Developmental Cascades of Social Inhibition and Friendships in Preterm and Full-Term Children

Abstract

Friendships are crucial to children's socioemotional development and quality of life. Children born preterm (<37 weeks gestation) have an increased risk for social relationship difficulties, including fewer friends, but the mechanisms underlying the link between lower gestational age and fewer friendships are not clear. The prospective Bavarian Longitudinal Study investigated potential cascading effects on N=1,181 children's friendships at 8 years. Path modeling indicated that higher gestational age predicted good early parent-infant relationship quality, good inhibitory control, and higher friendship scores. Good parent-infant relationship quality predicted good inhibitory control, which subsequently predicted low social inhibition at 6 years and higher friendship scores at 8 years. There is evidence of cascading effects from gestational age to early parent-infant relationships, to toddlers' inhibitory control, and to social inhibition, which partially explain differences in children's friendships at 8 years of age.

Highlights

- Preterm children are at risk for social problems and fewer friends, but the mechanisms underlying this risk are not known.
- Path modeling showed that gestational age predicted good early parent-infant relationship and inhibitory control, which subsequently predicted low social inhibition and higher friendship scores.
- Cascading effects from gestational age to parent-infant relationships, to inhibitory control, and to social inhibition partially explain differences in friendships at 8 years.

Keywords: *peer relationships, friendships, behavioral inhibition, gestational age, prematurity*

Developmental Cascades of Social Inhibition and Friendships in Preterm and Full-Term Children

Friendships are critical for children's emotional, cognitive, and social development (Engle, McElwain, & Lasky, 2011; Newcomb & Bagwell, 1995). Peer acceptance and close dyadic friendships are associated with higher self-worth (Bagwell, Newcomb, & Bukowski, 1998; Berndt, 2002), promote positive emotional, behavioral, and academic outcomes (Buhs, Ladd, & Herald, 2006; Laursen, Bukowski, Aunola, & Nurmi, 2007), and provide a buffer from peer victimization (Boulton, Trueman, Chau, Whitehand, & Amatya, 1999; Sapouna & Wolke, 2013; Schwartz, Dodge, Pettit, Bates, & The Conduct Problems Prevention Research, 2000). The protective effects of high-quality friendships may be especially important for children who are socially vulnerable (e.g. Burgess, Wojslawowicz, Rubin, Rose-Krasnor, & Booth-LaForce, 2006; Frenkel et al., 2015; Laursen et al., 2007), as positive peer relationships ameliorate the effects of early negative experiences (Criss, Pettit, Bates, Dodge, & Lapp, 2002).

Children born very preterm (VP; <32 weeks' gestation) have more difficulties in social relationships (Ritchie, Bora, & Woodward, 2015), including more social withdrawal (Reijneveld et al., 2006), victimization (Wolke, Baumann, Strauss, Johnson, & Marlow, 2015), and peer problems than term comparisons (Bora, Pritchard, Moor, Austin, & Woodward, 2011; Delobel-Ayoub et al., 2006). Lower gestational age has been associated with having fewer friends and lower rates of peer acceptance in middle childhood (Heuser, Jaekel, & Wolke, 2018). These social deficits appear to be long-lasting, as adults born preterm are at risk for lower social support and an inhibited personality type (Eryigit-Madzwamuse, Strauss, Baumann, Bartmann, & Wolke, 2015; Saigal et al., 2016). Although preterm children's more frequent functional differences (e.g. motor problems) and cognitive deficits (e.g. lower IQ) predicted their peer relationship difficulties in middle childhood in one study (Heuser et al., 2018), lower cognitive

abilities do not explain a withdrawn personality factor found in adults born preterm (Eryigit-Madzwamuse et al., 2015). Thus, the mechanisms underlying the link between preterm birth and social problems are still poorly understood (Montagna & Nosarti, 2016; Zmyj, Witt, Weitkämper, Neumann, & Lücke, 2017).

Developmental cascade models of behavior regulation (Bornstein, Hahn, & Suwalsky, 2013) may illuminate trajectories of social adjustment difficulties in preterm and full-term children. Inhibitory control – the component of executive function that represents the ability to voluntarily control one's attention, behavior, thoughts, and emotions, and override strong internal predispositions or external stimuli (Diamond, 2013) – first emerges in the second half of the first year of life, with individual differences becoming increasingly stable during toddlerhood and into preschool (Kochanska, Murray, & Harlan, 2000). Inhibitory control may impact the development and maintenance of friendships through its effects on social behavior, as children with good regulatory abilities interact more effectively with other children (Gleason, Gower, Hohmann, & Gleason, 2005). Indeed, inhibitory control has been positively associated with empathic and prosocial behaviors during preschoolers' peer interactions (Hughes, White, Sharpen, & Dunn, 2000). Conversely, poor inhibitory control of behavior (i.e. poor self-control; Diamond, 2013) may impair social interactions by failing to impede impulsive reactions, negative displays of emotions, and other antisocial behavior (Hughes et al., 2000), which have been reported to contribute to peer rejection (Ladd & Troop-Gordon, 2003; Rotenberg, Michalik, Eisenberg, & Betts, 2008).

Moreover, the effects of early inhibitory control on friendships may be related to temperamental characteristics. Indeed, poor inhibitory control of attention (i.e. impairments in the ability to suppress attention to threatening stimuli; Diamond, 2013) has been shown to

moderate the link between behaviorally inhibited temperament in early childhood and later social withdrawal (Pérez-Edgar et al., 2011; Thai, Taber-Thomas, & Pérez-Edgar, 2016), suggesting that regulatory problems may hinder children's social initiative and opportunities for making friends. Social inhibition, the temperament-based tendency to inhibit social approach behavior in reaction to unfamiliar people (Asendorpf, 1990; Fox, Henderson, Marshall, Nichols, & Ghera, 2005; Kagan, Reznick, & Gibbons, 1989), has also been related to peer difficulties (Coplan et al., 2013). Previous research has shown that preterm children have an increased risk for both inhibitory control problems (Jaekel, Eryigit-Madzwamuse, & Wolke, 2016) and social inhibition (Miranda, Jaekel, & Wolke, 2017), but it is unclear whether preterm children's poor inhibitory control predicts greater social inhibition and poorer social interactions in the peer context.

Additionally, the earliest social experiences take place within family relationships and may confer significant effects on social adjustment among peers (Clark & Ladd, 2000). In samples of very preterm children, sensitive parenting predicted better self-regulation at 2 years of age (Clark, Woodward, Horwood, & Moor, 2008), while maternal anxiety and negative or intrusive parenting predicted poorer social competence at age 4 years (Jones, Champion, & Woodward, 2013). Positive parenting at 6 and 9 months of age was associated with resilience across various domains of functioning, including peer relations, in preterm children at 6 years of age (Poehlmann-Tynan et al., 2014). Responsive parent-infant relationships were shown to predict more friends and higher peer acceptance in children at age 6 and 8 years across the whole gestational age range (Heuser et al., 2018). Thus, social skills and relationship patterns experienced in the early home environment appear to transfer to other settings such as the peer group (Ladd & Pettit, 2002), but whether self-regulatory abilities (e.g., inhibitory control)

mediate the relationship between early parenting and later peer relationships in preterm children has not been studied.

To identify the developmental cascades through which preterm birth adversely affects social functioning with peers, the current study used path analysis to explore links among gestational age, early parent-infant relationship quality, inhibitory control at 20 months, social inhibition at 6 years, and friendships at 8 years of age. Based on the literature, it was hypothesized that higher gestational age would predict higher inhibitory control, which would subsequently predict low social inhibition and higher friendship scores. In addition, it was expected that good early parent-infant relationship quality would predict good inhibitory control, which would in turn predict higher friendship scores.

Method

Participants

Participants were recruited as part of the prospective geographically defined whole population Bavarian Longitudinal Study of neonatal at-risk children who were born across the entire gestational age range in South Germany. All infants born between January 1985 and March 1986 who required admission to a children's hospital within the first 10 days of life (N = 7,505; 10.6% of all live births) and 916 healthy term control infants born in the same hospitals during the same period, who received normal postnatal care, were recruited into the study. Parents were approached within 48 hours of the infant's hospital admission and gave written informed consent before participation. For the 6 years follow-up, 1,495 children from the initial sample were randomly selected within the following stratification criteria: sex, socioeconomic background, and degree of neonatal risk. Detailed sampling criteria and dropout rates are provided elsewhere (Eryigit-Madzwamuse & Wolke, 2015; Jaekel, Baumann, & Wolke, 2013;

Schmid & Wolke, 2014; Wolke & Meyer, 1999). Children with complete data were included in the current study (n=1,181, see Table 1). Ethical approval was granted by the Ethics Committee of the University of Munich Children's Hospital and the Bavarian Health Council (Landesärztekammer).

Measures

Biological, medical, and socio-demographic variables at birth. Gestational age in weeks, birth weight and sex were obtained from obstetric records. Gestational age groups were coded as follows: very preterm, < 32 weeks; moderately preterm, 32-33 weeks; late preterm, 34-36 weeks; early term, 37-38 weeks; full-term, 39-41 weeks. Infant neonatal medical risk was measured with a comprehensive optimality index score (OPTI) that included 21 items including medical complications (e.g. ventilation or intubation, severe anemia, cerebral hemorrhage; Schmid, Schreier, Meyer & Wolke, 2011). Higher OPTI scores indicated more problematic neonatal course. Details of this score are provided in the *Appendix*. Family socioeconomic status (SES) at birth was based on maternal and paternal highest education and occupational status and coded from 1 (lowest) to 6 (highest social class) (Bauer, 1988).

Parent-Infant Relationship, postnatal. Early parent–infant relationship quality was assessed with the Parent-Infant Relationship Index (PIRI) from birth to five months (Breeman, Jaekel, Baumann, Bartmann, & Wolke, 2017; Wolke, Schmid, Schreier, & Meyer, 2009). The instrument consists of eight 'yes' or 'no' items obtained by trained nurses' observations and a standardized interview with the children's parents, assessing attachment-related parental concerns, feelings, and behaviors. Examples for items are as follows: *mother shows little pleasure when interacting with the child* (nurse's observation, neonatal), *father visits infant one time per week/less on the neonatal ward* (father or mother interview, neonatal), and *mother has*

difficulties in establishing a relationship to the infant (mother interview, at 5 months of age). The sum of responses was recoded into a binary variable [0= some concern (i.e. poor parent-infant relationship), 1= no concern (i.e. good parent-infant relationship)]. Further details of this assessment are described in the *Appendix* (see also Breeman et al., 2017).

Inhibitory control at 20 months. Children's inhibitory control abilities were measured with a standardized behavioral observation task – an adapted version of the snack delay task (Kochanska et al., 2000) – at 20 months corrected age (Jaekel et al., 2016). Children were presented with a raisin that was placed under an opaque plastic cup within reach. Then, three training runs were conducted during which eating the raisin was allowed after short but increasing time intervals (instant eating, then 5 and 10 seconds waiting time). The experimenter marked the end of each interval by blowing a whistle. After that, the actual test run was performed. Children's waiting time until they touched the raisins was measured with a stopwatch from 0 to 60 seconds. Scores of reaction times were not normally distributed and thus combined into a binary score: 0 = did not wait or waited up to 10 seconds (62%) and 1 = waited for ≥11 seconds (38%). The cut-off was based on normative reaction times at 20 months of age indicating meaningful differentiation of inhibitory control abilities (i.e., waiting for 0 to 10 seconds was classified as not waiting).

Social inhibition at 6 years. At 6 years of age, children's social inhibition in an unfamiliar setting was assessed with a standard experimental procedure of the child's interaction with an adult stranger (Asendorpf, 1990). Children and their mothers were placed in a specially equipped soundproof room without toys. The mother was seated 1.5 to 2 meters away from the child and instructed to answer a written questionnaire and not actively engage with the child. When the child started to show signs of being bored (between 2 to 5 minutes after entering the

room), an adult stranger entered with a transparent bag filled with toys, greeted child and mother, and sat down opposite of the mother about 1 meter from the child. The stranger then started unpacking the bag of toys and playing with them while looking at the child every ten seconds, but not actively approaching the child. If the child had not initiated nonverbal (e.g. pointing to toy and looking at stranger) or verbal (e.g. asking for toy; saying hello) contact after three minutes had passed, the stranger asked if he or she wanted to play with the toys. Latencies (in seconds) of children's first verbal social reaction towards the stranger were measured with a stopwatch. For the current study, latencies were coded into two categories of social inhibition behavior, based on the distribution of healthy (i.e., not neonatally hospitalized) full-term children's (n= 251) responses in the total sample. These cut-offs marked a meaningful difference in social approach behavior: 0= low social inhibition (<228 seconds), 1= high social inhibition (>227 seconds). Additional details of coding, including frequencies of responses for the healthy full-term control group, are provided in the *Appendix*.

Friendships at 8 years. The semi-structured Friendship and Family Interview (Heuser et al., 2018; Wolke, 1993) was used to assess children's friendships at 8 years. Children were asked to name up to ten playmates or friends (siblings not included), and these were summed into a *Number of Friends* index score. For the first five of these friends (or fewer, depending on the number listed) children were asked to give information about how often they met their friends and a *Frequency of Meeting Friends* index score was calculated by averaging responses across friends (Heuser et al., 2018). Parents' perceptions of their children's friendships at 8 years were assessed with the structured Mannheimer Parent Interview (MEI; subsection Contact with Peers) (Esser, Blanz, Geisel, & Laucht, 1989). Parents listed up to eight friends, including meeting frequencies, and the same index scores as those for the child reports were calculated (i.e.,

number of friends, frequency of meeting friends; (Heuser et al., 2018). Interviewers were trained over two months, and all interviews were video-taped and double-rated by two psychologists, yielding excellent interrater-reliability (Cohen's kappa >.95). Additional details of the measures are reported in the *Appendix*.

An adapted German version of the Pictorial Scale of Perceived Competence and Social Acceptance for Young Children (Asendorpf & Van Aken, 1993; Harter & Pike, 1984), subscale Peer Acceptance, was administered. The scale contains six items that are presented via two pictures displaying a gender-matched child. Children pick the child to whom they are most similar and responses are coded on a four-point scale with greater values indicating higher acceptance. The six items are averaged into a *Peer Acceptance* index score (Heuser et al., 2018). Internal consistency was acceptable ($\alpha = .70$). A parallel version of the described items, reformulated into questions, was answered by parents. Internal consistency was good ($\alpha = .80$). Further details are described in the *Appendix*. *Number of Friends*, *Frequency of Meeting Friends*, and *Peer Acceptance* scores reported by children and parents were highly correlated (see *Appendix*) and summed into a comprehensive Friendships z-score as the dependent variable for main analyses.

Statistical Analyses

Mean values and frequencies for descriptive characteristics were calculated by gestational age group using SPSS v.24 (Chicago, IL). Gestational age was scaled to a quadratic effect in the path model, based on previous literature (Eryigit-Madzwamuse & Wolke, 2015; Jaekel et al., 2013). Path analyses were performed using AMOS v.24 to test the direct and indirect effects of gestational age, parent-infant relationship quality, inhibitory control at 20 months, and social inhibition at 6 years on Friendships z-score at 8 years of age. In addition, the child's sex, family

SES at birth, and neonatal medical risk were included as potential confounders. Estimates for mediation effects were obtained from bias-corrected bootstrap confidence intervals. Model fit was evaluated by examining the χ^2 statistics, the root mean square of approximation (RMSEA) and its confidence interval (CI), and the comparative fit index (CFI).

Results

Table 1 shows descriptive results by gestational age group. Children of higher gestational age groups had higher proportions of good early parent-infant relationships and good inhibitory control at 20 months as well as higher Friendships z-scores at 8 years. There were no significant differences in distributions of child's sex, family SES at birth, and social inhibition at 6 years according to gestational age group. As expected, infants in lower gestational age groups had greater neonatal risk (i.e., higher average OPTI scores).

– Table 1 about here –

Figure 1 depicts the path model. The overall model provided a good fit to the data χ^2/df = 6.79/7, p=.452; CFI= 1.00; RMSEA= 0.00 [90% CI: .00 to .04], PCLOSE = .998. Higher gestational age directly predicted good early parent-infant relationship quality (β=.10, p =.035), children's inhibitory control abilities (β=.09, p=.035), and higher Friendships z-scores (β=.11, p=.015), controlling for child's sex, family SES at birth, and neonatal medical risk. Additionally, good early parent-infant relationships directly predicted good inhibitory control at 20 months (β= .06, p=.043), which subsequently predicted low social inhibition at age 6 (β= -.08, p=.009) and higher Friendships z-scores at 8 years (β=.08, p=.006). Social inhibition at 6 years had a direct negative effect on Friendships z-scores at 8 years (β= -.08, p=.006).

Regarding indirect effects, inhibitory control abilities at 20 months had a small but significant indirect effect on Friendships z-scores at 8 years (β= .01 [CI= .00 to .02]), suggesting

that social inhibition at 6 years partially mediated the relationship between inhibitory control abilities and Friendships z-scores. Additionally, gestational age had significant indirect effect on inhibitory control abilities at 20 months (β=.07 [.00 to .12]), suggesting that early parent-infant relationship quality partially mediated the association between gestational age and inhibitory control abilities. Parent-infant relationship quality had a small significant negative indirect effect on social inhibition (β= -.00 [-.01 to -.00]) and a small significant positive indirect effect on Friendships z-scores (β= .01 [.00 to .01]).

As for the effects of control variables, female sex directly predicted higher Friendships z-scores (β= .07, p=.011), whereas higher SES directly predicted good early parent-infant relationships (β= .07, p=.023), good inhibitory control (β= .10, p<.001), and low social inhibition (β= -.11, p<.001). Additionally, SES had small indirect effects on social inhibition (β= -.01 [-.02 to -.00]) and Friendships z-scores (β= .02 [.01 to .03]). Female sex also had small indirect effects on social inhibition (β= -.01 [-.02 to -.00]) and Friendship z-scores (β= .01 [.00 to .02]). Finally, neonatal medical risk had small indirect effects on social inhibition (β=.01 [.00 to .02]) and Friendships z-scores (β= -.01 [-.02 to -.00]). The full model explained 4% of the overall variance in children's Friendship z-scores. Standardized direct, indirect, and combined total effects are presented in Figure 2.

– Figure 1 about here –

– Figure 2 about here –

Discussion

Preterm children have more frequent peer relationship problems (Ritchie et al., 2015), but little is known about the mechanisms that underlie the effects of gestational age on friendships. The current study adds to the literature by showing that children born at lower

gestational age had poorer friendships at 8 years of age, and that this effect was strongest for the very preterm group, for which Friendship z-scores were two standard deviations below the full-term group's mean. Additionally, the current study provides evidence to help explain underlying mechanisms by showing that gestational age positively predicted early parent-infant relationship quality, inhibitory control at 20 months, and friendship scores at 8 years of age. In addition, early parent-infant relationship quality partially mediated the association between gestational age and inhibitory control abilities at 20 months. Importantly, good inhibitory control at 20 months predicted higher friendship scores at 8 years, as well as low social inhibition at 6 years, which in turn, also predicted higher friendship scores at 8 years of age. Nonetheless, the overall model explained a small amount of variance in Friendships z-scores at 8 years of age.

Findings of the current study support evidence of the impact of low gestation on children's inhibitory control (Jaekel et al., 2016), and indicate that deficits in early self-regulatory abilities may precede poor social functioning with peers. Consistent with prior research on normative samples, the current study suggests that children with poor inhibitory control have more problems in peer relationships (Dollar, Stifter, & Buss, 2017; Holmes, Kim-Spoon, & Deater-Deckard, 2016; Rotenberg et al., 2008). These social difficulties may further hinder children's school adjustment (Rotenberg et al., 2008) and academic outcomes (Oberle & Schonert-Reichl, 2013). Inhibitory control abilities are critical for everyday social functioning (Hay, Payne, & Chadwick, 2004). Suppressing impulsive or inappropriate responses in social contact with peers (e.g., engaging in socially problematic behaviors, telling secrets, negative emotionality; Fabes et al., 1999; Hughes et al., 2000; Rotenberg et al., 2008) may facilitate adaptive interaction and prevent negative peer relationships (Fabes et al., 1999; Gazelle & Ladd, 2003; Ladd & Troop-Gordon, 2003). Previous research argues that early self-regulatory deficits

may contribute to a range of developmental delays and maladaptive outcomes in children born preterm (Davis & Burns, 2001; Poehlmann-Tynan et al., 2014). This study suggests that early inhibitory control problems predict lower success in friendships in children across the whole gestational age range. Given that previous evidence has shown a protective function of self-regulation for children facing the risks of prematurity (Poehlmann-Tynan et al., 2014), future studies should consider using moderation analyses to explore whether early inhibitory control abilities promote resilience against the development of peer difficulties. What's more, although our findings do not show an effect of parent-child relationship quality on friendships, emerging evidence suggests that neonatal at-risk children may not only be more vulnerable (Jaekel, Pluess, Belsky, & Wolke, 2015) but also more susceptible to effects of sensitive parenting (Nichols, Jaekel, Bartmann, & Wolke, 2019). Such associations may be bi-directionally related with infants' regulatory abilities (Jaekel et al., 2019; Kim & Kochanska, 2012), and potential differential susceptibility to long-term effects on friendships remains to be explored in future studies.

Consistent with findings of previous studies on shy and inhibited children (Coplan et al., 2013; Ladd, Kochenderfer-Ladd, Eggum, Kochel, & McConnell, 2011; Zhang, Eggum-Wilkens, Eisenberg, & Spinrad, 2017), this study reveals that children who tend to inhibit social approach behavior in unfamiliar social situations are at increased risk of later peer difficulties. This temperamental style of reacting with fearfulness, reticent behavior, or avoidance to unfamiliar adults or peers (Asendorpf, 1990; Fox et al., 2005; Kagan et al., 1989; Rubin, Burgess, & Hastings, 2002) plays a critical role in the development of psychopathology including social anxiety disorder (Clauss & Blackford, 2012). Previous studies have linked behavioral inhibition with lower thresholds of limbic and sympathetic nervous system arousal and higher levels of

negative emotionality (Fox et al., 2005), which may promote social withdrawal and impede socially adaptive interactions, frequently found in normative samples of shy and inhibited children (Bohlin, Hagekull, & Andersson, 2005; Coplan, Prakash, O'neil, & Armer, 2004; Walker, Degnan, Fox, & Henderson, 2013) and in preterm children (Potijk, de Winter, Bos, Kerstjens, & Reijneveld, 2015; Ritchie et al., 2015; Talge et al., 2010). Thus, shy-withdrawn children may miss the opportunity to engage with peers and to learn how to interact appropriately with others (Suway, Degnan, Sussman, & Fox, 2012), which places them at risk for later peer problems (Coplan et al., 2013).

This study suggests that the effects of toddlers' inhibitory control abilities on children's later social functioning with peers may be, at least in part, explained by their individual differences in social approach tendencies. The role of cognitive regulatory processes in behavioral inhibition in social contexts is still not completely understood (Henderson, Pine, & Fox, 2015). Some studies found negative associations between social inhibition and effortful control (Geng, Hu, Wang, & Chen, 2011), which refers to a temperamental dimension covering attention regulation and inhibitory control (Spinrad, Eisenberg, & Gaertner, 2007). In contrast to the results of the current study, inhibitory control and shyness were positively related concurrently in toddlerhood, and longitudinally from age 3 to 7 years, whereas the ability to shift attention was negatively associated with shyness in studies addressing distinct components of effortful control (Eggum-Wilkens, Reichenberg, Eisenberg, & Spinrad, 2016; Volbrecht & Goldsmith, 2010). However, shyness decreased faster for children with high inhibitory control, but was still higher than for children with low inhibitory control (Eggum-Wilkens et al., 2016). There is emerging evidence that inhibited children have an attention bias toward environmental cues indicative of threat or distress (Pérez-Edgar et al., 2011). Therefore, interventions may be

promising, in which children learn how to control their automatic reaction tendencies by regulating negative arousal and disentangle attention from threatening or distressing aspects of social situations (Dollar et al., 2017; Fox et al., 2005). Children born preterm may particularly benefit from those interventions as previous studies have demonstrated higher emotional reactivity, more difficulties in emotion and attention regulation as well as effortful control (Jaekel et al., 2016; Jones et al., 2013; Witt et al., 2014).

Different approaches of defining and measuring inhibitory control may contribute to different patterns of findings. For example, compared with children born very preterm, full-term children exhibited better effortful control abilities as measured with delay and motor inhibition tasks, whereas no differences emerged in a parent-answered questionnaire assessing the same construct (Voigt, Pietz, Pauen, Kliegel, & Reuner, 2012). In the current study, inhibitory control was measured as a component of executive function (Diamond, 2013) using a snack delay task, which has shown positive associations with ratings of temperament-based effortful control, including inhibitory control and attention shifting in toddlerhood in another study (Spinrad et al., 2007). Tasks of gratification delay are considered as "hot" effortful control tasks involving regulation of emotions and approach tendencies (Kim, Nordling, Yoon, Boldt, & Kochanska, 2013). Effortful control and executive function are both related to self-regulation and overlap in definition and measurement, but stem from different research traditions (Zhou, Chen, & Main, 2012). Thus, to better understand the role of inhibitory control in predicting social inhibition and peer difficulties, future studies should combine multiple methods of measurement.

Given that specific executive functions may differentially impact children based on unique temperamental styles (Dollar et al., 2017), future studies should consider whether inhibitory control moderates the relationship between early temperamental traits (e.g. sociability,

shyness) and later peer outcomes. In the current study, social inhibition was measured at 6 years of age, and thus, earlier indicators of social dispositions may inform whether the impact of inhibitory control on social trajectories varies by child characteristics, such as early social approach. Additionally, studies that follow individuals longitudinally into adolescence and adulthood are necessary to identify whether deficits persist as different developmental tasks and social experiences become more salient, and what their implications are on social functioning over the course of adulthood.

Consistent with findings of several studies (Clark et al., 2008; Jones et al., 2013; Liu, Calkins, & Bell, 2018; Pallini et al., 2018; Roskam, Stievenart, Meunier, & Noël, 2014; Spinrad et al., 2007), the current study indicates that early positive parenting and secure attachment influence the development of toddlers' self-regulatory abilities in preterm and full-term children. Since children born at lower gestational age face an increased risk of poor early parent-infant relationship quality (Heuser et al., 2018), it is possible that improving parenting early at the neonatal ward may contribute to more adaptive developmental trajectories of social functioning for preterm children, considering the cascading effects found in this study. Accordingly, a very recent study showed that fearfully inhibited children exposed to maternal negative behavior and low in inhibitory control at age 3 years were at greater risk for later internalizing behavior problems at 6 years of age (Liu et al., 2018). However, in some studies, the longitudinal relations diminished after accounting for the stability of constructs (Spinrad et al., 2007). Thus, it is important to replicate the findings of the current study while controlling for the stability of constructs.

Although health care professionals can provide regular follow up assessments of all children born preterm to support screening and early identification of problems

in social competence (Doyle et al., 2014), future studies are necessary to clarify what (and for whom) interventions are indicated. Moreover, including such information in future studies may shed light on the impact of specific interventions on children's social outcomes over time. Future research should continue exploring the effect of executive functions on social competence, while distinguishing children who withdraw from social contexts because they fear unfamiliarity or social evaluation from unsociable children who prefer to play alone and inhibit social approach due to disinterest (Asendorpf, 1990; Coplan et al., 2004; Tang, Santesso, Segalowitz, & Schmidt, 2016).

This study has several strengths. Data was collected from a large, prospective, whole-population sample, followed longitudinally from birth to 8 years of age. Measures of child friendships consisted of in-depth interviews and included children's self-perceptions in addition to parents' reports. Teacher reports on social relationships with peers, when available, could further strengthen such measures in future studies. Inhibitory control and social inhibition were measured with previously validated standardized behavioral observations (Asendorpf, 1990; Kochanska et al., 2000). The evaluation of parent-infant relationship quality included nurse's observations in addition to parent interviews adopting multiple methods and sources of information. Moreover, analyses were adjusted for child's sex, neonatal medical risk, and family SES.

This study also has limitations. The sample was recruited between 1985 and 1986, and thus replications with more recent samples are necessary, given that with improvements in neonatal care survival of preterm infants has substantially improved over the past decades. Nevertheless, in general, the long-term neurodevelopmental outcomes after preterm birth appear to be comparable, even in more recent samples (Cheong et al., 2017; Pierrat et al., 2017; D.

Wolke et al., 2015). Despite the exceptionally good fit of the data to the model in the current study, it only explained a small amount of variance. Thus, other factors beyond individual characteristics (e.g. peer group composition and fluctuation, school climate) may further explain children's friendships and peer acceptance and should be included in future studies. In addition, preterm children have been shown to have more neurodevelopmental problems (Woodward et al., 2009) and delays in social-cognition (Witt, Weitkämper, Neumann, Lücke, & Zmyj, 2018) that may be related to less success with friendships. Thus, early neuropsychological characteristics and social cognition should be explored, in order to disentangle multiple potential mechanisms contributing to social difficulties. Moreover, the snack delay task may be an age-appropriate measure of inhibitory control at 20 months of age, achieving a ceiling effect of responses at preschool age (Spinrad et al., 2007), but may have been affected by differences in individual preferences for the snack. Thus, in future studies, children should have the opportunity to pick their favorite from several alternative snack options (Duckworth, Tsukayama, & Kirby, 2013). Since some studies have pointed towards a quadratic effect of effortful control as assessed, for example, with several delay tasks on behavior problems (i.e., moderate rather than low or high levels optimal; Murray & Kochanska, 2002), future studies should examine both linear and non-linear associations to gain a better understanding of the role of early self-regulatory abilities in predicting social functioning. In the current study, testing a quadratic effect was not possible due to the distribution of scores in the sample and respective binary variable coding.

In conclusion, this study finds evidence of cascading effects from gestational age over inhibitory control, to social inhibition, and friendships, thus, extending previous results and providing new insights into the underlying mechanisms of preterm children's social difficulties.

Moreover, findings of this study highlight the importance of early child characteristics and environmental factors for children's peer relationships at school age, and indicate that both early parent-infant relationships and toddlers' inhibitory control abilities predict better outcomes in preterm and full-term children. Knowing when and how developmental cascades occur can inform timely and strategic interventions (Masten et al., 2005), thus future research should continue to explore the impact of preterm birth on social relationships, and how early factors contribute to long-term social, emotional, and occupational functioning. More precise identification of early risks will lead to more effective interventions for those who need them.

References

Asendorpf, J. B. (1990). Development of inhibition during childhood: Evidence for situational specificity and a two-factor model. *Developmental Psychology, 26*(5), 721-730. doi: 10.1037/0012-1649.26.5.721

Asendorpf, J. B., & Van Aken, M. A. G. (1993). Deutsche versionen der selbstkonzeptskalen von Harter. *Zeitschrift für Entwicklungspsychologie und pädagogische Psychologie, 25*(1), 64-96.

Bagwell, C. L., Newcomb, A. F., & Bukowski, W. M. (1998). Preadolescent friendship and peer rejection as predictors of adult adjustment. *Child Development, 69*(1), 140-153. doi: 10.1111/j.1467-8624.1998.tb06139.x

Bauer, A. (1988). Ein Verfahren zur Messung des fuer das Bildungsverhalten relevanten Sozial Status BRSS ueberarbeitete Fassung. *Frankfurt: Deutsches Institut fuer Internationale Paedagogische Forschung.*

Berndt, T. J. (2002). Friendship Quality and Social Development. *Current Directions in Psychological Science, 11*(1), 7-10. doi:10.1111/1467-8721.00157

Bohlin, G., Hagekull, B., & Andersson, K. (2005). Behavioral inhibition as a precursor of peer social competence in early school age: The interplay with attachment and nonparental care. *Merrill-Palmer Quarterly, 51*(1), 1-19. doi: 10.1353/mpq.2005.0001

Bora, S., Pritchard, V. E., Moor, S., Austin, N. C., & Woodward, L. J. (2011). Emotional and behavioural adjustment of children born very preterm at early school age. *Journal of Paediatrics and Child Health, 47*(12), 863-869. doi: 10.1111/j.1440-1754.2011.02105.x

Bornstein, M. H., Hahn, C.-S., & Suwalsky, J. T. D. (2013). Developmental pathways among adaptive functioning and externalizing and internalizing behavioral problems: Cascades

from childhood into adolescence. *Applied Developmental Science, 17*(2), 76-87. doi:10.1080/10888691.2013.774875

Boulton, M. J., Trueman, M., Chau, C., Whitehand, C., & Amatya, K. (1999). Concurrent and longitudinal links between friendship and peer victimization: Implications for befriending interventions. *Journal of Adolescence, 22*(4), 461-466. doi: 10.1006/jado.1999.0240

Breeman, L. D., Jaekel, J., Baumann, N., Bartmann, P., & Wolke, D. (2017). Neonatal predictors of cognitive ability in adults born very preterm: a prospective cohort study. *Developmental Medicine & Child Neurology, 59*(5), 477-483. doi:10.1111/dmcn.13380

Buhs, E. S., Ladd, G. W., & Herald, S. L. (2006). Peer exclusion and victimization: Processes that mediate the relation between peer group rejection and children's classroom engagement and achievement? *Journal of Educational Psychology, 98*(1), 1. doi: 10.1037/0022-0663.98.1.1

Burgess, K. B., Wojslawowicz, J. C., Rubin, K. H., Rose-Krasnor, L., & Booth-LaForce, C. (2006). Social Information Processing and Coping Strategies of Shy/Withdrawn and Aggressive Children: Does Friendship Matter? *Child Development, 77*(2), 371-383. doi:10.1111/j.1467-8624.2006.00876.x

Cheong, J. L. Y., Anderson, P. J., Burnett, A. C., Roberts, G., Davis, N., Hickey, L., . . . Victorian Infant Collaborative Study, G. (2017). Changing neurodevelopment at 8 years in children born extremely preterm since the 1990s. *Pediatrics*, e20164086. doi: 10.1542/peds.2016-4086

Clark, C. A. C., Woodward, L. J., Horwood, L. J., & Moor, S. (2008). Development of Emotional and Behavioral Regulation in Children Born Extremely Preterm and Very

Preterm: Biological and Social Influences. *Child Development, 79*(5), 1444-1462. doi:10.1111/j.1467-8624.2008.01198.x

Clark, K. E., & Ladd, G. W. (2000). Connectedness and autonomy support in parent–child relationships: Links to children's socioemotional orientation and peer relationships. *Developmental Psychology, 36*(4), 485.

Clauss, J. A., & Blackford, J. U. (2012). Behavioral inhibition and risk for developing social anxiety disorder: a meta-analytic study. *Journal of the American Academy of Child & Adolescent Psychiatry, 51*(10), 1066-1075. e1061.

Coplan, R. J., Prakash, K., O'neil, K., & Armer, M. (2004). Do you" want" to play? Distinguishing between conflicted shyness and social disinterest in early childhood. *Developmental Psychology, 40*(2), 244.

Coplan, R. J., Rose-Krasnor, L., Weeks, M., Kingsbury, A., Kingsbury, M., & Bullock, A. (2013). Alone is a crowd: Social motivations, social withdrawal, and socioemotional functioning in later childhood. *Developmental Psychology, 49*(5), 861.

Criss, M. M., Pettit, G. S., Bates, J. E., Dodge, K. A., & Lapp, A. L. (2002). Family adversity, positive peer relationships, and children's externalizing behavior: A longitudinal perspective on risk and resilience. *Child Development, 73*(4), 1220-1237. doi: 10.1111/1467-8624.00468

Davis, D. W., & Burns, B. (2001). Problems of self-regulation: A new way to view deficits in children born prematurely. *Issues in Mental Health Nursing, 22*(3), 305-323.

Delobel-Ayoub, M., Kaminski, M., Marret, S., Burguet, A., Marchand, L., N′Guyen, S., . . . Larroque, B. (2006). Behavioral outcome at 3 years of age in very preterm infants: The EPIPAGE Study. *Pediatrics, 117*(6), 1996.

Diamond, A. (2013). Executive Functions. *Annual Review of Psychology, 64*, 135-168. doi:10.1146/annurev-psych-113011-143750

Dollar, J. M., Stifter, C. A., & Buss, K. A. (2017). Exuberant and inhibited children: Person-centered profiles and links to social adjustment. *Developmental Psychology*. doi: 10.1037/dev0000323

Doyle, L. W., Anderson, P. J., Battin, M., Bowen, J. R., Brown, N., Callanan, C., . . . Woodward, L. J. (2014). Long term follow up of high risk children: who, why and how? *BMC Pediatrics, 14*(1), 279. doi:10.1186/1471-2431-14-279

Duckworth, A. L., Tsukayama, E., & Kirby, T. A. (2013). Is it really self-control? Examining the predictive power of the delay of gratification task. *Personality and Social Psychology Bulletin, 39*(7), 843-855.

Eggum-Wilkens, N. D., Reichenberg, R. E., Eisenberg, N., & Spinrad, T. L. (2016). Components of effortful control and their relations to children's shyness. *International Journal of Behavioral Development, 40*(6), 544-554.

Engle, J. M., McElwain, N. L., & Lasky, N. (2011). Presence and quality of kindergarten children's friendships: Concurrent and longitudinal associations with child adjustment in the early school years. *Infant and Child Development, 20*(4), 365-386. 10.1002/icd.706

Eryigit-Madzwamuse, S., Strauss, V., Baumann, N., Bartmann, P., & Wolke, D. (2015). Personality of adults who were born very preterm. *Archives of Disease in Childhood-Fetal and Neonatal Edition, 100*(6), F524-F529. doi: 10.1136/archdischild-2014-308007

Eryigit-Madzwamuse, S., & Wolke, D. (2015). Attention problems in relation to gestational age at birth and smallness for gestational age. *Early Human Development, 91*(2), 131-138. doi:10.1016/j.earlhumdev.2015.01.004

Esser, G., Blanz, B., Geisel, B., & Laucht, M. (1989). *Mannheimer Elterninterview. Strukturiertes Interview zur Erfassung von kinderpsychiatrischen Auffälligkeiten [Mannheimer Parent Interview: A Structured Interview for the Detection of Child Psychiatric Disorders]*. Weinheim: Beltz.

Fabes, R. A., Eisenberg, N., Jones, S., Smith, M., Guthrie, I., Poulin, R., . . . Friedman, J. (1999). Regulation, emotionality, and preschoolers' socially competent peer interactions. *Child Development, 70*(2), 432-442. doi: 10.1111/1467-8624.00031

Fox, N. A., Henderson, H. A., Marshall, P. J., Nichols, K. E., & Ghera, M. M. (2005). Behavioral inhibition: linking biology and behavior within a developmental framework. *Annu. Rev. Psychol., 56*, 235-262.

Frenkel, T. I., Fox, N. A., Pine, D. S., Walker, O. L., Degnan, K. A., & Chronis-Tuscano, A. (2015). Early childhood behavioral inhibition, adult psychopathology and the buffering effects of adolescent social networks: a twenty-year prospective study. *Journal of Child Psychology and Psychiatry, 56*(10), 1065-1073. doi:10.1111/jcpp.12390

Gazelle, H., & Ladd, G. W. (2003). Anxious solitude and peer exclusion: A diathesis–stress model of internalizing trajectories in childhood. *Child Development, 74*(1), 257-278. doi: 10.1111/1467-8624.00534

Geng, F., Hu, Y., Wang, Y., & Chen, F. (2011). Two types of behavioral inhibition: Relations to effortful control and attention in school children. *Journal of Research in Personality, 45*(6), 662-669.

Gleason, T., Gower, A., Hohmann, L., & Gleason, T. (2005). Temperament and friendship in preschool-aged children. *Int'l Journal of Behavioral Development, 29*(4), 336-344.

Harter, S., & Pike, R. (1984). The pictorial scale of perceived competence and social acceptance for young children. *Child Development*, 1969-1982. doi:10.2307/1129772

Hay, D. F., Payne, A., & Chadwick, A. (2004). Peer relations in childhood. *Journal of Child Psychology and Psychiatry, 45*(1), 84-108.

Henderson, H. A., Pine, D. S., & Fox, N. A. (2015). Behavioral inhibition and developmental risk: a dual-processing perspective. *Neuropsychopharmacology, 40*(1), 207.

Heuser, K. M., Jaekel, J., & Wolke, D. (2018). Origins and predictors of friendships in 6- to 8-year-old children born at neonatal risk. *The Journal of Pediatrics*,193, 93–101.e5. doi: 10.1016/j.jpeds.2017.09.072

Holmes, C. J., Kim-Spoon, J., & Deater-Deckard, K. (2016). Linking executive function and peer problems from early childhood through middle adolescence. *Journal of Abnormal Child Psychology, 44*(1), 31-42. doi:10.1007/s10802-015-0044-5

Hughes, C., White, A., Sharpen, J., & Dunn, J. (2000). Antisocial, angry, and unsympathetic: "hard-to-manage" [reschoolers' peer problems and possible cognitive influences. *The Journal of Child Psychology and Psychiatry and Allied Disciplines, 41*(2), 169-179.

Jaekel, J., Baumann, N., & Wolke, D. (2013). Effects of gestational age at birth on cognitive performance: A function of cognitive workload demands. *Plos One, 8*(5). doi:10.1371/journal.pone.0065219

Jaekel, J., Breeman, L., Bilgin, A., Baumann, N., Baeuml, J., Sorg, C., & Wolke, D. (2019). Infant regulatory problems – Are they really a marker for life-long differential susceptibility? Paper presentation, Annual Meeting of the Pediatric Academic Societies (PAS), Baltimore, MD, USA, 26-30/04/2019.

Jaekel, J., Eryigit-Madzwamuse, S., & Wolke, D. (2016). Preterm toddlers' inhibitory control abilities predict attention regulation and academic achievement at age 8 years. *The Journal of Pediatrics*, *169*, 87-92.

Jaekel, J., Pluess, M., Belsky, J., & Wolke, D. (2015). Effects of maternal sensitivity on low birth weight children's academic achievement: a test of differential susceptibility versus diathesis stress. *Journal of Child Psychology and Psychiatry*, *56*(6), 693-701.

Jones, K. M., Champion, P. R., & Woodward, L. J. (2013). Social competence of preschool children born very preterm. *Early Human Development*, *89*(10), 795-802.

Kagan, J., Reznick, J. S., & Gibbons, J. (1989). Inhibited and uninhibited types of children. *Child Development*, 838-845.

Kim, S., & Kochanska, G. (2012). Child temperament moderates effects of parent–child mutuality on self-regulation: a relationship-based path for emotionally negative infants. *Child Development*, *83*(4), 1275-1289. doi:10.1111/j.1467-8624.2012.01778.x

Kim, S., Nordling, J. K., Yoon, J. E., Boldt, L. J., & Kochanska, G. (2013). Effortful control in "hot" and "cool" tasks differentially predicts children's behavior problems and academic performance. *Journal of Abnormal Child Psychology*, *41*(1), 43-56. doi:10.1007/s10802-012-9661-4

Kochanska, G., Murray, K. T., & Harlan, E. T. (2000). Effortful control in early childhood: continuity and change, antecedents, and implications for social development. *Developmental Psychology*, *36*(2), 220.

Ladd, G. W., Kochenderfer-Ladd, B., Eggum, N. D., Kochel, K. P., & McConnell, E. M. (2011). Characterizing and comparing the friendships of anxious-solitary and unsociable

preadolescents. *Child Development, 82*(5), 1434-1453. doi: 10.1111/j.1467-8624.2011.01632.x

Ladd, G. W., & Pettit, G. S. (2002). Parenting and the development of children's peer relationships. *Handbook of Parenting Volume 5 Practical Issues in Parenting*, 268.

Ladd, G. W., & Troop-Gordon, W. (2003). The role of chronic peer difficulties in the development of children's psychological adjustment problems. *Child Development, 74*(5), 1344-1367. doi: 10.1111/1467-8624.00611

Laursen, B., Bukowski, W. M., Aunola, K., & Nurmi, J.-E. (2007). Friendship moderates prospective associations between social isolation and adjustment problems in young children. *Child Development, 78*(4), 1395-1404. doi:10.1111/j.1467-8624.2007.01072.x

Liu, R., Calkins, S. D., & Bell, M. A. (2018). Fearful inhibition, inhibitory vontrol, and maternal negative behaviors during toddlerhood predict internalizing problems at age 6. *Journal of Abnormal Child Psychology*, 1-11.

Masten, A. S., Roisman, G. I., Long, J. D., Burt, K. B., Obradović, J., Riley, J. R., . . . Tellegen, A. (2005). Developmental cascades: linking academic achievement and externalizing and internalizing symptoms over 20 years. *Developmental Psychology, 41*(5), 733.

Miranda, L., Jaekel, J., & Wolke, D. (2017, May). Effects of preterm birth and early parenting on social inhibition at age six years. Annual Meeting of the Pediatric Academic Societies (PAS), San Francisco, USA.

Montagna, A., & Nosarti, C. (2016). Socio-emotional development following very preterm birth: pathways to psychopathology. *Frontiers in Psychology, 7*.

Murray, K. T., & Kochanska, G. (2002). Effortful control: factor structure and relation to externalizing and internalizing behaviors. *Journal of Abnormal Child Psychology, 30*(5), 503-514. doi:10.1023/a:1019821031523

Newcomb, A. F., & Bagwell, C. L. (1995). Children's friendship relations: A meta-analytic review. *Psychological Bulletin, 117*(2), 306.

Nichols, T., Jaekel, J., Bartmann, P., & Wolke, D. (2019). Differential susceptibility effects of maternal sensitivity in childhood on small for gestational age adults' wealth. *Development and Psychopathology*, 1-7. doi:10.1017/s0954579418001669

Oberle, E., & Schonert-Reichl, K. A. (2013). Relations among peer acceptance, inhibitory control, and math achievement in early adolescence. *Journal of Applied Developmental Psychology, 34*(1), 45-51. doi: 10.1016/j.appdev.2012.09.003

Pallini, S., Chirumbolo, A., Morelli, M., Baiocco, R., Laghi, F., & Eisenberg, N. (2018). The relation of attachment security status to effortful self-regulation: A meta-analysis. *Psychological Bulletin, 144*(5), 501.

Pérez-Edgar, K., Reeb-Sutherland, B. C., McDermott, J. M., White, L. K., Henderson, H. A., Degnan, K. A., . . . Fox, N. A. (2011). Attention biases to threat link behavioral inhibition to social withdrawal over time in very young children. *Journal of Abnormal Child Psychology, 39*(6), 885-895. doi:10.1007/s10802-011-9495-5

Pierrat, V., Marchand-Martin, L., Arnaud, C., Kaminski, M., Resche-Rigon, M., Lebeaux, C., . . . Ancel, P.-Y. (2017). Neurodevelopmental outcome at 2 years for preterm children born at 22 to 34 weeks' gestation in France in 2011: EPIPAGE-2 cohort study. *BMJ, 358*.

Poehlmann-Tynan, J., Gerstein, E. D., Burnson, C., Weymouth, L., Bolt, D. M., Maleck, S., & Schwichtenberg, A. J. (2014). Risk and resilience in preterm children at age 6. *Development and Psychopathology, 27*(3), 843-858. doi:10.1017/S095457941400087X

Potijk, M. R., de Winter, A. F., Bos, A. F., Kerstjens, J. M., & Reijneveld, S. A. (2015). Behavioural and emotional problems in moderately preterm children with low socioeconomic status: a population-based study. *European Child & Adolescent Psychiatry, 24*(7), 787-795.

Reijneveld, S. A., De Kleine, M., van Baar, A. L., Kollée, L. A., Verhaak, C. M., Verhulst, F. C., & Verloove-Vanhorick, S. P. (2006). Behavioural and emotional problems in very preterm and very low birthweight infants at age 5 years. *Archives of Disease in Childhood-Fetal and Neonatal Edition, 91*(6), F423-F428.

Ritchie, K., Bora, S., & Woodward, L. J. (2015). Social development of children born very preterm: a systematic review. *Developmental Medicine & Child Neurology, 57*(10), 899-918. doi:10.1111/dmcn.12783

Roskam, I., Stievenart, M., Meunier, J.-C., & Noël, M.-P. (2014). The development of children's inhibition: Does parenting matter? *Journal of Experimental Child Psychology, 122*, 166-182. doi: 10.1016/j.jecp.2014.01.003

Rotenberg, K. J., Michalik, N., Eisenberg, N., & Betts, L. R. (2008). The relations among young children's peer-reported trustworthiness, inhibitory control, and preschool adjustment. *Early Childhood Research Quarterly, 23*(2), 288-298. doi: 10.1016/j.ecresq.2007.04.003

Rubin, K. H., Burgess, K. B., & Hastings, P. D. (2002). Stability and social–behavioral consequences of toddlers' inhibited temperament and parenting behaviors. *Child Development, 73*(2), 483-495.

Saigal, S., Day, K. L., Van Lieshout, R. J., Schmidt, L. A., Morrison, K. M., & Boyle, M. H. (2016). Health, wealth, social integration, and sexuality of extremely low-birth-weight prematurely born adults in the fourth decade of life. *JAMA Pediatrics, 170*(7), 678-686. doi:10.1001/jamapediatrics.2016.0289

Sapouna, M., & Wolke, D. (2013). Resilience to bullying victimization: The role of individual, family and peer characteristics. *Child Abuse & Neglect, 37*(11), 997-1006.

Schmid, G., Schreier, A., Meyer, R., & Wolke, D. (2011). Predictors of crying, feeding and sleeping problems: a prospective study. *Child Care Health and Development, 37*(4), 493-502. doi: 10.1111/j.1365-2214.2010.01201.x.

Schmid, G., & Wolke, D. (2014). Preschool regulatory problems and attention-deficit/hyperactivity and cognitive deficits at school age in children born at risk: Different phenotypes of dysregulation? *Early Human Development, 90*(8), 399-405. doi:10.1016/j.earlhumdev.2014.05.001

Schwartz, D., Dodge, K. A., Pettit, G. S., Bates, J. E., & The Conduct Problems Prevention Research, G. (2000). Friendship as a moderating factor in the pathway between early harsh home environment and later victimization in the peer group. *Developmental Psychology, 36*(5), 646-662.

Spinrad, T. L., Eisenberg, N., Gaertner, B., Popp, T., Smith, C. L., Kupfer, A., . . . Hofer, C. (2007). Relations of maternal socialization and toddlers' effortful control to children's adjustment and social competence. *Developmental Psychology, 43*(5), 1170.

Spinrad, T. L., Eisenberg, N., & Gaertner, B. M. (2007). Measures of effortful regulation for young children. *Infant Mental Health Journal, 28*(6), 606-626. doi:10.1002/imhj.20156

Suway, J. G., Degnan, K. A., Sussman, A. L., & Fox, N. A. (2012). The relations among theory of mind, behavioral inhibition, and peer interactions in early childhood. *Social Development, 21*(2), 331-342. doi: 10.1111/j.1467-9507.2011.00634.x

Talge, N. M., Holzman, C., Wang, J., Lucia, V., Gardiner, J., & Breslau, N. (2010). Late-preterm birth and its association with cognitive and socioemotional outcomes at 6 years of age. *Pediatrics, 126*(6), 1124-1131. doi: 10.1542/peds.2010-1536.

Tang, A., Santesso, D. L., Segalowitz, S. J., & Schmidt, L. A. (2016). Distinguishing shyness and sociability in children: An event-related potential study. *Journal of Experimental Child Psychology, 142*, 291-311. doi: 10.1016/j.jecp.2015.08.008

Thai, N., Taber-Thomas, B. C., & Pérez-Edgar, K. E. (2016). Neural correlates of attention biases, behavioral inhibition, and social anxiety in children: An ERP study. *Developmental Cognitive Neuroscience, 19*, 200-210. doi: 10.1016/j.dcn.2016.03.008

Voigt, B., Pietz, J., Pauen, S., Kliegel, M., & Reuner, G. (2012). Cognitive development in very vs. moderately to late preterm and full-term children: Can effortful control account for group differences in toddlerhood? *Early Human Development, 88*(5), 307-313.

Volbrecht, M. M., & Goldsmith, H. H. (2010). Early temperamental and family predictors of shyness and anxiety. *Developmental Psychology, 46*(5), 1192. doi: 10.1037/a0020616.

Walker, O. L., Degnan, K. A., Fox, N. A., & Henderson, H. A. (2013). Social problem solving in early childhood: Developmental change and the influence of shyness. *Journal of Applied Developmental Psychology, 34*(4), 185-193. doi: 10.1016/j.appdev.2013.04.001

Witt, A., Theurel, A., Tolsa, C. B., Lejeune, F., Fernandes, L., de Jonge, L. v. H., . . . Gentaz, E. (2014). Emotional and effortful control abilities in 42-month-old very preterm and full-

term children. *Early Human Development, 90*(10), 565-569. doi: 10.1016/j.earlhumdev.2014.07.008

Witt, S., Weitkämper, A., Neumann, H., Lücke, T., & Zmyj, N. (2018). Delayed theory of mind development in children born preterm: A longitudinal study. *Early Human Development, 127*, 85-89. doi: 10.1016/j.earlhumdev.2018.10.005

Wolke, D. (1993). *Manual zum Freundschafts- und Familieninterview. 8-Jahres-Untersuchung. [Friendship and Family Interview]*. Munich: Bavarian Longitudinal Study.

Wolke, D., Baumann, N., Strauss, V., Johnson, S., & Marlow, N. (2015). Bullying of preterm children and emotional problems at school age: cross-culturally invariant effects. *The Journal of Pediatrics, 166*(6), 1417-1422. 10.1016/j.jpeds.2015.02.055

Wolke, D., & Meyer, R. (1999). Cognitive status, language attainment, and prereading skills of 6-year-old very preterm children and their peers: the Bavarian longitudinal study. *Developmental Medicine and Child Neurology, 41*(2), 94-109. doi:10.1017/s0012162299000201

Wolke, D., Schmid, G., Schreier, A., & Meyer, R. (2009). Crying and feeding problems in infancy and cognitive outcome in preschool children born at risk: a prospective population study. *Journal of Developmental & Behavioral Pediatrics, 30*(3), 226-238.

Wolke, D., Strauss, V., Johnson, S., Gilmore, C., Marlow, N., & Jaekel, J. (2015). Universal gestational age effects on cognitive and basic mathematic processing: 2 cohorts in 2 countries. *The Journal of Pediatrics, 166*(6), 1410-1416.e1412. doi: 10.1016/j.jpeds.2015.02.065

Woodward, L. J., Moor, S., Hood, K. M., Champion, P. R., Foster-Cohen, S., Inder, T. E., & Austin, N. C. (2009). Very preterm children show impairments across multiple

neurodevelopmental domains by age 4 years. *Archives of Disease in Childhood-Fetal and Neonatal Edition, 94*(5), 339-344. doi: 10.1136/adc.2008.146282

Zhang, L., Eggum-Wilkens, N. D., Eisenberg, N., & Spinrad, T. L. (2017). Children's shyness, peer acceptance, and academic achievement in the early school years. *Merrill-Palmer Quarterly, 63*(4), 458-484.

Zhou, Q., Chen, S. H., & Main, A. (2012). Commonalities and differences in the research on children's effortful control and executive function: A call for an integrated model of self-regulation. *Child Development Perspectives, 6*(2), 112-121. doi: 10.1111/j.1750-8606.2011.00176.x

Zmyj, N., Witt, S., Weitkämper, A., Neumann, H., & Lücke, T. (2017). Social cognition in children born preterm: A perspective on future research directions. *Frontiers in Psychology, 8*, 455. doi:10.3389/fpsyg.2017.00455

Table 1

Descriptive Characteristics of the Sample by Gestational Age Group (N= 1,181)

	Very preterm <32 w GA n=199	Moderately preterm 32-33 w GA n=79	Late preterm 34-36 w GA n=186	Early term 37-38 w GA n=175	Full term 39-41 w GA n=542	F /χ^2
Gestational age, weeks *M(SD)*	29.6 (1.5)	32.5 (0.5)	35.1 (0.8)	37.5 (0.5)	39.9 (0.7)	6141.582***
Birth weight, grams *M(SD)*	1,277.4 (319.2)	1,666.8 (384.7)	2,218.1 (562.1)	2,823.1 (539.3)	3,398.3 (496.0)	853.740***
Sex, % male	58.8%	48.1%	51.1%	47.4%	49.3%	6.633
Socioeconomic status *M(SD)*	3.5 (1.5)	3.5 (1.6)	3.3 (1.6)	3.3 (1.6)	3.4 (1.6)	0.715
Neonatal medical risk *M(SD)*	9.7 (2.6)	7.8 (2.5)	5.4 (2.9)	3.2 (2.7)	1.9 (2.1)	419.576***
% with good early parent-infant relationship	50.3%	58.2%	64.0%	64.6%	68.8%	22.76***
% with good inhibitory control at 20 months	18.6%	35.4%	41.4%	37.7%	43.9%	41.06***
% with high social inhibition at 6 ys	23.6%	26.6%	26.3%	25.1%	22.1%	2.002
Friendships z-score at 8 ys *M(SD)*	-0.2 (0.7)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.1 (0.6)	7.657***

Commented [WD1]: If this is the optimality score – actually scored as risk score here – why swap names with listing in Appendix. Should be consistent – please adjust

Note: ***p < .001. w GA = weeks of gestational age. Data are presented as *Mean (Standard Deviation)* for interval scaled and *Percentages* for categorical variables.

Figure Legends

Figure 1. Path model showing direct and indirect effects of gestational age, parent-infant relationship, early inhibitory control, and social inhibition on friendships at age 8 years (N = 1,181). Bold lines represent hypothesized effects, solid lines represent significant effects, and dotted lines represent non-significant effects. Numbers shown are standardized regression coefficients. SES = socioeconomic status; CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation.

Figure 2. Direct, indirect, and total effects of variables in the model on friendships at 8 years.

Note. Significance level for total effect is *p >.05, **p >.01.

Appendix: Measures

Table A1

Optimality Score (OPTI)

Commented [WD2]: Is this the medical risk score – why different labels across tables?

Description
Data on neonatal medical complications was collected prospectively and summarized into a comprehensive index score, ranging from 0 (best state) to 21 (worst state), based on the following items: 1. ventilation or intubation 2. Apgar at 1 min after birth <9 and at 5 min after birth <10 3. buffering and/or volume substitution 4. cord artery pH >= 7.3 5. outborn (i.e. infants were transported after birth from outside obstetric units for neonatal care) 6. body temperature <=36°C 7. artificial aspiration 8. apnoea/bradycardia 9. ventilation disorder 10. hypoglycaemia 11. heart failure 12. hyperbilirubinaemia 13. other metabolic diseases 14. severe anaemia 15. sepsis 16. operation 17. deficits in development (i.e. neurodevelopmental problems) 18. medication > one time/day 19. nasogastric feeding 20. neonatal seizures 21. cerebral haemorrhage (on ultrasound examination neonatally)

Table A2

Parent-Infant Relationship Index (PIRI)

Description	Coding
Standardized interview with parents and research nurses' observations of attachment-related parental concerns, feelings, and behavior. All research nurses were trained in advance, but inter-rater agreement was not assessed. The scale comprised 8 items of yes (1) or no (0) ratings on the following items: 1. mother does not yet know the infant (mother interview, neonatal), 2. mother visits infant once a week or less (mother interview, neonatal), 3. father visits infant less than once a week (mother or father interview, neonatal), 4. mother is insecure when taking care of child at home (mother interview, neonatal), 5. mother shows little pleasure when interacting with child (nurse observation, neonatal), 6. father shows little pleasure when interacting with child (nurse observation, neonatal), 7. the probability that these parents develop problems in taking care of infant is high (nurse observation, neonatal), 8. mother has trouble building a relationship with child (pediatrician rating after mother interview at 5 months of age). First, a sum score was calculated by adding one point for each 'yes' answer. Since the resulting sum score did not show a normal distribution as most parents reported and demonstrated a good relationship with their infant, the sum score was recoded into "no concerns for the parent–infant relationship" (score 0; 52.0%) and "some degree of concern for the parent–infant relationship" (score 1-8; 48.0%).	PIRI (0) no concerns for the parent–infant relationship (1) some degree of concern for the parent–infant relationship

Table A3

Distribution of Healthy Full-term Control Group (n= 251) Response to Stranger in Social Inhibition Assessment

	n	%	Range s	*M(SD)* s
(0) Low social inhibition < 228 s	200	80%	0-227	156 (75)
(1) High social inhibition > 227 s	51	20 %	228-307	268 (29)

Note. s = seconds

4

Overview of Assessment Measures for Children's Friendships and Peer Acceptance

Variable	Assessment & Description	Score / categories	Interview questions* / items
Children's friendships reported by children, 8 ys.	Semi-structured Friendship and Family Interview (Wolke, 1993)		
Number of friends index score	Children are asked to name up to 10 playmates or friends (siblings not included). If a child had no friends, the item was coded 0 (i.e., no friend).	Responses are summed up across 10 friends into a *Number of friends* index score, ranging from 0-10.	"Who do you like to play with? – What are the names of your friends or playmates? – Anyone else?"
Frequency of meeting friends index score	Children are asked how often they met these first 5 friends (or fewer depending on number listed) on a five-point scale (1= rarely, 2= one to three times a month, 3= once a week, 4= more often during the week, 5= daily). If the child had no friends or listed < 5, the item was coded 0 (i.e., 0= never). Only real, durable social interactions (i.e. playing/doing something together, but not just talking to each other in school) were considered.	Responses are averaged across 5 friends into a *Frequency of meeting friends* index score, ranging from 0 to 5	"How often do you meet NAME OF FRIEND to play with?"
Children's friendships reported by parents, 8 ys.	Adapted version of the structured Mannheimer Parent Interview (MEI) (Esser et al., 1989), subsection *Contact with Peers*		
Number of friends index score	Parents are asked to list up to 8 friends (siblings not included). If a child had no friends, the item was coded 0 (i.e. no friend).	Responses are summed up across 8 friends into a *Number of friends* index score, ranging from 0-8.	"Does your child have friends? Could you please list the friends, their first names, sex, ages, and whether he / she is in same grade?"?"
Frequency of meeting friends index score	Parents are asked how often their child met his / her friends on a six-point scale (1 = rarely (one to three days a month), 2 = one to two days a week, 3 = three to four days a week, 4 = five to six days a week, 5 = daily, 6 = several times daily). If the child had no friends,	Responses of the *Frequency of meeting friends* index score ranged from 0 to 6	"How often does your child meet his / her friends?" (multiple or at least one of the listed friends, during the whole last year)

	the item was coded 0 (i.e. 0 = never).		
Peer Acceptance index score (at 8 years)	Adapted German version of the Pictorial Scale of Perceived Competence and Social Acceptance for Young Children, subscale *Peer Acceptance* (Asendorpf & Van Aken, 1993; Harter & Pike, 1984)		
Child report	Six items are presented via 2 pictures displaying a gender-matched child doing a particular activity (e.g., doing a jigsaw puzzle). Then, 2 statements relating to the pictures are read to the child (e.g., "the child on the left is good at puzzles, but the child on the right is not very good at puzzles"). Children pick the child they are most similar to and indicate if they are a lot or just a little bit like the selected child. Responses are coded on a four-point scale with greater values indicating higher acceptance.	Responses of the 6 items are averaged into a *Peer Acceptance* index score, ranging from 1 to 4.	1) "Has friends to play with." 2) "Stays overnight at his / her friends' houses." 3) "Has friends to play games with." 4) "Has friends on the playground." 5) "Other children ask if child wants to play." 6) "Eats at his / her friends' houses."
Parent report	The same 6 items as in the child version, reformulated into questions (parallel version of the described items), are answered by parents. Responses are coded on a 4-point scale with greater values indicating higher acceptance.	Responses of the 6 items are averaged into a *Peer Acceptance* index score, ranging from 1 to 4.	1) "How many friends does your child have to play with?" 2) "How often does your child stay overnight at his/her friends' houses?" 3) "How many friends does your child have to play games with?" 4) "How many friends does your child have to play with on the playground?" 5) "How often do other children ask if your child wants to play?" 6) "How often does your child eat at his/her friends' houses?"

*Interviewer starts with standard questions but may ask additional questions to avoid misinterpretations and ensure full understanding.

Table A5

Correlations Between Variables Used for Friendships Z-Score at Age 8 Years

	1	2	3	4	5
1. Number of friends (child report)	_____				
2. Frequency of Meeting with friends (child report)	.506**	_____			
3. Peer acceptance (child report)	.248**	.203**	_____		
4. Number of friends (parent report)	.335**	.308**	.280**	_____	
5. Frequency of Meeting with friends (parent report)	.090**	.182**	.282**	.108**	_____
6. Peer acceptance (parent report)	.286**	.165**	.380**	.120**	.161**

Note. **Correlation is significant at the .01 level (2-tailed)