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Introduction
Introduction

The development of self-regulation is one of the major challenges of a child's healthy and adaptive development (Colman, Hardy, Myesha, Raffaelli, & Crockett, 2006; McClelland & Cameron, 2011a). Unlike many other species, humans are not at the mercy of automatic, stimulus-response associations, but with the help of others develop the ability to inhibit dominant responses and actively select alternative behaviors (Conway & Stifter, 2012). Self-regulation develops over an extended period starting already in infancy (Bernier, Carlson, & Whipple, 2010), with a rapid developmental spurt in early childhood (Anderson, 2002), and further maturation in adolescence (Crone, 2009). Though children are innately inclined to strive for self-regulation (Bronson, 2000) and many intrinsic factors such as child temperament and neurological development are key to early self-regulation, extrinsic factors such as high quality interactions with caregivers are essential to nourish and channel self-regulatory development (Bronson, 2000; Fox & Calkins, 2003). In the current thesis, the contribution and interplay of parental and biological factors in the development of self-regulation in the preschool period are studied.

Self-regulation of behavior and emotions

It was long assumed that young children had little capacity to regulate their behavior and emotions. In the last decades, however, evidence accumulated that early indicators of self-regulation are already developing in the preschool years (Bernier et al., 2010; Eisenberg & Sulik, 2012). The foundation for self-regulation is laid in infancy. First, the regulation of autonomic arousal and sleep-wake cycles and primitive emotion and behavior regulation are developed (Calkins, Smith, Gill, & Johnson, 1998; Kopp, 1982). In this early period regulation is primarily reactive and externally
regulated. During the toddler and preschool years, regulation becomes more proactive, planful, and conscious, and the locus of control of regulation moves from external to internal (Bronson, 2000; Kopp, 1982). At the end of the toddler period demands and expectations about self-regulation increase and it is expected that children are capable of basic self-regulation in behavioral, physiological, and emotional domains (Kopp, 1982). However, individual differences exist in the extent to which children demonstrate competent self-regulation, even in non-clinical populations (Calkins et al., 1998).

Research on the development of self-regulation has been conducted from different theoretical frameworks (Bridgett, Oddi, Laake, Murdock, & Bachmann, 2012) and therefore a variety of concepts and definitions have been formulated. In general, self-regulation refers to the capacity to control and direct one’s attention, thoughts, emotions, and behavior (McClelland & Cameron, 2011b) and to utilize and adapt this capacity to different contextual and personal demands (Colman et al., 2006). Developmental researchers have studied self-regulation from a framework of effortful control, which is defined as the ability to inhibit a dominant response in order to activate a subdominant response (Kochanska, Murray, & Harlan, 2000; Rothbart, 1989a, 1989b; Rothbart & Ahadi, 1994; Rothbart & Bates, 1998). Other developmental studies have focused specifically on emotion-related self-regulation which includes the temperamental processes to monitor, manage, and change the experience and expression of emotions (Eisenberg & Sulik, 2012; Silk, Steinberg, & Morris, 2003). Neuroscientists and cognitive psychologists investigating self-regulation often use the term executive function to indicate the set of higher-level cognitive processes needed to regulate behavior and emotions (Bridgett et al., 2012). Socialization research has focused on self-regulated, committed compliance as a marker of development of behavioral regulation in early childhood (e.g., Denham, Warren-Khot, Bassett, Wyatt, & Perna, 2011; Kochanska, Coy, & Murray, 2001). The parsing of the construct into unique processes has led to greater understanding of how specific self-regulatory processes relate to specific consequences (Conway & Stifter, 2012) but the variation in definitions and frameworks applied in these studies has also hindered research in this field (McClelland & Cameron, 2011b). Recently, scholars have attempted to integrate the various frameworks and have found that there is substantial overlap between the constructs used in the different research traditions (Bridgett et al., 2012; McClelland & Cameron, 2011b; Zhou, Chen, & Main, 2012). For this reason, in the current thesis we approach self-regulation as a broad construct, including aspects of behavioral regulation such as child compliance behaviors and executive function, and an aspect of emotion regulation in the form of internalizing problems.
Determinants of self-regulation

Studies on the origins of self-regulation in children have focused on a broad array of possible determinants, including biological factors such as brain development, genetic heritability, and child temperament, but also environmental factors such as the quality of the early attachment relationship, parenting, and contextual factors.

The upsurge of methods to image brain structures and activity and to study the contribution of molecular genetic determinants of development has resulted in an increase in studies on the biological nature of the higher-order cognitive skills involved in self-regulation. For example, children born very preterm or with very low birth weight with abnormalities in white matter maturation in the brain show higher levels of cognitive and executive function problems in childhood and adolescence (Skranes et al., 2009; Woodward, Clark, Pritchard, Anderson, & Inder, 2011). Neuroscientists have long thought that mainly the prefrontal cortex is involved in self-regulatory capacities, but recent evidence indicates that integrity of the entire brain is necessary for optimal executive function skills (Alvarez & Emory, 2006; Jacobs, Harvey, & Anderson, 2011; Skranes et al., 2009). Individual differences in self-regulatory capacity may also be due to genetic variation. Studies on the heritability and familiarity of executive function have found evidence for a heritable, genetic basis varying in size depending on the specific measure of executive function and on the nature of the sample (Friedman et al., 2008; Jester et al., 2009; Polderman et al., 2007; Yamagata et al., 2005).

From a socialization perspective, the quality of parenting may be an important predictor of self-regulation. Because of the protracted development of self-regulation and the fact that children rely on their parents to help them regulate behavior and emotions in infancy, parents may play a crucial role in self-regulation development (Bernier, Carlson, Deschênes, & Matte-Gagné, 2012; Conway & Stifter, 2012; Kopp, 1982). Positive parenting in toddlerhood, characterized by maternal warmth, praise, and guidance, has been found to be concurrently associated with higher levels of compliance (Calkins et al., 1998) and to predict better self-regulation in preschool and school-aged children (Colman et al., 2006; Jennings et al., 2008). However, a meta-analysis on the concurrent association between maternal responsiveness and self-regulation in preschool indicated that they were not related (Karrman, Van Tuijl, Van Aken, & Dekovic, 2006). Also, more global measures of positive parenting, such as calm maternal responses to transgressions, were not found to be longitudinally related to executive function development in preschool (Hughes & Ensor, 2009). In contrast, maternal positive discipline and control strategies, such as distraction and appropriate limit setting, were concurrently and longitudinally related to higher levels of compliance (Karrman et al., 2006), better ability to delay gratification (LeCuyer & Houck, 2006), and more advanced executive function abilities (Schroeder & Kelley, 2010). Negative discipline which is characterized by negative control strategies and
physically punitive behavior was concurrently and longitudinally related to less advanced levels of self-regulatory functions such as compliance and emotion regulation (Calkins et al., 1998; Colman et al., 2006; Karreman et al., 2006).

Recently, researchers have attempted to combine the biological and socialization perspectives to better explain differences in child development. Studies focusing on genetics and studies focusing on brain development showed that not all children might be equally affected by environmental factors due to biological or genetic differences. The buffering potential of positive parenting has been demonstrated in a study on the association between low birth weight and the risk of externalizing and internalizing problems in childhood (Laucht, Esser, & Schmidt, 2001). Similarly, the development of self-regulation was more hampered by early negative parenting for preterm or low birth weight infants with a difficult temperament than in those without biological and temperamental risk (Poehlmann et al., 2011). In addition, an intervention study aimed to enhance maternal sensitive discipline found that in children with a 7-repeat allele of the DRD4 gene whose mothers showed the largest increase in sensitive discipline, externalizing problems declined the most (Bakermans-Kranenburg, Van Ijzendoorn, Pijlman, Mesman, & Juffer, 2008). These findings are congruent with the theories of differential susceptibility and biological sensitivity to context which state that variation in susceptibility to environmental influences such as parenting has an evolutionary advantage (Belsky, Bakermans-Kranenburg, & Van IJzendoorn, 2007; Ellis, Boyce, Belsky, Bakermans-Kranenburg, & Van IJzendoorn, 2011). It is therefore important to investigate the interplay of both biological and parental determinants in the study of the development of self-regulation.

Consequences of self-regulation

Self-regulatory capacity has been implied in various aspects of child and adult well-being. Self-regulation deficits are related to psychopathologies, such as autism and ADHD (Pennington & Ozonoff, 1996). On the other hand, higher levels of self-regulation lead to more social competence (Eisenberg & Sulik, 2012), more advanced moral development and empathy in childhood and adolescence (Feldman, 2007; Kochanska, Murray, & Coy, 1997), and higher levels of academic achievement and school success (McClelland et al., 2007; Obradovic, 2010). Because early self-regulation is involved in a variety of developmental consequences from childhood up to adolescence and adulthood, it is important to study the origins of individual differences in self-regulation across children.

The current study

The role of parental and biological factors in the development of self-regulation was studied in the Generation R Study. The Generation R Study was designed to identify early environmental and genetic determinants of growth, development, and health
from fetal life onwards, in Rotterdam, the Netherlands (Jaddoe et al., 2012). Detailed measurements were obtained in a subgroup of children of Dutch national origin, meaning that the children, their parents, and their grandparents were all born in the Netherlands to reduce confounding and effect modification by ethnicity. The participating children were born between February 2003 and August 2005. Children and their parents visited the research centre regularly for various behavioral and somatic measurements. The measurements used in the current thesis are summarized in Figure 1.

**Aim of this thesis**

The general aim of the studies presented in this thesis is to provide more insight into the influence of biological and parental factors in the development of self-regulation in the preschool years. Observational measures, parental reports, and biological measures were used to assess these associations.

The main focus of Chapter 2 is the association between infant-mother attachment quality and toddlers’ compliance and active resistance during a clean-up task. In Chapter 3 we examine the role of maternal stress during pregnancy, maternal discipline, and child dopamine-related gene polymorphisms in the development of compliance. A mediation model is tested with maternal discipline as the mediator in the association between maternal stress during pregnancy and child compliance. In addition, the moderating effect of child COMT rs4680 genotype and DRD4
polymorphism in the association between maternal discipline and compliance is explored. In Chapter 4 we study whether parenting influences executive function at preschool age independently or in interplay with corpus callosum length in infancy. Chapter 5 concerns the association between maternal sensitivity and child internalizing problems in the preschool period. We examine longitudinal and bidirectional associations between maternal sensitivity and child internalizing problems in two large population-based studies. In Chapter 6 the effect of maternal 5-HTTLPR on sensitive parenting is studied. Moreover, the moderating effect of child fearful temperament in the association between 5-HTTLPR and maternal sensitivity is examined. Against the background of our results, parental and biological determinants in the development of child self-regulation are discussed in Chapter 7.
References

**A**


**B**


**C**


**D**

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