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Social development from preschool to primary school: Contribution of self-regulatory abilities during the preschool years

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ABSTRACT

Children's self-regulatory abilities in preschool significantly contribute to social development from preschool to primary school. However, few studies have included both *emotionally neutral executive functions* and *emotion-related* facets of preschool self-regulation as predictors of children's social development. This study analyses the role of a broad range of self-regulatory facets (inhibitory control, cognitive flexibility, phonological working memory, delay of gratification, and parent-reported effortful control at 3–5 years) in the development of prosocial behavior and peer relationships at ages 5, 7, and 9, while accounting for factors such as negative affectivity, surgency, receptive vocabulary and previous social development, among others. We used data from a large-scale longitudinal sample of 1898 German children (49.72 % females) and conducted growth curve modeling. Prosocial behavior and peer relationships showed a linear as well as a quadratic growth trend. When analysing the association of various self-regulatory facets to social development, cognitive flexibility, delay of gratification, and parent-reported effortful control were found to be significantly associated with the growth pattern of prosocial behavior, even after including controls and accounting for previous social development. Furthermore, these self-regulatory facets also predicted the development of peer relationships in models that treated emotionally neutral and emotion-related facets of self-regulation separately. Yet, in the overall model, the development of peer relationships was only predicted by parent-reported effortful control and this relation also did not remain significant when accounting for controls and previous social development. Overall, the results suggest a complex relation between self-regulatory facets and social development, requiring further investigation.

Introduction

The period from preschool to primary school is considered important, especially for children's social development (Rubin et al., 2013). Social development represents "the behavior, patterns, feelings, attitudes, and concepts that children manifest in relation to other people and the ways that these aspects change over time" (Schaffer, 1996, p. 1). Two important aspects of social development in childhood are prosocial behavior and peer relationships—that is, children's ability to engage in "voluntary behavior intended to benefit others" (Eisenberg et al., 1983, p. 3) and their ability to make and maintain peer relationships (Rubin et al., 2013). Children's self-regulatory abilities have been particularly emphasized and shown to significantly contribute to these aspects (Rademacher & Koglin, 2019; Williams & Berthelsen, 2017).

Self-regulation refers to "the internal and transitional processes that allow individuals to guide themselves in goal-directed activities" (Karoly, 1993, p. 25). It comprises different facets, including emotionally neutral executive functions (EF), which include inhibitory control, cognitive flexibility, and working memory (Miyake et al., 2000), as well as emotion-related facets, which have been studied particularly in research on effortful control (EC; e.g., parent-reported EC measure of this facet of child temperament; Rothbart et al., 2003) and delay of gratification (Jones et al., 2016; Mischel & Gilligan, 1964; Zelazo & Carlson, 2012), among others (see also Doshi et al., 2024). These self-regulatory facets develop rapidly during the preschool years (Jones et al., 2016) and are regarded as important for social development, especially during the transition from preschool to primary school (Liew, 2012; Snow, 2006, p. 9; Zhou et al., 2012). However, research to date has largely overlooked the joint consideration of a broad range of self-regulatory facets (i.e., emotionally neutral EF and emotion-related

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facets of self-regulation) as predictors of the development of prosocial behavior and peer relationships during preschool and primary school.

To address this gap, this study analyses how early self-regulation (at ages 3–5) predicts social development during preschool and primary school (i.e., from ages 5 to 9) using data from a large-scale German longitudinal study. In Germany, children usually attend preschool ("Kindergarten") from ages 3 to 5/6. Compulsory schooling begins at around 6/7 years of age, when children transition to primary school (generally lasting four years). Grades 1–2 (early primary school) typically comprise children aged 6 to 8 (see Table A3 for details on age).

Developmental trajectories of prosocial behavior and peer relationships from preschool to primary school

Children's prosocial behavior has been shown to typically develop during preschool and to increase as they transition to primary school (Eisenberg et al., 1983; Eisenberg & Spinrad, 2014). Despite variations in the specific types of prosocial behavior studied —such as cooperation, sharing, and helping—previous research has generally found some consistency in the development of these behaviors during the preschool years (Eisenberg et al., 1983; Malti, Ongley, et al., 2016). However, as children transition to primary school, deviations from these initial patterns of development have been reported. This is because, over time, children may increasingly discriminate between whom they help—friends or strangers—and develop differential self-esteem (high or low) as well as a nuanced understanding of when to give help and when to not (Malti & Dys, 2018). Given these factors, it is likely that children's prosocial behavior may temporarily decline (Kokko et al., 2006) or show inconsistent results over time. For instance, Malti, Ongley, et al. (2016) found a decline in children's prosocial behavior and no evidence of a linear trajectory in a six-year-long study investigating the period from preschool to primary school. Similarly, two other studies comparing children in preschool (4–5 year olds) with those in the later grades of primary school (8–10 year olds) found 8–10 year olds to engage in less prosocial behavior than 4–5 year olds, with their behavior varying depending on the social category of the recipient (friends or strangers; Flook et al., 2019; Malti, Gummerum, et al., 2016). Another study examining differences in prosocial behavior among primary school children (Jackson & Tisak, 2001) reported a curvilinear trend, suggesting that prosocial behavior may temporarily decrease before rising again during these years.

Like prosocial behavior, peer relationships are known to develop during preschool and beyond (Bukowski et al., 2011; Lansford et al., 2014). The development of peer relationships is often characterized by reciprocal friendships, sophisticated forms of play (cooperative play), peer group interactions, and reputations—that is, being a more or less liked member of the group (Bukowski et al., 2011). The primary school years are often marked by rapid change—a period during which the time spent with peers increases from 10 % up to more than 30 % (Rubin et al., 2008). The transition to primary school often involves the need to gain acceptance in a new peer group, form new friendships, develop trustworthiness, cooperate, maintain old friendships, and engage in more conversations (Bukowski et al., 2011; Quinn & Hennessy, 2010).

However, this period is also marked by indirect forms of negative behavior—such as insults, gossip, and threats—as well as specific biases and preferences. Other factors, such as displacement (moving to another school), can play a role, possibly initially slowing down the process of making and maintaining friends among children, but later leading to an increase. For instance, in an ethnographic study, Ledger et al. (2000) found that two out of six peer relationships survived the transition from preschool to primary school. Similarly, another study building on the research of Ledger et al. (2000) found that some friendships were continued and maintained during the transition from preschool (Quinn & Hennessy, 2010). However, in both studies, barriers such as parental involvement and displacement, among other things, contributed to children losing several peer relationships at these ages. Further gains were reported in the development of peer relationships in the later primary school years and beyond (Lansford et al., 2014), indicating a potential curvilinear growth trend over time.

Self-regulation during the preschool years

In the study of the development of self-regulation, there are two prominent research traditions: EF and EC research. EF refers to a set of mental processes that modulate attention, control, and goal-directed behavior (Jones et al., 2016). These processes comprise inhibitory control, working memory, and cognitive flexibility (Miyake et al., 2000). Inhibitory control helps regulate one's own attention, behavior, and thoughts while deliberately suppressing a prominent response, whereas cognitive flexibility allows individuals to switch between tasks or multiple pieces of information (Miyake et al., 2000). Working memory denotes the ability to maintain and manipulate information over a short period of time (Best & Miller, 2010). EC refers to the ability to intentionally manage thoughts, emotions, and actions (Rothbart, 1989) and is a developmental construct rooted in temperament research (Rothbart et al., 2003) which supports inhibitory control, cognitive flexibility, and the delay of gratification.

The integrated model by Jones et al. (2016) brings together these two distinct yet partly overlapping conceptualizations of self-regulatory abilities, EF and EC, during the preschool years. While both include the facets of inhibitory control and cognitive flexibility, they are also distinct, with working memory considered specific to EF and delay of gratification to EC (Jones et al., 2016). Thus, while acknowledging the overlaps between research traditions, the framework by Jones et al. (2016) differentiates a broad range of self-regulatory facets, ranging from purely cognitive to more emotionally salient components. Although some measures overlap across research traditions—such as Go/No-Go and Stroop tasks for inhibition—EF research predominantly relies on cognitive response tasks (e.g., flanker tasks, dimensional change card sort tasks; Zelazo et al., 2003). In contrast, EC research focuses on everyday behavior and largely implements emotion-related response tasks (e.g., the parent-reported Children's Behavior Questionnaire; Rothbart et al., 2000 or the delay of gratification task). The latter is also conceptualized as a "hot" facet of self-regulation in the EF framework of Zelazo and Carlson (2012). Moreover, while EC research typically focuses on emotion-related tasks, it also investigates emotionally neutral situations, such as maintaining focus on a task, resisting an impulse, following rules, and switching between tasks.

The present study adopts a multi-faceted approach incorporating a broad range of self-regulatory facets, including emotionally neutral EF facets as well as motivation- and emotion-related facets of self-regulation. It integrates perspectives on self-regulation by simultaneously and separately considering facets addressed in EF and EC research, while also including facets in "cool" (i.e., purely cognitive) and "hot" EF research observed in emotionally salient situations (Zelazo & Carlson, 2012). The emotionally neutral facets include behavioral indicators of inhibitory control, cognitive flexibility, and working memory (the focus of EF research). In addition to these neutral facets, everyday-related facets were measured using a parent-reported measure of effortful control (derived from temperament and EC research; Jones et al., 2016; Putnam & Rothbart, 2006), and emotion-related facets were assessed using a delay of gratification task (Doshi et al., 2024).

Note that in EC and temperament research, EC (reported) measures of self-regulation are (empirically and theoretically) differentiated from reactive facets of temperament such as negative affectivity (e.g., mood instability and dysfunctional negative emotions, Eisenberg et al., 2004; Rothbart et al., 2000). In particular, such reactive facets may either facilitate or hinder EC in motivation-related everyday situations and shall therefore be additionally considered in this study (see also section on control variables and Tables 6a, 6b). To sum up, this study will analyse the predictive effects of a broad range of self-regulatory facets—namely indicators of various emotionally neutral and emotion- or

everyday behavior-related facets of self-regulation (of children aged 3–5)—on social development, specifically prosocial behavior and peer relationships of children aged 5 to 9.

Self-regulation and social development during preschool and primary school

Children's ability to act in less self-focused ways and thus demonstrate greater generosity and cooperation and establish better peer relationships has been associated with their early self-regulatory abilities during preschool and primary school (Liew, 2012; Zhou et al., 2012). However, only a few studies to date have simultaneously examined a broad spectrum of facets of self-regulation—covering emotionally neutral EF and emotion-related facets simultaneously—in relation to social development (prosocial behavior and peer relationships).

Research considering emotionally neutral EF facets has examined the association of inhibitory control, cognitive flexibility, and working memory with social development. Children need to be able to "give to others/friends selflessly without holding a resource to themselves" (inhibitory control), "decide how much to give and hold information in the mind" (cognitive flexibility and working memory), and "follow through an act" (cognitive flexibility; Blake et al., 2015, p. 19). Existing research has shown significant associations between these facets and social development during the preschool years (Razza & Blair, 2009). However, when extending research to primary school, the findings are contradictory. On the one hand, some studies have found significant associations between various emotionally neutral EF facets in preschool children and their social development during primary school (Blake et al., 2015; de Wilde et al., 2016; Holmes et al., 2016; Hubert et al., 2017; Miller et al., 2020). These studies report prominent associations of (1) working memory with increased likeability among peers and of (2) inhibitory control and cognitive flexibility with the promotion of prosocial norms and better social functioning. The latter is characterized by fewer revenge goals and more neutral interpretations of their peers. On the other hand, other studies have reported weak to no longitudinal associations with social development during the primary school years (e.g., Devine et al., 2016; Lecce et al., 2020; Liu et al., 2016; Nilsen & Valcke, 2018; Smith et al., 2013). Some of these studies have pointed towards a possible "developmental shift in the direct relations" between early emotionally neutral EF facets and social development during the transition from preschool to primary school (Lecce et al., 2020, p. 15; see also de Wilde et al., 2016; Liu et al., 2016). While this may explain these differential findings, most studies investigated only selected emotionally neutral EF facets and social development aspects.

When considering an emotion-related facet, such as the ability to delay gratification, its associations with social development have been reported as being significant during the preschool years (Gruen et al., 2020; Kochanska et al., 2000; Ramani et al., 2010). Children who were better able to control their impulses were rated as more complacent and less defiant by adults and were more often seen as engaging in positive prosocial and peer relationships. While the implications of an early ability to delay gratification for children's later social development has been less widely studied, research by Mischel et al. (1988) suggests that preschoolers with a greater ability to control their impulses continue to demonstrate more socially competent behaviors beyond the primary school years. Adult-reported EC has also been associated with children's social development in preschool as well as in primary school (Laible et al., 2014; Spinrad et al., 2006; Stenseng et al., 2014). In the study by Laible et al. (2014), children with high or moderate parent- and teacher-reported EC and low negative emotionality were found to be the most prosocial and cooperative. On the other hand, children with low EC and high emotionality had comparatively more behavior problems. It is important to note, however, that the study examined prosocial behavior only at one time point.

When considering both emotionally neutral EF and the emotion-related facets of early self-regulation together as predictors of social development, studies of the preschool years have yielded mixed findings. In some studies, emotionally neutral EF and emotion-related facets have been positively associated with prosocial behavior. For instance, Paulus et al. (2015) found that inhibitory control and attentional control at 30 months along with children's ability to delay gratification at 24 months predicted prosocial behavior with friends at age 5. Similarly, Traverso et al. (2020) found that emotionally neutral EF facets, such as inhibitory control and cognitive flexibility, were significant predictors of prosocial behavior. However, their findings regarding the emotion-related facets in this study were less consistent: Emotion-related tasks, such as a gift wrap task (measuring whether the child resists peeking at a wrapped gift) and a gambling task (assessing decision-making based on risk-reward choices), did not significantly predict children's prosocial behavior. Furthermore, O'Toole et al. (2017) and Hao (2017) reported no significant associations between any self-regulatory facets—whether emotionally neutral or emotion-related—and social outcomes, such as prosocial behavior or peer relationships.

Studies conducted during the transition to primary school have reported somewhat more consistent findings than those conducted on preschoolers. However, they generally report fewer findings regarding prosocial behavior (Rademacher & Koglin, 2019) and no findings for peer relationships. For example, Williams and Berthelsen (2017) found that measures of emotional and attentional regulation during the preschool years predicted prosocial behavior at ages 6–7. Similarly, Rademacher et al. (2021) reported that the self-regulatory subscale from Koglin and Petermann's Behavior Rating Scales for Preschoolers significantly predicted prosocial behavior in 7-year-old children (Koglin & Petermann, 2016). Hao (2017) also found significant associations between both cool and hot inhibitory control and prosocial behavior in a study on social development during the primary school years. However, the study primarily focused on differentiating these associations by specific age groups rather than examining developmental changes throughout the primary school years.

Overall, while past studies have significantly advanced our understanding of how (i) emotionally neutral EF, (ii) emotion-related facets, and (iii) both types of self-regulation facets impact social development, important gaps remain. First, research on emotionally neutral EF facets has yielded mixed findings during the preschool and primary school years. Similarly, studies examining both emotionally neutral EF and emotion-related facets have reported mixed findings during the preschool years, with relatively few studies on the transition from preschool to primary school. Second, not many studies have provided a longitudinal perspective on how self-regulation during the preschool years relates to social development from preschool through primary school. Third, many studies have integrated only some relevant facets of self-regulation and social development, often focusing on specific facets in isolation. Fourth, few studies have adequately controlled for key covariates, such as relevant demographic, family and child factors which may act as confounders. Therefore, this study aims to address these gaps by including these factors and providing a more comprehensive understanding of how children's self-regulatory abilities during the preschool years predict the development of prosocial behavior and peer relationships from preschool to primary school. In doing so, the study may provide insights for early childhood programs and developmental support by guiding community- and policy-level efforts to promote children's self-regulatory and social development, especially during the transition from preschool to primary school (Flook et al., 2015; Zhou et al., 2012).

Covariates

To evaluate how a range of different facets of self-regulation (for children between ages 3 and 5) contribute to social development (at ages 5, 7, and 9), certain individual child and family characteristics were used as controls. These included (a) children's negative affectivity (mood instability and dysfunctional negative emotions) and (b) their surgency

(high-intensity pleasure seeking). These reactive facets of temperament have been found to be negatively interrelated with self-regulation, posing specific challenges for social development (Dollar & Stifter, 2012). Other factors included in the study were (c) non-verbal cognitive functioning and (d) receptive vocabulary, as both of these factors have been shown to influence children's self-regulatory abilities and social development (Huang et al., 2022; Rose et al., 2018). Furthermore, we included: (e) socioeconomic status, as children growing up in families with a low socioeconomic status may show deficits in self-regulation and related socio-emotional competencies (Huang et al., 2022); (f) the home interaction language, as self-regulation and the social development of children growing up with more than one language may differ from those of monolingual children, when the constructs are assessed in the majority language (Huang et al., 2024), and (g) the child's sex, as the self-regulatory performance and social development of boys and girls may differ (Ferschmann et al., 2024).

The current study

In the current study, we aimed to investigate the predictive associations between various self-regulatory facets and social development (i.e., prosocial behavior and peer relationships), while including relevant controls. In doing so, we addressed the following research questions:

1. How do prosocial behavior and peer relationships develop in children aged 5 to 9 years in Germany?

This initial question did not form the focus of the study (see the main question in the next paragraph). Given the mixed findings in the literature regarding the developmental trajectory of prosocial behavior and peer relationships—showing neither consistent linear nor curvilinear growth patterns—we hypothesized that children's development between ages 5 to 9 could exhibit a range of patterns. Consequently, the analysis was exploratory to account for the possibility of diverse developmental trajectories.

2. Are the self-regulatory facets under study predictive of the development of prosocial behavior and peer relationships from ages 5 to 9? Do these associations remain robust after controlling for potentially relevant covariates? Do they also remain robust when accounting for previous social development (at age 3), thus considering the stability and change of individual differences in social development? In addressing these questions, we primarily considered all self-regulatory facets simultaneously while also investigating whether the predictive contributions of the emotionally neutral EF and emotion-related facets to social development could be distinguished.

Overall, we expected a significant association between self-regulation, measured by a broad range of indicators and facets, and social development from ages 5–9 (Liew, 2012; Zhou et al., 2012), even after including covariates. Furthermore, children's earlier levels of social development (at age 3) were expected to be strongly related to their later social development (Ferschmann et al., 2024). However, despite the overall strong association, we expected the facets of early self-regulation to significantly predict developmental change.

Methods

Participants

We used data from the Newborn Cohort of the German National Education Panel Study (NEPS-SC1, Blossfeld & Roßbach, 2019; NEPS Network, 2022). It is a large-scale national longitudinal study comprising an initial sample of 3481 children and their families recruited between February and July 2012 in Germany (Weinert et al., 2016; Würbach et al., 2016). We utilized data from the fourth assessment wave of the NEPS-SC1 in 2015, when the children were roughly 3 years old (named Time Point 1 - T1 in the following). We included data collected at four more time points (Waves 5, 6, 8, and 10), until the children were 9 years old (see Tables 1 and A1 for details). Specifically, data on prosocial behavior and peer relationships were collected in every second wave of the NEPS-SC1—namely, Waves 6 (T2), 8 (T3), and 10 (T4)—which informed the time points selected for our analyses. In addition to direct measures, parents provided demographic information and reported on their children's characteristics at each measurement point. The analyses included 1898 children who participated in Wave 10 when they were 9 years old. As the study used already available data, no additional ethical or review board approval was required. Data were collected in the children's homes via direct assessments, computer-assisted parent interviews, and paper-and-pencil questionnaires, and were supplemented by computer-assisted telephone and web-based assessments. Detailed information on the original data collection procedures can be found in the NEPS study documentation (NEPS Network, 2022).

Measures

Emotionally neutral executive function (EF) facets of self-regulation

Phonological Working Memory (T1). The children were presented with a digit-span task taken from the German version of the Kaufman Assessment Battery for Children (K-ABC; $\alpha = 0.86$; Melchers & Preuß, 2009) which was administered using a tablet computer. The task required the child to immediately reproduce each sequence (item) of a series of verbally presented digit sequences in the correct order. The digit sequences of increasing length were continually presented to the child until the child could not reproduce them correctly anymore. Before the main learning and test phase, the children underwent a practice phase. This comprised an item which was repeated if the answer was incorrect. This practice item was not relevant for the main test phase and was only conducted to make sure the instructions were well understood. The main learning and test phase comprised five sets of three items each. The first two items in the first set were learning items, but were included in the total score if they were reproduced correctly at the first attempt. The number of items formed the maximum score of the test: 15. The child's total score in the study comprised all correctly solved learning and test items (ranging from 1 to 15).

Inhibitory Control (T2). Inhibitory control was collected using a child-adapted version of Erikson's flanker task (Eriksen & Eriksen, 1974), which is reported to have high test-retest reliability (Bauer & Zelazo, 2014). In the NEPS-SC1, it was implemented using fish as directional indicators. If the middle fish and the outer fish looked in the same direction (< < < < <), they represented congruent items. On the other hand, if the middle fish and the outer fish looked in different directions (< < > < <), they represented incongruent items. A tablet computer with a corresponding button was used to record the accuracy and reaction time of the responses. The children were instructed to concentrate on the middle fish and ignore the direction of the outer fish (< < > < <) on the tablet computer and press the corresponding button as fast as possible. Before starting the test phase, the children had to participate in up to three sessions. Those who successfully completed five of the seven practice items were allowed to move on to the test phase. The test phase comprised 30 items: 20 congruent and 10 incongruent items. For this study, the proportion of correct responses (ranging from 0.0 to 1.0) in the incongruent trials was used to determine the children's inhibitory control abilities (Oeri et al., 2018).

Cognitive Flexibility (T2). The children's cognitive flexibility was assessed using the same flanker task, but with a rule change. The children were now asked to focus on the direction of the outer fish instead of the middle fish (< < > < <) and to press the corresponding button as quickly as possible. In doing so, they now had to ignore the direction of the middle fish. Only those who had successfully completed the first and second practice phases of the inhibitory control task participated in this

Table 1
Overview of the assessed variables across time points.

Child age	Wave 4 3 years	Wave 5 4 years	Wave 6 5 years	*Wave 7 6 years	Wave 8 7 years	*Wave 9 8 years	Wave 10 9 years
Time point	T1	T2	T3	–	T4	–	T5
Predictors and Outcome variables	Phonological working memory Delay of gratification Parent-reported EC Prosocial behavior Peer relationships	Inhibitory control Cognitive flexibility Parent-reported EC	Parent-reported EC Prosocial behavior Peer relationships	–	Prosocial behavior Peer relationships	–	Prosocial behavior Peer relationships
Control variables	Negative affectivity Surgency Non-verbal cognitive functioning Receptive vocabulary Socioeconomic status (HISEI) Home interaction language Child's sex	Negative affectivity Surgency	Negative affectivity Surgency	–	–	–	–

Note. T = Time point, EC = effortful control, HISEI = Highest International Socio-Economic Index (Ganzeboom et al., 1992). Wave: Assessment Wave of NEPS-SC1. * Prosocial behavior and peer relationships data were not collected at T7 and T9 as part of the NEPS-SC1 design.

switch task. The task comprised three practice items and 16 test items: eight congruent and eight incongruent items. As with inhibitory control, the proportion of correct responses (ranging from 0.0 to 1.0) in the incongruent trials of the task was used to indicate the children's cognitive flexibility.

Emotion-related facets of self-regulation

Delay of Gratification (T1). This was measured using the setting and waiting paradigm (Mischel & Gilligan, 1964). In this task, children were presented with two wrapped gifts—one big and one small. A USB stick was placed between the two gifts. The children could either wait for an unknown amount of time to obtain the bigger gift or they could press the USB stick and receive the small gift immediately. The maximum amount of time that a child could wait to receive the big gift was set to 181 s. The children's tendency to wait or not wait (0 = *did not wait* and 1 = *waited*) was used as an indicator to determine their ability to delay gratification.

Parent-Reported Measure of Effortful Control (T1, T2, and T3). A very short German version of the Children's Behavior Questionnaire (CBQ-VSF; Putnam & Rothbart, 2006) was used to measure effortful control at ages 3, 4, and 5. Three items of this scale assessed the child's behavior with statements such as "when drawing or coloring in a book, shows strong concentration." Parents rated these items on a 7-point Likert scale ranging from 0 (*does not apply at all*) to 6 (*completely applies*). While the CBQ-VSF has demonstrated acceptable reliability in previous research (α = 0.62–0.78; Putnam & Rothbart, 2006) and has been shown to validly assess children's temperament (Kälin & Roebers, 2021), internal consistency in the current study was low at each age (α = 0.27 at age 3, α = 0.37 at age 4, and α = 0.29 at age 5). However, correlations across the three measurement points were moderate (0.48–0.52), and therefore, to improve the reliability of this very short scale, the measure was averaged across the individual items and waves at ages 3, 4, and 5 (α = 0.74).

Social development

Prosocial Behavior and Peer Relationships (T1, T3, T4, and T5). The children's behavior was rated by their parents using two subscales, comprising five items each, of the German version of the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997)—Prosocial Behavior and Peer Relationship Problems—using a 3-point Likert scale ranging from 0 (*does not apply*) to 2 (*certainly applies*). For the current study, we reversed the item coding of peer relationship problems to peer relationships. Prosocial behavior comprised items such as "considerate of other people's feelings" and "shares readily with other children." The peer relationships scale included items such as "has at least one good friend" and "generally liked by other children." While prosocial behavior (α = 0.52) and peer relationships (α = 0.48) at T1 were used as control variables, the measures at T3, T4, and T5 were included as main dependent variables in the growth curve model. We tested whether these two subscales fitted a one- or two- confirmatory factor model (CFA) at the given time points (T3, T4, and T5) beforehand and calculated the reliability (McDonald's Omega) of the scales based on the model that fitted the data best. To test the factorial structure, a longitudinal confirmatory factor analysis was conducted, allowing the residuals of similarly worded items to correlate across time. The one-factor model demonstrated a poor fit ($\chi^2 = 3925$; $df = 372$, $p < .001$; CFI = 0.71, TLI = 0.66; RMSEA = 0.07, 90 % CI [0.07, 0.07], WRMR = 2.97), whereas the two-dimension model demonstrated a good fit ($\chi^2 = 1181$, $df = 361$, $p < .001$, CFI = 0.93, TLI = 0.92, RMSEA = 0.03, 90 % CI [0.03, 0.04], WRMR = 1.55, see Figs. A1 and A2). In this model, the composite reliability of the prosocial behavior scale at T3, T4, and T5 (ω = 0.73, 0.78, 0.79) and of the peer relationships scale (ω = 0.76, 0.78, 0.78) was found to be acceptable (Deng & Chan, 2016; McDonald, 1999). Hence, the sum score of each subscale was used separately at ages 5, 7, and 9 in this study.

To test whether the scales for prosocial behavior and peer relationships measured equivalent constructs across ages 5, 7, and 9, measurement invariance was tested beforehand. Measurement invariance is essential to ensure that the respective latent scores can be compared across time points (i.e., that the same construct is measured across time). To test for measurement invariance, a series of increasingly restrictive models was specified: configural invariance (same factor structure across time points), metric invariance (equal factor loadings), and scalar invariance (equal factor loadings and intercepts, allowing latent mean comparisons). We found prosocial behavior and peer relationships to demonstrate configural and metric invariance across the three time points. While scalar invariance was not achieved, partial scalar invariance was revealed (see Table A2 for details), allowing a valid comparison of each of these two scales across ages 5, 7, and 9 (Byrne et al., 1989).

Control variables

Negative Affectivity and Surgency (T1, T2, and T3). These reactive facets of temperament (and effortful control) were assessed using the very short German version of the CBQ-VSF (Putnam & Rothbart, 2006)

when the children were 3, 4, and 5 years old. The parents rated their children's negative affectivity and surgency, respectively, using three items from each subscale and a 7-point Likert scale ranging from 0 (*does not apply at all*) to 6 (*completely applies*). Negative affectivity was collected with items such as "it is very difficult to soothe your child when he/she is upset," while surgency was assessed using items like "he/she is full of energy, even in the evening." The internal consistency of the Negative Affectivity subscale was α = 0.57, 0.62, and 0.57, and that of the Surgency subscale was α = 0.49, 0.55, and 0.57 at ages 3, 4, and 5, respectively. To improve the reliability of these very short scales, scores for each subscale—Negative Affectivity and Surgency—were averaged respectively across the waves at ages 3, 4, and 5 (negative affectivity: α = 0.76; surgency: α = 0.81). This within-subscale aggregation was used in the analysis. The correlations across the three measurement points were moderate for negative affectivity (0.49–0.57) and surgency (0.57–0.64).

Non-verbal Cognitive Functioning (T1). This was assessed using the subtest "categories" of the Snijders-Oomen non-verbal intelligence test (Tellegen et al., 2007) which measures young children's abstract thinking or reasoning abilities. In the NEPS-SC1, this test was administered using a tablet computer. The subtest comprised 15 items divided into two parts. In the first part, the child had to sort four out of six pictures based on specific characteristics (Items 1–7). This was followed by a practice item to ensure that the child understood the instructions of the second part of the test. In the second part (Items 8–15), the child was shown three pictures with a shared characteristic, for example, three different kinds of vegetables. The child was then asked to choose two more pictures with a similar characteristic as the first three out of a series of five or more pictures. As the items were implemented as a learning test, feedback was provided on the correctness of the answers after each item. The test ended after three incorrect responses. For this study, a weighted likelihood estimator (WLE) score was used to indicate non-verbal cognitive functioning (−4.05–6.09) as it provides the best point estimate of individual competence within the NEPS dataset. The scores were standardized with a mean of zero, with positive values reflecting above-average ability and negative values indicating below-average ability. Compared to simple sum scores, WLE scores have the advantage of better accommodating missing responses and providing improved comparability of competence scores across different waves and cohorts (for more information see Pohl & Carstensen, 2012).

Receptive Vocabulary (T1). A German adaptation of the Peabody Picture Vocabulary Test (Dunn & Dunn, 2007; Lenhard et al., 2015; internal consistency as reported by the test's authors: α = 0.97) was used to measure the children's receptive vocabulary. In this test, the child was presented with an auditory cue (words) and had to select one out of four pictures presented on a tablet that matched the respective word. Before starting the test phase, the child had to correctly solve at least two out of four items in a practice session. The test included a total of 19 sets with 12 items each (228 items in total). These sets followed a staggered level of difficulty, and the test was stopped after the child had made more than seven errors within a single set. For this study, the standardized sum score (−1.74–2.59) for the number of correctly solved items (actual range 0–121) was used to indicate receptive vocabulary.

Socioeconomic Status (T1). The Highest International Socio-Economic Index (HISEI; Ganzeboom et al., 1992) was used to indicate parental SES. The HISEI is based on the 2008 International Standard Classification of Occupations (ISEO) coding, which hierarchizes an individual's last occupational status based on his or her education and his or her average earning in that occupation. The variables were re-coded to generate the highest ISEO score of the two parents. In this sample, the HISEI scores ranged from 13.87 to 88.96, with a mean of 61.95 (SD = 20.17). For reference, lower scores (e.g., 13.87) typically reflect lower-skilled or manual occupations such as cleaners or laborers, while higher scores (e.g., 88.96) correspond to professions such as physicians, engineers, or legal professionals. The average score of the sample suggests that it predominantly consisted of parents with middle to upper-middle socioeconomic backgrounds and may not represent populations in lower-income regions or countries with different occupational structures. Additional family demographic characteristics, including parental education and household income, are presented in Table A3 in order to allow further understanding of the socioeconomic profiles and related information.

Home Interaction Language (T1). The parents reported the children's home interaction language as 0 = *the child spoke German equally often as another language*, 1 = *the child spoke only German*, 2 = *the child spoke mostly German, but sometimes also another language*, 3 = *the child spoke mostly another language but sometimes also German*, and 4 = *the child spoke only another language*. These categories were recoded as 0 = *an additional language other than German* (22.93 %) and 1 = *only German* (77.07 %) for this study.

Child's Sex (T1). The child's sex was coded as 0 (*male*) and 1 (*female*) based on the parent report. The sample comprised 50.28 % males and 49.72 % females.

Data analysis plan

Fig. 1 presents the step-by-step analytical approach used in the study. Specifically, to analyze the developmental change in prosocial behavior and peer relationships among children aged 5, 7, and 9, we used multivariate latent growth curve modeling. A multivariate latent growth curve model, unlike a univariate growth curve model, allows the intercepts and random slopes of two or more variables to be calculated.

The data can be analyzed using either an unconditional model (without predictors or covariates) or a conditional latent growth curve model that incorporates the effects of predictor variables and covariates (Bollen, 2006). The unconditional as well as conditional model were conducted for this study because it captures intra-individual developmental change as well as the associations of predictor and control variables with the initial status (intercept) and change across time (slope). The first set of models (1.1–1.3) estimated the unconditional multivariate growth curve models. In Model 1.1, we estimated a linear growth curve model from T3 (5 years old) to T5 (9 years old). In Model 1.2, we added an additional quadratic factor (with the variance of the quadratic factor fixed to 0; Raikes et al., 2007). Finally, Model 1.3 was implemented to freely estimate the developmental shape of prosocial behavior and peer relationships over time. By comparing these models, we aimed to determine which of them best captured the developmental trajectories of prosocial behavior and peer relationships and was therefore more suitable for the subsequent analytic steps addressed in Models 2.1–2.3.

The second set of models (2.1–2.3) addressed the predictive effect of all five self-regulatory facets on social development by estimating conditional multivariate growth curve models. Model 2.1 analyzed the predictive association of the self-regulatory facets with the development (intercept, slope factors) of prosocial behavior and peer relationships across T3 to T5. Model 2.2 added potentially confounding control variables: (a) negative affectivity, (b) surgency, (c) non-verbal cognitive functioning, (d) receptive vocabulary, (e) socioeconomic status, (f) home interaction language, and (g) the child's sex. Model 2.3 additionally included the children's previous level of prosocial behavior and peer relationships (at T1, age 3) to account for the stability and change of the individual differences in social development from early on. Finally, two additional models were planned as part of an exploratory analysis. However, based on previous findings (Doshi et al., 2024), correlational analyses of early self-regulatory facets (T1–T3) showed low correlations within and between emotionally neutral EF and emotion-related facets ($r = -0.15$ to 0.12). Confirmatory factor analyses did not support a one- or two-factor structure, and an exploratory factor analysis also did not yield evidence for a meaningful factor solution (see Doshi et al., 2024, for details). Therefore, these prior findings limits the interpretation of self-regulatory facets as representing empirically distinct facets. In the present study, we nonetheless retained the

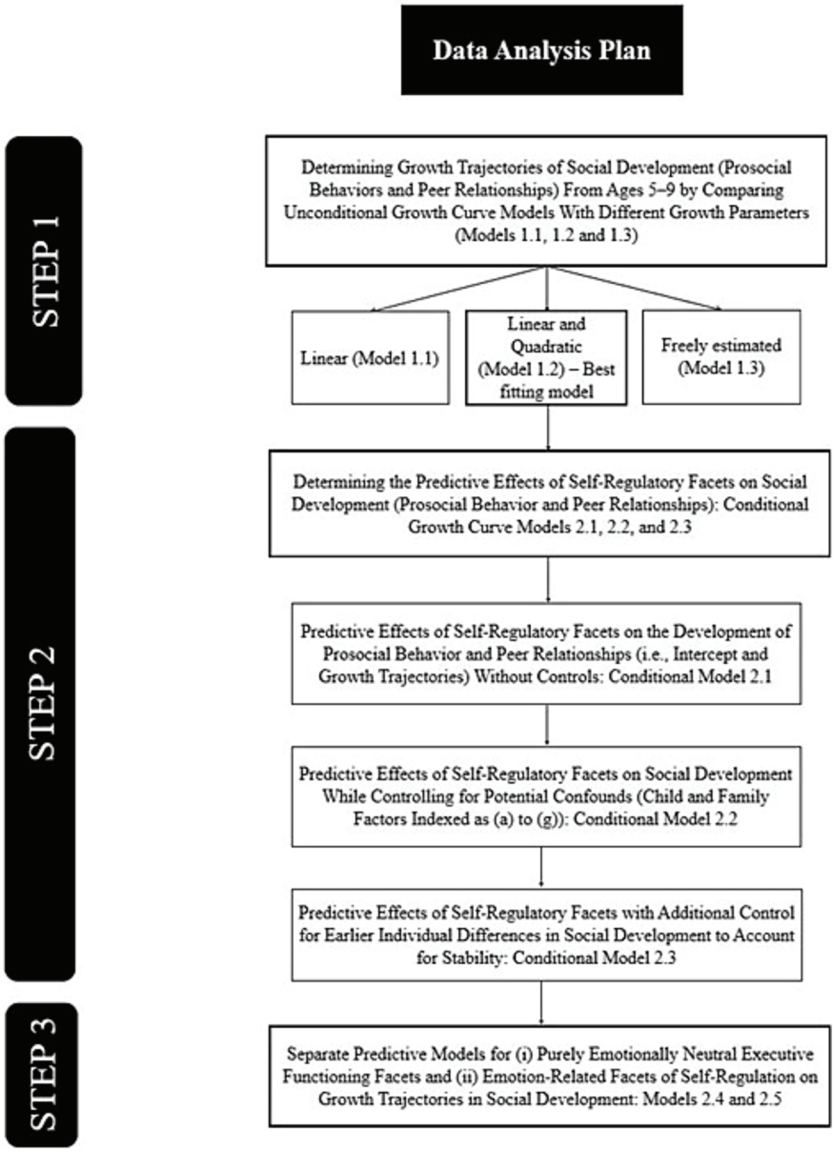

Fig. 1. Data analysis plan of the study.
Note. Models 1.1 to 1.3: 3 different unconditional growth curve models to analyze social development across time-point T3 to T5, i.e., ages 5 to 9; Models 2.1 to 2.3: Conditional (i.e., predictive) growth curve models including all five facets of self-regulation as predictors, 2.1 predictive model without covariates as controls; 2.2 same model as 2.1 but with covariates added; (a) to (g) refer to the control variables such as child sex, HISEI (see section on Covariates in the Method Part); Model 2.3 – same as Model 2.2 but additionally including differences in early social development at age 3 (measurement point T1). Models 2.4 and 2.5 Conditional models (i.e., predictive models) either including the three emotionally-neutral EF-facets as predictors (i) or the everyday and emotion-related facets as predictors (ii), see research question 2.

exploratory analysis (Models 2.4 and 2.5). Specifically, Model 2.4 analyzed (i) the predictive relation between the emotionally neutral EF facets of self-regulation (i.e., phonological working memory, inhibitory control, and cognitive flexibility) and social development; Model 2.5 analyzed (ii) the effects of the emotion-related facets of self-regulation (parent-reported EC and delay of gratification) on social development. This approach was used to determine whether these groups of facets, when analyzed separately, had any differential effects on social behavior compared to the model that included both groups of facets simultaneously (Model 2.1). Specifically, this allowed us to examine the unique contribution of the emotionally neutral EF facets without the presence of the emotion-related facets, and vice versa.

The framework of the (multivariate) growth curve models and the plots used was derived from the software Mplus 7.3 (Muthén et al., 2017). We used full information maximum likelihood (FIML) to handle missing data. For all the models, we applied the maximum likelihood estimator with robust standard errors (MLR), chosen for its robustness to non-normality. The model fit was assessed using goodness-of-fit indicators (CFI/TLI $\geq$ 0.95, RMSEA <0.08; SRMR <0.06; Bentler, 1990; Tucker & Lewis, 1973). The descriptive statistics and correlational analysis were calculated using the software STATA 7 (StataCorp, 2021).

Results

Descriptive statistics and interrelations between predictors

The descriptive statistics for the study variables are shown in Table 2. There were no significant differences in prosocial behavior at T4 (M = 1.58, SD = 0.33) compared to T3 (M = 1.58, SD = 0.31), $t(1509) = 0.38$, $p = .71$. However, prosocial behavior at T5 (M = 1.65, SD = 0.31) was significantly higher than at T4 (M = 1.58, SD = 0.33), $t(1647) = 8.96$, $p < .001$, and also significantly higher than at T3, $t(1716) = 8.36$, $p <$

Table 2
Descriptive analysis for all study variables.

Variables	*N*	*M*	*SD*	*Min*	*Max*	*Missing (%)*
Predictor Variables						
(1) Phonological working memory (3y)	958	3.32	2.35	0	10	49.53 %
(2) Inhibitory control (4y)	1340	0.72	0.26	0	1	29.50 %
(3) Cognitive flexibility (4y)	1237	0.53	0.31	0	1	34.83 %
(4) Delay of gratification (3y)	1694	78.16 % (child waited)		0	1	10.75 %
(5) Parent-reported EC (3–5y)	1896	4.38	0.80	1	6	11 %
Dependent Variables						
(6) Prosocial behavior (5y)	1720	1.58	0.31	0.20	2	9.38 %
(7) Prosocial behavior (7y)	1650	1.58	0.33	0.20	2	13.07 %
(8) Prosocial behavior (9y)	1895	1.65	0.31	0	2	16 %
(9) Peer relationships (5y)	1720	1.78	0.26	0.40	2	9.38 %
(10) Peer relationships (7y)	1650	1.75	0.29	0.40	2	13.07 %
(11) Peer relationships (9y)	1895	1.77	0.29	0	2	16 %
(12) Prosocial behavior (3y)	1814	1.53	0.31	0.20	2	4.43 %
(13) Peer relationships (3y)	1814	1.73	0.29	0	2	4.43 %
Control Variables						
(14) Negative affectivity (3–5y)	1896	3.31	0.93	0	6	11 %
(15) Surgency (3–5y)	1896	4.26	0.90	0.66	6	11 %
(16) Non-verbal cognitive functioning (3y)	1720	0.31	2.48	−4.05	6.09	9.38 %
(17) Receptive vocabulary_std mean (3y)	1407	−1.06	1.0	−1.74	2.59	25.87 %
(18) Socioeconomic status (HISEI- 3y)	1433	61.95	20.17	13.87	88.96	24.50 %
(19) Home interaction language (3y)	1784	77.07 % (only German)		0	1	6.01 %
(20) Child's sex (3y)	1814	49.72 % (female)		0	1	4.43 %

Note. EC = Effortful control, HISEI = Highest International Socio-economic Index (Ganzeboom & Treiman, 1992); std. = standardized, y = years.

.001. Thus, the mean value of prosocial behavior improved from T3 to T5, although the growth was not linear across the entire period (see also below).

The children's peer relationships were rated significantly higher at T3 ($M = 1.78$, $SD = 0.26$) than at T4 ($M = 1.75$, $SD = 0.29$), $t(1509) = -4.43$, $p < .001$. At T5 ($M = 1.77$, $SD = 0.29$) they were also significantly higher than at T4, $t(1647) = 3.08$, $p < .01$. However, there was no significant difference between their peer relationships at T5 and T3, $t(1716) = -1.32$, $p = .18$. Again, the descriptives suggest a curvilinear trend (see also Fig. 2 below). The correlations between the study variables are listed in Tables 3 and A6. Parent-reported EC was significantly associated with both prosocial behavior and peer relationships at T1, 3, 4, and 5. Cognitive flexibility was also significantly related to prosocial behavior at T1 and 4. Additionally, performance on the delay of gratification task was significantly associated with prosocial behavior at T1, 3, and 5.

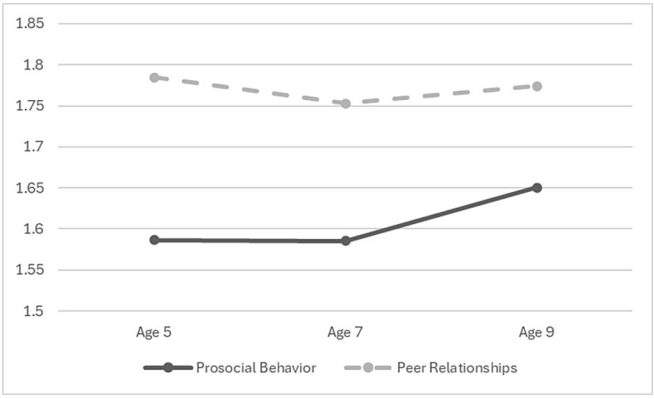

Fig. 2. Unconditional growth curve plot (estimated means) for prosocial behavior and peer relationships.

Unconditional latent growth curve models

Table 4 presents the model fit indices for the compared models (1.1–1.3). Of the three models, Model 1.2 showed the best fit, followed by Model 1.1, whereas Model 1.3 did not converge. To test whether Model 1.2 fit significantly better than Model 1.1, we conducted a Chi-square difference test. The results indicated that Model 1.2 fit the data significantly better than Model 1.1 ($\Delta\chi^2$ (2) = 43.66, $p < .001$). Model 1.2 also had a lower Bayesian Information Criterion (BIC = 2256.38), than Model 1.1 (BIC = 2278.74). Therefore, we decided to use a growth curve model including the linear and quadratic growth factors for prosocial behavior and peer relationships (see Fig. 2 for the unconditional plot of the mean growth curve). The means of the intercepts and growth factors (linear and quadratic) of this model were significant (see Table 5). The significant means of the linear and quadratic growth factors for prosocial behavior (linear $B = -0.03$, $p < .001$; quadratic $B = 0.03$, $p < .001$) and peer relationships (linear $B = -0.06$, $p < .001$; quadratic $B = 0.03$, $p < .001$) indicate that, on average, both growth patterns deviate from a purely linear trend (see Fig. 2). However, significant individual differences were found in both the intercept ($\sigma^2 = 0.07$, $p < .001$, $\sigma^2 = 0.04$, $p < .001$) and the linear growth factor ($\sigma^2 = 0.01$, $p < .001$), as indicated by the significant variances.

Conditional latent growth curve models

The results from Models 2.1–2.3 are presented in Tables 6a and 6b. Overall, the fit indices for the conditional models analyzing the associations of self-regulatory facets with prosocial behavior and peer relationships indicated good fits. Cognitive flexibility, delay of gratification, and parent-reported EC were found to be significantly associated with the development of prosocial behavior across all models. In particular, even after controlling for important child- and family-related covariates, all three self-regulatory facets were significantly associated with the quadratic trend (cognitive flexibility: $\beta = -0.43$, $p < .05$; delay of gratification: $\beta = 0.61$, $p < .001$; parent-reported EC: $\beta = -0.45$, $p < .05$). By contrast, the effect on the linear slope remained significant only for delay of gratification ($\beta = -0.30$, $p < .01$). Furthermore, delay of gratification ($\beta = 0.07$, $p < .05$) and parent-reported EC ($\beta = 0.17$, $p < .001$) were significantly and robustly (i.e., in the models with and without controls) associated with the intercept, indicating more prosocial behavior in children with comparatively better self-regulation in these two facets.

To illustrate the negative effect of cognitive flexibility and parent-reported EC (i.e., reduction of the curvilinear trend) and the positive effect of delay of gratification (i.e., increase of the curvilinear trend) on prosocial behavior, Figs. 3–5 show the developmental trends differentiated by children with comparatively higher and lower self-regulatory

Table 3
Bivariate correlations (Pearson and point-biserial) between all study variables (raw data).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
(1) PWM–3y	–																			
(2) Inhibitory control –4y	0.04	–																		
(3) Cognitive flexibility –4y	0.01	−0.15*	–																	
(4) Delay of Gratification –3y	0.10*	0.05	0.00	–																
(5) Parent-reported EC (3–5y)	0.10*	0.09*	0.01	0.13*	–															
(6) Negative affectivity (3–5y)	−0.07*	−0.03	0.01	0.00	−0.05*	–														
(7) Surgency (3–5y)	−0.01	−0.10*	−0.02	−0.05*	−0.12*	0.26*	–													
(8) Non-verbal CF (3y)	0.21*	0.14*	−0.00	0.04*	0.10*	−0.08*	−0.10*	–												
(9) Receptive vocabulary 3y	0.30*	0.17*	0.07*	0.08*	0.12*	−0.10*	−0.04	0.33*	–											
(10) HISEI –3y	0.08*	0.06*	0.03	0.02	0.09*	−0.06*	−0.12*	0.08*	0.13*	–										
(11) Home interaction language 3y	0.05	0.03	0.00	0.03	0.03	−0.00	−0.11*	0.05*	0.23*	0.15*	–									
(12) Child's sex –3y	−0.04	0.07*	0.00	0.11*	0.23*	−0.07*	−0.16*	0.15*	0.03	−0.00	−0.03	–								
(13) Prosocial behavior–3y	0.03	0.00	0.06*	0.06*	0.18*	−0.21*	−0.07*	0.09*	0.08*	−0.02	−0.01	0.11*	–							
(14) Peer relationships –3y	0.03	−0.02	0.05	0.02	0.09*	−0.12*	0.02	0.04	0.07*	0.08*	0.08*	0.04	0.17*	–						
(15) Prosocial behavior –5y	−0.03	−0.01	0.01	0.06*	0.17*	−0.22*	−0.05*	0.06*	0.03	−0.03	−0.03	0.17*	0.46*	0.11*	–					
(16) Prosocial behavior –7y	−0.04	0.00	0.06*	0.03	0.18*	−0.20*	−0.07*	0.07*	0.05	−0.04	−0.06*	0.19*	0.37*	0.10*	0.54*	–				
(17) Prosocial behavior –9y	−0.03	−0.00	0.02	0.09*	0.11*	−0.17*	−0.03	0.02	0.05*	−0.03	−0.08*	0.15*	0.33*	0.10*	0.47*	0.59*	–			
(18) Peer relationships –5y	0.03	0.00	−0.00	−0.01	0.09*	−0.13*	0.00	0.06*	0.08*	0.09*	0.10*	0.04	0.09*	0.36*	0.10*	0.10*	0.10*	–		
(19) Peer relationships –7y	0.04	0.04	0.04	0.04	0.12*	−0.13*	−0.07*	0.09*	0.12*	0.11*	0.11*	0.07*	0.11*	0.32*	0.10*	0.15*	0.15*	0.47*	–	
(20) Peer relationships –9y	0.02	0.04	0.01	0.02	0.07*	−0.17*	−0.05*	0.09*	0.09*	0.09*	0.06*	0.03	0.09*	0.28*	0.12*	0.14*	0.18*	0.40*	0.56*	–

Note. PWM = Phonological working memory EC = Effortful control, Non-verbal CF = Non-verbal cognitive functioning, HISEI = Highest International Socio-economic Index (Ganzeboom et al., 1992), y = years.
* $p < .05$.

abilities in these facets. Figs. 3 and 5 show the prosocial behavior development of children with high, middle, and low cognitive flexibility scores and high, middle or low parent-reported EC scores, respectively. Fig. 4 shows the mean scores differentiated for those children who waited and those who did not wait in the delay of gratification task. It is important to note that these figures are descriptive, illustrating the observed effects on the curvilinear trend: The flattened curvilinear trend for children with higher compared to lower cognitive flexibility and for those with higher compared to lower parent-reported EC; a more pronounced curvilinear trend for children who waited in the delay of gratification task compared to those who did not wait. The figures also illustrate the associations of the delay of gratification and parent-reported EC with the intercepts (i.e., comparatively higher prosocial behavior in children with better self-regulatory abilities in these facets than those with lower abilities).

When previous social development (at T1) was included in Model 2.3 (controlling for stability in social development), most effects of the self-regulatory facets on the development of prosocial behavior (particularly all effects on the quadratic trend illustrated in Figs. 3–5) remained significant. Cognitive flexibility remained a robust predictor of the quadratic trend ($\beta = -0.42$, $p < .05$). Delay of gratification remained predictive of both the linear slope ($\beta = -0.28$, $p < .01$) and the quadratic trend ($\beta = 0.60$, $p < .001$) and parent-reported EC still predicted both the intercept ($\beta = 0.09$, $p < .01$) and the quadratic trend ($\beta = -0.48$, $p < .01$).

For the development of peer relationships, only parent-reported EC was a significant predictor in Model 2.1 (without controls), showing significant associations with the intercept ($\beta = 0.11$, $p < .01$) and the quadratic trend ($\beta = -0.57$, $p < .01$). After the covariates were included, parent-reported EC continued to predict the intercept ($\beta = 0.08$, $p < .01$), but no longer predicted the quadratic trend. In Model 2.3, which included previous social development, none of the aforementioned effects remained significant.

To test how the emotionally neutral EF (and the emotion-related) facets uniquely predict social development, we analyzed their effects on prosocial behavior and peer relationships without including the emotion-related facets, and vice versa. When only the emotionally neutral EF facets were considered as predictors of prosocial behavior and peer relationships (Model 2.4; see Table 7), cognitive flexibility emerged as a key predictor. It predicted the linear ($\beta = 0.28$, $p < .05$) and quadratic trends ($\beta = -0.97$, $p < .001$) of the development of prosocial behavior as well as the development of peer relationships. However, the latter's effect on the quadratic trend, $\beta = -0.82$, $p < .001$, was not significant in the overall model. With regard to the emotion-related facets in Model 2.5 (see Table 7), both self-regulatory abilities were significantly associated with both facets of social development. In particular, delay of gratification was a significant predictor of both the development of prosocial behavior (intercept: $\beta = 0.06$, $p < .05$; linear slope: $\beta = -0.29$, $p < .01$; quadratic trend: $\beta = 0.80$, $p < .001$) and peer relationships (linear slope: $\beta = 0.23$, $p < .05$; quadratic trend: $\beta = -0.59$, $p < .05$), which was not the case in the overall model. In addition, parent-reported EC was significantly associated with the development of prosocial behavior (effect on the intercept: $\beta = 0.20$, $p < .001$, the linear slope: $\beta = 0.22$, $p < .05$, and the quadratic trend: $\beta = -0.72$, $p < .001$) and with peer relationships (effect on the intercept: $\beta = 0.11$, $p < .01$, linear slope: $\beta = 0.22$, $p < .05$, and quadratic trend: $\beta = -0.72$, $p < .01$).

Discussion

Self-regulatory abilities are important for social development, particularly during preschool and the transition to primary school. Specifically, Liew (2012) suggests that these abilities help children to manage their cognitive activities as well as their emotional and motivational arousal effectively, enabling them to adapt to social demands during these years. Despite their suggested importance (Liew, 2012; Zhou et al., 2012), empirical research on how different facets of self-

Table 4
Model fit indices for unconditional latent growth curve models for prosocial behavior and peer relationships.

Model	χ^2	*df*	*p*	AIC	BIC	CFI	RMSEA	SRMR
1.1: Intercept and slope	50.634	7	0.00	2167.77	2278.74	0.97	0.05	0.02
1.2: Intercept, slope, and quadratic factor (with the variance of the quadratic factor fixed to 0)	6.978	5	0.22	2124.31	2246.38	0.99	0.01	0.01
1.3: Freely estimated growth parameter	–	–	–	–	–	–	–	–

Table 5
Means and variances of the unconditional growth curve model.

	Unconditional Model 1.2	
	Prosocial behavior	Peer relationships
Mean intercept	1.59***	1.79***
Mean slope	−0.03*	−0.06***
Mean quadratic	0.03***	0.03***
Variance intercept	0.07***	0.04***
Variance slope	0.01***	0.01***
Covariance between intercept and slope	−0.01***	−0.01*
R-square		
Age 5	0.68***	0.59***
Age 7	0.54***	0.49***
Age 9	0.78***	0.76***

Note. Unstandardized parameter estimates. R-square represents the proportion of variance explained by the model for prosocial behavior and peer relationships. The variance of the quadratic trend could not be determined as it was fixed to 0 in this analysis.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

regulation—such as emotionally neutral EF and emotion-related facets—relate to the individual developmental trajectories of social development (e.g., prosocial behavior and peer relationships) over time remains relatively limited. Furthermore, the role of multiple covariates and previous social development has received little attention in this context. Thus, the present study investigated the role of various self-regulatory facets during the children's preschool years in relation to their social development across preschool and primary school.

Consistent with our hypothesis, the results from our unconditional latent growth curve model revealed that social development from preschool through primary school (ages 5 to 9) does not always follow a uniform linear trajectory, as both prosocial behavior (linear $B = -0.03$, $p < .001$; quadratic $B = 0.03$, $p < .001$) and peer relationships (linear $B = -0.06$, $p < .001$; quadratic $B = 0.03$, $p < .001$) also show curvilinear trends (see Fig. 2). The change in institutional context—from preschool to primary school—may play a significant role in shaping these developmental trends (Liew, 2012). These results are further supported by previous research documenting not always linear, but also non-linear trends (and even small declines) in aspects of social development during the transition from preschool to primary school (Jackson & Tisak, 2001; Malti, Ongley, et al., 2016).

As hypothesized, the results from our conditional latent growth curve models reveal that specific self-regulatory facets—cognitive flexibility, delay of gratification, and parent-reported EC—were significantly related to the trajectories of prosocial behavior across ages 5 to 9, even after accounting for controls and prior social development (Table 6a). These facets continued to predict the development of prosocial behavior and peer relationships across time in our separate models, which either included emotionally neutral EF or the emotion-related facets of self-regulation (Table 7). However, in the overall model, which, unlike the separated models, included all five facets under study, —the development of peer relationships was predicted only by parent-reported EC (Table 6b). This association was also no longer significant when the controls and prior social development were included in the model. Furthermore, contrary to our hypothesis, specific self-regulatory facets—phonological working memory and inhibitory control were not significantly associated with social development in any of our analyses.

In the following section, we will discuss the individual contributions of the self-regulatory facets in relation to prosocial behavior and peer relationships, respectively.

Relations between individual facets of self-regulation and social development

Cognitive flexibility and social development

As previously mentioned, our results suggest that cognitive flexibility significantly contributes to the development of prosocial behavior from preschool to primary school (Rademacher et al., 2021; Williams & Berthelsen, 2017). This is evident in Table 6a (Model 2.2),which shows that cognitive flexibility was associated with the trajectory of prosocial behavior from ages 5 to 9, even after controls are included (quadratic $\beta = -0.43$, $p < .05$). Importantly, these findings also hold true when accounting for earlier differences in social development, addressing both stability and the effect on change in Model 2.3 (quadratic $\beta = -0.42$, $p < .05$). The negative effect on the quadratic trend aligns with the previously described descriptive patterns (see Fig. 3), suggesting that cognitive flexibility contributes to a smoother, less curved development of prosocial behavior, particularly during the transition year (i.e., at age 7). A plausible explanation for this is that the transition from preschool to primary school requires significant adjustments and involves increased social complexity, which may be especially challenging for children with lower cognitive flexibility (Blake et al., 2015). In contrast, children with better cognitive flexibility may continue to engage in more consistent prosocial behaviors as they are better able to adhere to established norms around altruistic giving and maintain these behaviors during the transition years (Blake et al., 2015; Williams & Berthelsen, 2017).

Delay of gratification, parent-reported EC, and social development

Alongside cognitive flexibility, children's performance on the delay of gratification task was also positively related to prosocial behavior at the initial time point at age 5 (see Table 6a; Gruen et al., 2020; Kochanska et al., 2000; Paulus et al., 2015; Ramani et al., 2010), and this association remained significant when including controls (intercept $B = 0.07$, $p < .05$). Furthermore, when analyzing its association with the developmental change of prosocial behavior over time, a negative effect on the linear and a positive on the quadratic trend were observed across all models (e.g., Model 2.3; linear $B = -0.28$, $p < .01$; quadratic $\beta = 0.60$, $p < .001$). The data suggest that, although children who performed better on the delay of gratification task showed more prosocial behavior, they were more likely to display a more pronounced curvilinear trend in prosocial behavior during the transition from preschool to school. In contrast, children who did not delay gratification seemed to engage in consistently lower levels of prosocial behavior throughout these years (see Fig. 4). When considering these results, it is important to note that about 78 % of the children in our sample were able to delay gratification. Hence, the observed trend in prosocial behavior largely reflects patterns in children who could delay gratification rather than those who could not. Nevertheless, the general associations with the developmental trends in our study align with and extend the findings of Mischel et al. (1988) and Hao (2017), who reported a significant relation between delay of gratification and prosocial behavior during the primary school years and beyond.

In addition to the above mentioned facets, parent-reported EC also remained a significant predictor of prosocial behavior at age 5 (Table 6a;

Table 6a
Latent growth curve model with intercept, linear and quadratic growth factors: prosocial behavior with self-regulatory facets and covariates.

Variables	Prosocial behavior (Model 2.1)			Prosocial behavior (Model 2.2)			Prosocial behavior (Model 2.3)		
	Intercept β (SE)	Linear slope β (SE)	Quadratic slope β (SE)	Intercept β (SE)	Linear slope β (SE)	Quadratic slope β (SE)	Intercept β (SE)	Linear slope β (SE)	Quadratic slope β (SE)
Phonological working memory (3y)	−0.06(0.04)	−0.07(0.16)	0.15(0.30)	−0.09*(0.05)	−0.06(0.17)	0.15(0.28)	−0.08*(0.04)	−0.05(0.16)	0.13(0.28)
Inhibitory control (4y)	−0.04(0.04)	0.10(0.14)	−0.16(0.26)	−0.05(0.04)	0.06(0.14)	−0.07(0.23)	−0.04(0.03)	0.05(0.13)	−0.06(0.23)
Cognitive flexibility (4y)	0.01(0.03)	0.27*(0.13)	−0.53*(0.21)	0.02(0.04)	0.24(0.13)	−0.43*(0.21)	−0.00(0.03)	0.23(0.12)	−0.42*(0.20)
Delay of gratification (3y)	0.07*(0.03)	−0.28*(0.11)	0.66***(0.19)	0.07*(0.03)	−0.30***(0.11)	0.61***(0.17)	0.05(0.03)	−0.28**(0.11)	0.60***(0.17)
Parent-reported EC (3–5y)	0.21***(0.03)	0.21 (0.11)	−0.60**(0.18)	0.17***(0.03)	0.17(0.12)	−0.45*(0.18)	0.09**(0.03)	0.21(0.11)	−0.48**(0.18)
Negative affectivity (3–5y)				−0.27***(0.03)	0.10(0.12)	−0.09(0.21)	−0.16***(0.03)	0.04(0.12)	−0.04(0.21)
Surgency (3–5y)				0.05(0.03)	−0.13(0.12)	0.22(0.20)	0.05(0.03)	−0.13(0.12)	0.21(0.20)
Non-verbal cognitive functioning (3y)				0.06(0.03)	0.03(0.13)	−0.20(0.21)	0.04(0.03)	0.03(0.12)	−0.18(0.21)
Receptive vocabulary (3y)				0.02(0.04)	0.09(0.15)	−0.05(0.25)	−0.00(0.03)	0.11(0.14)	−0.06(0.25)
HISEI (3y)				−0.07*(0.03)	−0.05(0.13)	0.13(0.21)	−0.03(0.03)	−0.08(0.12)	0.15(0.21)
Home interaction language (3y)				−0.04(0.03)	−0.14(0.12)	0.14(0.21)	−0.02(0.03)	−0.16(0.12)	0.15(0.21)
Child's sex (3y)				0.14***(0.03)	0.17(0.12)	−0.31(0.20)	0.12***(0.03)	0.17(0.11)	−0.31(0.19)
Prosocial behavior (3y)							0.50***(0.03)	−0.24*(0.11)	0.16(0.21)
Peer relationships (3y)							0.01(0.03)	−0.03(0.11)	0.11(0.19)
Model fit indices	$\chi^2 = 6.50$, $df = 5$, $p = .26$, CFI =0.99, RMSEA = 0.01, 90 % CI [0.00, 0.04], SRMR = 0.00			$\chi^2 = 6.13$, $df = 5$, $p = .29$, CFI =1.00, RMSEA = 0.01, 90 % CI [0.00, 0.03], SRMR = 0.00			$\chi^2 = 6.73$, $df = 5$, $p = .24$, CFI =0.99, RMSEA = 0.01, 90 % CI [0.00, 0.04], SRMR = 0.00		

Note. EC = Effortful control, HISEI = The Highest International Socio-Economic Index (Ganzeboom et al., 1992), y = years.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

intercept $B = 0.21$, $p < .001$; quadratic $B = -0.60$, $p < .01$) and its further development over time, even when controlling for prior social development (intercept $B = 0.09$, $p < .01$; quadratic $B = -0.48$, $p < .01$). These results align with Stenseng et al. (2014), who reported that preschool children with poor EC were at a greater risk of social exclusion than those with higher EC. The analysis of this association over time revealed a negative effect on the quadratic trend across all models, indicating that higher parent-reported EC was associated with a less curved trajectory of prosocial behavior from preschool to primary school (Table 6a). Accordingly, children with higher parent-reported EC consistently showed higher patterns of prosocial behavior than those with lower parent-reported EC (see Fig. 5). These findings hold further support from previous studies showing comparatively high EC in children to be related to greater prosocial and cooperative behavior, and comparatively low EC to be related to less prosocial and more aggressive behavior (Laible et al., 2014; Spinrad et al., 2006; Williams & Berthelsen, 2017).

Furthermore, parent-reported EC was also significantly associated with peer relationships at age 5, even after controls were included (Table 6b; intercept $B = 0.08$, $p < .01$). However, this effect disappeared when social development at age 3 was included in the model (intercept $B = 0.05$, $p = .07$). This result suggests that the association between parent-reported EC and peer relationships at age 5 may largely be accounted for by earlier social development at age 3. In other words, parent-reported EC may play a role in establishing and maintaining interindividual differences in early peer relationships already at age 3, but it may not contribute to changes of interindividual differences in peer relationships between ages 3 and 5. Additionally, its association with developmental change between ages 5 and 9 did not remain consistent after controls were included in the model, suggesting an indirect relation (quadratic $B = -0.28$, $p = .17$). One possible explanation for this finding, as suggested by Fox (1989), is that children with high EC and low negative emotionality may be more inhibited and less expressive, which could affect their social interactions with peers over time. Alternatively, since the results were largely influenced by covariates other than negative affectivity—such as surgency, socioeconomic status (HISEI), and home interaction language—it may be that accounting for these variables diminished the unique contribution of parent-reported EC to individual trajectories.

Cognitive flexibility, delay of gratification, parent-reported EC, and social development in the main vs. the separated exploratory models

Contrary to our hypothesis, delay of gratification (intercept $B = -0.02$, $p = .42$; linear $B = 0.22$, $p = .07$; quadratic $B = -0.49$, $p = .07$) and cognitive flexibility (intercept $B = -0.02$, $p = .65$; linear $B = 0.23$, $p = .07$; quadratic $B = -0.50$, $p = .08$) were not significantly associated with peer relationships (only with prosocial behavior) in the main models including all of the self-regulatory facets as predictors (Table 6b). However, in our exploratory investigation of the potentially distinct roles of emotionally neutral EF and the emotion-related facets of self-regulation in social development, we found that these facets were significantly associated with the development of peer relationships (delay of gratification intercept $B = 0.06$, $p < .05$; linear $B = -0.29$, $p < .01$; quadratic $B = 0.80$, $p < .001$; cognitive flexibility quadratic $B = -0.82$, $p < .001$; Table 7). The reduction of their effects for peer relationships in the main models, along with the question as to why these self-regulatory facets play an important role only for prosocial behavior—in both the exploratory and main models—remains open for discussion.

Although speculative, these self-regulatory facets may be particularly important for prosocial behavior (Hao, 2017; Rademacher et al., 2021; Williams & Berthelsen, 2017), as children with higher self-regulation are better able to recognize and respond to others' distress and needs—a key process in the development of prosocial behavior (Willis, 2016). These abilities may be especially relevant during the transition from preschool to primary school. However, as suggested by

Table 6b
Latent growth curve model with intercept, linear and quadratic slope: peer relationships with self-regulation and covariates.

Variables	Peer relationships (Model 2.1)			Peer relationships (Model 2.2)			Peer relationships (Model 2.3)		
	Intercept β (SE)	Linear slope β (SE)	Quadratic slope β (SE)	Intercept β (SE)	Linear slope β (SE)	Quadratic slope β (SE)	Intercept β (SE)	Linear slope β (SE)	Quadratic slope β (SE)
Phonological working memory (3y)	0.03(0.04)	−0.00(0.16)	0.00(0.40)	−0.04(0.05)	0.01(0.15)	0.01(0.30)	−0.04(0.04)	0.01(0.15)	−0.00(0.30)
Inhibitory control (4y)	−0.02(0.04)	0.19(0.12)	−0.32(0.29)	−0.03(0.04)	0.11(0.13)	−0.12(0.24)	−0.02(0.04)	0.10(0.12)	−0.12(0.24)
Cognitive flexibility (4y)	−0.02(0.04)	0.23(0.13)	−0.50(0.28)	−0.02(0.04)	0.19(0.12)	−0.32(0.23)	−0.04(0.04)	0.21(0.12)	−0.34(0.23)
Delay of gratification (3y)	−0.02(0.04)	0.22(0.12)	−0.49(0.27)	−0.02(0.03)	0.18(0.12)	−0.30(0.22)	−0.03(0.03)	0.19(0.12)	−0.32(0.22)
Parent-reported EC (3–5y)	0.11**(0.03)	0.20(0.11)	−0.57**(0.24)	0.08**(0.03)	0.11(0.11)	−0.28(0.20)	0.05(0.03)	0.12(0.11)	−0.27(0.20)
Negative affectivity (3–5y)				−0.18***(0.03)	0.09(0.11)	−0.28(0.20)	−0.12***(0.03)	0.08(0.11)	−0.28(0.19)
Surgency (3–5y)				0.10**(0.03)	−0.28*(0.11)	0.44*(0.21)	0.05(0.03)	−0.27*(0.11)	0.44*(0.21)
Non-verbal cognitive functioning (3y)				0.05(0.04)	0.01(0.12)	0.01(0.24)	0.04(0.03)	0.02(0.12)	0.00(0.23)
Receptive vocabulary (3y)				0.04(0.04)	0.11(0.13)	−0.22(0.25)	0.03(0.04)	0.11(0.13)	−0.21(0.24)
HISEI (3y)				0.12**(0.04)	0.03(0.13)	−0.09(0.25)	0.08*(0.04)	0.03(0.13)	−0.08(0.25)
Home interaction language (3y)				0.11**(0.03)	0.08(0.12)	−0.26(0.23)	0.08*(0.03)	0.08(0.12)	−0.25(0.23)
Child's sex (3y)				0.03(0.03)	0.12(0.11)	−0.30(0.20)	0.02(0.03)	0.12(0.11)	−0.28(0.20)
Prosocial behavior (3y)							0.02(0.03)	0.04(0.12)	−0.11(0.22)
Peer relationships (3y)							0.44(0.04)	−0.06(0.12)	−0.02(0.23)
Model fit indices	$\chi^2 = 6.51$, $df = 5$, $p = .26$, CFI =0.99, RMSEA = 0.013, 90 % CI [0.00, 0.04], SRMR = 0.004			$\chi^2 = 6.13$, $df = 5$, $p = .29$, CFI =1.00, RMSEA = 0.011, 90 % CI [0.00, 0.03], SRMR = 0.002			$\chi^2 = 6.74$, $df = 5$, $p = .24$, CFI =0.99, RMSEA = 0.014, 90 % CI [0.00, 0.04], SRMR = 0.002		

Note. EC = Effortful control, HISEI = The Highest International Socio-Economic Index (Ganzeboom et al., 1992), y = years.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

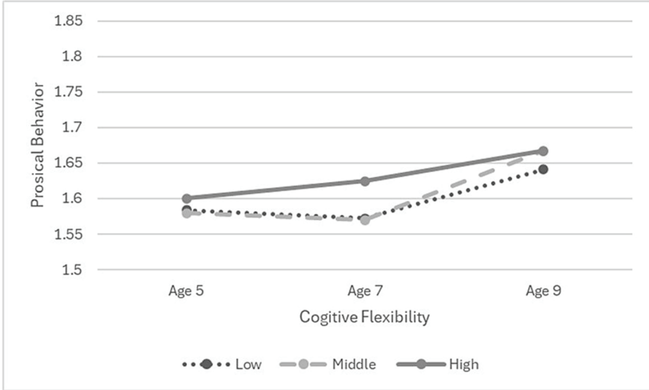

Fig. 3. Development of prosocial behavior by cognitive flexibility groups.
Note. The figure illustrates the (significant) effect of cognitive flexibility on prosocial development by showing the means (across age) separately for groups with low, middle, and high predictor scores (based on raw data).

our findings, the role of delay of gratification and cognitive flexibility in peer relationships may be less direct than initially expected. This may be because peer relationships are inherently complex, requiring negotiation, conflict resolution, and adaptation to social dynamics, which may limit the direct influence of self-regulation (Ladd, 2005). Instead, the effect of these self-regulatory facets on the development of peer relationships may depend on additional factors—potentially confounding "third" factors, including the effects of other facets of self-regulation.

While our study design did not allow us to identify the underlying factors explaining the associations between delay of gratification, cognitive flexibility, and peer relationships, we analyzed whether similar effects on peer relationships persisted when relevant controls were included in the separate models (see Table A7), as was done in the main models. Interestingly, the separate model with controls yielded similar results to the main models, with delay of gratification (intercept $B = -0.03$, $p = .36$; linear $B = 0.19$, $p = .11$; quadratic $B = -0.32$, $p < .16$) and cognitive flexibility (intercept $B = -0.02$, $p = .60$; linear $B = 0.20$, $p = .12$; quadratic $B = -0.35$, $p = .15$) showing nonsignificant associations with peer relationships. These results could be largely explained by the covariates, most of which demonstrated significant associations with either the intercept, linear, or quadratic slopes. This underscores the importance of including such controls when examining self-regulation and peer relationships (Liew et al., 2019).

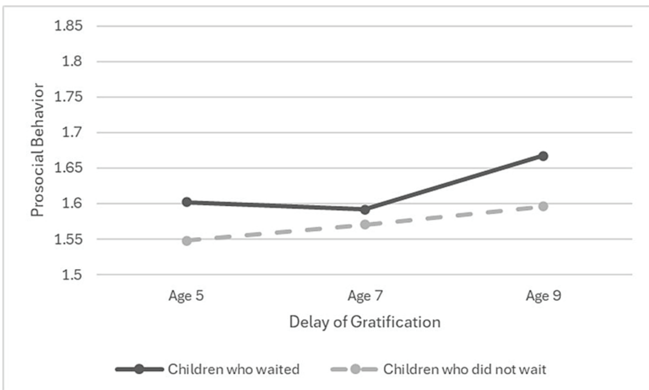

Fig. 4. Development of prosocial behavior by delay of gratification groups.
Note. The figure illustrates the (significant) effect of delay of gratification on prosocial development by showing the means (across age) separately for groups with children who waited and children who did not wait (based on raw data).

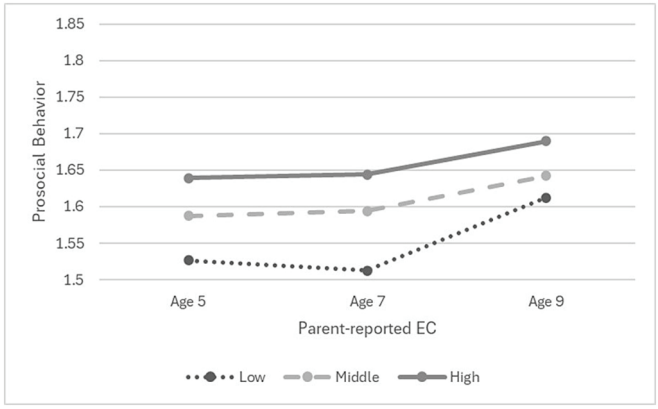

Fig. 5. Development of prosocial behavior by parent-reported EC groups.
Note. EC = Effortful control. The figure illustrates the (significant) effect of parent-reported EC on prosocial development by showing the means (across age) separately for groups with low, middle, and high predictor scores (based on raw data).

Phonological working memory, inhibitory control, and social development

Contrary to our assumptions, phonological working memory and inhibitory control did not significantly relate to the two important aspects of social development we studied—prosocial behavior and peer relationships. This outcome was unexpected, given the assumption that these facets of self-regulation play a crucial role in social development (Liew, 2012; Zhou et al., 2012). Specifically, our findings contradict those of several studies reporting significant associations between working memory (de Wilde et al., 2016; Hubert et al., 2017; Miller et al., 2020), inhibitory control (Blake et al., 2015; Hao, 2017; Hubert et al., 2017), and social development during the preschool and primary school years. Our findings suggest that the role of working memory and inhibitory control in social development may be influenced by various factors (Lecce et al., 2020) or depend on the specific indicators used (Best & Miller, 2010, see limitations for more details).

Strengths of the study

The present study makes several contributions to the literature by analyzing the associations of various self-regulatory facets between ages 3–5 simultaneously and separately. It distinguishes between emotionally neutral EF and emotion-related facets of self-regulation in relation to social development at age 5 and its intraindividual trajectories over the next four years. Instead of focusing on a global construct, we examined how various self-regulatory facets between ages 3–5 relate to two important aspects of social development–prosocial behavior and peer relationships–between ages 5 and 9. Additionally, our comprehensive longitudinal design deepens the understanding of these associations by accounting for relevant control variables that may influence the outcomes. We also evaluated the effect on inter- and intraindividual change across time by accounting for previous social development (at age 3) in the analyses.

Limitations and future directions

That said, this study is not without limitations. First, measures of the various self-regulatory facets were not examined uniformly between ages 3 and 5. Most of them (except parent-reported EC) were partially measured at only one measurement point between ages 3 and 4 years. As a result, the developmental trends of these self-regulatory facets and their relation to social development could only be analyzed as predictive factors for social development. This limitation means that the continuous interplay between self-regulation and social outcomes remains unclear, which future studies could address by including uniform measurement across time points.

Table 7
Latent Growth Curve Model of Prosocial Behavior and Peer relationships With Intercept, Linear and Quadratic Slope: With the Emotionally Neutral (EF) and Emotion-related Facets of Self-regulation.

	Prosocial behavior (Model 2.4)			Peer relationships (Model 2.4)			Prosocial behavior (Model 2.5)			Peer relationships (Model 2.5)		
Variables	Intercept β (SE)	Linear slope β (SE)	Quadratic factor β (SE)	Intercept β (SE)	Linear slope β (SE)	Quadratic factor β (SE)	Intercept β (SE)	Linear slope β (SE)	Quadratic factor β (SE)	Intercept β (SE)	Linear slope β (SE)	Quadratic factor β (SE)
Emotionally neutral EF												
Phonological working memory (3y)	−0.04 (0.04)	−0.07 (0.16)	0.25 (0.52)	0.04 (0.04)	0.05 (0.16)	−0.25 (0.60)						
Inhibitory control (4y)	−0.01 (0.03)	0.10 (0.14)	−0.30 (0.45)	−0.01 (0.04)	0.23 (0.13)	−0.62 (0.40)						
Cognitive flexibility (4y)	0.02 (0.04)	0.28* (0.13)	−0.97*** (0.14)	−0.02 (0.04)	0.25 (0.13)	−0.82*** (0.30)						
Emotion-related facets												
Delay of gratification (3y)							0.06* (0.03)	−0.29** (0.11)	0.80*** (0.16)	−0.02 (0.03)	0.23* (0.12)	−0.59* (0.27)
Parent-reported EC (3-5y)							0.20*** (0.03)	0.22* (0.11)	−0.72*** (0.18)	0.11** (0.03)	0.22* (0.11)	−0.72** (0.24)
Model fit indices	$\chi^2 = 6.63$, $df = 5$, $p = .24$, CFI =0.99, RMSEA = 0.01, 90 % CI [0.00, 0.04], SRMR = 0.00						$\chi^2 = 6.82$, $df = 5$, $p = .23$, CFI = 0.99, RMSEA = 0.01, 90 % CI [0.00, 0.04], SRMR = 0.00					

Note. EC = Effortful control, y = years.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Second, the parent-reported measures, which included effortful control, negative affectivity, and surgency, were assessed using a very short instrument (CBQ-VFS; Putnam & Rothbart, 2006), with only 3 of the twelve items per dimension included in the NEPS assessment. Consequently, the reliability of these scales was reduced—a common challenge for short-form measures in large-scale research, as standard reliability estimators may underestimate scale quality even when all items are included (Rammstedt & Beierlein, 2014; Sijtsma, 2009). Therefore, we aggregated the scores of each dimension across ages 3, 4, and 5 to increase reliability (see also Doshi et al., 2024). Future studies should use scales with more items for these measures. However, to check whether inclusion of the age 5 measures led to an overestimation of effects, the models were re-analyzed as a robustness check, including the CBQ-VSF measures (effortful control, negative affectivity, and surgency) only for ages 3 and 4 (Doshi et al., 2024), thereby realizing a sequential longitudinal design (Mitchell & Maxwell, 2013; see Tables A4 and A5). This analysis was conducted to determine whether including the CBQ-VSF measures at age 5 might have influenced our results (as the measure at age 5 coincides with the intercept of social development at age 5). However, as the β-weights were relatively close to those in the reported model, the partial cross-sectional overlap did not appear to lead to an overestimation of the effects. Also, with respect to the social development measures, a more extended questionnaire could be more preferable. Although the CFA-based composite reliability (ω) was greater than 0.70 for the measure at ages 5, 7, and 9 (Deng & Chan, 2016), Cronbach's alpha, was not very high, which should be considered when interpreting the findings.

Third, both EC and the outcome variables (prosocial behavior and peer relationships) were assessed solely through parent reports. This may introduce bias as parents potentially overestimate or underestimate certain behaviors. Furthermore, the current study assessed only one indicator of each of the self-regulatory facets. For instance, the study included phonological working memory, whereas other studies have often focused on central executive tasks, such as the backward digit span. Furthermore, while the flanker switch task (the second part of the flanker task requiring a change in focus from the direction of the middle to the direction of the outer fish) has been used in some studies to assess cognitive flexibility (Gashaj et al., 2019), the flanker task is generally recognized as a tool for measuring inhibitory control (i.e., the first part of the flanker task, requiring children to focus on the direction of the middle fish, Bauer & Zelazo, 2014; Oeri et al., 2018). Inhibitory control and cognitive flexibility share overlapping processes, such as attentional control, response inhibition, and the regulation of behavior and thought. While they are distinct in their core functions, they often work interdependently in tasks that require both the ability to suppress automatic responses and switch between cognitive tasks (Zhou et al., 2012). Hence, given that both measures were assessed in different parts within the same task, shared variance might have influenced the results, potentially explaining why only cognitive flexibility emerged as a reliable predictor. This raises the question of whether our findings reflect the specific indicator used (i.e., the flanker switch task) or if the variance related to inhibitory control also contributed to the observed patterns (Doshi et al., 2024). This limitation highlights the need for future research including a broader range of self-regulatory tasks. For instance, incorporating a variety of tasks for each facet—such as Go/No-Go tasks for inhibitory control, additional direct measures for delay of gratification, and the dimensional change card sort for cognitive flexibility—alongside the tasks in the present study could provide a more comprehensive understanding of their impact.

Fourth, although the study controlled for factors such as the language spoken at home (with most children speaking only German), the children's heritage languages might also affect self-regulation. Hence, future research should explore how both majority languages and minority languages influence self-regulatory abilities (Bohlmann et al., 2015). In the same vein, another control variable—the parents' highest International Socio-Economic Index (HISEI; Ganzeboom et al., 1992)—was available for most children (86.67 %) based on reports from both parents. For a minority of the sample (13.33 %), HISEI data were available from only one parent. Although a supplementary analysis (see Appendix S1 and Table A8) indicated that this missing data did not significantly influence the results, this warrants further consideration in future research (Størksen et al., 2015). Additionally, future studies could include relevant preschool and school-related facets such as classroom environment or child-teacher interactions as controls (Özcan et al., 2023).

Fifth, only partial scalar invariance was achieved for the measures of social development in this study. However, meaningful comparisons across groups were still possible (Byrne et al., 1989). Recent literature suggests that full or even partial measurement invariance may not always be a strict prerequisite for group comparisons (Robitzsch & Lüdtke, 2023).

Finally, when interpreting these results, it is important to consider the context of the COVID-19 pandemic as it significantly altered typical social interactions due to repeated school closures, disruptions, and discontinuity of extracurricular activities and interaction with peers in Germany (Oppermann et al., 2024). These changes were particularly relevant for the prosocial behavior and peer relationships measures when the children were 9 years of age in the NEPS-SC1 dataset, as they were assessed in the year 2021.The absence of regular school environments and peer group activities could have disrupted the development of prosocial behavior and peer relationships. However, despite the challenges posed by the pandemic, the findings suggest that children's prosocial behavior and peer relationships remained relatively stable at age 9. While it is possible that specific self-regulatory abilities could have acted as protective influences in children's social development, more studies are needed to examine these effects in the context of COVID-19-related disruptions, especially during the primary school years.

Practical implementations

Despite the limitations, our findings shed light on the relations between various self-regulatory facets and social development. They also suggest that support for children's self-regulatory abilities should begin early, including the preschool years, to promote prosocial behavior. As intervention programs targeting prosocial behavior have shown only moderate effectiveness (Flook et al., 2019; Malti, Gummerum, et al., 2016; Mesurado et al., 2019), it may be necessary to also focus on enhancing self-regulatory abilities—such as cognitive flexibility, delay of gratification, and effortful control—to better promote prosociability during these years (Zhou et al., 2012). For instance, in a study implementing a 12-week mindfulness-based kindness curriculum (KC) with preschoolers, the KC intervention group showed greater improvements in prosociability, cognitive flexibility, and delay of gratification, among other outcomes, than the control group (Flook et al., 2015). However, further investigations into such programs are needed during the preschool and primary school years. In addition to structured programs, classroom-based strategies—such as consistent routines (Rimm-Kaufman et al., 2009) and play-based executive function games (e.g., computerized training, non-computerized games; Diamond & Lee, 2011)—have also been shown to effectively support self-regulation in early childhood settings.

While these findings highlight the importance of preschool programs in promoting self-regulation (Narea et al., 2025) and prosocial behaviors (Zhou et al., 2023), it is important to acknowledge that access to formal preschool varies widely across countries. In Germany almost all children attend preschool, whereas in the United States approximately half of 3- to 4-year-olds did not attend formal preschool between 2018 and 2022, with enrollment declining further in the aftermath of the COVID-19 pandemic (Annie, 2023). This gap disproportionately affects children from families with socioeconomic or other risk factors (Annie, 2023). Therefore, the provision of self-regulation and prosocial behavior-focused support through community-based platforms (i.e., home

visitation programs, family resource centers, and parent- or family-based intervention programs) could be another option. Such considerations are relevant not only for educators and practitioners but also for community organizations, government agencies, and policymakers who play a central role in supporting the design, implementation, and evaluation of these programs. For instance, programs like the Triple P–Positive Parenting Program, which applies self-regulatory principles across child, parent, and practitioner levels (Sanders & Mazzucchelli, 2013), and the Incredible Years Parenting Program (IYP; Zhou et al., 2023) offer valuable models for extending the impact of such interventions beyond formal preschool settings.

Conclusion

Overall, the findings of this study contribute to the literature by demonstrating associations between the individual trajectories of prosocial behavior and specific self-regulatory facets, namely, cognitive flexibility, delay of gratification, and parent-reported EC. However, according to these findings, none of these self-regulatory facets are associated with peer relationships after accounting for social development at age 3. These results suggest that, while self-regulation plays a role in fostering prosocial behavior, it may not directly influence peer relationships at these developmental ages (5 to 9). In particular, intervention programs associated with strengthening these specific self-regulatory abilities and promoting prosocial behavior during the transition from preschool to primary school may be beneficial.

CRediT authorship contribution statement

Aashna Doshi: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Sabine Weinert:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization. **Wei Huang:** Writing – review & editing, Validation, Methodology.

Declaration of competing interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appdev.2026.101924.

Data availability

Data will be made available on request.

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