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Curious minds: stimulating parent-child interaction to foster neurocognitive functioning in four- to eight-year-olds

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Citation
Spruijt, A. M. (2019, September 25). *Curious minds: stimulating parent-child interaction to foster neurocognitive functioning in four- to eight-year-olds*. Retrieved from https://hdl.handle.net/1887/77911

Version:	Publisher's Version
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Note: To cite this publication please use the final published version (if applicable).

Cover Page

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Issue Date: 2019-09-25

CHAPTER 1

General introduction

Adaptive behavior, or the ability to respond in a constructive manner to adjust to a situation, reflects a person's ability to meet the demands of everyday life. This behavior is known to depend largely on the development of Executive Functioning (EF): a broad concept that encompasses various neurocognitive functions that regulate thoughts, feelings and behavior, like inhibition, cognitive flexibility, and working memory, as well as the more complex functions such as problem-solving and planning (Diamond, 2013). Together with attentional control (sometimes considered to be part of the EF domain), social cognition, and language development, EF is essential for the goal-oriented and adaptive social behavior that is expected of children at school and at home (e.g. Best, Miller, & Jones, 2009; Diamond, 2013; Garon, Bryson, & Smith, 2008; Green, Bunge, Briones Chiongbian, Barrow, & Ferrer, 2017; Miller Singley & Bunge, 2014; Shala, 2013). Extensive interest in fostering the development of these functions during childhood stems from associations with quality of functioning in many important aspects of life, such as school performance, health, and job success (e.g. Diamond, 2013).

During the transition from dependence to greater autonomy, young children's neurocognitive development is influenced by the relationship with their parents and the conditions in their caregiving environment (Bernier et al., 2012; Diamond, 2013; Fox & Calkins, 2003). Children become more active participants in parent-child interactions as they reach primary school age, which leads to parents systematically having to increase their contingent instructions (i.e. following the child's lead) to adaptively challenge their child's skills (Conner & Cross, 2003). Parents require understanding of their children's changing developmental needs during the early school years to provide them with these supportive, age-appropriate contingent responses (Landry, Smith, Swank, & Guttentag, 2008). Educating parents in child neurocognitive development can better equip them to recognize their child's level of competence. With increased understanding of how their child reasons and learns, parents may be better able to facilitate neurocognitive development through parent-child interaction. Whether and to what extent parents can be educated to provide an optimal learning environment to facilitate the development of neurocognitive functions by adaptively challenging their child's skills during parent-child interaction, however, warrants further study (Bierman & Torres, 2016; Diamond, 2013).

The studies discussed in this thesis will focus on the associations between aspects of parent-child interaction and two major neurocognitive components underlying goal-oriented and adaptive social behavior: an attentional/ executive component and a social cognitive component.

Executive functions are adaptive neurocognitive processes fundamental to problem-solving that enable us to plan, guide and control goal-oriented behavior (Best et al., 2009). ***Attentional control*** is tightly intertwined with executive functioning and entails both the ability to actively focus on one thing without being distracted (i.e. focused attention) and the ability to maintain attention over prolonged periods of time (i.e. sustained attention) (Cohen, 2014; Garon et al., 2008). There is general agreement that the three core executive functioning components inhibitory control, working memory and cognitive flexibility are interrelated but can be distinguished (Miyake et al., 2000). Inhibitory control often refers to the ability to suppress a dominant or automatic response also known as response inhibition, but it also encompasses an attentional component known as interference control: the ability to selectively attend to certain stimuli and ignore irrelevant stimuli (Diamond, 2013). Working memory refers to the ability to temporarily hold, manipulate and control information in the mind (Garon et al., 2008), and cognitive flexibility is the ability to shift between mental sets or tasks and adapt to changing situations (Best et al., 2009).

Social cognition can be described as the neurocognitive mechanisms underlying social competence, including the ability to interpret, predict, and empathize with others' mental states and behaviors (Baron-Cohen et al., 1999). Though linked with executive functioning and attentional control, research has shown that social cognition can be conceptualized as a separate construct. For instance, research in clinical populations has shown impairments in the social cognitive component but not in the attentional/executive component and vice versa (see Beauchamp & Anderson, 2010). Together with adequate communicative skills, such as expressive and receptive language, all these neurocognitive functions are fundamental to social interaction and reasoning and problem-solving in general.

In this thesis I will address how parent-child interaction is related to the child's level of attentional control, executive functioning and social cognitive development during the early school-age years. Furthermore, I will address whether educating parents how to adapt parent-child interactions to support neurocognitive development improves the interaction with their child, and subsequently can promote the development of the neurocognitive functions underlying children's goal-oriented and adaptive social behavior.

Neurocognitive functions during the early school-age years

Even though rudimentary forms of attentional control, executive functioning and social cognition already emerge early in life, they do not reach their full potential until much later. For instance, infants as young as 9 months of age are already capable of updating information in their working memory, while the ability to retain large amounts of information and mentally manipulate this information continues to develop well into adolescence (see Diamond, 2013). Early childhood is known to mark a time of rapid growth in children's neurocognitive development (e.g. Casey, Tottenham, Liston, & Durston, 2005). Nonetheless, a growing body of neurodevelopmental research indicates that a substantial part of the development of attentional control, executive functions and social cognition takes place after the age of four, designating the school-age years also as an interesting developmental period for researching possible influences from the child's environment (see Best & Miller, 2010; Peterson, Wellman, & Slaughter, 2012). Neurocognitive development during the school-age years appears to be especially rapid between ages five and eight and becomes more moderate between ages nine to twelve, suggesting the early school years may be of particular interest as a developmental window of opportunity for environmental influences (Korkman, Kemp, & Kirk, 2001; Korkman, Lahti-Nuuttila, Laasonen, Kemp, & Holdnack, 2013; Romine & Reynolds, 2005). During the early school years children also experience many novel challenges, such as dealing with unfamiliar adults and children, staying seated in class, and joining group discussions, which ask for adaptive behaviors and reasoning skills. Thus far, however, most studies on the normal development and enhancement of neurocognitive functions have mainly focused on the preschool years (Best et al., 2009). In this thesis I will focus on the early school years, specifically on four- to eight-year-olds.

Fostering neurocognitive development

Different environmental influences such as sensory stimuli, hormones, parent-child interactions or family stress may result in differential effects on neurocognitive development. This is nicely captured by the description of Kolb & Gibb (2011, p. 265): "the development of the brain reflects more than the simple unfolding of a genetic blueprint but rather reflects a complex dance of genetic and experiential factors that shape the emerging brain". Adverse environmental conditions may have a negative impact on developing neurocognitive functions, but optimal environmental conditions may provide opportunities to foster development. As Bjorklund (2018) describes in his overarching theory of cognitive development ***(Evolutionary developmental psychology)***,

children are equipped with developing neurocognitive mechanisms such as executive functioning, which are designed to be sensitive to environmental factors in order to learn and achieve adaptive behavior. It has been suggested that biological maturation may especially be important in the development of neurocognitive functions in young children, whereas environmental factors may be more influential in older children, who are becoming more active participants during interactions due to developmental phase (Best et al., 2009).

Social interaction is essential to the development of neurocognitive functions; an insight posed by Vygotsky (1978) no less than 40 years ago. Significant others, like parents and teachers, play an important role in shaping the child's environment. In this thesis I will focus on the role of parents in fostering the development of neurocognitive functions through parent-child interaction. Parental behavior has been shown to be a valuable factor in promoting the development of neurocognitive functions in their children during infancy and the pre-school years through adequate stimulation, support and practice (e.g. Fay-Stammbach, Hawes, & Meredith, 2014; Lengua, Honorado, & Bush, 2007; Spinrad et al., 2007), and is assumed to continue to play a very important part during the early school years and beyond. Parents provide their children with learning opportunities to practice and internalize functions that will help them to control their behavior, like attention, executive functions, and social cognition, and are responsible for communicating social rules (e.g. Attili, Vermigli, & Roazzi, 2010; Bennett, Farrington, & Huesmann, 2005; Diamond, 2013; Vygotsky, 1978). Parents can help their children to take a step back during problem-solving and reflect upon the problem at hand, helping them to practice these skills (Giesbrecht, Muller, & Miller, 2010). By analogy, just as a parent holds onto a child learning to ride a bike before letting go and letting him experience the balancing on his own, so may parents help children experience executive functioning skills before they can adequately implement these skills themselves. For instance, asking questions to focus the child's attention on important aspects of the problem that the child was not yet able to notice on its own, will challenge the child's mental representations and will facilitate internalization of attentional control. As such, parent-child interaction is assumed to play an important role in children's neurocognitive development.

Parents as change-agents

Attempts to foster the development of children's neurocognitive functions have especially proven to be successful when including social interactive components in the real-life

social context, with children being guided by a familiar adult (e.g. Bierman & Torres, 2016; Engelmann, Neuhaus, & Fischer, 2016; Hofmann et al., 2016). Furthermore, repetition appears to be essential for the best results, in which skills are continually challenged with increasing demands, adaptive to the child's age and ability (e.g. Bergman Nutley et al., 2011; Diamond, 2013; Holmes, Gathercole, & Dunning, 2009; Thorell, Lindqvist, Bergman Nutley, Bohlin, & Klingberg, 2009). This places parents in an ideal position, provided that they are informed about different ways to help stimulate their child's neurocognitive functioning, adaptive to his or her age and ability, and that they will continually stimulate these aspects at home. Thus far, the majority of studies linking parenting dimensions and children's neurocognitive development focus on parent-child interactions during infancy and the preschool years (e.g. Fay-Stammbach et al., 2014) even though the fostering influence of parents on neurocognitive development may be equally important at later ages.

Parenting dimensions that have been associated with neurocognitive development in younger children include sensitivity, i.e. parents' ability to perceive and adequately respond to their child's signals, and scaffolding, i.e. providing their child with structure (for a review, see Fay-Stammbach et al., 2014). In this thesis I will focus on the associations between children's neurocognitive functions and two aspects of parental sensitivity: ***supportive presence***, referring to affective and supportive caregiving, and ***intrusiveness***, referring to negative and controlling parenting behaviors interfering with the child's autonomy (Dotterer, Iruka, & Pungello, 2012). In addition, caregivers use scaffolding to enable the child to gain control over his or her cognitive performance and behavior, basically helping the child to engage in a complex task by providing structure when needed, either verbally (e.g. asking questions) or non-verbally (e.g., attention redirection behaviors) (Lewis & Carpendale, 2009). In this thesis I will also focus on the associations between children's neurocognitive functions and parental ***verbal scaffolding***, which can be defined as the parental input during parent-child interaction promoting independent problem-solving and learning (Dieterich, Assel, Swank, Smith, & Landry, 2006; Mermelshtine, 2017). Verbal input can be subdivided into directive (i.e. telling the child what to do) and elaborative verbalizations (i.e. comment on the child's own course of action). Directive verbalizations leave little room for the child to reflect on the problem on his own, while elaborative verbalizations evoke self-guided exploration and conceptual thinking (Bibok et al., 2009; Bonawitz et al., 2011). During elaborative verbal scaffolding parents provide their children with age-appropriate contingent responses (i.e. they follow the child's conversational lead), respecting the child's autonomy and

stimulating explorative behavior. A specific scaffolding strategy to enhance effective self-guided exploration is the use of open-ended and metacognitive questioning when asking for explanations, such as "Why do you think this is happening?" (Hmelo-Silver & Barrows, 2006). In this thesis I am specifically interested in the associations between parental questioning style and children's neurocognitive functions.

Adaptive parenting

The current thesis aims to investigate the associations between parent-child interaction with children's attentional control, executive functioning, social cognition, and reasoning skills, a higher order executive functioning component, in four- to eight-year-old boys and girls. It is believed that small improvements in neurocognitive skills may result in large benefits regarding outcomes in later life, as self-control in childhood follows a gradient linked to outcomes such as better health, less substance dependence, and less criminality (Moffitt et al., 2011). This emphasizes the importance of an optimal environment to foster the development of neurocognitive functions in young children. In comparison, one could provide a sapling with sufficient water and nutrition and it will grow, but provide optimal care adaptive to the individual tree and it will thrive.

However, the development of neurocognitive functions is not only influenced by, but also reciprocally influences the interactions with others, illustrating the subtle nature of these interactions between parent and child and child development. According to the *Evolutionary developmental psychology* perspective (Bjorklund, 2018), each stage of child development is functional in adapting to the environment and learning complex neurocognitive skills. For instance, children's immature cognition may play a role in evoking certain parenting behaviors necessary for development, as adults have been shown to attribute positive affect more frequently to children expressing some forms of immature cognition compared to more mature children (see Bjorklund, Periss, & Causey, 2009). This suggests some aspects of children's immature cognitive development may evoke more parental investment as parents either consider it endearing or are triggered to stimulate their child to catch up in development. Dubas (2009) extended this view with the notion that inappropriate overinvestment of parents may, however, become maladaptive, suggesting: "…a saturation point for investment in children has been reached and that at some point the level of involvement begins to do more harm than good" (p. 144). This would suggest that non-linear effects may represent the best fit to depict parental influence on child development (Kiel, Premo, & Buss, 2016). It is important to learn more about these subtle associations between parent-child interaction and

children's neurocognitive development, as they are reciprocal in nature and define future quality of functioning in many important aspects of the child's life.

Age and gender may affect the way neurocognitive functions are related to and stimulated through parent-child interaction. At different ages and developmental stages, children may need customized stimulation and guidance adapted to the situation, their needs, and the task at hand. For instance, parental directiveness has been shown to have a positive effect on cognitive development in toddlers, but this effect reversed after age four, in line with the child's diminished need for structure (Landry et al., 2000). Individual differences between boys and girls may cause different needs for parental guidance and can also result in a differential impact of environmental influences on child behavior (Rutter, Caspi, & Moffitt, 2003), similar to the shifting associations between parenting and child behavior with age (Bradley, Pennar, & Iida, 2015). Adaptive and supportive parenting requires parental understanding of changing developmental needs during the early school years (Landry et al., 2008). Parents may become more involved in their children's learning when they are educated about how their child reasons and learns, and how neurocognitive functions develop (Gleason & Schauble, 1999). Educating parents about their children's neurocognitive development may result in them being better equipped to recognize their child's level of competence and allow them to elicit optimal development by adaptively challenging their child's attentional control, executive functioning, reasoning and social cognitive skills during daily interactions. This raises the question of whether key aspects of parenting strategies are related to attentional control, executive functioning, reasoning and social cognition during the early school years, and to what extent age and gender moderate these associations. Consequently, it also raises the question whether parents can be educated on the neurocognitive development of their children to adjust their daily interactions with their child, in order to provide an optimal environment to adaptively foster the development of these functions.

AIMS AND STRUCTURE OF THIS THESIS

The central aims of this thesis are: (i) to explore the associations between parent-child interaction with children's attentional control, executive functioning and social cognition in four- to eight-year-old children (**Chapter 2 and 3**); (ii) to investigate the impact of age and gender on the associations between parent-child interaction and neurocognitive functioning in four-to eight-year-olds (**Chapter 2 and 3**); (iii) to explore to

what extent parents can be educated to enhance their supportive presence, intrusiveness and questioning style in parent-child interaction (**Chapter 4 and 5**); and (iv) to explore whether improved parent-child interaction results in enhanced neurocognitive functioning (**Chapter 4**) and reasoning (**Chapter 5**) in their four-to eight-year-old children.

Curious Minds: Aims, design and procedures

The research described in this thesis was conducted as part of the Curious Minds Consortium. The Curious Minds Consortium is a collaboration of seven Dutch and Flemish research institutes studying the development of science and technology reasoning skills and exploratory behavior in children in the context of excellent learning environments (Van Geert, 2011). The studies described in this thesis are embedded within the Leiden Curious Minds program: a longitudinal program investigating the development of neurocognitive functioning in primary school-aged children in the Netherlands, and the effects of a compact psycho-educational parent and a teacher program.

Design. The Leiden Curious Minds program uses a pre-test post-test care-as-usual control group design (see Figure 1). Participants in the Leiden Curious Minds program are typically developing children between four and eight years of age, their parents and their teachers. Parents of 404 children from the lowest four grades of two Dutch primary schools were invited to participate in this Curious Minds cohort. Of the 233 participating children, 95 took part in the teacher program part of the program and were not included in the studies described in this thesis. The remaining students (*N* = 138) were randomly assigned to either the parent educational program condition (*N* = 69) or the control condition (*N* = 69).

Procedures. Children's neurocognitive functions were measured at baseline and after the parent educational program was completed: (i) attentional control; (ii) executive functioning; (iii) social cognition; (iv) social reasoning level; and (v) scientific reasoning, using paper-and-pencil tasks, computer-based performance tasks, and hands-on tests during individual test sessions at school. Parent and teacher reports on social behavior at school and at home were also obtained. Parental strategies were measured on four

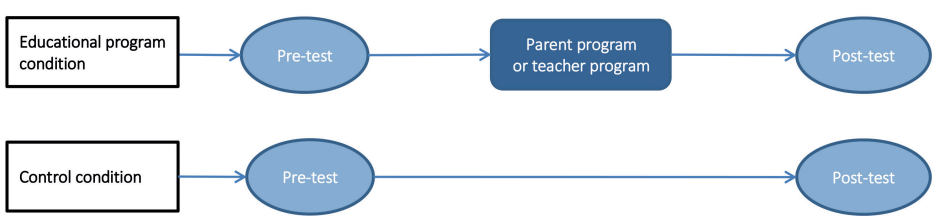

Figure 1. Design of the Leiden Curious Minds study.

dimensions at baseline and after the parent educational program was completed: (i) supportive presence; (ii) intrusiveness; (iii) question format; and (iv) question category, using observational data of parents' problem-solving interactive behavior with their child collected during home visits. Children and their parents were randomly assigned to either task version A or task version B of each task at pre-test, which were reversed at post-test to avoid test-retest learning effects. Pre-test baseline data were collected in the period between November 2013 and February 2014 (school 1) and between May and June 2014 (school 2). Post-test data were collected in the period between June and July 2014 (school 1) and between January and February 2015 (school 2).

Parent educational program. The Curious Minds parent educational program consisted of four, monthly group-sessions of approximately two hours each at the child's school and was provided by a skilled clinical neuropsychologist specialized in child and adolescent neurodevelopment. The content of the program was inspired by the Vygotskian principles of the Tools of the Mind curriculum for pre-school children (Bodrova & Leong, 2007; Diamond, Barnett, Thomas, & Munro, 2007), which focuses on supporting and scaffolding the development of cognitive, social-emotional and self-regulatory skills necessary for adaptive behavior and learning, using a familiar adult in a real-life setting as a change agent. The aim of the program was twofold: (1) to educate parents to recognize and foster the attentional control, executive functioning and social cognition in their children; and (2) to stimulate their children's explorative behavior and reasoning abilities, by teaching parents how to scaffold their children's experiences and by practicing this during home assignments. Each session focused on a specific (neuro) cognitive mechanism, for which parents received basic information about development, illustrations using everyday examples of parent-child interaction and a workbook with corresponding home assignments. These home assignments were discussed during the following session, allowing parents to learn from the trainer's feedback and each other's day-to-day experiences.

Outline of this thesis

Chapter 2 discusses the results of a cross-sectional study focusing on the associations between child attentional control and executive functioning with parental supportive presence, intrusiveness and questioning style. At different ages, children need parental stimulation and guidance adapted to the situation, their needs, and the task at hand. The associations between aspects of parenting behavior and child behavior have been shown to shift with age (Bradley, Pennar, & Iida, 2015). That is why in this study, both

linear and curvilinear associations between parental strategies and child neurocognitive functioning were examined, as well as the moderating effect of age. We hypothesized that supportive and non-intrusive behavior of parents and parents who scaffold the interaction with their child by asking more open-ended and elaborative questions have children who show better attentional control and executive functioning.

Chapter 3 examines whether the different aspects of parental strategies (i.e. supportive presence, intrusiveness, and the amount and type of questions parents ask their children) are associated with various aspects of children's social competence (social cognition and social behavior at home and at school). We assumed that gender and age would influence the social interaction between parents and children and the development of social (cognitive) skills. Therefore, we examined to what extent (1) these parental strategies mediated the relation between gender and social competence (differential socialization model) and (2) whether gender and age moderated these relations, distinguishing a differential susceptibility model (for better and for worse) from a diathesis-stress model (for worse).

Chapter 4 evaluates whether the Curious Minds parent educational program was successful in improving parental supportive presence and intrusiveness by educating parents about their child's neurocognitive development and practicing ways to foster neurocognitive functions during daily parent-child interactions using home-assignments. We hypothesized that parents in the educational program condition would show greater improvements in parental support and intrusiveness than parents in the control condition. As these parenting strategies have been shown to be associated with children's attentional control and executive functioning, we explored whether this would result in improved attentional control and executive functioning in their children.

Chapter 5 evaluates whether the Curious Minds parent educational program was successful in improving the manner in which parents scaffold their children's experiences by enhancing their questioning style. Furthermore, we explored if this resulted in improved social and scientific reasoning, as scaffolding has been shown to be associated with children's reasoning skills. We hypothesized that parents in the educational program condition would ask more open- than closed-ended questions and more elaborative questions than parents in the control condition, which would potentially result in improved social and scientific reasoning in their children.

Finally, **Chapter 6** reviews the conclusions of the studies presented in this thesis, implications for future research and recommendations to improve educational programs for parents to foster the neurocognitive development in their children.

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