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Are relations between children's hyperactive behavior, engagement, and social interactions in preschool transactional? A longitudinal study

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Based on bioecological systems theory, engagement is the mechanism for children's learning and development. However, children with hyperactive behavior tend to be less engaged in early childhood education and care (ECEC), which might negatively influence their learning and development. On the other hand, social interaction might support children with hyperactive behavior staying engaged in these activities. The current study investigates whether the association between teacher responsiveness, positive peer-to-child interaction (i.e., the quality of peer interaction) and children's hyperactive behavior and engagement levels are transactional. Two hundred and three children aged 1 to 5 in Swedish preschool settings were followed. Data was collected at three points in time between 2012 and 2014. This data was then analyzed to identify associations and how they changed over time. Transactional paths were found between children's levels of core engagement, teacher responsiveness, and the quality of positive peer-to-child interaction. Children's core engagement increases the probability of better quality positive peer-to-child interaction and teacher responsiveness, increasing core engagement over time. Teacher responsiveness and the quality of positive peer-to-child interaction are predictors of reduced hyperactive behavior over time. Meanwhile, children's hyperactive behavior does not significantly influence these two types of social interaction, that is, decreased hyperactivity may not improve social interaction to the same extent as increased engagement. The findings are discussed in relation to how special support for children with hyperactive behavior can be designed, with a focus on increasing core engagement in preschool settings.

KEYWORDS

hyperactive behavior, core engagement, social interaction, early childhood education, bidirectional paths, special support needs

Introduction

A large body of research stresses the importance of engagement in early childhood education and care (ECEC). Engagement is assumed to be essential for children's learning and development, both in the short and long term (Fredricks et al., 2004; Skinner et al., 2008; Aydogan, 2012; Cadima et al., 2015). It has been suggested that global engagement (e.g., cognitive, social, and emotional engagement), which becomes increasingly complex as the child matures, is the mechanism for children's learning and development (Bronfenbrenner and Evans, 2000).

However, not all children show global engagement due to developmental delay or behavior difficulties (BD), such as hyperactive behavior or conduct problems, which negatively affect their opportunities to learn and develop new skills (Gustafsson et al., 2021). On the other hand, not all aspects of engagement behavior necessarily become more complex over time. For instance, studies show that attention and persistence behavior, part of engagement behavior, is not related to child maturity but is related to motivation and is an essential pre-academic skill, which is a salient predictor of later outcomes (McClelland et al., 2007, 2013; Skinner et al., 2008; Kasari et al., 2012; Nesbitt et al., 2019). Children displaying behavioral difficulties (BD) such as hyperactive behavior often lack attention and the ability to exclude non-relevant stimuli (Allan et al., 2015). Moreover, children with BD tend to spend more time in teacher-child conflict and less time in positive peer-to-child interaction (Hamre and Pianta, 2001; Sheridan, 2007). Thus, it is crucial to support their core engagement in order to improve their learning and development. For instance, proximal processes, such as teacher responsiveness, positive peer-to-child interaction, and engagement, are the engine for children's development and learning (Bronfenbrenner and Evans, 2000; Sjöman et al., 2016). Teacher responsiveness refers to their emotional tone and approval responses to children's behavior, which is a significant predictor for children's engagement in ECEC and less BD in grade 1 (Spivak and Farran, 2016).

Thus, although there is evidence of a negative association between children's hyperactive behavior, global engagement, and social interaction, less is known concerning how the child's behavior and social environment in ECEC influence each other over time. It is therefore essential to investigate the reciprocal influences between children's behavior and social interaction (Sameroff, 2009). The current study investigates the association between children's core engagement, hyperactive behavior, and two types of social interactions (e.g., positive peer-to-child interaction and teacher responsiveness) in Swedish preschool settings, and whether transactional paths exist.

The association between children's core engagement and hyperactive behavior

Engagement refers to children's active involvement in social interactions with materials or everyday activities at different levels of complexity and in a developmentally appropriate manner (Raspa et al., 2001). Numerous studies have demonstrated that a child's global engagement (i.e., social, cognitive, emotional, and behavioral engagement) varies depending on the child's maturity and gender (Raspa et al., 2001; Vitiello et al., 2012; Aguiar and McWilliam, 2013; Searle et al., 2013; Williford et al., 2013). For children with BD, it has been found that their hyperactive behavior negatively affects their engagement (Sjöman et al., 2016). One explanation might be that children with hyperactive behavior usually have self-regulation challenges, resulting in difficulties maintaining engagement long enough to be active participants in everyday activities in preschool settings (Metcalfe et al., 2013; Searle et al., 2013; Allan et al., 2015). Severe behavior difficulties might be predictive of psychiatric diagnoses such as Attention Deficit/Hyperactivity Disorder (ADHD) in later life (Hong et al., 2015). However, although most children with hyperactive behavior during preschool years do not meet the requirements for formal diagnoses (Vasileva et al., 2021), they might still have issues sustaining their attention and engaging in social interactions or with materials. For instance, proxy ratings reported by preschool staff in Swedish preschools showed that between 11 and 17% of children aged 1–5 display a BD, such as hyperactive behavior, peer–interaction problems, or conduct issues, to a degree that negatively affects their everyday functioning (Lutz, 2009; Lillvist and Granlund, 2010).

Previous research showing a strong association between hyperactive behavior and engagement indicates that improving children's engagement may have a more substantial effect on decreasing behavior problems as it may elicit reactions from teachers that promote the child's future engagement behavior. On the other hand, other studies show that children with hyperactive behavior tend to be less engaged in complex activities, such as symbolic and cooperative play, and spend more time in solitary play (Coplan et al., 2001; Searle et al., 2013; Coplan et al., 2015).

Thus, it might be sufficient to investigate the intensity of engagement behavior for children with hyperactive behavior, regardless of its complexity and maturity, from low to high levels of engagement behavior. High levels of engagement could be observed in the child's body language, e.g., the child concentrates highly and shows persistence and attention behavior. Meanwhile, low levels of engagement might be observed when the child briefly looks around without paying attention to or interest in something specific (Farran, unpublished manuscript). Several studies, based on proxy ratings, showed that the construct 'engagement' consists of two underlying dimensions: developmental engagement and core engagement (De Kruif and McWilliam, 1999; Aguiar and McWilliam, 2013; Sjöman et al., 2016). Developmental engagement is related to child maturity and could be observed during problem-solving and pretend play in ECEC. Meanwhile, core engagement refers to the child's attention and persistence behavior unrelated to maturity or complexity. These behaviors could also be observed among children with autism or in toddlers (De Kruif and McWilliam, 1999; Kasari et al., 2012; Aguiar and McWilliam, 2013).

Moreover, a cross-sectional study (Sjöman et al., 2016) investigated the association between children's hyperactive behavior and less complex engagement behavior (core engagement), such as shared attention or persistence behavior; versus complex engagement behavior (developmental engagement), such as problem-solving. A negative association was found between hyperactive behavior and developmental engagement. Meanwhile, a weak negative association between hyperactive behavior and core engagement was found. Moreover, attention and persistence behavior has also been shown to positively impact motivation (Skalski et al., 2021), learning, and development among children with BD (Sjöman et al., 2016).

Thus, although there is evidence for a negative association between global engagement and BD, investigated over time or cross-sectional, less is known about the association between core engagement, hyperactive behavior, and possible transactional paths between child behavior and social interactions.

Proximal processes – engine for engagement for children with BD

Based on bioecological systems theory (Bronfenbrenner and Evans, 2000), proximal processes seem to be the engine for child development. Proximal processes are transactional paths between the child and the

environment and are mutually rewarding. Engagement can be viewed as a snapshot of a proximal process between the child and their surroundings, with intensive engagement behavior in everyday activities or social interactions expressing an effective proximal process (Bronfenbrenner and Evans, 2000) improving the child's competence in cognitive domains (White et al., 2021). However, less intense engagement behavior represents a non-effective proximal process (Bronfenbrenner and Evans, 2000) associated with hyperactive behavior and difficulties in maintaining attention, which in turn has a negative influence on the child's learning and development (Yoder et al., 2019).

Over the past decades, research has stressed positive social interactions as an essential factor promoting children's engagement and acquisition of pre-academic skills, such as early mathematics, letter skills, and the ability to shift focus and sustain attention (Birch and Ladd, 1997; Howes et al., 2008; Nesbitt et al., 2019). Examples of positive social interaction are teacher-child interaction characterized by teacher responsiveness, adequate scaffolding, and learning support (Yates and Yates, 1990; Sylva et al., 2006). Moreover, teacher responsiveness is based on reciprocal paths between the child and teacher through 'serve-and-return' processes (i.e., transactional processes) (Vygotskij and Cole, 1978). An observational study revealed that when teachers interacted with children in an emotional and responsive manner during instruction, this was positively associated with gains in children's language and literacy skills, regardless of their initial patterns of classroom engagement (Williford et al., 2013). Moreover, a longitudinal observational study by Curby et al. (2014) indicated that teachers' emotionally and supportive behaviors was associated with children's engagement. However, the only significant transactional paths were found between children's engagement and later teacher emotional supports. In other words, the study indicated that children's engagement was the force that improved teachers emotional and supportive behavior. A similar association has been found in other studies, i.e., teachers seem to interact more frequently with children who respond with positive emotions and interact less frequently with children who respond negatively or do not respond at all (Birch and Ladd, 1997; Shonkoff and Phillips, 2000).

Moreover, teachers' behavior has been found to be associated with behaviors among children within the classroom. For instance, a cross-sectional study by Sheridan (2007) conducted in ECEC settings in Germany and Sweden revealed that teachers' use of abdication or dominant behavior, such as overriding the child's initiatives, was associated with more conflicts between children. In addition, little space for children's own initiatives was observed, which in turn showed a negative influence on their engagement. On the other hand, teachers' use of democratic/learning strategies, such as sensitive, social, and negotiating teaching strategies, promoted interplay, participation, communication, and cooperation between the teachers and children and among children in the peer group.

Another important social interaction for children's engagement is positive peer-to-child interaction, which refers to the quality of the interaction between peers and the focal child, which has been found to promote engagement among children with BD (Almqvist, 2014; Sjöman et al., 2016). Examples of high-quality positive peer-to-child interaction are when peers show interest in what the child is doing or when another child can direct the child's interest toward a shared object, activity, or person (Granlund and Olsson, 1998). A longitudinal study (Sjöman et al., 2021) revealed that positive peer-to-child interaction might reduce hyperactive behavior among children with BD.

However, it has been shown that there are critical aspects of proximal processes and frequencies among children with hyperactive behavior in social interaction with teachers and peers (Doumen et al., 2008; Sameroff, 2009). For instance, children with BD tend to be less engaged with materials, peers, and teachers in appropriate ways (Searle et al., 2013), which in turn can lead to less teacher responsiveness and positive peer-to-child interaction (Sjöman et al., 2016). Moreover, studies show that children with BD are more often involved in teacher-child conflicts (Hamre and Pianta, 2001; Buyse et al., 2008; Zhang and Sun, 2011), and meet with less teacher responsiveness, more reprimands and teacher use of more disapproving behavior (e.g., disapproving facial expressions or a negative tone of voice) and spend less time in peer-to-child interaction (Buhs et al., 2006; Almqvist et al., 2018). Moreover, the results of a longitudinal study by Almqvist (2014) showed decreased teacher responsiveness towards children with BD. In summary, less time in positive interactions with teacher and peers, and more time when the child experiences negative behaviors from the teacher or less time in peer-interaction are aspects related to non-effective proximal processes.

Moreover, a previous longitudinal study by Gustafsson et al. (2021) showed that children displaying multiple risk factors such as low engagement behavior, hyperactive behavior, conduct problems, and less engagement in social interaction are at higher risk for later maladjustment. On the other hand, children who displayed one or two risk factors but also protective factors, such as engagement in social play, did not show the same negative pattern. Thus, later maladjustment is not only related to the number of risk factors but also protective factors such as children's engagement and social interactions with peers and teachers. Similarly, although a negative association between BD (e.g., hyperactive behavior) and core engagement (e.g., attention and persistence behavior) was found in a cross-sectional study (Sjöman et al., 2016) in Swedish preschool settings, teacher responsiveness and positive peer-to-child interaction mitigate the negative association between children's engagement and hyperactive behavior. Thus, the study indicates that although children show BD, they also show core engagement if they are meet with positive interactions in ECEC. Moreover, a longitudinal study has shown that teacher responsiveness and positive peer-to-child interaction were significantly associated with children's hyperactive behavior and attention and persistence (i.e., core engagement) (Sjöman et al., 2021). In other words, increased core engagement led to decreased hyperactive behavior over time.

Based on the above, the inconsistent findings regarding the direction of the association between children's engagement, hyperactivity, teacher responsiveness and the child are unclear. Thus, more knowledge is needed concerning the association between social interactions, engagement behaviors, and hyperactive behaviors over time. The current study proposes that the development of the relationship, rather than the individuals, is the appropriate unit of analysis for identifying transactional paths. Transactional paths are not only ongoing and simultaneous processes involving the behavior of the child and others, but also encompass how different individuals change their behavior over time (Kuczynski and Parkin, 2009).

Aim and hypothesis

Based on previous research, children with hyperactive behavior are meet with less positive peer-to-child interaction and teacher

responsiveness and spend less time in social play (see Hamre and Pianta, 2001; Zhang and Sun, 2011; Curby et al., 2014; Coplan et al., 2015). On the other hand, when children demonstrate intense engagement behavior (i.e., core engagement), it is associated with positive peer-to-child interaction as well as teacher responsiveness (see Searle et al., 2013; Williford et al., 2017; Sjöman et al., 2021). However, both the direction of these associations and possible transactional paths are unclear. To investigate the direction of these associations and their possible transactional paths, the relationships need to be investigated over time.

Thus, the current study aimed to explore possible directional or transactional paths between social interactions (e.g., teacher responses and positive peer-to-child interactions) and core engagement and hyperactive behavior over time. The data was collected at three points in time between 2012 and 2014. Two models were used to investigate the possible transactional paths. The first model tested the associations between teacher responsiveness and children's core engagement and hyperactive behavior over time. The second model tested the associations between positive peer-to-child interaction and children's core engagement and hyperactive behavior over time.

For the teacher-child model, the following hypotheses were tested:

> Children's hyperactive behavior at time-point one is associated with less teacher responsiveness at time-point two, which is associated with increased hyperactive behavior at time-point three.
>
> Children's core engagement at time-point one is associated with teacher responsiveness at time-point two, which is associated with increased core engagement at time-point three.

For the peer-to-child model, the following hypotheses were tested:

> Children's hyperactive behavior at time-point one is associated with less positive peer-to-child interaction at time-point two, and less positive peer-to-child interaction at time-point two increased hyperactive behavior at time-point three.
>
> Children's core engagement at time-point one is associated with positive peer-to-child interaction at time-point two, which is associated with increased core engagement at time-point three.

Method

The current study is based on a longitudinal survey design that used preschool staff members' ratings of children's engagement, BD, and social interactions. The participants in the current sample were children with complete data collected at three points in time between 2012 and 2014. The data came from a longitudinal study conducted in Swedish preschools during 2012 to 2014 (Granlund et al., 2015).

Participants

The sample consisted of 203 children (114 boys and 89 girls) in 23 classrooms in public preschools. The first assessments were done when most children were 2.5 years old ($M = 32$; $SD = 9.05$). The group size ranged from 9 to 44 children ($M = 20$; $SD = 8.81$). The child to staff ratio for toddlers—usually between 15 and 36 months old—was, on average, 5:1 ($SD = 1.23$). In classrooms for preschool-age children—usually between 37 and 71 months old—the average child to staff ratio was 6:1 ($SD = 1.76$). The staff responded to a survey asking whether the children were formally identified as needing special support due to developmental delay and/or BD affecting their everyday functioning in preschool. The number of children needing special support in each classroom ranged from 0 to 9 ($SD = 0.96$); 45 children needed special support due to BD or for other reasons.

Procedures and ethical considerations

The current study is based on a longitudinal design, The surveys were filled out by the preschool staff. Data was collected at three points in time between 2012 and 2014 in the autumn between August to October. Initially, the survey package was evaluated by an expert panel consisting of experienced preschool teachers and special educators. Following the expert panel's suggestions, some items on the survey were adapted to the Swedish preschool environment.

The directors of the preschools and the preschool staff gave written informed consent to participate in the project. All parents of the participating children were informed about the study by the preschool staff and given a request for consent for their child to participate. Each Fall, the surveys were handed out by project group members during the first visit, and each preschool unit returned them during the second visit. The ethical review committee in Linköping, Sweden approved the project (Reg. no. 2012/199–31).

Measurements

Preschool staff rated children's everyday functioning (i.e., engagement, social interaction, and BD) at three points in time between 2012 and 2014. Questions about staff collaboration with parents and the preschool's physical environment (e.g., access to materials) were also included in the survey. The whole survey package contained 159 items. For the current study, only the demographic data and items that relate to the study's aim were used for the analyses, i.e., items related to teacher responsiveness, positive peer-to-child interaction, hyperactive behavior, and core engagement. The content of the scales used is described in greater detail below.

Social interactions in preschool

Social interactions were measured with an adapted version of the questionnaire "Interaction – your child, your interaction" (Granlund and Olsson, 1998), in which preschool teachers rated their experiences of different types of social interactions between peers and the child as well as between the teachers and the child. The instrument used included 36 items covering teacher–child interactions, child–teacher interactions, positive peer-to-child interactions, and child-to-peer interactions. The responses are based on a five-point Likert scale from 1 to 5, where 1 = "seldom" and 5 = "often." In the current study's analyses, two subscales were used to measure *teacher responsiveness to the child* (10 items) and *other children's interactions with the child,* i.e., *peer-to child interactions* (five items). Examples of items for teacher responsiveness were: 'I comment or show interest in what the child is doing,' 'I know what situations inspire the child to interact and can, if necessary, create such situations.' Examples of items for positive peer-to-child interaction were: 'Other children show interest in what the

child is doing,' 'Other children can steer the child's interest towards a common object, activity or person.' According to Almqvist (2006a) and Sjöman et al. (2016), the internal validity was high for each subscale measuring teacher responsiveness (α = 0.77) and positive peer-to-child interaction (α = 0.92). In the current study, the Cronbach alpha coefficients for teacher responsiveness for each data collection point were data collection 0.75, 0.80, and 0.72. The Cronbach alpha coefficients for positive peer-to-child interaction for each data collection point were 0.92, 0.90, and 0.91.

Behavior difficulties

Children's BD was measured using the "Strength and difficulties questionnaire" (SDQ) by Goodman (1997). This instrument has 25 items covering five subscales related to conduct problems, hyperactive behavior, emotional problems, peer problems, and prosocial behavior. Responses are provided on a three-point Likert scale from 0 to 2: 0 = "not at all," 1 = "only a little" and 2 = "quite a lot." It has been suggested that, using cutoff scores for each subscale, the total score on the BD scale can be divided into three subgroups: normal, abnormal, and borderline, where abnormal to borderline cutoff scores are signs of poor mental health (Goodman, 1997). However, the objective of the present study is not to identify children's mental health problems; the focus is instead on the transactional paths between their levels of hyperactive behavior and social interactions. Thus, a continuous scale was used for the analyses, with the total scores ranging between 0 = "no hyperactive behavior" to 10 = "high level of hyperactive behavior." The internal consistency for the SDQ subscale for hyperactivity was α = 0.69. In addition, the hyperactivity scale had shown good validity and reliability for children aged 1–3 years (Gustafsson et al., 2016).

Engagement

Children's engagement in preschool was measured with the "Child engagement questionnaire" (CEQ) (McWilliam, 1991). The preschool staff rated children's engagement behavior using free-recall impressions of the level of each child's engagement with teachers, peers, activities, or materials. The questionnaire consists of 32 items on a four-point Likert scale with values from 1 to 4. The response alternatives for the child's behavior were 1 = "not at all typical," 2 = "somewhat typical," 3 = "typical," and 4 = "very typical." To further clarify each item, examples were provided. For instance, the item "Seems constantly aware of what's going on around him or her," gives the example of "The child looks at sources of noises and at moving objects and people" was given. Based on an earlier adaptation of the questionnaire, only 29 of the original 32 items were used, since feedback from an expert panel had indicated that three of the items were not suitable for the Swedish preschool context. One of the omitted items, for instance, was "Uses repetitive vocalizations," with the example "The child says, 'Ba-ba-ba-ba-ba." "This type of engagement behavior is most frequently observed in infants who, in Sweden, are usually cared for at home during their first year of life. Earlier studies have reported high content and construct validity and intra-rater reliability for the CEQ (Almqvist, 2006a).

According to an earlier study by Sjöman et al. (2016), the CEQ has two related underlying constructs. The first construct, *core engagement*, is primarily a rating of focus of attention/less complex behavior and has a relatively low correlation with chronological age ($r = 0.28$). The second construct, *developmental engagement*, is related to more complex behavior (e.g., the child talks about things in the past or the future), and it has a higher correlation with chronological age ($r = 0.54$). Since the purpose of the current study was to explore the possible transactional paths between social interactions and children's engagement, regardless of their chronological age or developmental delay, only core engagement was used in the analyses.

Data analytic strategy

In order to longitudinally explore the relationships between teacher responsiveness/positive peer-to-child interaction and the child's core engagement/hyperactive behavior, a series of autoregressive, cross-lagged path analyses were conducted within the framework of structural equation modeling design by using two models: a *peer-to-child interaction model* and a *teacher-child model*.

The analyses are presented below in two main subsections of the Results section. Firstly, descriptive statistics and bivariate correlations for the variables of interest, covering the data collection point 1, point 2, and point 3 between 2012 and 2014, August to October. The strength of the correlation is based on the guidelines suggested by Cohen (1992): weak $r = 0.10$ to 0.29, moderate $r = 0.30$ to 0.49, and strong $r = 0.50$ to 1.00. In addition, Cronbach alphas were used to describe internal consistency for each construct: *core engagement*, *hyperactive behavior*, *positive peer-to-child interaction,* and *teacher responsiveness*. Secondly, a series of autoregressive, cross-lagged path analysis models assessing the concurrent and prospective associations between children's core engagement, hyperactive behavior, teacher responsiveness, and positive peer-to-child interaction, respectively, were examined by using AMOS 21.0 (Arbuckle, 2013).

When the model fit was evaluated, three fit indices were used: X^2, comparative fit index (CFI; Bentler, 1990), and root mean square error of approximation (RMSEA; Browne and Cudeck, 1993). For X^2, $p > 0.05$ (i.e., no differences between the model and the data) was used as the criterion for a good model fit. Comparative fit index values above 0.90 indicate good model fit (Byrne, 2013), RMSEA values less than 0.05 indicate a good model fit, and RMSEA between 0.05 and 0.08 indicate a moderate model fit (Browne and Cudeck, 1993). Due to the clustering effect, the standard errors were corrected using the bias-corrected bootstrap resampling method in Amos (Nevitt and Hancock, 2001; Arbuckle, 2013). Clustering effects are common in research conducted in natural environments such as preschools or schools, where children in the same classroom tend to show similar behavior, due to the influence of the same context, compared to children in other classrooms (Killip, 2004; McCoach and Adelson, 2010). The bias-corrected bootstrap resampling method corrects for the bias in the central tendency of the estimate, accommodates the non-normal distribution of the estimator of the indirect effects, and adjusts the actual sample according to the clustering effect (Shrout and Bolger, 2002; Mackinnon et al., 2004).

Results

Descriptive statistics for the variables of interest are presented in Table 1. On average, the children showed high levels of core

engagement at each data collection point, increasing over time. On average, teachers reported low levels of children's hyperactive behavior, decreasing over time. Meanwhile, teacher responsiveness and positive peer-to-child interaction increased over time.

The association between two types of social interactions and children's hyperactive behavior and core engagement are presented in Table 2. For hyperactive behavior a moderate to strong significant positive association was found between data collection points 1 and 3 (0.558**). For core engagement a moderate significant correlation was found between data collection points 1 and 3 (0.205**) The results indicate stability on each construct over time. The association between hyperactive behavior and core engagement showed a strong correlation between data collection points 1 och 3 (0.434**). Moreover, a weak positive correlation was found between teacher responsiveness at data collection points 1 and 2 (0.261**), as well as between data collection points 2 and 3 (0.0.427**). However, a non-significant correlation between teacher responsiveness at T1 and T3 (0.056) was found. Similar paths were found for positive peer-to-child interaction. A significant positive association was found between data collection points 1 and 2 (0.396**), and between data collection points 2 and 3 (0.455**), while a non-significant association was found between data collection points 1 and 3 (0.127). Thus, the non-significant association between data collection points 1 and 3 for teacher responsiveness as well as for peer-to-child interaction indicates a non-linear stability over time.

Autoregressive, cross-lagged path analysis

A series of autoregressive, cross-lagged path analyses were used for the two models—the teacher-child-model and peer-to-child-model—to assess the directional and transactional paths between the level of social interaction, level of core engagement, and hyperactive behavior, respectively.

Teacher–child model

For the teacher-child model, three autoregressive, cross-lagged path analyses were conducted (teacher-driven, child-driven, and transactional) which tested the within-time and prospective relationship between teacher responsiveness, children's core engagement, and hyperactive behavior, respectively. All three models with the paths showed adequate fit with the data. Thus, the models were improved by deleting non-significant associations. In accordance with CFI and RMSEA, the model with transactional paths provided the best fit with the data (see Table 3).

The association between children's hyperactive behavior, core engagement, and teacher responsiveness

Hypotheses I and II were used to investigate the association over time between children's hyperactive behavior and teacher responsiveness, and the association between children's core engagement and teacher responsiveness, respectively. The first hypothesis was not supported. Children's hyperactive behavior at data collection point 1 is associated with less teacher responsiveness at data collection point 2. Meanwhile, a non-significant association was found between teacher responsiveness at data collection point 2 and hyperactive behavior at data collection point 3. As Figure 1 shows, a non-significant association was found between hyperactive behavior

TABLE 1 The table presents the internal validity for children's core engagement, hyperactive behavior, teacher responsiveness, and peer-to-child interaction at three points.

Variables	α	Mean	SD	Range	Skewness	Kurtosis
Core engagement						
T1	0.88	3.40	0.55	1.88–4.0	−0.88	−0.09
T2	0.87	3.53	0.52	1.63–4.0	−1.38	1.68
T3	0.86	3.64	0.45	1.88–4.0	−1.65	2.75
Hyperactive behavior						
T1	0.85	3.03	2.45	0–10	0.95	0.37
T2	0.89	2.85	2.80	0–10	1.05	0.31
T3	0.88	2.28	2.55	0–10	1.15	0.58
Teacher responsiveness						
T1	0.75	4.54	0.33	2.8–5.0	−1.6	4.2
T2	0.80	4.59	0.34	2.9–5.0	−1.5	3.2
T3	0.72	4.62	0.28	3.5–5.0	−1.4	2.2
Peer-to-child interaction						
T1	0.92	3.70	1.02	1.0–5.0	−0.79	0.01
T2	0.90	4.25	0.75	1.4–5.0	−1.2	1.3
T3	0.91	4.49	0.67	1.4–5.0	−1.78	3.87

Hyperactivity, sum score 1–10; Core engagement, range 1–4, mean score of 12 items; Peer-to-child interaction, range 1–5, mean score of 5 items; Teacher responsiveness, range 1–5, mean score of 10 items.

TABLE 2 Pearson correlation.

Variables	1	2	3	4	5	6	7	8	9	10	11	12
Hyperactive behavior												
1. T1												
2. T2	**0.473****											
3. T3	**0.503****	**0.558****										
Core engagement												
4. T1	−0.467**	−0.419**	−0.253**									
5. T2	−0.294**	−0.533**	−0.441**	**0.513****								
6. T3	−0.209**	−0.279**	−0.545**	**0.205****	**0.434****							
Teacher responsiveness												
7. T1	−0.364**	−0.321**	−0.195**	0.487**	0.273**	0.094						
8. T2	−0.132	−0.281**	−0.331**	0.274**	0.466**	0.362**	0.261**					
9. T3	−0.028	−0.061	−0.377**	0.009	0.197**	0.531**	0.056	0.427**				
Peer-to-child interaction												
10. T1	−0.412**	−0.289**	−0.194**	0.579**	0.301**	0.074	0.510**	0.272**	0.080			
11. T2	−0.202**	−0.423**	−0.348**	0.433**	0.736**	0.456**	0.310**	0.512**	0.233**	0.396**		
12. T3	−0.162*	−0.202**	−0.488**	0.105	0.393**	0.749**	0.056	0.364**	0.567**	0.127	0.455**	

Note The bold values show significant association on each construct over time indicating stability over time.
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

TABLE 3 Model fit indices for the modified path models.

Model	X^2 (df)	CFI	RMSEA (90% CI)
Teacher – child model			
1. Teacher-driven path	34.16 (15), $p < 0.01$	0.969	0.080 (0.044–0.115)
2. Child-driven path	55.46 (19), $p < 0.001$	0.941	0.097 (0.068–0.128)
3. **Transactional path**	29.83 (19), $p < 0.01$	0.978	0.065 (0.026–0.101)
Peer – to – child model			
4. Peer-driven path	47.65 (16), $p < 0.001$	0.963	0.099 (0.067–0.132)
5. Child-driven path	62.65 (17), $p < 0.001$	0.947	0.115 (0.086–0.147)
6. **Transactional path**	48.60 (18), $p < 0.001$	0.964	0.092 (0.061–0.123)

Best-fitting models are shown in boldface.

at data collection point 1and teacher responsiveness at data collection point 2, as well as between data collection points 2 and 3. Thus, the results indicate that children's hyperactive behavior did not influence teacher responsiveness over time. In other words, no transactional paths were found between children's hyperactive behavior and teacher responsiveness.

The association between children's core engagement and teacher responsiveness

Hypothesis II was supported. Children's core engagement at data collection point 1is associated with teacher responsiveness at data collection point 2, which is associated with increased core engagement at data collection point 3. As Figure 1 shows, a positive association was found between children's core engagement at data collection point 1 and teacher responsiveness at data collection point 2 (0.165*), and between teacher responsiveness at data collection point 2 and core engagement at data collection point 3 (0.203*). Thus, the results indicate that children's core engagement was a significant predictor of teacher responsiveness. In other words, if children display attentive and persistence behavior (e.g., core engagement), this seems to contribute to teacher responsiveness over time, which in turn improve children's attentive and persistence behavior. These associations are indicators of a transactional path.

Peer-to-child model

For the peer-to-child model, the within-time and prospective relationship between positive peer-to-child interaction, children's core engagement, and hyperactive behavior were each tested, respectively. The paths—peer-driven, child-driven, and transactional-driven—were not entirely satisfactory. Thus, the models were improved by deleting non-significant associations, and the modified models with peer-driven and transactional paths fit the data well. Following RMSEA, the model with a transactional path provided the best fit with the data (see Table 3).

The association between children's hyperactive behavior and peer-to-child interaction

The third hypothesis was not supported. Children's hyperactive behavior at data collection point 1 is associated with less positive peer-to-child interaction at data collection point 2, and less positive peer-to-child interaction at data collection point 2 increased hyperactive behavior at data collection point 3.

As Figure 2 shows, a non-significant association was found between children's hyperactive behavior at data collection point 1 and peer-to-child interaction at data collection point 2, as well as between

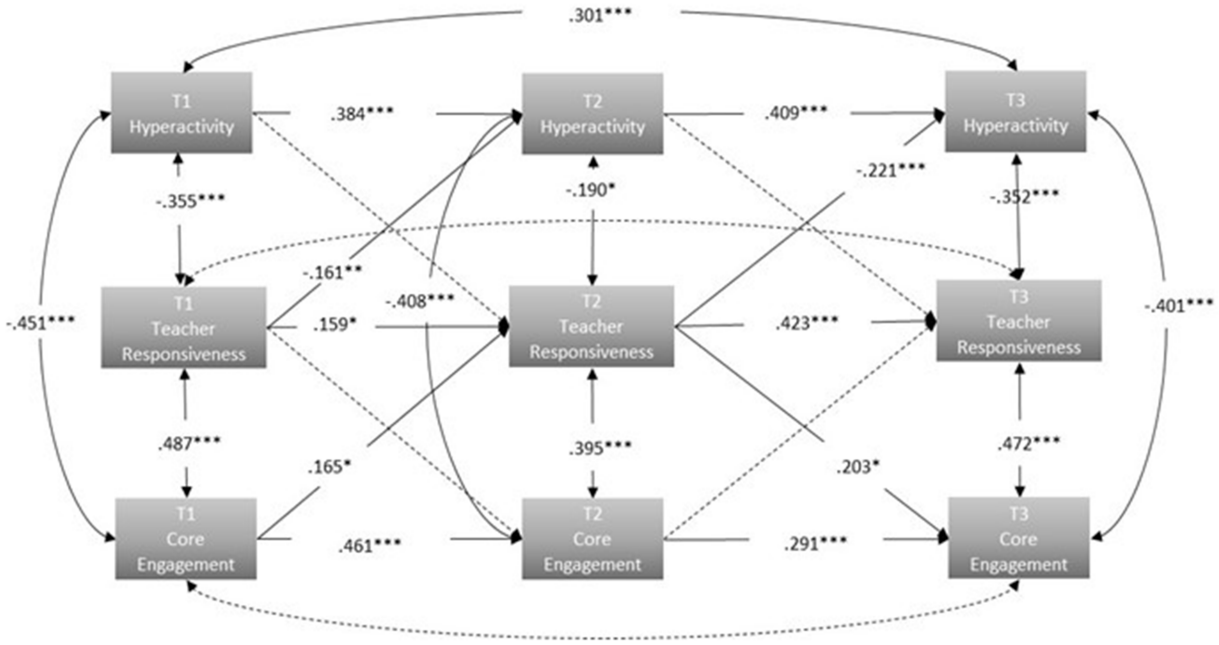

FIGURE 1
Teacher–child model with transactional paths with standardized estimates presented (Sjöman et al., 2016). Dashed lines indicate non-significant paths. ***p<0.001, **p<0.01, *p<0.05.

data collection points 2 and 3. In other words, children's hyperactive behavior seems not to be a significant predictor for less peer-to-child interaction. However, a significant negative association was found between peer-to-child interaction at data collection point 2 and children's hyperactive behavior at data collection point 3. The results indicate that less peer-to-child interaction predicts increasing hyperactive behavior, whereas hyperactive behavior is not a significant predictor of less peer-to-child interaction. Thus, there are no transactional paths between children's hyperactive behavior and peer-to-child interaction.

The association between children's core engagement and peer-to-child interaction

The fourth hypothesis was supported. Children's core engagement at data collection point 1 is associated with positive peer-to-child interaction at data collection point 2, which is associated with core engagement at data collection point 3. As Figure 2 shows, children's core engagement at data collection point 1 predicts positive peer-to-child interaction at data collection point 2 (0.243***), which in turn was associated with a stronger association with children's core engagement at data collection point 3 (0.447***). In other words, if children display attentive and persistent behavior (e.g., core engagement), this seems to contribute to positive peer-to-child interaction over time, which in turn improves children's core engagement. Similarly, as in the teacher-child model, a transactional path was found between core engagement and peer-to-child interaction.

To conclude, the results indicate that when the children showed core engagement in everyday activities in preschool at data collection point 1, they were more likely to be met over time with teacher responsiveness and positive peer-to-child interaction. In contrast, hyperactive behavior was not a significant predictor of less teacher responsiveness or less positive peer-to-child interaction over time. The only significant association was found between peer-to-child interaction at data collection point 2 and hyperactive behavior at data collection point 3. Thus, the two models did not show transactional paths between social interactions and children's hyperactive behavior.

Discussion

The current study was conducted in a Swedish preschool context and explores possible transactional paths over time between social interactions (e.g., teacher responsiveness and positive peer-to-child interaction), children's core engagement and hyperactive behavior, respectively. The associations were examined at three points in time between 2012 and 2014, August to October. This data was then analyzed to identify associations and how they changed over time.

Providing support for the proximal processes hypothesized by the bioecological systems theory (Bronfenbrenner and Evans, 2000), the transactional-driven paths fit the data best for both the teacher-child and peer-to-child models. The analyses yielded three significant findings. Firstly, transactional paths were found across time between children's core engagement, teacher responsiveness, and positive peer-to-child interaction, respectively. Secondly, no transactional paths were found between children's hyperactive behavior and social interactions (i.e., teacher responsiveness and positive peer-to-child interaction). The only significant associations for peer-to-child model between hyperactive behavior and peer-to-child interaction was between data collection points 2 and 3. Thirdly, a weak and negative association was found between teacher responsiveness at data collection point 1 and hyperactive behavior at data collection point 2.

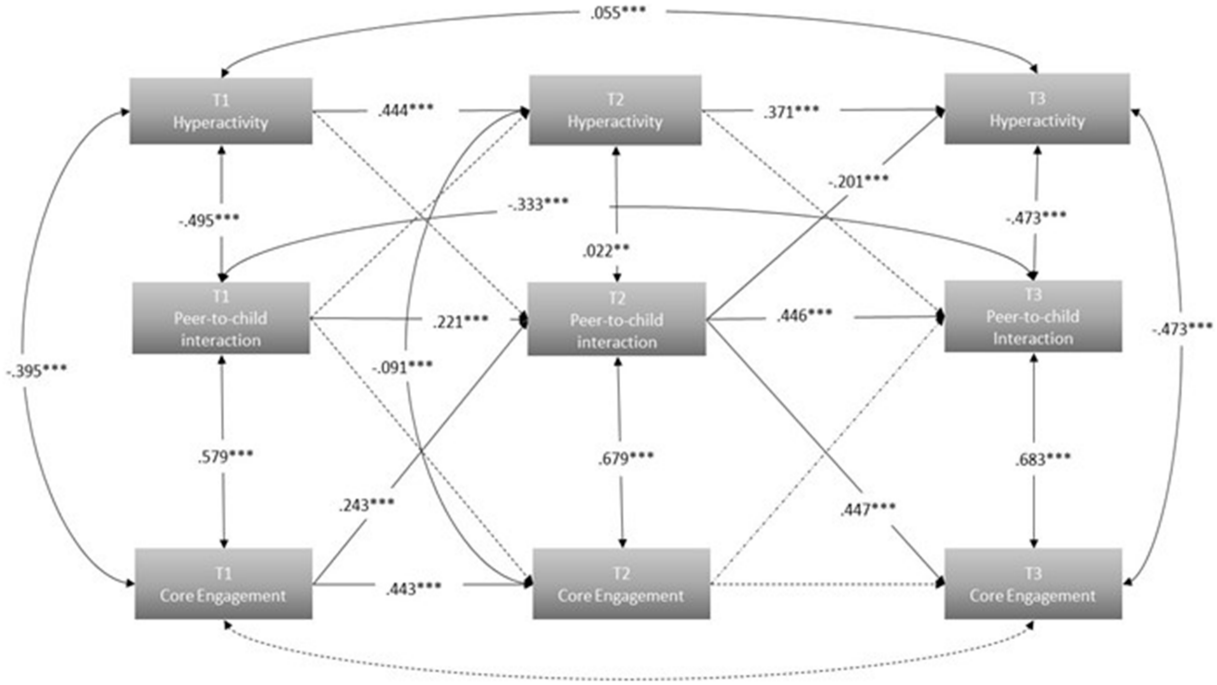

FIGURE 2
Peer-to-child model with transactional paths with standardized estimates presented (Sjöman et al., 2016). Dashed lines indicate non-significant paths. ***p<0.001, **p<0.01, *p<0.05.

After modifying the models to account for the stability in core engagement, teacher responsiveness, and positive peer-to-child interaction across the three sets of data, indications of transactional paths were found. In addition, social interactions had significant associations with levels of core engagement over time. These findings align with earlier studies that show that teachers interact more frequently with children who respond positively to the interaction (Birch and Ladd, 1997; Shonkoff and Phillips, 2000), indicating that children's engagement behavior had a positive influence on teacher behavior, e.g., increased responsiveness. The results showing an association between core engagement and social interaction could also be interpreted from the opposite direction. Low core engagement is associated with less teacher responsiveness and less positive peer-to-child interaction, which in turn predict less core engagement. Accordingly, the association over time between children's core engagement, teacher responsiveness and peer-to-child interaction, respectively, supports the hypothesis that transactional paths exist. Following the cross-sectional study by Sjöman et al. (2016), the previous research shows a negative association between hyperactive behavior and social interaction. On the other hand, that study also showed that both teacher responsiveness and peer-to-child interaction mitigate the negative association between children's core engagement and hyperactive behavior. However, when investigating transactional paths for the present study, neither positive peer-to-child interaction nor teacher responsiveness was associated with hyperactive behavior. On the other hand, the present study's investigation of transactional path shows that for a child with hyperactive behavior, their involvement in positive social interactions not only helps the child to focus and sustain attention in everyday activities in preschool (i.e., their core engagement), it also positively impacts teachers' and other peers' interactions with the child. Thus, these positive social interactions create a positive feedback loop for children with hyperactive behavior. It is, therefore, essential to design interventions that target core engagement among children with hyperactive behavior, which seems to be the engine for positive peer-to-child interaction and teacher responsiveness. For instance, Yoder et al. (2019) observed more positive peer engagement during free play, snack time, and meal time. Similarly, Sheridan (2007) found that sensitive, social, and negotiating teaching strategies promoted the interplay, participation, communication, and cooperation between the teachers and children and among children in the peer group. Thus, results from previous studies and the present study indicate that social interactions (e.g., peer-to-child interaction, teacher responsiveness) as well as structural aspects such as activity settings (e.g., free play, meal times) might be the mechanism for increased engagement among children with and without hyperactivity.

Hyperactive behavior and social interactions

After the stability in hyperactive behavior, teacher responsiveness, and positive peer-to-child interaction had been accounted for, both models showed stability across time. Contrary to the original hypotheses, no significant cross-lagged paths were found between children's hyperactive behavior and social interactions over time. The results are in contrast with earlier longitudinal studies reporting that children's externalizing BD predicts more conflict with teachers and peers (Hamre and Pianta, 2001; Zhang and Sun, 2011). Other studies have also suggested that children's externalizing BD negatively influences

their social interactions, which in turn might lead to peer rejection and solitary play (Buhs et al., 2006; Coplan et al., 2015; Sjöman et al., 2016).

However, additional longitudinal studies have indicated the opposite directional paths, i.e., high levels of teacher responsiveness and positive peer-to-child interaction predict reduced BD over time and increased cognitive self-regulation and social competence (Fuhs et al., 2013; Spivak and Farran, 2016). In contrast, this study showed no transactional path between hyperactive behavior and teacher responsiveness over time.

Core engagement and social interaction

In contrast with previous studies (Birch and Ladd, 1997; Howes et al., 2008; Spivak and Farran, 2016; Nesbitt et al., 2019) neither teacher responsiveness nor peer-to-child interaction was a significant predictor for children's core engagement. One explanation might be that previous studies have investigated children's global engagement, while the present study investigates core engagement, e.g., persistence and attentive behavior, not related to child maturity. Children with BD show less engagement in more complex activities such as symbolic and cooperative play (Coplan et al., 2001; Searle et al., 2013; Coplan et al., 2015), which require sustained attention and persistence behavior in a cognitively demanding activity long enough to become engaged.

For the present study, core engagement was a significant predictor for both teacher responsiveness and peer-to-child interaction. The path indicated the existence of a transactional path between children's core engagement and teacher responsiveness. However, it seems that core engagement is the engine for the transaction paths, e.g., core engagement improves teacher responsiveness and peer-to-child interaction, which in turn leads to increased core engagement. Moreover, as the results show that a negative association was found between core engagement and hyperactive behavior at each data collection point. These negative associations within the child must be considered in order to understand how environmental factors such as social interactions and the child's behavior shape each through 'serve-and-return' paths (Vygotskij and Cole, 1978; Sameroff, 2009). Interventions aiming solely to reduce children's BD are probably insufficient for improving engagement (see Kirkhaug et al., 2016; Almqvist et al., 2018), and they will not automatically lead to better teacher responsiveness and positive peer-to-child interactions. Accordingly, preschool staff need to reflect on how to improve engagement for children with BD, and how social interactions shape the children over time. In line with previous studies showing that engagement and social interactions are essential for the child's development and learning (Aydogan, 2012; Cadima et al., 2015), the present study shows that core engagement is important to consider when attempting to understand how social interactions, such as teacher responsiveness and positive peer-to-child interaction, are influenced by children's behaviors.

Implications for preschool practices

Overall, the findings of this study support the idea that children's behavior, especially their core engagement (e.g., attention and persistence), has a considerable influence on how teachers and peers respond to children with BD. These findings also demonstrate different transactional paths between children's core engagement, hyperactive behavior, and interaction with teachers and peers. Both teachers and peers are more likely to respond to children exhibiting high levels of core engagement, to some extent whether the children display hyperactive behavior or not. However, the probability that children with hyperactive behavior also show high levels of engagement is low. Thus, different types of support strategies may be needed in the classroom, depending on whether children exhibit both hyperactive and low core engagement, low core engagement alone, or hyperactive behavior alone. For example, in their interactions with children with BD, teachers tend to give more reprimands and use more disapproving behavior (e.g., disapproving facial expressions or a negative tone of voice; Almqvist et al., 2018) as compared to their interactions with children without BD. The teacher might be supported by encouraging them to use a positive emotional tone associated with children's core engagement behavior (e.g., attentive and persistence behavior). For example, they show interest in a child's positive actions and interact more frequently with children when exploring a topic using inferential, open-ended questioning that has several conversational turns (Spivak and Farran, 2016). Teachers also play an essential role in supporting peer interaction. For example, during free-choice play activities, children with hyperactive behavior need to be supported in initiating play activities with peers in their proximal development zone. Examples of such activities that can sustain their attention in play are simple role-plays or play with repeated actions that can be done while moving around.

Comprehensive strategies, such as teacher reflection on democratic/learning strategies, abdication/dominance behavior, and approval or disapproval behavior, encourage preschool staff to reflect on barriers to or facilitators for children's engagement, but also, how children's engagement and hyperactive behaviors influence teachers' and other children's behaviors. Understanding the transactional paths between the individual child's behavior and the people in their proximal environment is necessary to improve teacher responsiveness and positive peer-to-child interactions. Accordingly, intervention studies on designing special support measures in preschool settings to improve social interactions and core engagement among children with BD are needed.

Limitations and future research

Overall, the current study contributes to the body of research on children's hyperactive behavior, core engagement, and directional and transactional paths involving social interactions (i.e., teacher responsiveness and positive peer-to-child interaction) in preschool settings. The sample included children—aged 1 to 5 in preschool settings—showing different degrees of hyperactive behavior and core engagement, from low to high. The children in the sample represent a diversity of ages and levels of hyperactive behavior and core engagement. The findings may be generalizable to other natural preschool settings. Nonetheless, the data are based on teachers' ratings, which may have led to bias due to teachers' apprehension that their perceptions of the positive and negative behaviors in the classroom might affect how their performance is rated. On the other hand, other studies have yielded similar results, showing that teachers' perceptions of children's behavior in everyday activities in preschool influence their responses to the children (Coplan et al., 2015), and that preschool staff's ratings of their responsiveness decreased over time (Almqvist, 2006b). Thus, further research, including observations and children's reports of social interactions, hyperactive behavior, and engagement, may find other associations that differ from those found in the current study.

The current study reveals several non-significant paths in both models which fit the data adequately. One explanation for this might be related to clustering effects observed in the data, which are common in research in natural environments such as preschools. Children from the same classroom tend to exhibit similar behavior due to the influence of the same context. In contrast, these behaviors may differ from that of children from other classrooms with other contextual factors (Killip, 2004). The clustering effects in the current study were addressed by bias-corrected bootstrap resampling methods in AMOS (Nevitt and Hancock, 2001; Arbuckle, 2013). These methods correct for the bias and adjust the actual sample according to the sampling effect (Shrout and Bolger, 2002; Mackinnon et al., 2004). Moreover, given the three-year sampling period, the children in the study were older at each data collection point, and this may have affected their levels of hyperactive behavior (causing it to decrease over time) and of core engagement (causing it to increase over time). This factor has not been controlled for. On the other hand, the results revealed moderate stability in the autoregressive paths for core engagement and hyperactive behavior for the teacher-child model, whereas the non-significant paths for core engagement between data collection points 2 and3 indicate non-linear stability over time.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the author, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics committee in Linköping, Sweden. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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