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ABSTRACT

Objective: To identify trajectories of peer relationships in very preterm and term-born individuals from 6 to 26 years of age and test early life predictors of these trajectories.

Method: As part of the Bavarian Longitudinal Study, 218 very preterm/very low birthweight (VP/VLBW; <32 weeks gestation / <1,500 grams) and 220 healthy term-born (37-42 weeks gestation) individuals were followed prospectively from birth to adulthood. Parent and self-reports at 6, 8, 13, and 26 years were combined into comprehensive developmentally-appropriate scores across three domains: peer acceptance, friendships, and peer problems. Latent profile analyses were used to identify trajectories across these three domains. Binary and multinomial logistic regressions were used to test the following potential predictors of trajectories: VP/VLBW status, sex, socio-economic status, neonatal medical risk, parent-infant relationship at 5 months, child inhibitory control at 20 months, and child cognitive abilities at 20 months.

Results: Three trajectories were identified for peer acceptance and friendships and two trajectories were identified for peer problems. Higher cognitive abilities predicted more optimal trajectories in peer acceptance (OR: 1.03 [95% CI= 1.01-1.05]), friendships (1.03 [1.00-1.05]), and peer problems (1.06 [1.04-1.09]). Additionally, good parent-infant relationships predicted lower peer problems trajectories (1.61 [1.03-2.50]).

Conclusions: Early cognitive deficits may underlie persistent peer relationship difficulties in VP/VLBW samples. Positive parent-infant relationships may help reduce preterm children's risk for long-term peer problems.

Key terms: prematurity, social relationships, cognitive abilities

Social relationships are central to human development across the lifespan. Peer acceptance and close dyadic friendships in childhood promote positive emotional and behavioral outcomes and protect against peer victimization (1). Early success in peer relationships predicts better social adjustment in adulthood and throughout later life (2).

Distinct domains of social relationships may confer unique benefits during different developmental periods. For instance, peer acceptance (i.e., sociometric popularity), which refers to the degree to which individuals are liked by their peer group, is thought to be particularly important in middle childhood, as it affords opportunities for friendship formation and contributes to self-perceptions of interpersonal competence (3). Friendships, in contrast, are deep dyadic relationships characterized by their reciprocal nature, and provide companionship and emotional support, which are crucial for meeting adolescents' increasing need for intimacy (4). Peer problems more broadly encompass conflict or negative social experiences, such as being disliked or teased. Successfully resolving conflicts with peers is important for building life-long social skills, but consistent failure in these attempts is associated with enduring problematic social interactions into adulthood. Because these overlapping but distinct social relationships domains constitute unique influences on development (3, 4), researchers have emphasized the need for assessment methods that take into account the nature, quantity, and quality of peer relationships to more accurately reflect the complexities of individuals' social lives.

Preterm birth and peer relationships

Preterm birth may disrupt the typical development of social relationships. Signs of social interaction difficulties in very preterm and/or very low birthweight (VP/VLBW; < 32 weeks gestation/ < 1,500 grams) infants present as early as in the first year of life (5). In childhood, VP/VLBW individuals have fewer friends, lower rates of peer acceptance (6), and more

difficulties with social interactions (7) than term-born (here: 39-41 weeks gestation)

comparisons. The early onset of difficulties may exacerbate social problems over time due to

their direct impacts on future relationships as well as constrained opportunities to learn new

adaptive social skills (7). Indeed, early social difficulties appear to be long-lasting, as VP/VLBW

individuals continue to be at risk for social withdrawal and peer problems in young adulthood

(8).

However, the course of social difficulties in preterm samples from childhood to

adulthood is unclear, especially regarding specific domains of peer relationships. For instance,

although a recent meta-analysis found that adults born preterm were less likely to have ever

experienced a romantic relationship, sexual intercourse, or parenthood than term comparisons

(9), no difference was found for perceptions of peer social support between both groups.

Importantly, in this meta-analysis, authors were unable to compare data on participants' number

of friends, which has been shown to be lower for preterm children and adults in most studies (6,

10) compared to term comparisons. To make sense of these findings, the authors propose two

explanations: It could be that despite fewer close relationships, when adults born preterm have

friends, their relationship quality is not poorer than for term-born comparisons; or that the quality

of social relationships in preterm individuals improves into adulthood (9). These complexities

highlight the need to explore social outcomes of preterm birth longitudinally and differentiate

between domains of peer relationships (e.g., friendships, peer acceptance), to better understand

their potential differential impact on preterm individuals' social adjustment.

Hypothetical models of preterm children's socio-emotional development have focused on

biological vulnerabilities (e.g., brain damage leading to general cognitive deficits) and

environmental influences (e.g., early parenting) as potential pathways to long-term social

difficulties (11). Indeed, preterm birth is a risk factor for cognitive impairments (12), and there is a co-occurrence of cognitive and socio-emotional difficulties, both in the general population and in preterm samples. However, whereas some studies showed that preterm children's more frequent cognitive deficits (e.g., lower IQ) predicted lower social competence at 4-years of age (7) peer difficulties in middle childhood (5), others found that lower cognitive abilities were not associated with a withdrawn personality factor found in adults born preterm (8).

Additionally, research has shown that parents of preterm infants have more psychological distress and symptoms of mental health problems, suggesting there could be vulnerability in their early parenting strategies even if symptoms decrease as the child overcomes medical risks (13). Indeed, better maternal mental health, lower intrusiveness, and lower distress predict preterm children's better social skills and socio-emotional regulation (7, 14). However, since children's own traits influence parenting behaviors and strategies (15, 16), their individual differences should be concurrently explored as potential predictors of social outcomes.

In the general population, individual differences in inhibitory control – the ability to control behavioral impulses – have been shown to impact social outcomes. For instance, inhibitory control has been linked to empathic and prosocial behaviors during preschoolers' peer interactions (17). Conversely, poor inhibitory control of behavior appears to impair social interactions by failing to impede impulsive reactions, negative displays of emotions, and other antisocial behaviors (17), which contribute to peer rejection. Accordingly, in a recent study of children born across the entire gestational age (GA) range, toddlers' poor inhibitory control predicted less success with peers at 8 years of age (18). Given that a substantial portion of VP/VLBW individuals display resilient neurodevelopmental profiles, as indicated by the absence of cognitive or psychiatric impairments despite substantial neonatal risk (12, 19), whether

childhood regulatory skills contribute to a more positive course of peer relationship outcomes in preterm samples should be explored.

The current study

The goals of the current study are to identify peer relationship trajectories in VP/VLBW and healthy term-born (37-42 weeks GA) individuals from childhood to adulthood across three domains (i.e., friends, peer acceptance, peer problems), and to identify early predictors of these trajectories, including potential biological (e.g., cognitive vulnerability), environmental (e.g., parenting), and individual (e.g., inhibitory control) factors. We hypothesized that VP/VLBW birth will predict suboptimal peer relationship trajectories across all domains, whereas higher cognitive abilities, higher inhibitory control and good parenting will predict more optimal trajectories.

METHOD

Design and Participants

The Bavarian Longitudinal Study is a prospective, whole-population, geographically-defined study that followed VP/VLBW children born in Southern Bavaria (Germany) in 1985-1986 who required admission to one of 16 children's hospitals within the first 10 days after birth. During the same period, healthy term-born comparisons (37-42 GA) were recruited in obstetric units in the same area. Full details of this sample are provided elsewhere (20, 21). Ethical approval was obtained from the University of Munich Children's Hospital and ethical approval for the adult follow-up was granted by the Ethical Board of the University Hospital Bonn. Of 682 VP/VLBW individuals assessed in the larger study, 411 VP/VLBW were presumed alive, living in Germany, and eligible for the 26-year follow-up. Of these, 260 (63.3%) participated in

the adult assessment (Figure 1) and 218 had sufficient peer relationships data (i.e., complete data

on at least three of the assessment timepoints at 6, 8, 13, and 26 years of age) to be included in

the current study. The VP/VLBW participants did not differ from VP/VLBW adults who

dropped out in terms of gestational age, birthweight, duration of hospitalization, gender, maternal

age, parental marital status, and childhood cognitive scores, but had fewer prenatal complications

and were of higher socioeconomic status (21). Of 916 healthy term-born comparison infants at

birth, 350 were selected and stratified to match the VP/VLBW participants at the 6 years follow-

up assessment. Of these, 308 individuals were eligible for inclusion and 229 (74.4%) participated

at 26 years (21). Two-hundred and twenty of these had sufficient peer relationships data and

were thus included in the current study.

-    Figure 1 about here -

Measures

Predictors

      <u>Biological, medical, and socio-demographic variables at birth</u>. Gestational age in

weeks, birth weight and child sex were obtained from obstetric records. Infant neonatal medical

risk was measured with a comprehensive index score comprised of 21 items representing

medical complications (e.g. ventilation or intubation, severe anemia, cerebral hemorrhage) with

higher scores indicating more problematic neonatal course. Details of this score are in Table S2

of the Supplemental Digital Content. Family socio-economic 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).

      <u>Parenting</u>. Early parenting was assessed with the Parent-Infant Relationship Index

(PIRI) from birth to five months (22). 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 with items such

as, *mother shows little pleasure when interacting with the child* (nurse's observation, 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). Details of

this assessment are described in Table S3 of the Supplemental Digital Content.

Inhibitory control at 20 months. Children's inhibitory control abilities were measured

with a standardized behavioral observation task adapted from the snack delay task (23) when the

children were 20 months of age (corrected for prematurity). Children were presented with a

raisin that was placed under an opaque plastic cup within reach. After three training runs, the

time that children waited before touching the raisin was measured with a stopwatch from 0 to 60

seconds. Since scores of reaction times were not normally distributed, they were recoded into a

binary score: 0 = did not wait or waited up to 10 seconds, i.e., poor inhibitory control (62%), and

1 = waited for ≥11 seconds, i.e., good inhibitory control (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).

Cognitive abilities at 20 months. Early cognitive functioning was assessed with the

Griffiths Mental Development Scale (GMDS; 24), a standardized developmental test

administered by trained research pediatricians when children were 20 months of age (corrected

for prematurity). The GMDS assesses five dimensions of mental development: locomotor,

personal-social development, hearing and speech, hand/eye coordination, and performance. A

total developmental quotient across the five domains was computed according to German norms

(24). Scores in the current sample ranged from 24-122 (*M*=101.7, *SD*=13.4). The GMDS has

shown satisfactory reliability and good construct validity across different studies and cultures

(25).

Peer Relationship Indicators

Peer acceptance. At age 6 and 8 years, children completed an adapted German version

of the Pictorial Scale of Perceived Competence and Social Acceptance for Young Children (26),

subscale Peer Acceptance. The scale contains six items (Supplemental Digital Content Table S4)

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 (6).

Internal consistency was acceptable (α = .70). Parents answered a parallel version of the items

reformulated into questions. Internal consistency was good (α = .80). To form a comprehensive

score of parent and child's perspectives of the child's peer acceptance, child and parent index

scores were each z-standardized and then averaged into a Peer Acceptance z-score at 6 and 8

years.

At 13 years of age, participants completed a measure adapted from Nicholls' (27) work

on self-concept of attainment. Adolescents were presented with a sheet of paper with 25

vertically aligned schematic faces, with polarizing statements at the top and bottom of the faces.

They were then asked to select the face best representing how closely they identified with the top

versus the bottom statement. The face closest to the top statement had a score of 25, and the face

closest to the bottom had a score of 1, with the middle face having a score of 13. The following

were the statements with scores of 25 in the peer subscale of the questionnaire: (1) *I make friends*

very easily, (2) *I have many friends*, (3) *I am very popular with other children,* (4) *Other children*

like me very much. On the opposite end were statements with a score of 1: (1) *I find it hard to make friends*, (2) *I have few friends*, (3) *I am not popular with other children*, (4) *Other children do not like me*. Items had acceptable internal consistency (α = .74) and were z-standardized and averaged to create a Peer Acceptance z-score at 13 years. At 26 years of age, participants rated themselves on two items parallel to and coded in the same way as those from the 13-year assessment: (1) *I make friends easily*, and (2) *I am very popular with others*. Items were z-standardized and averaged to create a Peer Acceptance z-score at 26 years.

Friendships. At 6 and 8 years, the semi-structured Friendship and Family Interview (6) was used to assess the nature of children's friendships. Children were asked to name up to ten playmates or friends (siblings not included). These listed friends were summed into a *Number of friends* index score. The children were also asked to name their best friends. Whether the child had at least one best friend was coded as a binary variable (0 = no, 1 = yes). To assess parents' perceptions of their children's friendships at 6 and 8 years of age, the structured *Mannheimer Parent Interview* (28), subsection *Contact with peers*, was administered. Parents were instructed to list up to eight friends. Parents were also asked whether the child had a best friend. All interviews were videotaped and double-rated by two psychologists. Interrater reliability was excellent with a Cohen kappa of > 0.95. The child and parent's report of the number of friends were each z-standardized and then averaged into a *Number of friends z-score*. The child and parent's report of whether there was a best friend were recoded, z-standardized, and averaged into a *Best friend z-score*. The *Number of friends z-score* and the *Best friend z-score* were then averaged to create at Friendships z-score at each age (6 and 8 years).

At 13 years, adolescents and their parents were separately asked to indicate whether the child had at least one good friend, with the possible responses: 0 = certainly true, 1 = somewhat

true, 2 = not true. Answers for both parents and individuals' reports were recoded, z-standardized, and averaged into a *Good friend z-score*. Since individuals were not directly asked to list their friends in adolescence as they had at previous timepoints, their self-rating from 1 (*I don't have many friends*) to 25 (*I have many friends)* was z-standardized and used as a proxy for *Number of friends score.* The score was then averaged with the *Good friend z-score* to create a Friendships z-score at 13 years. At 26 years, during a structured interview, participants were asked about their number of friends and whether they had at least one good friend. Responses on each item were z-standardized and averaged into a Friendships z-score at 26 years.

Peer problems. During the 6- and 8-year assessments, parents completed the German version of the widely-used Child Behavior Checklist (CBCL; 29). The social problems subscale of the CBCL contained six items (e.g., *gets teased a lot*, *does not get along with other children*) with the following possible responses: 0 = not true, 1 = somewhat or sometimes true, 2 = very or often true. Responses were averaged and z-standardized to construct a Peer Problems z-score at both ages (6 and 8 years).

During the 13-year assessment, peer problems were assessed with parent and adolescent versions of the Strengths and Difficulties Questionnaire (SDQ; 30) on which responses have the following options: 0 = not true, 1 = somewhat true, 2 = certainly true. For each version, responses to the following three items were averaged and z-standardized: (1) *tends to be a loner*, (2) *is bullied by others*, and (3) *gets on better with adults than other children.* The z-scores from parent and child reports were then averaged into a Peer Problems z-score at 13 years. At 26 years, individuals completed the social problems subscale of the Young Adult Self Report (YASR; 31). Six items that paralleled those from the 6- and 8-year CBCL and were combined and z-standardized into a Peer Problems z-score at 26 years. Table S4 in the Supplemental

Digital Content provides details for all of the peer relationship indicators (i.e., Peer problems,

Peer acceptance, Friendships).

Statistical Analyses

Preliminary and descriptive analyses were conducted using SPSS v.24 (IBM; Chicago,

IL). Independent samples t-tests were performed to assess differences in Friendships, Peer

Acceptance, and Peer Problems z-scores between the VP/VLBW and term-born groups at each

timepoint. Subsequently, latent profile analyses were performed with Mplus v8 (Muthén &

Muthén; Los Angeles, CA). Latent profile analysis (LPA) is a variant of latent class analysis

(i.e., based on observed continuous rather than categorical variables) and is used to identify

homogeneous subgroups within a sample through maximum likelihood (ML) estimation. For

Peer Acceptance and Peer Problems, z-scores at the four timepoints were used as indicators of

latent profiles. Due to lack of variation in the Friendships variable at the last timepoint (26

years), only the three earlier timepoints could be used as indicators in the LPA for Friendships.

Models with increasing numbers of subgroups or "classes" were estimated, and the Bayesian

information criterion (BIC), Akaike's information criterion (AIC), sample size adjusted BIC

(ssBIC), and Consistent Akaike Information Criterion (CAIC) were used as goodness of fit and

parsimony criteria, along with entropy values and interpretability, to select the best class

solution. Lower BIC, AIC, ssBIC, and CAIC indicate a better model fit. Entropy values closer to

1 indicate clearer delineation of classes. Cases were assigned to classes based on posterior

probabilities. Finally, multinomial and binary logistic regressions were used to test predictors of

class membership in two steps. In the first step, the effect of VP/VLBW status alone was tested.

In the second step, the following predictors were included in addition to VP/VLBW status: child

sex, family SES, neonatal medical risk, good parent-infant relationship at 5 months, good

inhibitory control at 20 months, and cognitive abilities at 20 months.

RESULTS

Descriptive characteristics for the final sample are presented in Table 1. As expected,

individuals in the VP/VLBW group had lower GA, lower birthweight, and higher neonatal

medical risk scores than the term-born group. Additionally, there were greater proportions of

good parent-infant relationships, good inhibitory control and higher cognitive abilities in the

term-born group than the VP/VLBW group. At all timepoints, the VP/VLBW had lower peer

acceptance and friendships z-scores and higher peer problems z-scores than the term-born group

(Table S1 in Supplementary Digital Content).

- Table 1 about here -

Peer Acceptance

The LPA for peer acceptance (Figure 2A) supported a three-profile solution with lowest

BIC (3824.06). Goodness of fit statistics for all latent profile models are shown in Table S5 in

the Supplemental Digital Content. The average posterior probabilities of the final latent profile

assignment were good (.86).

– Figure 2 about here –

The three profiles contain an "Average" peer acceptance trajectory (42% of the sample), a

"Low" peer acceptance trajectory (41.6% of the sample) and an "Improving" peer acceptance

trajectory (16.4% of the sample). The Average trajectory profile was comprised of individuals

who had peer acceptance z-scores within half of a standard deviation from the mean across all

timepoints. The Low trajectory profile was characterized by lower peer acceptance z-scores than

the average group that also appeared to decrease over time, particularly in adolescence. The

Improving trajectory group was the smallest and included individuals with scores similar to the

Average trajectory group in childhood, but whose scores improved significantly in adolescence

and adulthood.

Results of multinomial logistic regressions testing the effect of VP/VLBW status showed

that being in the VP/VLBW group predicted increased odds of being in the Low peer acceptance

trajectory (OR: 1.52 [CI: 1.01 - 2.29]) compared to the Average peer acceptance trajectory.

However, when all predictors (i.e., VP/VLBW, sex, SES, neonatal medical risk, good parent-

infant relationship, good inhibitory control, and cognitive abilities) were included in the model,

only cognitive abilities were significantly associated with trajectories. Specifically, higher

cognitive abilities predicted decreased odds of being in the Low peer acceptance trajectory

compared to the Average trajectory (OR: .97 [.95 - .99]; Table 2).

– Table 2 about here –

Peer Problems

The LPA for peer problems (Figure 2B) supported a two-profile solution with lowest BIC

(4090.98) and highest entropy (.75). The average posterior probabilities of the final latent profile

assignment were excellent (.93). The profiles depict a "High" peer problems trajectory (50% of

the total sample) with z-scores above the mean across all timepoints, and a "Low" peer problems

trajectory (50% of the total sample), with z-scores below the mean across all timepoints. Binary

logistic regressions showed that being in the VP/VLBW group predicted decreased odds of being

in the Low peer problems trajectory (OR: .44 [.30 - .65]). However, when all predictors were

included in the model, VP/VLBW status was no longer significant. Instead, higher cognitive

abilities predicted increased odds of being in the Low peer problems trajectory (OR: 1.06 [1.04 -

1.09]). Additionally, good parent-infant relationship at 5 months predicted increased odds of

being in the Low peer problems trajectory (OR: 1.61 [1.03 - 2.50], Table 3).

– Table 3 about here –

Friendships

The LPA for friendships (Figure 2C) supported a three-profile solution (BIC: 1944.47, entropy =

.77). The average posterior probabilities of the final latent profile assignment were good (.90).

The three friendships profiles show an "Average" trajectory (56.4% of the sample), a "Low"

trajectory (8% of the sample) and an "High" trajectory (35.6% of the sample). The Average

friendships trajectory profile was comprised of individuals who had friendships z-scores close to

the mean across all timepoints. The Low friendships trajectory profile was the smallest and was

characterized by friendships z-scores that were similar to the average group at 6 years but

decreased significantly at 8 years and even more in adolescence, then rose closer to (but still

lower than) the average group in adulthood. The High trajectory group included individuals with

scores that were slightly higher than the Average trajectory group at all timepoint

Results of multinomial logistic regression showed that being in the VP/VLBW group

predicted increased odds of being in the Low friendships trajectory (OR: 2.36 [1.09 - 5.13])

compared to the Average friendships trajectory. However, when all predictors were included in

the model, only cognitive abilities were significantly associated with trajectories. Specifically,

higher cognitive abilities predicted increased odds of being in the High friendships trajectory

compared to the Average trajectory (OR: 1.03 [1.00 - 1.05]; Table 4).

– Table 4 about here –

Subgroup analyses testing trajectories for all peer relationship domains and predictors separately for the VP/VLBW and the term-born groups are described in the Appendix and results are presented in Tables S6 – S11 and Figure S1 in the Supplemental Digital Content.

DISCUSSION

The current study explored trajectories across three domains of peer relationships from childhood to adulthood in VP/VLBW and term-born individuals. As hypothesized, better early cognitive abilities predicted more optimal trajectories in peer acceptance, peer problems, and friendships. Additionally, good early parenting predicted reduced peer problems trajectories. In contrast to our hypothesis, inhibitory control did not predict peer relationship trajectories. In line with previous literature, trajectories in peer problems appeared to be relatively stable from school-age to adulthood (32), whereas difficulties with peer acceptance and friendships were more dynamic and peaked in adolescence. These patterns contrast potential situational influences on friendships and peer acceptance (e.g., a new school) versus persistent peer problems that may reflect enduring behavioral or mental health issues (33,34).

Consistent with models of preterm individuals' socioemotional development that highlight the role of biological vulnerability (11), our findings support the hypothesis that general cognitive problems may underlie social difficulties across multiple domains, including peer acceptance, peer problems and friendships. Studies suggest that poor cognitive abilities may contribute to negative social interactions (17). Moreover, a study of 6-12-year-old VP and term-born children found that child IQ mediated the association between VP birth and socioemotional problems (33). In the same study, the association between low IQ and socioemotional problems was more pronounced in the VP than the term-born group. Consistent with this literature, our

study showed that general cognitive abilities as early as 20 months age predict peer relationships

trajectories into adulthood, especially for VP/VLBW individuals (see subgroup analyses in the

Supplemental Digital Content). The effect of VP/VLBW disappeared once cognitive ability was

entered in logistic regression. This suggests that the effect of VP/VLBW on peer relationship

trajectories may be mediated by low early cognitive ability. This is likely, given that low

cognitive abilities detected in toddlerhood are highly stable in VP/VLBW children into

adulthood but less so in term-born children (12). Indeed, a recent study (34) found that

adolescents' IQ mediated the effect of VP birth on their social problems. Given that the study

also found that a latent factor representing cognitive control (tested in a separate model) was a

stronger mediator than IQ (34), future work could also compare the contribution of specific

versus general cognitive deficits to preterm individuals' long-term social functioning.

Moreover, these findings provide evidence that early environmental factors, such as

parenting, may also have an important role in shaping trajectories, specifically in the peer

problems domain. Consistent with studies reporting that more adaptive parenting is associated

with preterm children's higher social skills and socio-emotional regulation (7, 14), our study

found that as early as 5 months of age, good parent-infant relationships predicted lower peer

problems trajectories. Nonetheless, given that parenting strategies are actively influenced by

children's unique characteristics (15), their transactional influence on parents' behaviors should

be acknowledged (13). For instance, mothers of preterm children have been shown, on average,

not to be less sensitive than mothers of full-term children (35), but instead, appear to adapt their

parenting strategies to their child's cognitive status (16). Notably, our study found a significant

effect of parent-infant relationships even while including child cognitive abilities in the model.

Previous research has shown that parenting itself is related to higher cognitive scores (22). Thus,

future studies that consider transactional associations between child characteristics, such as

cognitive abilities, and parenting behaviors are needed to help disentangle the complex

mechanisms involving children's inputs into their own social environments.

In contrast to our hypothesis, inhibitory control was not associated with any of the

outcomes tested. This was surprising, given that in a recent study, early inhibitory control

partially mediated the relationship between GA and success with peers at 8 years of age (18).

Inhibitory control is a modifiable factor that may improve throughout childhood, and even small

increases in childhood self-control may confer long-term benefits (36). Thus, individual

differences at later ages could be more closely related to long-term peer relationship trajectories

than inhibitory control in toddlerhood.

This study has many strengths. This is the first study to explore preterm individuals' peer

relationship trajectories across multiple domains from childhood to adulthood. Data was

collected from a large, prospective, whole-population sample, followed longitudinally from birth

to 26 years of age and assessed at multiple timepoints with an exceptional participant retention

rate (Figure 1). Measures of peer relationships consisted of standardized instruments and in-

depth interviews that included both individuals' self-perceptions and parents' reports. Predictors

were also measured with previously validated standardized behavioral observations, multiple

informants, and standardized, pediatrician-administered developmental assessments.

This study also has limitations. Improved neonatal care has substantially increased

survival of preterm infants over the past decades, warranting replications with more recent

cohorts. Nevertheless, in general, the long-term neurodevelopmental outcomes after preterm

birth appear to be comparable, even in more recent samples. Loss to follow up may have resulted

in biased estimates, but this concern is mitigated by the fact that the VP/VLBW participants did

not differ from VP/VLBW adults who dropped out in terms of gestational age, birthweight,

duration of hospitalization, gender, maternal age, parental marital status, and childhood cognitive

scores. Although our findings established early predictors of peer relationship trajectories into

adulthood, we did not test more complex associations such as mediation and moderation. The

subgroup analyses were exploratory, and analyses to test whether VP/VLBW status moderates

predictors of peer trajectories were beyond the scope and statistical power of this paper. Thus,

future studies may consider testing whether early cognitive abilities mediate the association

between VP/VLBW and peer trajectories, as well as whether VP/VLBW status and good

parenting moderate these links. Finally, although z-standardization is a useful technique to

compare distributions around the group mean, it obscures information about an individual's

relative rank at different timepoints. Future studies that describe individual trajectories over time

could shed light on this issue.

     In conclusion, the current study found evidence of early life predictors of peer

relationship trajectories from childhood to early adulthood, thus providing new insights into the

potential mechanisms of long-term social difficulties in preterm samples. These findings

highlight the role of early biological and environmental factors in peer relationships from

childhood to adulthood, indicating that both early parenting and toddlers' cognitive abilities

predict more adaptive peer relationships for VP/VLBW individuals. Given the importance of

peer relationships for social development and mental health, health professionals could ask about

friendships and peer relationships during routine follow-up assessments. Although not yet

common in the health care field, this is a practice that adolescents endorse (37), and which could

help identify lonely, excluded, and bullied children, for whom support material could be made

available to help their situation (38). Future research should continue to explore the impact of

preterm birth on social relationships, and the mechanisms through which early factors contribute

to long-term social, emotional, and occupational functioning, with the aim of identifying

appropriate follow up services and early interventions.

References

1.   Sapouna M & Wolke D. Resilience to bullying victimization: The role of

individual, family and peer characteristics. Child Abuse & Neglect. 2013; 37(11): 997-

1006.

2.   Bagwell CL, Newcomb AF, Bukowski WM. Preadolescent friendship and peer rejection

predictors of adult adjustment. Child Development. 1998;69(1):140-53.

3.   Nangle DW, Erdley CA, Newman, JE, et al. Popularity, friendship quantity, and

friendship quality: Interactive influences on children's loneliness and depression. Journal

of Clinical Child and Adolescent Psychology. 2003;32(4), 546-555.

4.   Narr RK, Allen JP, Tan JS, et al. Close friendship strength and broader peer group

desirability as differential predictors of adult mental health. Child Development,

2017;90(1), 298-313. doi: 10.1111/cdev.12905

5.   Landry SH. The development of joint attention in premature low birth weight infants:

Effects of early medical complications and maternal attention-directing behaviors. 1995.

6.   Heuser KM, Jaekel J, Wolke D. Origins and predictors of friendships in 6- to 8-year-old

children born at neonatal risk. The Journal of Pediatrics. 2018;193:93-101.

7.   Jones KM, Champion PR, Woodward LJ. Social competence of preschool children born

very preterm. Early Human development. 2013;89(10):795-802.

8.   Eryigit-Madzwamuse S, Strauss V, Baumann N, et al. Personality of adults who were

born very preterm. Archives of Disease in Childhood-Fetal and Neonatal Edition.

2015;100(6):F524-F9.

9. Mendonça M, Bilgin A, Wolke D. Association of preterm birth and low birth weight with romantic partnership, sexual intercourse, and parenthood in adulthood: A systematic review and meta-analysis. JAMA Network Open. 2019;2(7):e196961-e.

10. Darlow BA, Horwood LJ, Pere-Bracken HM, et al. Psychosocial outcomes of young adults born very low birth weight. Pediatrics. 2013;132(6):e1521.

11. Montagna A, Nosarti C. Socio-emotional development following very preterm birth: pathways to psychopathology. Frontiers in Psychology. 2016;7.

12. Breeman LD, Jaekel J, Baumann N, et al. Preterm cognitive function into adulthood. Pediatrics. 2015;136(3):415-23.

13. Treyvaud K. Parent and family outcomes following very preterm or very low birth weight birth: a review. Seminars in Fetal and Neonatal Medicine; 2014.

14. Treyvaud K, Anderson VA, Lee KJ, et al. Parental mental health and early social-emotional development of children born very preterm. Journal of Pediatric Psychology. 2009;35(7):768-77.

15. Belsky J. The determinants of parenting: A process model. Child Development. 1984:83-96.

16. Jaekel J, Wolke D, Chernova J. Mother and child behaviour in very preterm and term dyads at 6 and 8 years. Developmental Medicine & Child Neurology. 2012;54(8):716-23.

17. Hughes C, White A, Sharpen J, et al. Antisocial, Angry, and Unsympathetic: "Hard-to-manage" Preschoolers' Peer Problems and Possible Cognitive Influences. The Journal of Child Psychology and Psychiatry and Allied Disciplines. 2000;41(2):169-79.

18. Reyes LM, Jaekel J, Heuser KM, et al. Developmental cascades of social inhibition and friendships in preterm and full-term children. Infant and Child Development. 2019;28(6):e2165.

19. Lean RE, Lessov-Shlaggar CN, Gerstein ED, et al. Maternal and family factors differentiate profiles of psychiatric impairments in very preterm children at age 5-years. Journal of Child Psychology and Psychiatry. 2019. doi: 10.1111/jcpp.13116

20. Baumann N, Bartmann P, & Wolke D. Health-related quality of life into adulthood after very preterm birth. Pediatrics. 2016:2015-3148. doi: 10.1542/peds.2015-3148

21. Eryigit Madzwamuse S, Baumann N, Jaekel J, et al. Neuro-cognitive performance of very preterm or very low birth weight adults at 26 years. J Child Psychol Psychiatry. 2015 56(8):857-64. doi: 10.1111/jcpp.12358

22. Breeman LD, Jaekel J, Baumann N, et al. Neonatal predictors of cognitive ability in adults born very preterm: a prospective cohort study. Developmental Medicine & Child Neurology. 2017;59(5):477-83.

23. Kochanska G, Murray KT, Harlan ET. Effortful control in early childhood: continuity and change, antecedents, and implications for social development. Developmental Psychology. 2000;36(2):220.

24. Brandt I. Griffiths Entwicklungsskalen (GES) zur Beurteilung der Entwicklung in den ersten beiden Lebensjahren. Beltz. Weinheim; 1983.

25.   Luiz D, Foxcroft C, & Stewart R. The construct validity of the Griffiths Scales of Mental Development. Child: Care, Health and Development. 2001; 27(1), 73-83.

26.   Asendorpf JB, Van Aken MAG. Deutsche versionen der selbstkonzeptskalen von Harter.

        Zeitschrift für Entwicklungspsychologie und pädagogische Psychologie. 1993;25(1):64-

        96.

27.   Nicholls JG. The development of the concepts of effort and ability, perception of

        academic attainment, and the understanding that difficult tasks require more ability. Child

        Development. 1978:800-14.

28.   Esser G, Blanz B, Geisel B, et al. Mannheimer Elterninterview. Mannheim, Germany:

        Beltz. 1989.

29.   Döpfner M, Schmeck K, Berner W, et al. Zur Reliabilität und faktoriellen Validität der

        Child Behavior Checklist—eine Analyse in einer klinischen und einer Feldstichprobe.

        Zeitschrift für Kinder-und Jugendpsychiatrie und Psychotherapie. 1994.

30.   Klasen H, Woerner W, Rothenberger A, et al. German version of the Strength and

        Difficulties Questionnaire (SDQ-German)--overview and evaluation of initial validation

        and normative results. Praxis der Kinderpsychologie und Kinderpsychiatrie.

        2003;52(7):491-502.

31.   Achenbach TM. Manual for the young adult self-report and young adult behavior

        checklist: University of Vermont, Department of Psychiatry; 1997.

32.   Linsell L, Johnson S, Wolke D, et al. Trajectories of behavior, attention, social and

        emotional problems from childhood to early adulthood following extremely preterm

        birth: a prospective cohort study. European Child & Adolescent Psychiatry. 2018;

        28:531-542.

33. Bayless S, Pit-ten Cate IM, Stevenson J. Behaviour difficulties and cognitive function in children born very prematurely. International Journal of Behavioral Development. 2008;32(3):199-206.

34. Twilhaar ES, de Kieviet JF, Bergwerff CE, et al. Social adjustment in adolescents born very preterm: evidence for a cognitive basis of social problems. The Journal of Pediatrics. 2019;213:66-73. e1.

35. Bilgin A, Wolke D. Maternal sensitivity in parenting preterm children: A Meta-analysis. Pediatrics. 2015;136(1):e177.

36. Moffitt TE, Arseneault L, Belsky D, et al. A gradient of childhood self-control predicts health, wealth, and public safety. Proceedings of the National Academy of Sciences. 2011;108(7):2693-8.

37. Scott E, Dale J, Russell R., et al. Young people who are being bullied – do they want general practice support? BMC Family Practice. 2016;17(1), 1-9.

38. Dale J, Russell R., & Wolke D. Intervening in primary care against childhood bullying: an increasingly pressing public health need. Journal of the Royal Society of Medicine. 2014;107(6): 219-223.

Figure Legends

Figure 1. Flowchart of participants throughout the study.

Note: Participants were considered to have 'sufficient peer data' if they had complete data on any of the peer relationship domains for at least three of the four assessment timepoints.

Figure 2. Mean z-scores for peer relationship trajectories in the full sample (N = 438)