Aggression in infancy and toddlerhood: the roles of prenatal risk, parenting behavior and cognition

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SUMMARY AND GENERAL DISCUSSION

Chapter 6

Besides the large societal impact of externalizing behavior problems (Gielen & Akkermans, 2019; Hoeffler, 2017; McCollister, French, & Fang, 2010; Moolenaar, Vlemmings, van Tulder, & de Winter, 2019), aggressive behavior during early childhood has been related to a wide range of negative developmental child outcomes, including delinquency, internalizing behavior problems, school dropout, and problems in academic achievement during school age, adolescence and adulthood (Brennan, Shaw, Dishion, & Wilson, 2012; Broidy et al., 2003; Campbell, Spieker, Burchinal, & Poe, 2006; Mesman, Bongers, & Koot, 2001). Because interventions aiming at prevention or reduction of externalizing behavior problems are most effective when carried out early in life (Fossum, Handegard, Adolfsen, Vis, & Wynn, 2016), a further understanding of the underlying mechanisms of aggressive behavior during the first years of life is essential. The main aim of the current dissertation was to gain more insight into associations between specific environmental influences (i.e. prenatal risk and parenting behavior), temperamental negative affect and specific self-regulatory aspects of cognition in relation to the development of aggressive behavior during infancy and toddlerhood.

Early development of aggressive behavior

Physical aggression can already be observed during the first year of life, as soon as children have gained the motor skills to use force (Hay et al., 2010). Use of physical aggression increases from infancy until around the second birthday and typically subsequently decreases during the following years (Alink et al., 2006; Nærde, Ogden, Janson, & Zachrisson, 2014). However, it has been found that not all children follow this specific pattern of physical aggression. Studies examining distinct developmental trajectories of aggressive behavior identified several patterns during early childhood. Studies so far did not include children before 1.5 years of age. Therefore, the first aim of this dissertation was to examine the distinct developmental patterns of physical aggression from infancy to toddlerhood.

Previous studies focusing on the development of physical aggression from 1.5 years onwards have frequently identified three developmental pathways: a low-stable, a moderate-increasing and a high-increasing or high-stable trajectory of physical aggression (Huijbregts, Séguin, Zoccolillo, Boivin, & Tremblay, 2008; Mazza et al., 2017; Wildeboer et al., 2015). As described in Chapter 2, we found three trajectories between age 12 months and 30 months as expected based on earlier findings: the majority of children were assigned to a low-stable group (65.7%), a small part had a low-increasing trajectory (18.6%), and a minority of the children displayed a high-stable trajectory (3.5%). In addition to these three expected, a fourth trajectory was found (12.2% of the children): this group of children followed a moderate-decreasing pattern, showing moderate levels of physical aggression at 12 months, which decreased up to 30 months. Thus, a previously unidentified trajectory was found at this specific age range. This group of infants possibly shows physical aggression as part of exploratory behaviors rather than being instigated by negative emotions (Lorber, Del

Vecchio, & Slep, 2018). Whereas increased motor skills might, on the one hand, underlie an increase in physical aggression during toddlerhood (Hay, 2017), for the group of children with declining levels of physical aggression, an increased repertoire of behavior might also lead to other behavioral options. At the same time, this behavior is regulated by developmental processes like the increasing ability to realize the impact of one's behavior on other people, associated with the ability to feel empathy (Hughes & Leekam, 2004). In addition, the decrease in aggressive behavior from infancy to toddlerhood more generally also underlines the role of cognitive maturation (Adolph & Berger, 2015). Overall, our results showed that differential development of physical aggression already starts at (or before) 12 months of age.

Associations between early cognition and aggressive behavior

Cognitive functioning is one of the aspects of self-regulation and is important for adequate behavioral functioning (Beauchamp & Anderson, 2010; Calkins & Keane, 2009; Dodge & Pettit, 2003). Studies have frequently shown associations between less developed cognitive functions, including aspects of executive functions, attention, language skills, and social cognition, and elevated levels of aggression or externalizing behavior problems (Bellanti & Bierman, 2000; Menting, van Lier, & Koot, 2011; Olson, Choe, & Sameroff, 2017; Olson, Lopez-Duran, Lunkenheimer, Chang, & Sameroff, 2011; Towe-Goodman, Stifter, Coccia, Cox, & Investigat, 2011). However, most research so far has been conducted during preschool or school age examining cognitive functioning. Therefore, the second aim of this dissertation was to examine associations between (the development of) cognition and (the development of) aggressive behavior during infancy and toddlerhood.

Executive functions. Regarding executive functioning, it was first investigated whether the level of inhibitory control was related to the level of aggressive behavior and the identified developmental trajectories of physical aggression from infancy to toddlerhood. In line with research during preschool and school age (Ellis, Weiss, & Lochman, 2009; Olson et al., 2017), our results described in Chapter 2, 3 and 5 showed that deficits in inhibitory control are associated with aggressive behavior during infancy and toddlerhood. Specifically, children with lower levels of inhibitory control during infancy (12 months) showed higher levels of physical aggression during infancy (12 months) and toddlerhood (20 months; described in Chapter 3). In relation to the developmental aggression trajectories (as described in Chapter 2**)**, it was shown that children with lower levels of inhibitory control at 12 months more often followed an aggression trajectory showing moderate levels of aggression during infancy, followed by a decrease in physical aggression during toddlerhood, compared to a low-stable trajectory. In addition, it was shown that children showing an increase in aggressive behavior from infancy to toddlerhood showed a persistent pattern of relatively low inhibitory control from age 12 to 30 months compared to the low-stable group. In line with this result, relatively low inhibitory control at 30 months was related to a higher level of aggressive behavior at the same age (described in Chapter 5**)**. These

results clearly suggest that children's inhibitory control is an important cognitive function associated with the development of aggressive behavior during the first years of life. Inhibitory control is one of the first executive functions to develop (Garon, Bryson, & Smith, 2008), which may therefore have substantial impact on children's early regulation of social behavior.

Our inhibitory control measures involved affective and motivational elements, also known as 'hot' contexts. In the literature a distinction is often made between 'hot' and 'cool' aspects of executive functioning (Seguin, Arseneault, & Tremblay, 2007; Zelazo & Carlson, 2012): 'hot' cognitive processes are triggered by emotional or motivational contexts, whereas 'cool' cognitive functions operate in more emotionally neutral situations. Studies which examined these differential aspects of inhibitory control in relation to externalizing behavior problems in older children found mixed results: whereas some studies only found relations between 'cool' aspects and behavior problems, others emphasized the importance of 'hot' inhibitory control (Kim, Nordling, Yoon, Boldt, & Kochanska, 2013; O'Toole, Tsermentseli, Humayun, & Monks, 2019; Poland, Monks, & Tsermentseli, 2016). As our inhibitory control measures involved affective and motivational elements, our results suggest a role of 'hot' aspects of inhibitory control in regulating aggressive behavior: infants and toddlers who are less able to suppress impulses and dominant responses in situations that generate motivation or emotion seem to have problems regulating their behavior in an effective way (Garon et al., 2008). These children are less able to withhold maladaptive behavior during social interactions (which, per definition, involved affective components), which could result in aggressive acts.

Attention. In addition to inhibitory control, it was examined whether attention was related to the level of aggressive behavior and the identified developmental trajectories of physical aggression from infancy to toddlerhood. It was found that lower levels of attention at 12 months and an increase in attention from 12 to 30 months were related to a greater likelihood to follow the moderate-decreasing aggression trajectory compared to the low-stable group (described in Chapter 2). The increase in attention was preceded by relatively low levels of attention in infancy compared to the low-stable group, which normalized to comparable levels of attention into toddlerhood. Attention at 30 months was not related to the level of aggressive behavior at the same age (Chapter 5). In line with previous studies at older ages (Bellanti & Bierman, 2000; Hill, Degnan, Calkins, & Keane, 2006), these results suggest that deficits in attention during infancy are related to deviating patterns of aggressive behavior. It is hypothesized that children who are less able to switch and sustain attention are worse at modulating their emotional experiences by redirecting attention when stimuli cause negative feelings. In addition, young children with problems in sustaining attention might miss or have problems in recognizing relevant social cues and signals in interaction with others (Murphy, Laurie-Rose, Brinkman, & McNamara, 2007). These children more often show less adequate adaptive social behavior including higher levels of aggression. In addition, the results suggest that maturation of attention plays a role in behavioral

change - characterized by a decline in aggression (Adolph & Berger, 2015). While attention improved in this group of children from infancy to toddlerhood, physical aggression decreased in this period to a low level.

Language skills. First, we examined whether vocabulary was related to the identified physical aggression trajectories from infancy to toddlerhood. As described in Chapter 2, children with less developed vocabulary at 12 months, but also with poorer vocabulary between age 12 and 30 months, were more likely to follow the low-increasing trajectory compared to the low-stable trajectory. We also examined the relation between vocabulary at 30 months and aggressive behavior at the same age (see Chapter 5), and again found that children with a less developed vocabulary show more aggressive behavior during toddlerhood. Thus, our results are largely in line with those of other studies investigating associations between language development and aggressive behavior during toddlerhood and preschool age (Dionne, Tremblay, Boivin, Laplante, & Perusse, 2003; Estrem, 2005; Girard et al., 2014). Children who have less well developed language skills might be less able to communicate with others about their needs and desires, resulting in more frustration and higher levels of behavioral problems (Keenan & Shaw, 1997).

Social cognition. Regarding social cognition, we examined the relation between precursors of theory of mind and the level of aggressive behavior during toddlerhood (Chapter 4). Theory of mind is one of the core social-cognitive skills, a necessary skill to adequately explain and predict behavior of other people (Baron-Cohen, Leslie, & Frith, 1985), and which has consistently been related to aggressive behavior during preschool and school age (Capage & Watson, 2001; Olson et al., 2011). In our study, we examined two precursors of theory of mind during toddlerhood: imitation and visual perspective-taking. In line with studies examining theory of mind, our results indicated that poorer imitations skills at 20 months were associated with higher levels of aggressive behavior at 30 months. Visual perspective-taking at 20 months was not associated with the level of aggression at 30 months. When toddlers are less able to imitate behavior of others (linking behavior of others to their own behavior), they could be less aware of the link between their own and other's mental states and subsequently less able to link mental states and behavior (Meltzoff, 2005). This could result in higher levels of perceived aggressive behavior. The absence of the effect of visual perspective-taking on aggression may be explained by the nature of the social behavior examined, as visual perspective-taking may possibly be more strongly related to other aspects of social functioning, such as prosocial behavior including helping and sharing in interaction with others (Carlo, Knight, McGinley, Goodvin, & Roesch, 2010; Cigala, Mori, & Fangareggi, 2015). Also, other early aspects of theory of mind, such as joint attention, self-recognition, pretend play and understanding of discrepant desires, could be more predictive of aggressive behavior (Hughes & Ensor, 2007; Laranjo, Bernier, Meins, & Carlson, 2010; Wade, Moore, Astington, Frampton, & Jenkins, 2015).

The results regarding the different aspects of cognition extend the literature demonstrating relations between cognitive functions and (the development of) aggressive behavior during the first years of life, which were so far mainly examined during preschool and school age. Cognitive functioning is, next to physiological and emotional processes, important in self-regulation and plays a central role in behavioral functioning (Calkins and Keane 2009). Deficits in these regulatory systems have been found to negatively influence children's ability to deal with challenging situations. Our studies showed that the development of specific aspects of cognition during infancy and toddlerhood already plays an important role in regulating behavior and emotions. Infants and toddlers who have problems in controlling impulses, in regulating attention, in their ability to recognize and process (e.g. to imitate) behavior of others, and who have poorer vocabulary show more aggressive behavior between 12 and 30 months.

The mediating role of cognition in associations between environmental influences and aggression

Aggression is seen as a particular and unfavourable form of social behavior. Social behavior during early childhood is not only influenced by cognitive development, but also by numerous external factors (Beauchamp & Anderson, 2010; LaPrairie, Schechter, Robinson, & Brennan, 2011). The impact of environmental factors is established in interaction with children's brain development and includes both prenatal and postnatal influences. Previous research has shown that (prenatal) risk factors and adverse parenting during early childhood negatively influence the child's social adaptive behavior, and are associated specifically with higher levels of externalizing problem behaviors during early childhood (LaPrairie et al., 2011; Pinquart, 2017). Cognitive functioning has been proposed as a mechanism establishing the influence of adverse environmental factors on child behavior problems (Beauchamp & Anderson, 2010; Dodge & Pettit, 2003). Therefore, the third aim of this dissertation was to examine the mediating role of cognition in the associations between prenatal risk and parenting behaviors, and aggressive behavior during infancy and toddlerhood.

Prenatal risk. The study described in Chapter 3 examined whether prenatal cumulative risk predicted physical aggression in infants and toddlers. In line with previous research (Carneiro, Dias, & Soares, 2016; Evans, Li, & Whipple, 2013; LaPrairie et al., 2011), results indicated that a higher number of risk factors during pregnancy was related to higher levels of aggressive behavior during infancy (at 12 months) and toddlerhood (at 20 months). Prenatal risk factors might directly affect children's structural and functional brain development and brain neurochemistry (e.g. through substance abuse) or have indirect effects via increased stress (e.g. risk factors such as low education, financial problems and a limited social network; Juster et al., 2011; Sterling, 2012). These effects on children's neurodevelopment, in turn, could increase the risk of developing behavior problems. In addition, an indirect effect of the

prenatal risk-child aggression relation via infant's inhibitory control was examined. In line with earlier research (Hughes & Ensor, 2008; Roman, Ensor, & Hughes, 2016), results indeed showed an indirect effect for inhibitory control: higher prenatal risk was related to lower inhibitory control at 12 months, which in turn led to higher levels of physical aggression at 12 and 20 months. Exploratory analyses suggested that the indirect effect of inhibitory control was found especially for social risk factors such as mother's financial problems and a limited social network, rather than for risk factors with supposedly more direct effects on brain development and neurobiology, such as maternal psychopathology or use alcohol, drugs of nicotine during pregnancy. In addition, we were specifically interested whether any mediating effects were present for both boys and girls. Results showed that the indirect effect of prenatal cumulative risk on physical aggression at 20 months via inhibitory control was observed for girls, but not for boys. Our results indicated that boys tended to show more physical aggression than girls at 20 months. According to the evolutionary view, girls tend to adapt more flexibly in case of exposure to adverse prenatal environmental risk, which results in greater variability in cognitive coping strategies compared to boys (Sandman, Glynn, & Davis, 2013; Sutherland & Brunwasser, 2018). Subsequently, the role of such cognitive coping strategies (i.e., inhibitory control) may be more prominent in girls at this young age.

Parenting behavior and parental beliefs. Because children interact mostly with their parents during infancy and toddlerhood, parenting behavior is often assumed to be the most important postnatal environmental factor impacting child development (Pinquart, 2017). In addition to parenting behavior, the subjective beliefs of parents about caregiving might also impact child cognitive and behavioral development. Therefore, as described in Chapter 4, we examined whether parental beliefs and parenting behavior of the mother predicted aggressive behavior during toddlerhood. In addition, the indirect effects of parental beliefs, via parenting behavior, through precursors of theory of mind on aggressive behavior were examined. In line with previous studies (Ardelt & Eccles, 2001; Côté et al., 2007), results showed that lower parental self-efficacy regarding caregiving was directly related to a higher level of aggressive behavior. Because parents serve as a role model for their children, parental beliefs might directly impact child development: children may internalize beliefs and attitudes of their parents, such as feelings of low parental self-efficacy, independent of the actual parenting behavior, leading to behavior problems (Ardelt & Eccles, 2001; Bandura, 1997; Donnellan, Trzesniewski, Robins, Moffitt, & Caspi, 2005). In addition, the results indicated an indirect effect from perceived parental impact via positive engagement and child imitation abilities to child aggression. These results indicated that parental beliefs can also indirectly impact child development via parenting behavior (Jones & Prinz, 2005; Patterson, 2002): parents who believe that their behavior has little impact on their child's development might be less motivated to engage in positive and supportive interactions with their child, which in turn could influence children's cognitive skills and behavioral development. To our knowledge,

this indirect association including a precursor of theory of mind was examined for the first time in 20-month-olds. The results showed that children who are having fewer positive interactions with their caregivers on average lag behind regarding the early development of theory of mind and show an enhanced level of aggressive behavior in toddlerhood.

It can be concluded that both adverse pre- and postnatal environmental influences have an impact on child aggression: higher prenatal risk, lower parental self-efficacy, lower perceived parental impact and lower positive engagement were directly or indirectly related to higher levels of aggression. The results emphasize the importance of examining subjective experiences regarding parenting, such as parental self-efficacy and perceived parental impact, next to observable prenatal risk factors and parenting behavior, in relation to children's social development. The findings with respect to the indirect effects from prenatal risk, parenting behavior and parental beliefs show that relatively poor cognitive functioning, in this case inhibitory control and imitation skills, play a role in the relations between pre- and postnatal environmental influences and aggressive behavior. Cognitive functioning appears an essential mechanism establishing the influence of adverse environmental factors in child aggressive behavior.

The moderating role of cognition in the associations between temperament and environmental influences and aggressive behavior

In addition to the mediating role of cognitive functions, it has also been proposed that impaired cognitive abilities constitute a vulnerability for psychopathology (including externalizing behavior problems) in case of adverse environmental factors (Masten, 2001) or high temperamental reactivity (Muris & Ollendick, 2005). One of the main reactive components of temperament is negative affect, which includes the tendency to experience and express negative emotions, such as sadness, frustration and anger (Rothbart & Bates, 2006; Sanson & Rothbart, 1995). Therefore, the fourth aim of this dissertation was to examine the moderating role of cognition in the associations between prenatal risk, temperamental negative affect and aggressive behavior during infancy and toddlerhood. It was hypothesized that higher prenatal risk and higher negative affect would be related to higher levels of externalizing behavior problems, but only in children with limited cognitive regulation abilities. Our study regarding the moderating role of cognition focused on inhibitory control, attention and vocabulary at 30 months (Chapter 5). With regard to the interactions between environmental factors and cognition, it was found that inhibitory control moderated the relation between prenatal cumulative risk and aggressive behavior at 30 months. As expected and in line with previous research during school age (Lengua, 2002), high inhibitory control served as a protective factor in the prenatal risk-aggression relation: higher prenatal risk was related to higher levels of aggressive behavior, but only in children with low inhibitory control during toddlerhood. Children with high inhibitory control showed relatively low levels of aggressive behavior

regardless of the level of prenatal risk. In case of high prenatal risk, poor inhibitory control increases the risk of externalizing behavior problems, while good inhibitory control protected against the development of aggressive behavior.

For examining interactions between cognition and temperament, we focused on negative affect during infancy (at 6 months) and toddlerhood (at 20 months). In addition to the main effects of negative affect on aggressive behavior, it was found that high negative affect during infancy predicted higher levels of aggressive behavior during toddlerhood, but only in children with low vocabulary. Children with high vocabulary showed relatively low levels of aggressive behavior, regardless of their temperamental negative affect during infancy. This underlines the hypothesis that good vocabulary serves as a protective factor against aggressive behavior. In addition, an interaction between negative affect during toddlerhood and inhibitory control was found. Instead of the hypothesized protective effect of relatively high inhibitory control (Moran, Lengua, & Zalewski, 2013; Suurland et al., 2016), the results indicated that low levels of inhibitory control served as a risk factor. Higher negative affect during toddlerhood was related to higher levels of aggression at 30 months, but only in children with high inhibitory control. Children with low inhibitory control had relatively high levels of aggressive behavior, independent of their level of negative affect during toddlerhood. Children who are highly emotionally reactive during toddlerhood or are less able to inhibit impulses are at higher risk for aggressive behavior. Only children who react less emotionally in situations and have high inhibitory control show low levels of aggressive behavior.

Although no moderating effects of attention at 30 months were found in this study, results suggest that inhibitory control and vocabulary might be important child factors influencing the effects of environmental and biologically based factors during the first years of life. Not all children are equally vulnerable for high environmental risk or the effect of temperamental reactivity: poor inhibitory control and vocabulary increase the risk of developing aggressive behavior in case of risk factors during pregnancy or a highly reactive temperament during early development.

Implications

In the last decades, studies focusing on the developmental trajectories and predictors of aggressive behavior have mainly examined children during preschool age, school age, and adolescence, whereas research has rarely focused on the first years of life. However, high levels of externalizing behavior problems during school age and adolescence often reflect a continuation of a behavioral pattern that has started during early childhood (Bongers, Koot, van der Ende, & Verhulst, 2004). The results of the studies presented in this dissertation further emphasize that future longitudinal research into the development of aggression should try to include participants already when they are infants or toddlers. Such research would also benefit from a further expansion and refinement of the instruments used to assess early cognitive abilities and aggression.

The results of the studies in this dissertation are also relevant for clinical practice. First, the results (Chapter 3 and 5) indicate that a higher number of prenatal risk factors (i.e. cumulative risk) was related to higher levels of child aggression during infancy and toddlerhood. This indicates that children of young woman suffering from, among others, psychopathology, experience financial problems, lack secondary education, are single parents, or use alcohol, drugs of nicotine during pregnancy, are at risk for behavior problems during early development. This underscores the importance of identifying pregnant women with multiple co-occurring risk factors by midwifery clinics to offer supportive interventions during pregnancy (Doyle, Harmon, Heckman, & Tremblay, 2009). For example, high-risk families have been found to benefit from home-visiting programs starting prenatally and offering support to improve mother's and child's pre- and postnatal health, enhance economic family circumstances, enlarge mother's social network, promote the use of health and social services, and improve parent's child care behavior (Olds et al., 2014). Our results (Chapter 4) also indicated that negative parental beliefs and adverse parenting behavior can have negative effects on child outcomes during toddlerhood. To lower the risk for externalizing behavior problems during early childhood, it may therefore be considered to focus on enhancing mother's self-efficacy regarding caregiving and mother's awareness of their impact on their child's development, in combination with improving mother's parenting behaviors. Several home-visiting programs starting prenatally, as well as interventions focusing on maternal beliefs or parenting behavior showed positive effects on children's developmental outcomes (Olds et al., 2014; Peacock, Konrad, Watson, Nickel, & Muhajarine, 2013; Roskam, Brassart, Loop, Mouton, & Schelstraete, 2015; Shah, Kennedy, Clark, Bauer, & Schwartz, 2016).

Second, early identification and monitoring of children showing high levels of aggression during infancy by child healthcare centers would be recommended. Although we did not follow-up children until school age, several studies have indicated that children showing persistent high levels of aggressive behavior during early development are at risk of negative outcomes later in life (Broidy et al., 2003; Campbell et al., 2006; Masten et al., 2005; Mesman et al., 2001). Our results (Chapter 2) indicate that groups of children showing increasing patterns or high stable patterns of physical aggression can already be identified during the first 2.5 years of life. By monitoring behavior problems during the first years of life, children who show high or moderate-increasing patterns in behavior problems during infancy and toddlerhood can be identified in order to offer interventions early in life to prevent continued behavior problems and the associated negative developmental outcomes. This is line with research suggesting that interventions focusing on behavior problems are most effective when offered early in life (Doyle et al., 2009; Fossum et al., 2016).

Third, the results in this dissertation underline the importance of monitoring cognitive development from an early age onwards to prevent developmental risk for externalizing behavior problems. Cognitive functions like inhibitory control, attention, vocabulary and imitation skills are directly associated with aggressive behavior

(Chapter 2 to 5). Inhibitory control and imitations kills also serve as mechanisms explaining relations between negative environmental influences, especially prenatal risk, negative parental beliefs and adverse parenting behavior, and aggressive behavior (Chapter 3 and 4). In addition, the effect of prenatal risk and temperamental negative affect, in part, seems to depend on cognitive abilities of the child that support self-regulation, such as inhibitory control and vocabulary (Chapter 5). Training of early cognition, including executive functioning, attention, vocabulary and precursors of theory of mind, could be incorporated in pedagogical methods in early childhood education and offered to children based on their individual profile of cognitive strengths and difficulties. Interventions aimed at improving executive functioning during preschool were shown to be effective (Diamond & Lee, 2011; Dowsett & Livesey, 2000). Although studies focusing on training attentional and executive functions during the first years of life show promising results (Kovacs & Mehler, 2009; Wass, Porayska-Pomsta, & Johnson, 2011), comprehensive intervention programs should be developed, simultaneously targeting cognition, environmental risk factors, parenting beliefs and behaviors.

Limitations and future directions

Several limitations of the studies in this dissertation should be mentioned. First, the power regarding the analyses showing differential trajectories of aggressive behavior during infancy and development was limited. Although the proportion of children belonging to the trajectory showing high stable levels of aggression was comparable to other studies involving somewhat older children (Campbell et al., 2006; Olson et al., 2017; Wildeboer et al., 2015), the group size was too small to be able to examine cognitive correlates. Because this group is especially at risk for negative developmental outcomes (Broidy et al., 2003; Campbell et al., 2006), future studies should replicate our results and examine the relations between cognition and the trajectories using larger sample sizes.

Because we assessed many different constructs in a limited number of test sessions, it was generally only feasible to examine aspects of cognitive functioning, temperamental negative affect and aggressive behavior with a single instrument or test, and for a number of constructs we had to rely on maternal report. Because the performance on single instruments may be biased due to test method, characteristics of the informants or the relationship with the child (Kerr, Lunkenheimer, & Olson, 2007; van Dulmen & Egeland, 2011), future studies should replicate the results of our studies using multiple instruments and observational methods or multiple informants. In addition, we do not know the exact association of cognitive tasks we have used during infancy and toddlerhood and tasks for older children. Although there is a handful of studies examining longitudinal associations between cognitive tasks (Charman et al., 2000; Kochanska, Murray, & Harlan, 2000; Olineck & Poulin-Dubois, 2007), it remains largely unclear whether our measures during infancy and toddlerhood predict later cognitive functioning on more traditional tests during

preschool and school age. Future studies should examine the developmental continuity between early cognitive abilities during infancy and toddlerhood, and more advanced cognitive skills in older children.

Several studies in this dissertation focused on prenatal risk and parenting behavior. However, the ranges of prenatal risk and parenting behavior scores were limited, with mothers having no more than three risk factors during pregnancy, and relatively few mothers scoring on the low ends of parenting behavior scales. Therefore, the results of our studies probably apply to the majority of mothers in the general population. It is also possible this has resulted in an underestimation of some associations between the constructs of interest. Future studies should examine the relations between environmental conditions, cognitive development and aggressive behavior in samples of high-risk mothers.

The results of this dissertation underline the importance of examining cognitive functioning in relation to aggressive behavior (Chapter 2 to 5). However, it should be noted that we did not take other self-regulatory processes in account, such as physiological regulation (Calkins, 2007). Although the integration of the processes of self-regulation (e.g. physiological, emotional and cognitive processes) makes it complex to examine them as distinct concepts (Calkins, 2007), support exists that the regulatory processes can be differentiated during early childhood (Blankson, O'Brien, Leerkes, Marcovitch, & Calkins, 2012). The different self-regulatory processes mutually influence and support each other (Blair & Diamond, 2008), which could also indicate that deficits in specific early developing processes of self-regulation may have cascading effects (Calkins, Blandon, Williford, & Keane, 2007). For example, it has been proposed that lasting alterations in the physiological regulatory systems, due to repeated or prolonged adverse environmental influences, may impact child emotional, cognitive and behavioral development (Ganzel, Morris, & Wethington, 2010; McEwen, 2000). Future studies should address the associations and interactions of the distinct self-regulatory processes, including physiological, cognitive, emotional regulation, in relation to aggressive behavior. This may provide more insight in the (cascading) effects of different aspects of self-regulation, and specifically cognitive functioning, in the development of behavior problems.

Furthermore, the results indicated a pathway from low maternal self-efficacy via less maternal positive engagement to child development (Chapter 4). However, child functioning is not only considered to be a consequence of environmental influences, such as parenting behavior, but also to be a cause (Patterson, 2002). Therefore, future studies should incorporate a longitudinal design in order to explore bidirectional associations between the level of risk, parenting behavior, cognition and child aggression during early childhood.

In addition, more research is needed examining the role of gender in the relation between cognitive functioning and aggressive behavior. Although no difference was found at 12 months, boys showed higher levels of physical aggression at 20 months (Chapter 3). When examining aggressive behavior as a broader construct at 20 and 30

months, no gender differences were found (Chapter 4 and 5). In addition, it was found that girls have higher inhibitory control than boys. The indirect effect of prenatal risk on physical aggression at 20 months via inhibitory control was only observed for girls. Gender differences in aggressive behavior and in the associations between cognition and aggressive behavior have also been found in previous studies (e.g. Alink et al., 2006; Baillargeon et al., 2007; Granvald & Marciszko, 2016; Hay, 2017). Therefore, it is important that future research focusing on the relations between cognition and aggressive behavior take the role of gender into account.

Conclusion

Aggressive behavior is seen already in infancy and toddlerhood, as soon as children are able to use force. The studies of this dissertation indicate that differential development of physical aggression already starts at (or before) 12 months of age. Four trajectories were found between age 12 and 30 months: we found a low-stable, a low-increasing, moderate-decreasing and high-stable trajectory of physical aggression. In addition, our studies indicate that impairments in children's early cognitive regulation abilities play a role in the development of aggressive behavior. It was found that infants and toddlers who have impairment in inhibitory control, regulating attention, imitating others, and vocabulary show more (physical) aggressive behavior or are at risk for the low-increasing or moderate-decreasing aggression trajectories. It can also be concluded that both adverse pre- and postnatal environmental influences have an impact on child aggression: higher prenatal risk, lower parental self-efficacy, lower perceived parental impact and lower positive engagement were directly or indirectly related to higher levels of aggression. The studies of this dissertation also indicate that poor inhibitory control and imitation skills, appears to be an essential mechanism establishing the influence of adverse environmental factors in child aggressive behavior. In addition, it was found that poor cognitive skills, namely inhibitory control and vocabulary, increased the risk of developing aggressive behavior in case of high prenatal risk or a highly reactive temperament during early development.

Overall, our findings suggest an important role of early cognitive functioning in the development of aggressive behavior during infancy and toddlerhood. Therefore, the studies of this dissertation provide support for monitoring aggressive behavior and targeting early cognitive development in interventions based on children's cognitive profile to prevent or reduce aggressive behavior during infancy and toddlerhood.

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