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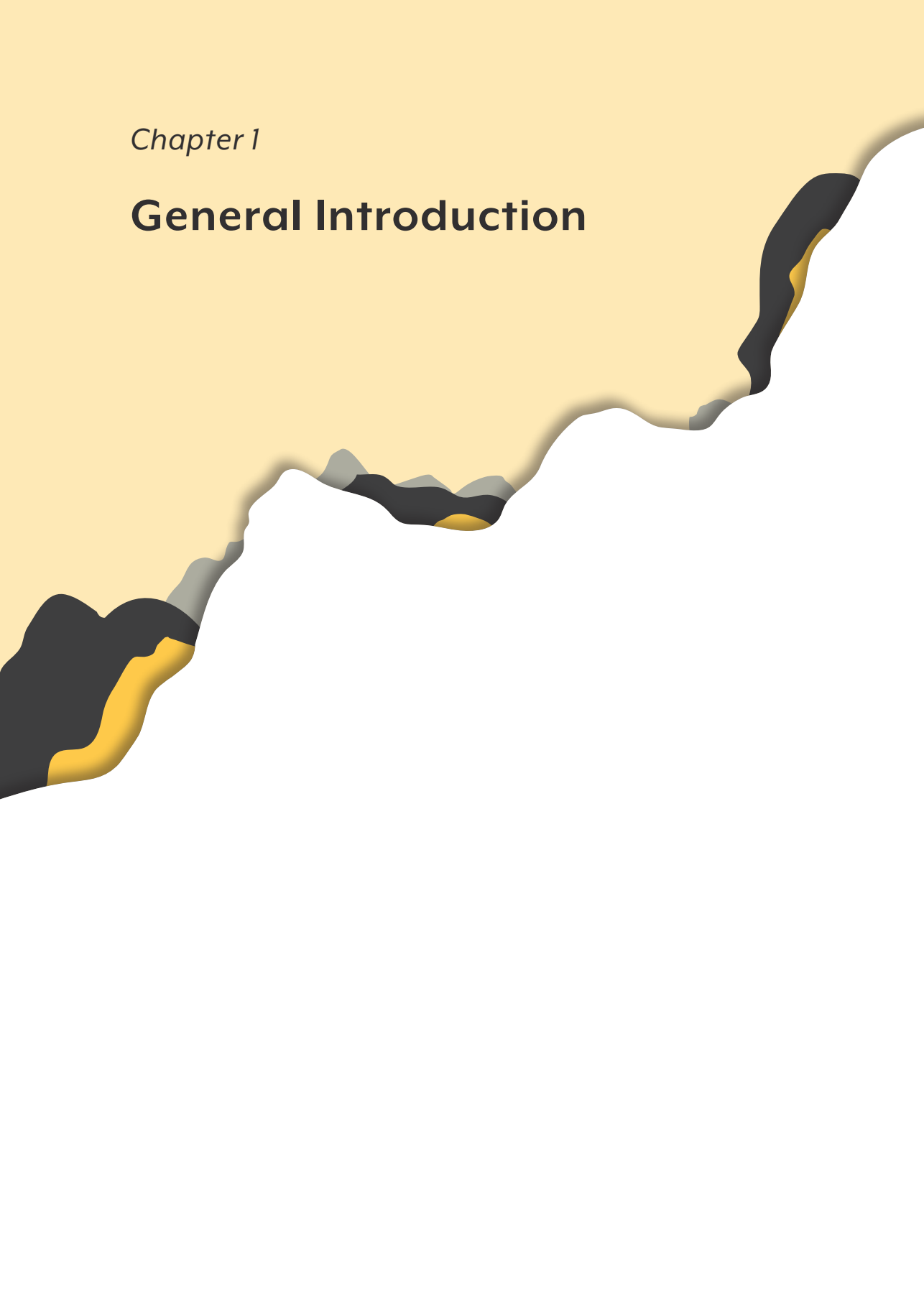
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Chapter 1

General Introduction



Imagine a child that just enters kindergarten. This child may respond anxiously when approached by a new peer, may show aggressive behaviors during an interaction with a peer, or may be reluctant to share objects such as toys with others. These different behaviors may evoke negative responses from classmates and this child may become disliked by the larger peer group. What are the potential consequences of this negative social evaluation in terms of the social behavior they will show across childhood and adolescence? How will these experiences influence brain development? And importantly, do we need to worry about this child?

Decades of research have shown that peer relationships during the formal schooling period play an important role in children's and adolescents' social and behavioral development (Bukowski, Laursen, & Rubin, 2018). With the start of primary school, most children will for the first time enter a classroom context with age-matched peers. These peers can function as important socialization agents by giving feedback on children's behavior, thereby allowing children to learn social norms and adapt their behavior in meaningful ways to the social environment (Bukowski, Castellanos, Vitaro, & Brendgen, 2015). With the transition to secondary education, often coinciding with the onset of puberty, adolescents spend more time with their peers and less time with their parents (Brown, 2004; Larson, Richards, Moneta, Holmbeck, & Duckett, 1996; Nickerson & Nagle, 2005). Moreover, the opinions of peers become increasingly important for adolescent behavior (Brechwald & Prinstein, 2011). Therefore, across the primary and secondary school period, peers provide an important social context that is essential for a healthy behavioral, emotional and social development of youth.

It is, however, important to note that peer relationships may not always be beneficial for the development of children and adolescents. Chronic experiences of negative peer treatment, such as enduring forms of rejection or victimization by classmates constitutes an important source of stress (e.g., Behnsen, Buil, Koot, Huizink, & van Lier, 2018; Gunnar, Sebanc, Tout, Donzella, & van Dulmen, 2003; Westenberg, Drewes, Goedhart, Siebelink, & Treffers, 2004). Such difficulties with peers have consistently been linked to the development of psychopathology symptoms such as anxiety, depression, aggression, and antisocial behavior, during childhood (Ladd & Troop-Gordon, 2003; Miller-Johnson, Coie, Maumary-Gremaud, & Bierman, 2002), adolescence (Laird, Jordan, Dodge, Pettit, & Bates, 2001) and even in adulthood (Modin, Östberg, & Almqvist, 2011; Prinstein & Aikins, 2004; Takizawa, Maughan, & Arseneault, 2014). This psychopathology may arise from a complex and dynamic interplay between child and adolescent behavior, the peer environment, and neurobiological processes (Beauchaine, Neuhaus, Brenner, & Gatzke-Kopp, 2008; Rutter, 2002; Schriber & Guyer, 2016). To understand how chronic negative peer experiences may lead to psychopathology, it is important to adopt a

comprehensive approach and examine how child and adolescent peer relationships interact with both behavior and brain functioning. Therefore, the studies in this thesis examine the role of peers in the normative development of social behavior and brain functioning and explore how different peer experiences are associated with individual differences in social behavior and brain responses, to enhance our understanding of how peer experiences shape child and adolescent behavioral and neurobiological development.

The importance of peers during development

Children and adolescents interact with others daily. Yet the nature and frequency of these social interactions change significantly across development. During infancy, social interactions mostly consist of interactions between children and their primary caregivers. Interactions with primary caregivers contribute to the development of several important skills, such as joint attention and inhibitory control, necessary for establishing and maintaining successful social relationships with peers (Grossmann & Johnson, 2007; Hay, Payne, & Chadwick, 2004). With the start of formal schooling, children have to interact and establish relationships with age-matched peers, and teachers. Initially, children's peer interactions are primarily focused on play and these play activities gradually become more organized and rule-governed with age such as when children play soccer or hide-and-seek (Fabes, Martin, & Hanish, 2009; Power, 1999). Moreover, peer interactions of children vary from interactions in larger groups to dyadic interactions and both contribute to the development of important social skills such as teamwork and self-disclosure (Coplan & Arbeau, 2009; Fabes et al., 2009; Power, 1999; Rubin, Bukowski, & Laursen, 2011). During adolescence peer interactions often exceed the school context and interactions become increasingly complex and are focused on social communication (Rubin et al., 2011; Scholte & van Aken, 2006). Furthermore, adolescence is characterized by a heightened sensitivity to both positive and negative peer influences (Brechwald & Prinstein, 2011). Thus, the peer environment appears to be an important social context that provides children and adolescents with experiences that help them to develop and master key social skills.

An important process occurring with the transition to formal schooling and with the placement in the classroom peer group is that children start to socially evaluate each other. Children judge classroom peers based on personality characteristics and their behaviors and use this information to form preferences about who they like and do not like. These evaluations are considered very salient for children and adolescents as they, just like adults, have a fundamental need to belong to a peer group and to be accepted by others (Baumeister & Leary, 1995; Williams, 2007). When

a child receives a negative social evaluation, this may indicate a difficulty to fulfill this fundamental need to belong. A failure to fulfill this need has been linked to feelings of distress, reflected in decreases in mood, increased levels of stress hormones and an enhanced inflammatory response (Giletta et al., 2018; Gunnar et al., 2003). These affective and biological signals to such an acute stressor are thought to function as an alarm system to initiate behaviors that ensure social reconnection (Taylor, 2011). Indeed, prior studies in adults showed that initial responses to acute social exclusion or rejection experiences are behaviors that may increase the likeability or chance of establishing re-inclusion, such as higher prosocial behavior or more social confirmative behavior (Gardner, Pickett, & Brewer, 2000; Lakin, Chartrand, & Arkin, 2008; Pickett, Gardner, & Knowles, 2004; Williams, Cheung, & Choi, 2000), although other studies also found increases in aggressive behaviors (Twenge & Baumeister, 2004; Twenge, Baumeister, Tice, & Stucke, 2001; Twenge, Catanese, & Baumeister, 2002).

Some children, however, experience difficulties in improving their social status and will be exposed to negative peer evaluations for prolonged periods. Indeed, negative social evaluations among peers are quite persistent across primary school (Brendgen, Vitaro, Bukowski, Doyle, & Markiewicz, 2001; Gooren, van Lier, Stegge, Terwogt, & Koot, 2011). It has been suggested that these negative peer evaluations may occur partly because of children's behavioral characteristics (i.e., aggression, anxiety). However, behavioral problems become even more problematic over time as a consequence of chronic peer difficulties. That is, children who demonstrate more aggressive or withdrawn behavior have been shown to develop more difficulties in their peer relationships and these peer difficulties have in turn been linked to increases in aggression and depression (Gooren et al., 2011; Laird et al., 2001; Reijntjes et al., 2011; Troop-Gordon & Ladd, 2005; van Lier & Koot, 2010). As a result, individual differences in social evaluations and problem behaviors become magnified across development. The fact that behavioral problems and peer problems become increasingly intertwined during development underscores the importance of examining peer relationship processes early during development.

The social brain and peer relationships

Given the importance of belonging to a peer group, children and adolescents are highly motivated to engage and interact with others. These interactions are supported by the dynamic interplay of neural activation in a large number of regions throughout the brain (Blakemore, 2008; Nelson, Leibenluft, McClure, & Pine, 2005). This neural network, often referred to as the 'social brain', is involved in detecting social information, processing affective information and deciding how to

respond to this information (Figure 1.1). Brain regions comprising the social brain are amongst others (but not solely) the superior temporal sulcus (STS), temporoparietal junction (TPJ), anterior insula (AI), ventral striatum (VS), dorsal anterior cingulate cortex (dACC), medial prefrontal cortex (mPFC) and dorsolateral prefrontal cortex (dlPFC) (Kilford, Garrett, & Blakemore, 2016; Nelson et al., 2005; Silston, Bassett, & Mobbs, 2018; Stanley & Adolphs, 2013).

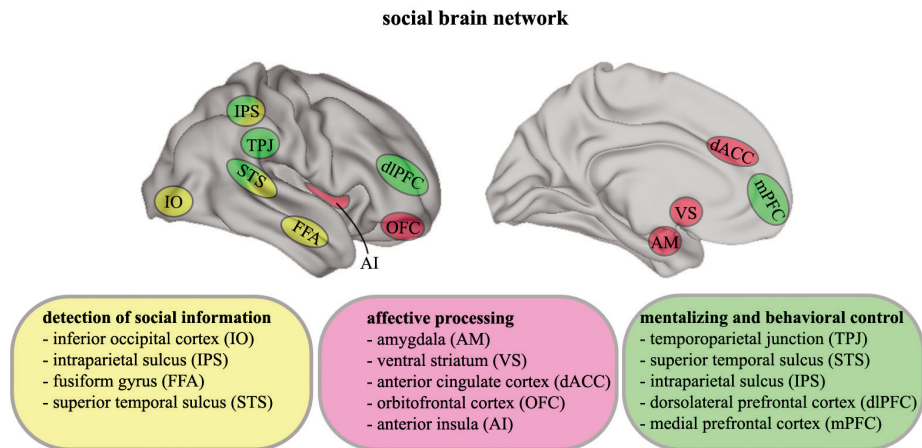


Figure 1.1. Overview of several brain regions involved in social behavior.

These brain regions undergo rapid changes during childhood and adolescence (Mills et al., 2016; Mills, Lalonde, Clasen, Giedd, & Blakemore, 2014). The interactions children and adolescents have with their peers, both positive and negative, may provide important input for the development and refinement of these regions (Fox, Levitt, & Nelson III, 2010; Schriber & Guyer, 2016). In other words, peer experiences allow children and adolescents to learn and adapt their behavior to the peer context, a process that is likely to unfold on a neural level as well. Importantly, although many of these regions may be sensitive to peer experiences throughout development, subcortical and prefrontal regions may be especially sensitive to this input. That is, the accelerated development of subcortical regions in late childhood and adolescence (Goddings et al., 2014) and the gradual maturation of prefrontal regions until late adolescence (Gogtay et al., 2004; Kolb et al., 2012) allow more opportunities for environmental input to exert its influence on these rapidly developing brain regions. Thus, peer experiences may be particularly important in the influences they have on brain development, especially in subcortical and prefrontal regions, prior to adulthood.

Negative peer events, such as receiving a negative comment from a peer or being excluded from a social interaction, are very salient experiences in children's and adolescents' lives and may provide important input for the developing brain (Schriber & Guyer, 2016; Westenberg et al., 2004). Acute negative peer events are suggested to increase the level of stress hormones like (nor)adrenaline and cortisol in the body (Behnsen et al., 2018; Sapolsky, Romero, & Munck, 2000). Stress hormones can cross the blood-brain barrier and bind to mineralocorticoid (MR) and glucocorticoid (GR) receptors on neurons (de Kloet, 2003). Receptor binding consequently influences (inter)cellular processing including increased energy consumption, cellular metabolism, cell signaling, neuronal connectivity, and neural transmission (Arnsten, 2009; de Kloet, Joëls, & Holsboer, 2005). These described effects of acute stressors on brain functioning have been found amongst others in the amygdala, hippocampus, and the prefrontal cortex which are involved in affect processing, memory, and cognitive control, respectively (Lupien, McEwen, Gunnar, & Heim, 2009). As such, peer stressors may temporarily enhance attention toward the stressor, improve memory formation, and support emotion processing. These short-term changes in brain functioning are thought to be adaptive so that a child or adolescent may respond adequately to negative peer events.

Empirical studies in adolescents indeed have shown that different kinds of acute peer stressors (e.g., negative feedback, social exclusion), are associated with brain activation in the adolescent brain (for a review see Guyer & Jarcho, 2018). For example, studies in adolescents have found that acute social exclusion experiences increase activation in the medial prefrontal cortex, insula, anterior cingulate cortex, precuneus, and lateral prefrontal cortex during social exclusion relative to social inclusion (Cacioppo et al., 2013; Masten et al., 2009; Vijayakumar, Cheng, & Pfeifer, 2017). These regions are involved in affective processing and emotion regulation, suggesting that social exclusion is experienced as distressing by adolescents and is processed in several regions across the brain. However, only more recently studies started to examine how the child brain relative to the adolescent brain responds to different kinds of peer stressors. This is an important advancement as childhood is also a key period for social development because many brain structures and processes that underlie social behavior undergo major changes across middle childhood (Giedd et al., 1999; Gogtay et al., 2004; Mills et al., 2014).

Compared to the more adaptive neural changes during acute social stressors, long-lasting forms of peer stress may have detrimental consequences for the morphology and functioning of brain regions. Animal studies found that enduring levels of social stress cause a dysregulation of the stress system which may lead to alterations in – amongst others – the prefrontal cortex, hippocampus, and amygdala (Karatsoreos & McEwen, 2013). In the prefrontal cortex and hippocampus,

the most important effects appear to be neuronal cell loss (Arnsten, 2009; McEwen, Nasca, & Gray, 2015). Moreover, the ability of the hippocampus (involved in memory formation) to form new neurons is impaired (Lucassen, Korosi, Krugers, & Oomen, 2016). Alterations in the amygdala (involved in affect processing), in contrast, comprise increases in neuronal growth which have been linked to hyperactivation of the amygdala during new stressors (Rooszendaal, McEwen, & Chattarji, 2009). These stress-induced neural alterations may have serious consequences for child and adolescent development as these alterations have been found to be an important predictor for anxiety, depression, and aggression problems (Bolton, Molet, Ivy, & Baram, 2017; Heim & Binder, 2012).

Prior studies in adolescents indeed suggest that chronic peer difficulties may lead to neural alterations in the adolescent brain. For example, adolescents who scored high on rejection sensitivity or who had a history of peer rejection or victimization exhibited increased neural activation in the dorsal anterior cingulate cortex during new rejection events, a region implicated in salience processing (Masten et al., 2009; Rudolph, Miernicki, Troop-Gordon, Davis, & Telzer, 2016; Will, van Lier, Crone, & Güroğlu, 2016). This heightened neural activation in chronically rejected and victimized adolescents may suggest that chronic peer difficulties may result in a hypersensitivity to rejection on a neural level. Another structural imaging study showed that victimization levels were associated with smaller ventrolateral prefrontal cortex volumes in adolescent boys (du Plessis, Smeekens, Cillessen, Whittle, & Güroğlu, 2019). Moreover, being disliked by peers during adolescence was associated with decreased grey matter volume in frontal regions and increased grey matter volume in the hippocampus (Tyborowska et al., 2018). These studies thus provide the first evidence that prior experiences of rejection or victimization with peers may affect brain development.

Positive peer experiences (e.g., friendships) may also affect brain development. These effects have mostly been studied in the context of socially enriched environments in animal models (i.e., social housing). Results of these studies show that social enrichment reduces the level of stress hormones in the brains of rat pups while at the same time the level of neurotrophins increases which stimulates neuronal growth (Curley & Champagne, 2016; van Praag, Kempermann, & Gage, 2000). In children, positive social environmental factors (e.g., high maternal sensitivity/attachment) also have been linked to increased brain volumes and connectivity between brain regions (Kok et al., 2018; Kok et al., 2015; Kopala-Sibley et al., 2018; Wang et al., 2019; Whittle et al., 2014). These neural alterations may link to lower levels of anxiety and increased social behavior (Baldini et al., 2013; Branchi et al., 2006; Goes, Antunes, & Teixeira-Silva, 2015; Kok et al., 2018; Lehmann & Herkenham, 2011; Sparling, Baker, & Bielajew, 2018). Together, these studies suggest that positive

and negative peer experiences may interact with the developing brain and may influence social and emotional development.

Despite the advances in the field of social developmental neuroscience, knowledge on the influence of peer experiences on brain functions and development during childhood is limited. This is a major gap in the literature as peer experiences during earlier developmental periods may influence the subsequent development of other brain regions in later developmental periods (Beauchaine et al., 2008; Fox et al., 2010). As such, positive peer experiences during childhood and adolescence may cause neurobiological changes that foster adaptive social, emotional and cognitive development. However, negative peer experiences may compromise the typical development of some of these neural structures which may increase children's and adolescents' susceptibility to psychopathology later in life. It is therefore very important to gain a better understanding of how these peer experiences are associated with child and adolescent brain development.

The present thesis

The goal of this thesis is to advance our knowledge on the impact of peer relationships on the development of social behavior and brain functioning across childhood and adolescence. The two overarching questions addressed in this thesis are:

1. What is the role of peers in the normative development of social behavior and brain functioning across childhood and adolescence?
2. How do negative peer experiences shape individual differences in social behavior and brain functioning?

These two overarching questions are addressed in three sections. Specifically, part one of this thesis provides a framework of how peer experiences may impact brain development. Moreover, part one also provides an overview of the state-of-the-art research on peer experiences and brain functioning during the formal schooling period. The second part of this thesis addresses in two empirical studies the normative development of social behavior and brain functioning in the context of peer relationships during childhood and adolescence. The third part of this thesis focuses on individual differences. Specifically, it examines in three empirical studies how negative peer experiences, compared to positive peer experiences, may shape children's social behavior and brain functioning. Together, these studies contribute to our understanding of how peers may promote social and emotional development and how unfavorable developmental outcomes may arise when peer relationships go awry.

Part 1: Peers and the developing brain

Persistent levels of negative peer experiences may result in the development of serious behavioral and mental health problems (Laird et al., 2001; Miller-Johnson et al., 2002; Modin et al., 2011; Prinstein et al., 2018). These problems may emerge from a complex interplay between peer experiences, behavior and neurobiological processes (Beauchaine et al., 2008; Schriber & Guyer, 2016). As such, it seems important to understand how peer experiences may shape social behavior and brain functioning during childhood. Therefore, in the first part of this thesis, comprised of **Chapter 2**, a theoretical framework describes how peer experiences may interact with the developing brain. Along with this framework, a comprehensive overview provides the state-of-the-art research examining brain activation in response to varying peer experiences (e.g., peer feedback, social exclusion) during childhood as a comparison to the more extensive adolescent literature. Moreover, this overview includes research examining individual differences in peer experiences and associations with brain activation. The framework, as well as the overview of studies examining how the typical child brain responds to peer stressors, helps to interpret the results of the empirical chapters presented in the other two parts of this thesis.

Part 2: Peers and the normative development of social behavior and brain function

The second part of this thesis focuses on the normative development of social behavior and brain functioning during childhood and adolescence in relation to the peer context. Although not exclusively, two important behaviors shown in the peer context are sharing behavior (**chapter 3**) and risk-taking behavior (**chapter 4**). Both sharing behavior and risk-taking behavior are thought to contribute to children's and adolescents' social and emotional development (Berndt, 2002; Crone & Dahl, 2012; Duell & Steinberg, 2019). For example, a child who shares its toys with another peer during play hour in school may be liked by that peer which may foster positive relationships with peers. However, a child who refuses to share its toys may become disliked by that peer which may decrease the likelihood of having a mutually satisfying relationship with that peer. Similarly, risk taking is considered to be part of children's and adolescent's explorative behavior and may influence their social position or visibility among peers (Crone & Dahl, 2012; Duell & Steinberg, 2019; Steinberg, 2008). For example, an adolescent who jumps from the high dive in a swimming pool may be perceived as cool and interesting by peers and may, therefore, gain social acceptance. However, when failing to dive out of anxiety or when hitting

the water flat on the face and stomach may result in ridicule and laughter among peers which may hurt the adolescent's social position. Of importance though is to recognize that excessive risk taking may comprise healthy development (Kann et al., 2018). Despite the efforts of prior studies examining the normative development of these behaviors in parts of childhood or adolescence (Defoe, Dubas, Figner, & van Aken, 2015; Eisenberg, Eggum-Wilkens, & Spinrad, 2015; MacPherson, Magidson, Reynolds, Kahler, & Lejuez, 2010; Malti, Gummerum, Keller, Chaparro, & Buchmann, 2012; Malti et al., 2016; Padilla-Walker, Carlo, & Memmott-Elison, 2018; Tieskens, Buil, Koot, Krabbendam, & van Lier, 2018), our understanding of the role of the peer environment on the development of sharing behavior and risk-taking behavior is far from complete.

Chapter 3 focuses on the development of sharing behavior. Prior studies demonstrated that sharing behavior increases from infancy to middle childhood (Eisenberg et al., 2015). However, the development of sharing behavior from middle childhood throughout adolescence is less clear (Eisenberg et al., 2015; Malti et al., 2012; Malti et al., 2016). Importantly, prior studies demonstrated that sharing behavior during childhood and adolescence depends on characteristics of the recipient (Güroğlu, van den Bos, & Crone, 2014; Moore, 2009; Paulus & Moore, 2014) as well as the social experiences a child has with peers (Malti et al., 2012). However, knowledge on the development of sharing behavior with different peers (i.e., anonymous others, friends, disliked peers) and whether this development is similar for children who are well liked or poorly liked by classroom peers across primary school is limited. To understand the normative development of sharing behavior during childhood within the peer context, the present thesis examines within-person changes in sharing behavior toward anonymous others, friends, and disliked peers and the role of a child's social position among peers (i.e., peer likeability and dislikeability) on this development across grades 2 – 6 of primary school.

Chapter 4 focuses on risk-taking behavior in adolescence. Risk-taking behavior is another important behavior shown in the peer context during childhood and adolescence (Duell & Steinberg, 2019). Prior studies showed that the level of peer attachment may increase risk-taking as well as neural activation in the reward system during risk-taking behavior (Piko, 2000; Telzer, Fuligni, Lieberman, Miernicki, & Galvan, 2015). Yet, it has been argued that risk taking is the result of a neural computation of both reward processing and risk processing (d'Acromont & Bossaerts, 2008; Mohr, Biele, & Heekeren, 2010). In other words, an adolescent may take more risks because of the rewarding nature of the risk or because he or she is less sensitive to information about the potential risks. Whereas prior adolescent studies focused predominantly on the reward processing (Silverman, Jedd, & Luciana, 2015; van Duijvenvoorde, Peters, Braams, & Crone, 2016), longitudinal

studies on the development of risk processing during adolescence are limited. To understand the role of peers in the development of risk-taking behavior, the present thesis also investigates the normative development of neural risk processing and associations with peer attachment across ages 13 – 17 years.

Part 3: The impact of negative peer experiences on social behavior and brain function

The third part of this thesis aims to increase our understanding of how individual differences in peer experiences affect children. Specifically, the objective is to understand how negative experiences with peers, compared to positive peer experiences, may alter social behavior and brain functioning during childhood. With the start of formal schooling, some children will have difficulties with establishing positive peer relationships. Children who are repeatedly exposed to negative peer treatment may develop a sensitivity to new negative peer evaluations. This idea was first proposed by Downey and Feldman (1996) who suggested that children who experience rejection by their peers over some time start to expect rejection in situations in which rejection may (but not necessarily will) occur. On a socio-cognitive level, this rejection sensitivity may become expressed by an interpretation bias of rejection cues. In other words, chronically rejected children become hypersensitive to and overly interpret rejection cues in socially ambiguous situations and have angry or anxious expectations about being rejected (Downey, Lebolt, Rincon, & Freitas, 1998). This increased sensitivity to rejection may result in the enactment of maladaptive behavior in situations in which the child is faced with a social exclusion or rejection experience. Indeed, it has been found that children with a history of peer rejection respond more anxious, aggressive or hostile to new rejection events (London, Downey, Bonica, & Paltin, 2007; Rudolph, Troop-Gordon, & Flynn, 2009).

Chronic negative peer experiences may also change children's motivations to demonstrate positive social behaviors. That is, the initial responses of a child who is faced with a negative peer experience may be to repair one's social position. However, children who experienced enduring levels of negative peer treatment may have learned that showing positive social behavior is not effective anymore in restoring their social position, and may, therefore, refrain from such responses (Williams, 2007, 2009, 2011). Longitudinal studies show that children who experience chronic forms of negative peer treatment engage in heightened levels of negative behaviors including increased aggression and antisocial behavior which may persist into adulthood (Ladd, 2006; Ladd & Troop-Gordon, 2003; Laird et al., 2001; Miller-Johnson et al., 2002). Despite the efforts of prior studies to understand the

consequences of chronic peer difficulties, such as increases in aggression and antisocial behavior, relatively little is known about how negative peer experiences may shape sharing behavior. This seems an important short-coming as sharing behavior may be key in forming or having positive relationships with classroom peers (Berndt, 2002).

Therefore, the first goal in part three of this thesis is to explore whether it is specifically peer rejection that predicts changes in sharing, and furthermore to whom these changes in sharing behavior are directed to (**chapter 5**). Children can be liked or disliked by their peers. However, being rejected indicates a negative balance between (low) likeability and (high) dislike among peers (Coie, Dodge, & Coppotelli, 1982; Gunnar et al., 2003). It is unknown whether it is indeed this ratio between likeability and dislikeability that drives sharing behavior. Moreover, rejected children may alleviate their vulnerable social position by showing more prosocial acts, or share more with peers who may protect them, such as friends (Hodges, Boivin, Vitaro, & Bukowski, 1999; Laursen & Hartup, 2002). It has yet to be determined whether this potentially effective social strategy is the typical behavioral pattern of rejected children. Therefore, in **Chapter 5** it is investigated how likeability, and dislikeability, and the combination of these two social evaluations predict sharing behavior toward friends, disliked peers and anonymous others across one year. Findings of this chapter may reveal a potential embedding of peer rejection experiences on a behavioral level.

The stress associated with negative peer experiences may, apart from affecting the child's behavior, also have an impact on the developing brain (Fox et al., 2010; Schriber & Guyer, 2016). It is important to understand the impact of negative peer experiences on brain function during childhood as earlier changes in brain development may impact further development (Fox et al., 2010). Yet, few studies have examined how differences in peer relationships during primary school may be associated with differences in brain functioning during childhood.

Therefore, in **Chapters 6 and 7** of this thesis differences in brain responses between boys with a history of stable low versus stable high peer preference during primary school are examined. Participants studied in chapters 6 and 7 were selected from a large longitudinal classroom-based study. The selection of boys was based on their classroom social preference score assessed across three consecutive years prior to the functional magnetic resonance neuroimaging (fMRI) study. Boys, who were on average 10 years old, and who had a history of stable low or stable high social preference among classroom peers across these three years were invited to participate in the fMRI study. During the fMRI study, participants shared coins between themselves and friends and anonymous peers before and after a social exclusion experience. The focus of **Chapter 6** is on the neural responses during

the social exclusion paradigm. It is explored whether children with a history of low peer preference during primary school differ in their neural responses to a new social exclusion experience from children who have very stable levels of high peer preference during primary school.

Next, **Chapter 7** focuses on differences in changes in neural responses during sharing decisions from before to after the social exclusion experience, between low and high peer preferred boys. To this end, low and high peer preferred boys shared coins between themselves and friends/anonymous peers, before and after the social exclusion experience. Changes in neural activation from before to after social exclusion during sharing decisions are compared between high and low peer preferred children. Differences in these neural responses between low and high peer preferred children may enrich our understanding on why low peer preferred children demonstrate different behaviors following peer provocations (London et al., 2007; Rudolph et al., 2009).

Outline of this thesis

The overall aim of the present thesis is to investigate the interplay between the peer context and the development of social behavior during childhood and adolescence, both on a behavioral and neural level. The purpose of part one of this thesis, comprised of **Chapter 2**, is to provide a theoretical framework of the role of peers in brain development and provide an overview of state-of-the-art research on peer experiences and brain functioning during childhood. This overview chapter is followed by two empirical sections that use data from various longitudinal studies in which data on (classroom-based) peer experiences, youth's social behavior, and fMRI data were collected. An overview of these empirical chapters (**chapters 3 – 7**) is presented in Table 1.1. Finally, in **Chapter 8** the main findings and implications of these findings for understanding the role of peers in the normative development and the potential impact of negative peer experiences on behavior and brain function are discussed. Moreover, suggestions for future research and practice are provided.

Chapter 1 - General Introduction

Table 1.1. Study characteristics per empirical chapter

Chapter	N	Age (years)	Design	Peer variables	Outcome
<i>Part 2: Peers and the normative development of social behavior and brain function</i>					
3	1108	8-12	Longitudinal behavioral study, four annual assessments	peer likeability/ dislikeability	sharing behavior with friends, disliked peers, anonymous peers
4	167	13-17	Longitudinal fMRI study, four annual assessments	peer attachment	neural responses during risk processing
<i>Part 3: The impact of negative peer experiences on social behavior and brain function</i>					
5	963	9-10	Longitudinal behavioral study, two annual assessments	peer likeability/ dislikeability/ rejection	sharing behavior with friends, disliked peers, anonymous peers
6	27 LPP, 28 HPP	10	fMRI study nested within longitudinal behavioral study	history of peer preference from ages 7 - 10 years	neural responses to social exclusion
7	25 LPP, 20 HPP	10	fMRI study nested within longitudinal behavioral study	history of peer preference from ages 7 - 10 years	changes in neural responses during sharing decisions with friends and anonymous peers from before to after social exclusion

Note. LPP = low peer preferred; HPP = high peer preferred; fMRI = functional magnetic resonance imaging.