when examining associations with other measures. In two chapters in this dissertation, I found that measures obtained in infancy were predictive of relatively intrinsic regulation, but not to extrinsic regulation. In Chapter 2, two attention measures predicted effortful control, but not compliance. To measure effortful control, I relied on a delay task, where the experimenter gave instructions and left the room. To measure compliance, I coded parent-child interactions during clean-up. The compliance procedure allows for more opportunities to control the child's behavior, as an adult remains present. In Chapter 3, fussing and maternal sensitivity predicted self-regulation in the preschool years, but not in toddlerhood. Self-regulation in toddlerhood predominantly comprised compliance, including compliance to clean up toys. Self-regulation in the preschool years was measured with various lab-tasks that tapped executive functions, such as the Dimensional Card Sorting Task, as well as an age-appropriate supervised delay task. Although the results of Chapter 3 are confounded with age, i.e., it may be easier to predict self-regulation at an older age, the two studies together do indicate that it is

useful to focus on relatively intrinsic self-regulation when researchers are interested in finding predictors of self-regulation.

Related to this topic is research focused on heterogeneity in the motivation that comes with compliance (Kochanska, Coy, & Murray, 2001), which shows that differences in the degree of dependence matter in young children. Moments of situational compliance, i.e., relatively instable moments of compliance that are contingent upon parental efforts to keep children maintained to the task, differ from so-called committed compliance, in which children fully embrace the task that is given to them by parents. For instance, infant attention regulation, i.e., distracting oneself, during the still face procedure, has found to be predictive of less situational (extrinsic) compliance and more committed (intrinsic) compliance (Hill & Braungart-Rieker, 2002). Overall, the results presented in this dissertation fit well within the body of literature that suggests that the degree of required independence is an important characteristic that should be taken into account when distinguishing forms of self-regulation in early childhood.

Type of measurement. As effortful control, executive functioning, and compliance stem from different research traditions, they are also measured in different ways. These differences in measurement may explain more differences in regulation than the differences in conceptualization of self-regulation per se. Effortful control is generally measured with questionnaires or assessed with tasks that involve dealing with problems within an emotional context. For instance, the inhibitory control subscale of the Child Behavior Questionnaire asks whether children can resist temptations, lower their voice, and wait in a line (Rothbart, Ahadi, Hershey, & Fisher, 2001). Additionally, research conducted by Kochanska and collaborators (2000) on effortful control includes tasks during which children have to wait before they can touch a snack, walk slowly, or take turns while building a block tower with an experimenter. Likewise, compliance is often measured during moments that elicit defiance in children, such as clean-up and electrocardiogram (ECG) electrodes placement (Denham et al., 2012; Stifter, Spinrad, & Braungart-Rieker, 1999), and, though less often, with questionnaires, such as the compliance subscale of the Infant Toddler Social Emotional Assessment (Carter & Briggs-Gowan, 2006) used in Chapter 2.

In contrast, executive functions are typically assessed with lab-based tasks that are conducted within an emotionally neutral environment. These tasks are often highly standardized, and typically measure accuracy and speed. For instance, the Stroop task assesses participants ability to inhibit a dominant response (reading the word on the screen) and activate a learned response (name the color of the ink of the word) (Stroop, 1935). Exceptions are so-called hot executive functions, which are assessed in situations that involve intense emotions or motivational interests (Zelazo & Carlson, 2012).

There is considerable overlap between measures from different research traditions when the same type of instrument is used. For instance, self-reported executive functions are strongly associated with self-reported effortful control (Bridgett et al., 2013). In addition, some lab tasks for measuring effortful control in toddlerhood are also used to assess executive functioning, such as the gift delay and the Shape Stroop task (Carlson, 2005). However, when comparing executive functions assessed through questionnaires with executive functions assessed through cognitive tasks, associations between both measures are often not significant, even though these measures stem from the same research tradition (Toplak et al., 2013). So, it is not necessarily the label, but the way in which self-regulation is measured that matters.

An important task for researchers is to examine whether findings with self-regulation measures that are conducted in isolated lab settings also translate into real life behavior. This is important for the scientific understanding of self-regulation, but it is especially pertinent for the development of interventions, as these should be designed to improve real-life behavior. Whereas questionnaires often measure real life day-to-day behavior and have a high ecological validity, most lab-based tasks measure the potentials of an individual in a carefully controlled setting. Observations and tasks that measure hot executive functions fall in the middle of this continuum: They provide more controlled measures of self-regulation, and they measure behavior that is more closely tied to real-life behavior. However, they are also limited by the relatively brief duration of assessments compared to ratings that assess day-to-day behavior. In addition, participants still have to adhere to externally laid out goals, whereas questionnaires typically also assess the ability to achieve self-formulated goals.

In Chapter 4, I noted that most knowledge regarding the development of inhibitory control comes from laboratory assessments. I therefore complemented this research by examining measurement invariance and the development of inhibitory control as assessed through questionnaires. The results showed that the development of parent-reported inhibitory control went through a similarly shaped development as lab assessed inhibitory control, although the magnitude of change seemed limited for parent-reported inhibitory control. In Chapter 5, I found no association between self-reported and lab-based self-regulation of parents, but both measures were similarly associated with reactive negative parenting practices. Although we were not able to test whether self-reported and lab-based self-regulation made a unique contribution

to reactive negative parenting, due to the small sample size in Chapter 5, it is certainly possible that both forms of self-regulation are uniquely related to parenting practices. For instance, Barkley and Murphy (2010) found that self-reported and lab-based self-regulation were each uniquely related to occupational problems.

Overall, a comparison between types of measures based on their ecological validity may be more beneficial in moving the field forward than comparing constructs such as effortful control and executive functioning. Such a distinction allows to examine how cognitive potentials and the ability to apply self-regulation in day-to-day life contribute to development.

Clinical Implications

Numerous studies have made it clear that self-regulation is associated with a wide range of outcomes later in development, including performance at school and psychological wellbeing. Interventions that target self-regulation early in development may therefore indirectly impact a broad range of domains. However, although it is convincingly demonstrated that self-regulation can be trained across the life span, there is little evidence that such trainings transfer into widespread benefits (Diamond & Ling, 2016; Melby-Lervåg & Hulme, 2013). In addition, it is unclear whether training self-regulation results in long-lasting effects (Diamond & Ling, 2016). The results in this dissertation provide three implications for interventions: (1) problems with self-regulation may be identified with the Dysregulation Profile; (2) early interventions targeting self-regulation may focus on visual attention and negative reactivity; (3) interventions focused on parents with poor self-regulation could target household chaos and should take broader environmental conditions into account.

Identifying children with dysregulation. The results in this dissertation (Chapter 6) demonstrate the usefulness of DP as a marker of developmental risks in young children. DP is typically administered with either the CBCL1.5-5 or C-TRF, which are completed before clinicians meet their new patients. Elevated scores on all three AAA scales could indicate that children experience difficulties with regulation, and also mark children who are seriously at risk in their development. DP can therefore be seen as a low-effort method to signal clinicians on possible regulation problems and severe problems in the early stage of the clinical assessment of preschool children.

Targeting self-regulation in early childhood. Although the effectiveness of early interventions on self-regulation are not well researched yet, it is possible that interventions on self-regulation are more effective when implemented in early childhood because of the vast development in this time (Hendry et al., 2016). The results of this dissertation point towards two individual precursors of self-regulation in infancy that could be the focus of early interventions. First, the results of this dissertation demonstrate that infant visual attention forecasts self-regulation. In the second half of the first year, features related to the executive attention network may form an important predictor for later self-regulation. There are indications that attention in infancy can be trained (Wass, Porayska-Pomsta, & Johnson, 2011). However, whether there is a causal relation between enhanced attention and self-regulation yet remains to be examined.

A more fruitful avenue for interventions may be to focus on negative reactivity. The results in the current dissertation also add to the growing body of literature demonstrating the interplay between negative reactivity and regulation in development (e.g., Blair, Berry, & Investigators, 2017; Ursache, Blair, Stifter, & Voegtline, 2013). Consistent with optimal arousal models, interventions for young children who show impairments in their ability for self-regulation could therefore target both reactivity and self-regulation.

An interesting group of interventions may be those that incorporate mindfulness (Zelazo & Lyon, 2012). These interventions are designed to train behaviors that promote self-regulation and at the same time tackle negative reactivity. Mindfulness is "the awareness that emerges through paying attention on purpose, in the present moment, and non-judgmentally to the unfolding of experience" (Kabat-Zinn 2003, p. 145). A small body of research has demonstrated the feasibility of adjusting mindfulness trainings in such a way that they are applicable to young children (e.g., Burke, 2010). For instance, preschool children can do a body scan by using a hula-hoop as an imaginary scanning machine (Zelazo & Lyon, 2012). Evidence for effectiveness in young children comes from a small study (*N* = 29) with a quasi-experimental pretest/posttest treatment and control design, that demonstrated that yoga combined with mindfulness promoted three indices of 3-to-5-year old children's self-regulation (i.e., attention, delay of gratification and inhibitory control; Raza et al., 2015).

Parental self-regulation and parenting. The results in the current dissertation also point towards the importance of parenting in the development of self-regulation, and highlight the role of parents' own self-regulation and the level of chaos in their house. In Chapter 5, I demonstrate that a household that is low in chaos may be helpful for parents with low self-regulation, as parents with relatively poor self-regulation living in a low chaotic house show less instances of reactive negative parenting. Interventions should therefore consider incorporating ways to reduce household chaos, in order

to increase the likelihood of lasting change in parenting practices for parents with poor self-regulation. It should also be noted that other studies have shown that environmental stressors that are more severe, or mount on each other, will impede functioning in most individuals (Evans, Li, & Whipple, 2013; Trentacosta et al., 2008). Taken this broader literature into account, the results add to a growing body of literature that demonstrates that environmental stressors should be addressed in parenting interventions.

Strengths, Limitations and Future Directions

The results in this dissertation provide a wide examination of factors that are related to the early development of self-regulation. I examined both individual and family factors that are related to self-regulation and dysregulation. In addition, I analyzed data from four unique longitudinal studies that covered the first years of life, which all had unique assets. Two studies included measures in infancy and one study included a particularly interesting sample of preschool children who were clinically referred for externalizing problem behavior. In all studies, I comprehensively examined self-regulation and dysregulation, either by taking a multi-method approach (Chapter 2, 3, 5 and 6) and/or by applying factor models (Chapter 4 and 6).

As with many studies on child development, an important limitation in this dissertation concerns the reliance on samples that are characterized by a higher socio-economic status, many Caucasian families, and traditional family structures (with the exception of the sample described in Chapter 6). The results of the studies in this dissertation should be replicated in more diverse samples to gain more insight into the early development of self-regulation of all children. For instance, in Chapter 4, I examine whether high levels of maternal sensitivity strengthen the association between infant fussiness and later self-regulation. This is in line with the bioecological perspective. In a more diverse sample, researchers could examine whether low levels of maternal sensitivity also strengthen the association between fussiness and later self-regulation. This would be in line with a differential susceptibility model, stating that individual differences are more noticeable in both low and high quality environments (Belsky, Bakermans-Kranenburg, & Van IJzendoorn, 2007).

Moreover, although almost all studies in this dissertation rely on a longitudinal design, precursors of self-regulation, i.e., visual attention, crying, fussing, and parenting, were measured only at one time-point. The fast development that characterizes the first year of human life comes with the implication that factors may have predictive power for a limited amount of time. Future research should examine which early predictors of self-regulation serve well as an early marker of self-regulation for an extended period of time. Related to this issue is the notion that all studies in this dissertation are correlational in nature, precluding me from drawing causal inferences. Also, I did not take the prenatal stage into consideration, even though prenatal risk factors such as maternal stress are found to have long lasting effects on development (e.g., Gutteling et al., 2005).

Lastly, this dissertation does not include any assessments of genetic or biological processes that are implicated in the development of self-regulation and the transmission of self-regulation from one generation to another. It is, for instance, possible that parents' self-regulation is related to their children's self-regulation because of the shared genes between parents and children, instead of the parenting practices that parents provide (i.e., passive gene-environment correlations). Studies utilizing an adoption design are particularly interesting to examine if parenting is uniquely related to children's self-regulation (Bridgett et al., 2018).

Concluding Remarks

By the time children reach school age, they went through a tremendous development in their ability for self-regulation. At the same time, children differ in the degree in which they are capable of self-regulation. Severe problems in self-regulation can be identified with the Dysregulation Profile, and provide a marker of developmental risks. Individual differences in self-regulation can be traced back to infancy: Both visual attention and negative reactivity in infancy predict later self-regulation. The findings in this dissertation point towards a changing role of parents in the development of their children's self-regulation. In infancy, when children still require ample support in self-regulation, it is of particular importance that parents notice the cues of their infant and respond timely and appropriately. In toddlerhood, parents have to give their children space to explore, and interfere sparingly. Parents' own self-regulation, and the level of household chaos, support parents in their parenting practices, and may partly explain why low self-regulation runs in families.

TABLE 1

Summary of Main Findings

Chapter	Main findings
2	- When all three measures of visual attention are taken into account, longer fixations and less variation in fixation duration in infancy (10 months) predict better effortful control, but are unrelated to compliance (2.5 years). - Disengagement neither predicts effortful control nor compliance.
3	- Infant fussing, crying, and maternal sensitivity in infancy (6 months) do not predict self-regulation in toddlerhood (1.5 years). - Moderate levels of infant fussing relate to enhanced self-regulation in the preschool years (4.5 years), but only for children of relatively sensitive mothers. For infants of less sensitive mothers, fussing is unrelated to later self-regulation. Crying does not predict preschool self-regulation.
4	- Parent-reported inhibitory control undergoes conceptual changes and increases at a decelerating rate across the preschool years (2.5-6.5 years). - Mothers and fathers play a similar role in the development of inhibitory control. More sensitivity and intrusiveness of both parents is associated with higher initial levels of inhibitory control. Lower levels of parental intrusiveness are associated with a faster growth of inhibitory control.
5	- Lower parental self-regulation, either measured as effortful control or executive functioning, predicts more reactive negative parenting practices in chaotic households. - In households characterized by low levels of household chaos, parents showed less reactive negative parenting practices.
6	- The Dysregulation Profile is best conceptualized as a broad syndrome of dysregulation that exists in addition to specific syndromes related to the Anxious/Depressed, Aggressive Behavior, and Attention Problems (AAA) scales. - The Dysregulation Profile is concurrently and longitudinally associated with markers of dysregulation (including lower task-based inhibitory control) and clinically relevant criteria, whereas the specific problems are more differentially related to those criteria.

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SUMMARY

The aim of this dissertation was to enhance knowledge concerning the early development of self-regulation, by (1) examining mean-level development, as well as early markers of self-regulation; (2) identifying family factors that might play a role in the development of self-regulation, including parental characteristics, parenting practices, and household chaos; and (3) examining problem behavior related to deficits in self-regulation in early childhood. These research questions were examined in five empirical studies utilizing four datasets.

The *first aim* of this dissertation was to examine mean-level development, as well as to identify early markers of self-regulation. The results show that visual attention and negative reactivity in infancy predict self-regulation later in development. Longer fixations and less variation in fixation duration in infancy (10 months) predict better effortful control, but are unrelated to compliance (2.5 years). Disengagement neither predicts effortful control nor compliance. In addition, infant fussing, crying, and maternal sensitivity in infancy (6 months) do not predict self-regulation in toddlerhood (1.5 years). However, moderate amounts of infant fussing are related to enhanced self-regulation in the preschool years (4.5 years), but only for children of relatively sensitive mothers. For infants of less sensitive mothers, fussing is unrelated to later self-regulation. Crying does not predict preschool self-regulation. In the preschool years (i.e., between 2.5 and 6.5 years), parent-reported inhibitory control undergoes both conceptual changes as well as mean-level development. Specifically, inhibitory control is partial scalar invariant over time, and increases in a decelerating rate.

The *second aim* of this dissertation was to identify family factors that might play a role in the development of self-regulation. The results show that parenting practices are related to the development of self-regulation, and that parents' behavior towards their young children is in turn predicted by their own self-regulation and the level of chaos in their house. In infancy, sensitivity in combination with moderate amounts of fussing predict enhanced self-regulation. In toddlerhood, sensitivity and intrusiveness predict higher levels of inhibitory control, but nonintrusiveness predicts a faster development of inhibitory control. Parents' own self-regulation and a low level of chaos in their household support parents in refraining from responding negatively towards their toddler's noncompliance.

The *third aim* of this dissertation was to examine problem behavior related to deficits in self-regulation in early childhood. Here, the focus was on problems that are identified with the Dysregulation Profile. In the preschool years, the Dysregulation Profile is best

conceptualized as a broad syndrome of dysregulation that exists in addition to anxious/depressed, aggression, and attention problems. In addition, the Dysregulation Profile can be seen as a marker of developmental risks, as it is associated with a wide range of clinically relevant criteria, both concurrently and longitudinally.

Together, the results of this dissertation demonstrate that both child, parent, and family factors contribute to the early development of self-regulation. These factors can already be assessed in infancy, toddlerhood, and the preschool years, which comes with relevant implications for prevention strategies aimed at promoting healthy self-regulation development.

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SAMENVATTING

Al op de basisschool kunnen de meeste kinderen langere tijd aan hetzelfde taakje werken, instructies voor taken opvolgen en ruzies met klasgenootjes oplossen. Kinderen hebben hier zelfregulatie voor nodig, oftewel het vermogen om eigen emoties, gedrag en aandacht te beheersen. Deze vaardigheid heeft zich in de jaren voor de basisschoolleeftijd in rap tempo ontwikkeld. Er zijn echter ook individuele verschillen in de mate waarin kinderen in staat zijn tot zelfregulatie. Deze individuele verschillen zijn belangrijk: kinderen die meer moeite hebben met zelfregulatie blijken later in verschillende domeinen (o.a. op school en in relaties met anderen) minder goed te functioneren. Het is dus belangrijk om goed in kaart te brengen hoe de vroege ontwikkeling van zelfregulatie verloopt en wat deze ontwikkeling voorspelt, zodat we vroeg in de ontwikkeling kunnen bepalen welke kinderen hulp nodig hebben bij de ontwikkeling van zelfregulatie vaardigheden.

In dit proefschrift heb ik gekeken naar processen die een rol spelen in de vroege ontwikkeling van zelfregulatie. Ik heb onderzoek gedaan naar kenmerken van baby's, ouders en het huishouden waarin kinderen opgroeien. Specifiek was het doel om meer inzicht te verkrijgen in: [1] de voorspellers en ontwikkeling van zelfregulatie, [2] gezinsfactoren die een rol spelen in de ontwikkeling van zelfregulatie en [3] probleemgedrag gerelateerd aan zelfregulatie. Dit proefschrift omvat vijf empirische studies die zijn uitgevoerd met vier verschillende datasets.

Wat is Zelfregulatie?

Zelfregulatie wordt door wetenschappers uit verschillende vakgebieden onderzocht, wat heeft geresulteerd in een brede waaier van vaardigheden die op de één of andere manier gerelateerd zijn aan zelfregulatie. In dit proefschrift kijk ik voornamelijk naar executieve functies, doelbewuste controle en gehoorzaamheid, welke ik hieronder kort toelicht. Voor de leesbaarheid van deze samenvatting noem ik deze vormen hierna allemaal zelfregulatie.

Vanuit de cognitieve en experimentele psychologie wordt zelfregulatie vaak gemeten als executieve functies. Dit zijn cognitieve vaardigheden die ondersteunend werken voor zelfregulatie; men heeft deze vaardigheden nodig om emoties, gedrag en aandacht te kunnen beheersen. Een voorbeeld van een executieve functie taak is de dag nacht taak (gebruikt in hoofdstuk 3). Bij deze taak krijgen kinderen afwisselend plaatjes te zien van een zon en een maan. Als kinderen het plaatje van de zon zien moeten ze "nacht" zeggen en visa versa: bij een plaatje van de maan moeten ze "dag" zeggen. Het idee achter deze taak is dat kinderen de neiging om een logische reactie te geven ("dag" bij

de zon en "nacht" bij de maan) moeten onderdrukken en in plaats daarvan een minder logische reactie moeten geven ("nacht" bij de zon en "dag" bij de maan).

Ontwikkelingspsychologen en pedagogen meten zelfregulatie vaak als doelbewuste controle. Doelbewuste controle is een onderdeel van temperament en omhelst vaardigheden om impulsen te beheersen, fouten op te merken en te plannen. Deze vaardigheden worden veelal gemeten met vragenlijsten of geobserveerd tijdens taakjes. Een voorbeeld van een dergelijke taak is de wachttaak (gebruikt in hoofdstuk 2, 3 en 6): tijdens zo'n taakje krijgt een kind een cadeau of een snoepje en de instructie om even te wachten. Een belangrijk verschil met de vaardigheden die gemeten worden vanuit een executieve functie benadering is dat de taken die ontwikkelingspsychologen en pedagogen gebruiken vaak lijken op situaties die ook in het echte leven kunnen plaatsvinden. Bij peuters en kleuters wordt gehoorzaamheid richting volwassenen, bijvoorbeeld tijdens het opruimen (gebruikt in hoofdstuk 2, 3 en 5), ook gezien als een vroege vorm van zelfregulatie.

Doel 1: Voorspellers en Ontwikkeling van Zelfregulatie

In hoofdstuk 2 presenteer ik de resultaten van een onderzoek waarvoor kinderen met 10 maanden en rond 2.5 jaar onderzocht zijn. De vraag was of het kijkgedrag in de babytijd, gemeten met een eye-tracker, kon voorspellen welke kinderen later betere zelfregulatie lieten zien. Eerdere onderzoeken hebben laten zien dat kijkgedrag inderdaad een voorspeller lijkt te zijn van zelfregulatie op latere leeftijd, maar deze onderzoeken hebben vaak gebruik gemaakt van relatief grove aandacht maten, die handmatig gecodeerd zijn. Met eye-trackers kunnen kleinere oogbewegingen worden gemeten. Uit het onderzoek beschreven in hoofdstuk 2 bleek dat lange fixaties (periodes waarin het oog niet beweegt) en weinig variatie in de fixatieduur bij baby's van 10 maanden oud betere zelfregulatie in de peutertijd voorspellen. De mate waarin baby's hun aandacht kunnen losmaken van datgene waarop ze focussen bleek geen voorspeller te zijn van latere zelfregulatie.

Hoofdstuk 3 omvat een onderzoek naar de voorspellende rol van jengelen en huilen in de babytijd voor zelfregulatie in de peuter- en kleutertijd. Alhoewel jengelen en huilen vaak als negatief gedrag worden gezien, laten meerdere onderzoeken zien dat enige mate van huilen en jengelen positief kunnen zijn voor de ontwikkeling van zelfregulatie. Kinderen zouden op momenten waarop ze overstuur zijn kunnen oefenen met emotieregulatie, wat vervolgens als basis kan dienen voor het ontwikkelen van meer complexe vormen van zelfregulatie.

Voor dit onderzoek zijn kinderen onderzocht toen ze 6 maanden, 18 maanden en 4.5 jaar waren. Uit het onderzoek kwam dat kinderen die enigszins jengelden in de babytijd in de kleutertijd (maar nog niet in de peutertijd) betere zelfregulatie lieten zien. Dit was alleen het geval voor kinderen van relatief sensitieve moeders (zie doel 2).

In hoofdstuk 4 lag de focus op de ontwikkeling van zelfregulatie. Specifiek onderzocht ik: [1] veranderingen in de *manier* waarop zelfregulatie zich uit bij jonge kinderen en [2] ontwikkeling in het *niveau* van zelfregulatie. Voor dit onderzoek zijn de data gebruikt van een longitudinaal onderzoek waarvoor kinderen vier jaar lang zijn gevolgd. Ik maakte gebruik van de antwoorden van vaders en moeders op een vragenlijst naar zelfregulatie die elk jaar is afgenomen. Omdat de kinderen in het onderzoek niet allemaal even oud waren hebben we data over vijf jaar: van 2.5 tot 6.5 jaar.

De resultaten lieten allereerst zien dat de manier waarop zelfregulatie zich uit maar beperkt veranderde tussen 2.5 en 6.5 jaar. Dit is belangrijk, omdat we alleen onderzoek kunnen doen naar de ontwikkeling van het niveau van zelfregulatie als er slechts geringe verandering plaatsvindt in de uiting van zelfregulatie. Als zelfregulatie zich heel anders uit op verschillende leeftijden vergelijken we namelijk appels met peren. Vervolgens liet ik zien dat het niveau van zelfregulatie stijgt, maar dat deze stijging over de tijd steeds minder snel gaat.

Doel 2: Familie Factoren Gerelateerd aan Zelfregulatie

Omdat baby's nog niet in staat zijn tot zelfstandige regulatie worden zij hierin bijgestaan door hun ouders. Dit proces van zogeheten co-regulatie vormt de basis waarop kinderen zelfstandige vormen van regulatie ontwikkelen. Sensitieve ouders zijn in staat om de signalen van hun kind op te merken, correct te interpreteren en er vervolgens adequaat op te reageren. Ik verwachtte daarom dat kinderen van sensitieve ouders beter in staat zijn om adequate zelfregulatie vaardigheden te ontwikkelen, omdat hun ouders beter kunnen helpen tijdens momenten waarop het nodig is om te reguleren. In hoofdstuk 3 laat ik zien dat baby's van sensitieve moeders inderdaad meer profijt lijken te hebben van momenten waarop ze jengelen: zij hebben in de kleutertijd (maar nog niet in de peutertijd) betere zelfregulatie vaardigheden ontwikkelt.

Gedurende de eerste levensjaren worden kinderen steeds zelfstandiger: Er is in steeds grotere mate sprake van *zelf*regulatie en in steeds mindere mate van *co*-regulatie. Kinderen hebben steeds meer de ruimte nodig om zelf te oefenen met reguleren. Ouders die dit niet geven passen hun opvoeding niet aan op de behoeften van hun kind. Dit is een kenmerk van een intrusieve opvoeding. Intrusieve ouders houden weinig

rekening met hun kind, ze leggen vaak hun wil op en geven hun kind weinig ruimte. In hoofdstuk 4 heb ik gekeken naar twee aspecten van opvoeding van peuters en kleuters: ouderlijke sensitiviteit en intrusiviteit. De resultaten uit dit proefschrift laten zien dat een opvoedingsstijl die gekenmerkt wordt door weinig intrusiviteit bevorderlijk is voor de ontwikkeling van zelfregulatie in de peuter- en kleutertijd (tussen 2.5 en 6.5 jaar). Sensitiviteit voorspelde deze ontwikkeling niet. De resultaten lieten daarnaast geen verschillen zien tussen het belang van opvoeding van moeders en vaders: beide waren even belangrijk.

De resultaten uit dit proefschrift wijzen op een veranderende rol van ouders in de ontwikkeling van zelfregulatie. Alhoewel de onderzoeken beschreven in hoofdstuk 3 en 4 niet direct vergelijkbaar met elkaar zijn, passen de resultaten wel bij het algemene idee dat regulatie een steeds zelfstandiger proces wordt, waarbij het in de babytijd belangrijk is dat ouders goed opmerken wat hun kind nodig heeft om hierbij te kunnen helpen (hoge sensitiviteit), maar waarbij het later steeds belangrijker wordt dat ouders hun kind de ruimte geven om zichzelf te kunnen reguleren (lage intrusiviteit).

Meerdere onderzoeken laten zien dat de mate waarin ouders zichzelf kunnen reguleren een belangrijke voorspeller is voor de mate waarin kinderen dit later zelf kunnen. Een deel van deze relatie tussen zelfregulatie van ouders en kinderen is genetisch, maar deze relatie wordt ook deels verklaard door de manier waarop ouders hun kind opvoeden. Ouders die moeite hebben met zichzelf te reguleren vinden het hoogstwaarschijnlijk ook lastiger om consequent oog te blijven houden voor de behoeften van hun kind. In hoofdstuk 5 verplaatste ik mijn aandacht daarom naar *ouderlijke* zelfregulatie en kenmerken van het huishouden waarin kinderen opgroeien.

De resultaten in hoofdstuk 5 zien dat ouderlijke zelfregulatie en huishoudelijke chaos samen een rol spelen in de manier waarop ouders reageren op opstandig gedrag van hun peuter. In relatief chaotische huishoudens reageren ouders met relatief lage zelfregulatie vaker negatief. In huishoudens die gekenmerkt worden door een lage mate van chaos was dit verschil niet zichtbaar: ouders waren in deze context minder geneigd om negatief te reageren, ongeacht het niveau van zelfregulatie.

Doel 3: Probleemgedrag Gerelateerd aan Zelfregulatie

In hoofdstuk 6 heb ik onderzoek gedaan naar probleem gedrag gerelateerd aan zelfregulatie, het Dysregulatie Profiel, gemeten met de angstig/depressief, agressief en aandachtsproblemen schaal van één van de meest bekende vragenlijsten voor ouders (Child Behavior Checklist). Als kinderen verhoogde scores laten zien op al deze drie schalen lijken zij moeite te hebben met de regulatie van de zogenoemde ABC: Affect, Behavior en Cognition. Eerder onderzoek heeft laten zien dat deze kinderen een risico lopen in hun ontwikkeling. Zo hebben zij een meer kans om verslavingen, psychosociale problemen en suïcidale neigingen te ontwikkelen.

In hoofdstuk 6 heb ik onderzoek gedaan naar dit profiel aan probleemgedragingen met data van een groep kleuters, waarvan een deel naar een polikliniek verwezen vanwege serieuze gedragsproblemen. Daarnaast heb ik gekeken naar de risico's die geassocieerd zijn aan dit profiel in de kleutertijd.

De resultaten in hoofdstuk 6 laten zien dat het Dysregulatie Profiel het best kan worden gezien als een breed, onderliggend probleem in de zelfregulatie. Dit onderliggende probleem bestaat náást aparte problemen van angsten en depressieve gevoelens, agressief gedrag en aandachtsproblemen. Dit betekent dat kinderen kunnen verschillen in hun mate waarin zij kwetsbaar zijn voor het ontwikkelen van specifieke problemen zoals angst en depressie, maar dat sommige kinderen ook kwetsbaar zijn voor het ontwikkelen van dysregulatie. Dysregulatie hing samen met allerlei vormen van probleemgedrag, zowel op hetzelfde moment, maar ook anderhalf jaar later.

Al met al lijkt het Dysregulatie Profiel te duiden op een onderliggend probleem in de zelfregulatie. Kleuters met deze regulatieproblemen lijken een risico te lopen in hun ontwikkeling en verdienen de aandacht van onderzoekers en mensen in de klinische praktijk.

Conclusie

Samengevat laten de resultaten in dit proefschrift zien dat zowel kindfactoren (kijkgedrag en jengelen), ouderfactoren (opvoeding en zelfregulatie) en gezinsfactoren (huishoudelijke chaos) direct of indirect een rol spelen in de ontwikkeling van zelfregulatie. Deze factoren kunnen al in de vroege kindertijd (babytijd, peutertijd en/of kleutertijd) gemeten worden. De resultaten in dit proefschrift kunnen daardoor bijdragen aan het vroeg signaleren en voorkomen van problemen in de ontwikkeling van zelfregulatie.

CURRICULUM VITAE

Sanne Geeraerts was born June 23th in Rotterdam. She first finished a bachelor program in law (Sociaal Juridische Dienstverlening) at the Hogeschool Utrecht. After that, she obtained a bachelor degree in Child and family studies (with honors) and two master degrees (clinical master track and the research master Development and socialization in childhood and adolescence; the latter cum laude and as best student of the year) at Utrecht University. During her studies she worked as a research- and teaching assistant for various projects. She also studied for six months at the University of Western Australia. To gain experience with clinical work, Sanne completed a one-year internship at the Erasmus University MC Infant mental health outpatient clinic. She simultaneously started her PhD project at the Clinical child and family studies department, which led to the present dissertation. Currently, Sanne works as a post-doc at the department of Youth and family studies at Utrecht University, focusing on intergenerational transmission of parenting practices.

LIST OF PUBLICATIONS

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Geeraerts, S.B., Hessels, R.S., Van der Stigchel, S., Huijding, J., Endendijk, J.J., Van den Boomen, C., … & Deković, M. (2019). Individual differences in visual attention and self-regulation: A multimethod longitudinal study from infancy to toddlerhood. *Journal of Experimental Child Psychology, 180*, 104-112.

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