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CHILD DEVELOPMENT

EMPIRICAL ARTICLE

Inhibitory control, dyadic social behavior, and mental health difficulties in preschoolers

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Abstract

Although inhibitory control is typically associated with positive outcomes, several theoretical frameworks suggest that too little *and* too much inhibitory control may be problematic. Using a longitudinal, latent variable approach, we examined whether a multi-method index of inhibitory control at Time 1 (N = 105, 52 girls, M_{age} = 3.50 years, 87% White) predicted observed social behavior with an unfamiliar peer and maternal report of preschoolers' mental health difficulties at Time 2 (M_{age} = 4.76 years). Data collection occurred between 2017 and 2019. Inhibitory control displayed a U-shaped relation with prospective outcomes, where high *and* low levels of inhibitory control were associated with higher levels of avoidant social behaviors and mental health difficulties. The results are discussed in the context of under- and over-regulation in understanding individual differences in children's social behavior and mental health difficulties.

Inhibitory control refers to one's ability to inhibit a prepotent, easily accessible response in favor of activating a less dominant, less accessible response, and is a key component of temperamental effortful control during the preschool period (Rothbart & Bates, 2006; Rothbart et al., 2001, 2003). The typical developmental trajectory of inhibitory control and related constructs, like effortful control, is non-linear, and follows a steep increase from late toddlerhood to the early preschool years, and then levels off, exhibiting a less steep increase from the late preschool to early childhood years (Dennis et al., 2007; Geeraerts et al., 2021; Klenberg et al., 2001; Kochanska et al., 1996; Schoemaker et al., 2014; Williams et al., 1999). Given the importance of the preschool period for the development of inhibitory control, it is particularly important to study the correlates and consequences of inhibitory control during this time.

Most often, inhibitory control is regarded as a positive temperamental quality that is associated with more adaptive socioemotional and psychological outcomes that have important implications for children's ability to secure and maintain healthy social relationships. Indeed, inhibitory control and related constructs have been positively linked to social competence (Di Norcia et al., 2015; Rhoades et al., 2009), prosocial tendencies (Diener & Kim, 2004; Eisenberg et al., 1995, 1997, 2007; Rothbart et al., 2001), the emergence of consciousness and some self-conscious emotions (Eisenberg, 2010; Kochanska & Aksan, 2006), and fewer experiences of aggression (Di Norcia et al., 2015) and mental health difficulties (Eisenberg et al., 2009; Krueger et al., 1996; Olson et al., 2005; Petitclerc et al., 2015; Rapport et al., 1986; Rhoades et al., 2009; B. A. White et al., 2013).

Although inhibitory control is typically regarded as a positive quality, several theoretical models have suggested a U-shaped relation may exist between inhibitory control and socioemotional and psychological outcomes. The construct of ego control, for example, refers to one's ability to modulate impulses, emotions, and desires in response to dynamic environmental demands

Abbreviations: AIC, Akaike information criterion; BIC, Bayesian information criteria; CBCL, Child Behavior Checklist; CBQ, Children's Behavior Questionnaire; CFA, confirmatory factor analyses; CFI, comparative fit index; MCAR, missing completely at random; RMSEA, root mean square error of approximation; SEM, structural equation model; SRMR, standardized root mean square residual; T1, Time 1; T2, Time 2.

(J. Block, 2002; J. H. Block & Block, 1980). Within Block and Block's (1980) framework, ego overcontrol and ego undercontrol represent two extremes, and there is a distinction between adaptive and non-adaptive inhibitory control (Funder & Block, 1989). High ego overcontrol is defined as excessive inhibition of behavior, impulses, emotions, and desires leading to unnecessary denial of pleasure, and a constrained behavioral presentation, whereas high ego undercontrol is defined as inability to delay gratification, emotional lability, impulsivity, and a socially inappropriate behavioral presentation (J. Block, 2002; J. H. Block & Block, 1980; Funder & Block, 1989; Henderson et al., 2015).

Eisenberg and Fabes (1992) have described undercontrolled and highly inhibited children in a similar vein to Block and Block (1980). For example, undercontrolled children exhibit high levels of emotionality, low levels of regulation, and high levels of impulsivity and aggression. Highly inhibited children exhibit high levels of regulation but low flexibility and may be prone to higher levels of anxiety and depression. Here, undercontrolled children are comparable to children with low levels of ego control, and highly inhibited children are comparable to children with high levels of ego control (J. H. Block & Block, 1980; Eisenberg & Fabes, 1992).

Derryberry and Rothbart (1997) similarly have discussed the negative influence of both underregulation and overregulation in the context of children's psychopathology more specifically. Because inhibitory control in each of these frameworks appears to have negative social and psychological consequences at low and high levels, inhibitory control should presumably display a U-shaped relation to socioemotional and psychological outcomes, with most optimal outcomes exhibited by individuals who display moderate levels of inhibitory control.

Several empirical studies have provided support for the theoretical frameworks suggesting that intermediate levels of inhibitory control may be associated with the most optimal outcomes (J. H. Block & Block, 1980; Derryberry & Rothbart, 1997; Eisenberg & Fabes, 1992). Two questionnaire-based studies using the concept of ego control found that undercontrolled boys exhibited academic, behavioral, and emotional problems, whereas overcontrolled boys exhibited internalizing problems (Robins et al., 1996), and that intermediate levels of reactive control in preschoolers, a measure of self-regulation conceptually related to ego control, were related to the highest levels of prospective resiliency in a high-risk adolescence sample (Martel et al., 2007). The relation between inhibitory control and resiliency was extended in another study that found intermediate levels of impulsivity were related to the highest resiliency in 4- and 8-year-old children concurrently (Eisenberg et al., 2002).

Beyond questionnaire-measures of self-regulation, two studies using behavioral composites of effortful control in young children found that intermediate levels of effortful control were related to the lowest levels of internalizing and externalizing difficulties (Murray & Kochanska, 2002) and that the modulation of negative affect was also most effective when children displayed intermediate levels of inhibitory control (Carlson & Wang, 2007). Collectively, these studies suggest the relation between inhibitory control and socioemotional and psychological difficulties may be U-shaped rather than linear and positive.

Despite the theoretical perspectives (J. H. Block & Block, 1980; Derryberry & Rothbart, 1997; Eisenberg & Fabes, 1992) and empirical studies (Carlson & Wang, 2007; Eisenberg et al., 2002; Martel et al., 2007; Murray & Kochanska, 2002; Robins et al., 1996) suggesting a U-shaped relation between inhibitory control and socioemotional and psychological outcomes, there are several gaps in the literature. First, although previous theoretical models have discussed the potential for negative social consequences of very low and high levels of inhibitory control because of the behavioral consequences of overcontrol (i.e., excessively restricted emotional and behavioral presentation) and undercontrol (i.e., impulsivity, emotional lability, socially inappropriate behavioral presentation, J. Block, 2002; J. H. Block & Block, 1980; Funder & Block, 1989; Henderson et al., 2015; Henderson & Wilson, 2017; Rothbart et al., 1992), to our knowledge, no study has examined whether there is indeed a U-shaped relation between inhibitory control and observed social behavior with a peer.

The lack of considering the peer context is an important gap in the extant literature that should be addressed for at least two reasons. First, it is important to include direct observation of social behavior whenever possible because parental reports of social behavior may not align with how children truly behave with their peers. Parents do not always have opportunities to unobtrusively observe their children's behavior, for example, on the playground. Furthermore, friendships and peer acceptance are protective against psychopathology across childhood (Schmidt & Bagwell, 2007; Schwartz et al., 2000; Sette et al., 2017), and so it is important to determine factors that influence children's ability to secure positive social relationships with their peers.

A second important gap is that most of the studies considering a non-linear relation have focused on impulsivity (Eisenberg et al., 2002), over- and under-control (Martel et al., 2007; Robins et al., 1996), and effortful control (Murray & Kochanska, 2002). These are important starting points, but theoretical accounts of the potentially negative impacts of "too much" self-regulation focus on descriptions depicting inhibitory control specifically (J. H. Block & Block, 1980; Derryberry & Rothbart, 1997; Eisenberg & Fabes, 1992). Furthermore, other studies have suggested that different components of effort control (i.e., inhibitory control, attentional focusing, attentional shifting) may be differentially related to social adjustment (Eggum-Wilkens et al., 2016; L. K.

White et al., 2011), highlighting the importance of examining inhibitory control specifically.

A third important gap is the multifaceted nature of inhibitory control. Indices of inhibitory control vary from parent report (Rothbart et al., 2001), coded behavioral observation (Goldsmith et al., 1993; Kochanska et al., 1996, 2000), and cognitive tests (Zelazo et al., 2013). Although different studies have used parent report (Hassan et al., 2020; Sette et al., 2018), cognitive indices (Thorell et al., 2004; Troller-Renfree et al., 2019; L. K. White et al., 2011), and behavioral composites (Brooker et al., 2016; Carlson & Wang, 2007; Murray & Kochanska, 2002) when examining the correlates of inhibitory control, the multifaceted nature of inhibitory control calls for a latent factor approach. Latent variable approaches are advantageous because they capture an unobserved variable encompassing the different loadings of various observed variables while accounting for measurement error, potentially creating a more accurate picture of a variable (Kline, 2015).

The present study

Given the gaps in the extant literature, the present study used a sample of 105 typically developing preschoolers to examine whether inhibitory control at age 3 influenced observed social behavior with an unfamiliar peer and maternal report of child internalizing and externalizing difficulties approximately 1 year later. We controlled for sex (Hassan et al., 2019; Kochanska & Knaack, 2003; Kochanska et al., 2000), household income (Essex et al., 2006; Lawson et al., 2018), and fearful temperament (i.e., shyness; Aksan & Kochanska, 2004; Eggum et al., 2012; Poole et al., 2020) at T1 because of potential links between each of these covariates and inhibitory control, social behavior, and mental health difficulties. We used a latent variable approach to define inhibitory control and social behavior because of the multifaceted nature each of these constructs.

We elected to focus specifically on the preschool period for several reasons. First, the preschool years are a sensitive period for self-regulation development (Dennis et al., 2007; Geeraerts et al., 2021; Klenberg et al., 2001; Kochanska et al., 1996; Schoemaker et al., 2014; Williams et al., 1999). Second, this time reflects a period prior to formal school entry, and social relationships in the early school years are known to be protective against several negative outcomes (Schmidt & Bagwell, 2007; Schwartz et al., 2000; Sette et al., 2017). Third, mental health difficulties that emerge during the preschool period may persist into preadolescence (Mesman & Koot, 2001). Identifying factors that influence children's social behaviors and internalizing and externalizing problems prior to formal school entry can help identify modifiable targets of intervention that may set children on a positive developmental trajectory.

The present study was considered confirmatory given previous theoretical (J. H. Block & Block, 1980; Derryberry & Rothbart, 1997; Eisenberg & Fabes, 1992) and empirical work (Carlson & Wang, 2007; Eisenberg et al., 2002; Marcovitch et al., 2010; Martel et al., 2007; Miller et al., 2017; Murray & Kochanska, 2002; Robins et al., 1996). Based on this prior work, we predicted that inhibitory control at age 3 would display a U-shaped relation to negative social outcomes and both internalizing and externalizing problems approximately 1 year later. Specifically, intermediate levels of inhibitory control would be related to the lowest risk for social and psychological difficulties.

METHOD

Participants

Participants were 105 typically developing 3-year-old children (52 girls, M_{age} = 3.50 years, SD_{age} = 0.19 years) and their mothers who were recruited from the Child Database in the Psychology, Neuroscience & Behaviour at McMaster University in Ontario, Canada. This database contains the names and contact information for parents of healthy, full-term newborn infants recruited from hospitals across the greater Hamilton metropolitan area who consented to participation in future infant and child studies conducted at McMaster University. Most of the children were White (87%), and their families had a mean household income of between $75,000 and $100,000 in Canadian dollars. Data collection occurred between 2017 and 2019.

Procedure

The present study was part of a larger study examining the influence of temperament on children's prospective social and emotional outcomes across the preschool period. Children and their mothers visited the Child Emotion Laboratory at McMaster University at Time 1 (T1) when the children were 3 years old. At T1, the child, mother, and one female experimenter began in a room together. While the child played with a puzzle, the experimenter explained the study procedures to the mother. Once the child was acclimated to the laboratory room, the mother went into a separate room in the laboratory to complete a series of questionnaires. She could view her child on a closed-circuit computer monitor in the separate laboratory room. The child completed a Flanker Task on an iPad from the NIH Toolbox Cognitive Battery for preschool-aged children (Zelazo et al., 2013) followed by a dinky toys task (Goldsmith et al., 1993).

Mothers and their children returned to the laboratory for a second time approximately 1 year later (Time 2; T2) where the child was paired with another same sex and

same age unfamiliar child who had also participated in the T1 visit (M_{age} at T2 = 4.76 years SD_{age} = 0.38). The dyad met for the first time in the playroom and proceeded to engage in play activities. The mother was present for the first portion of the play activities, then left the room to complete a series of questionnaires. As with T1, the mother could view the child on a closed-circuit computer monitor while she filled out the questionnaires. All families were provided with small toys, *Junior Scientist* certificates, and $30 gift cards as tokens of appreciation for their participation. Mothers provided written consent and children provided verbal assent for both visits. All procedures were approved by the McMaster Research Ethics Board.

Measures

Inhibitory control (T1)

A latent factor of inhibitory control included maternal report, coded behavior from the dinky toys task, and cognitive performance on the Flanker Task. Details for the confirmatory factor analysis (CFA) supporting the latent factor of inhibitory control are described in the Results section.

Maternal report

Mothers completed the Children's Behavior Questionnaire (CBQ), which is a parent-rated questionnaire evaluating 3- to 7-year-old children's temperament (Rothbart et al., 2001). Of particular interest to the present study were parental ratings of inhibitory control. On this 14-item scale, parents rate items on a 7-point scale with 1 = *never* and 7 = *always*. Mean scores were computed, and thus scores could range from 1 to 7. A sample item from the inhibitory control scale is "Can wait before entering into new activities if s/he is asked to," and the scale exhibited strong internal consistency (α = .82).

Dinky toys task

This task is a behavioral measure of inhibitory control and is adapted from a previous study (Kochanska et al., 1996) and the Preschool Lab-TAB (Goldsmith et al., 1993). The experimenter and child were seated cross-legged across from each other on the floor, and the child was presented with a box of attractive dinky toys and asked to indicate using their words which toy they would like while keeping their hands on their lap. The experimenter then slid the box over to the child and gave the child a reminder to keep their hands on their lap before removing the lid of the box. The child then either told the researcher which toy they wanted or grabbed the toy. The experimenter gave the child one more reminder to keep their hands on their lap if a choice was not made within 5 s. Following the first choice, the child was told, "Because you did such a good job today, I'm going to let you pick another prize to take home." The procedure was then repeated.

Performance on the dinky toys task was unobtrusively digitally recorded and was subsequently coded. Children's strategy was coded on a 0- to 5-point scale, following a previously published coding scheme (Kochanska et al., 1996). A 0 was assigned if the child grabbed the toy out of the container; a 1 was assigned if the child touched the toys in the container but did not take a toy out; a score of 2 was given if the child pointed to the toys but did not touch them; a 3 was assigned if the child removed their hands from their lap but did not touch the toy; a 4 was assigned if the child's hands twitched or moved slightly but did not leave the lap; and a 5 was assigned if the child did not move their hands from their lap. Because this task was completed twice and the scores were highly correlated (r = .73, $p < .001$), scores for children's strategies were averaged between the two trials. To establish reliability, independent coders overlapped on 18% of the videos and good interrater reliability was established (κ trial 1 = .95, κ trial 2 = .96).

Flanker Task

The Flanker Task from the NIH Toolbox Cognitive Function Battery was used to measure cognitive inhibitory control which was administered using an iPad (Zelazo et al., 2013). During this task, the child was first presented with a row of fish and was instructed to press the button that matched the direction that the middle fish was pointing. This task consisted of congruent trials where all the fish were facing the same direction and incongruent trials where all the fish were facing the opposite direction from the middle fish. If the child performed above a certain cut-off point, they completed a second version of this task where they saw arrows instead of fish. The Flanker Task consisted of four practice trials, 20 trials using fish as stimuli, and 20 trials using arrows as stimuli. Detailed information on how scoring is computed is described elsewhere (Zelazo et al., 2013). Each child was given a percentile based on their standardized, age-corrected score.

Observed dyadic social behavior (T2)

Children's social behavior was observed in a free play context with an unfamiliar peer with the mothers present and separately without the mothers present. A latent factor of avoidant social behaviors included displays of *negative affect* in the free play session with the mothers present and a separate free play session without the mothers present, and *unoccupied/onlooking behaviors* during the freeplay session without the mothers. We focused specifically on negative affect and unoccupied and onlooking behaviors because these social behaviors can be a result of internal (e.g., fear) and external (e.g., peer rejection) triggers, and presumably would capture a dynamic picture of negative social experiences.

Details for the CFAs supporting the latent factor of avoidant social behaviors are described in the Results section.

Observed dyadic social behavior: Procedures and measures

One member of the dyad pair was in the laboratory playroom with their mother. The second member of the dyad pair was brought into the laboratory playroom with their mother by a female research assistant, and the female research assistant introduced the two unfamiliar children for the first time. Following the introduction, the research assistant immediately brought in a large plastic bin filled with different toys (e.g., puzzles, blocks, dolls, cars) into the playroom and told the children they had 10 min to play with the toys in the bin together, and then she left the room. The mothers sat in the corner of the room on two chairs and completed questionnaires on a clipboard using a pen and paper. After 10 min, the research assistant returned to the room and told the children it was time for their next activity. After the structured building and cleaning up task described below, the mother was escorted to a separate laboratory room, and the children participated in another identical free play session without their mother present.

Children's social behavior was unobtrusively digitally recorded and was subsequently coded by independent research assistants, and behavioral codes were heavily adapted from the Play Observation Scale (see Rubin, 2001). Children's negative affect and unoccupied/onlooking behaviors were coded every 10 s. Negative affect in both the free play session with and without the mothers was based on facial (e.g., pouting lips, frowning), verbal (e.g., crying, whining), and behavioral displays (e.g., hanging head, slacked posture) on a scale of 1 (none displayed) to 4 (continued mild or stronger expression >7 s; two or more distinct, strong expressions; four or more distinct, mild-to-moderate expressions).

Unoccupied/onlooking behavior was operationalized as the child staring blankly into space or wandering around with no specific purpose and was coded when it was displayed the most out of several other mutually exclusive play behaviors derived from the Play Observation Scale (Rubin, 2001). Although this behavior was coded in the free play sessions both with and without the mothers' present, the instance was very low when the mothers were present. As such, we focused only on unoccupied/onlooking behavior in the free play session without the mothers' present. Because of small delays (e.g., 15 s) in ending the play episode, proportion scores were used where the sum of each behavior was divided by the number of minutes the play episode lasted. Negative affect with (κ = .87) and without the mother (κ = .84) and unoccupied/onlooking without the mother (κ = .86) exhibited acceptable to excellent interrater reliability.

Mental health difficulties (T2)

Child Behavior Checklist

Mothers completed the Child Behavior Checklist (CBCL), which is a parent-rated questionnaire evaluating emotional and behaviors in children ages 1.5 to 8 years old (Achenbach & Edelbrock, 1978; Achenbach & Rescorla, 2000). Of particular interest to the present study were maternal ratings of internalizing and externalizing problems. Parents rate items on a 3-point scale with 0 = *not true (as far as you know)* and 2 = *very true or often true*. Mean scores were computed, and thus scores could range from 0 to 2. A sample item from internalizing scale includes "Looks unhappy without a good reason" and a sample item from the externalizing scale includes "screams a lot." The internalizing (α = .79) and externalizing (α = .93) difficulties scales exhibited good and excellent internal consistency, respectively.

Covariate: Fearful temperament (T1)

The six-item shyness subscale from the CBQ was used as an index of fearful temperament at T1 (Rothbart et al., 2001). Statements were rated by mothers on a scale ranging from 1 (*never*) to 7 (*always*). A sample item from the shyness scale includes "Acts shy around new people." The shyness (α = .89) scale demonstrated good internal consistency.

Missing data and loss to follow up

Of the 105 children at T1, 18 were missing Flanker data due to either not passing the teaching trials (n = 16) or refusal to participant or finish the task (n = 2), three were missing data on the dinky toys due to experimenter error (n = 1) or refusal to participate (n = 2), and 2 were missing maternal report of inhibitory control due to refusal to participate (n = 2). Because children overlapped on missing data, 87 children had complete data at T1.

This present study was part of a larger study examining the influence of temperament on prospective social relationships in preschool children and included both a dyadic and individual visit at T2. The variables of interest in the present study occurred during the dyadic portion of T2. Because it was difficult to align schedules of families with children of the same sex for the dyadic portion, 62 children returned for their T2 dyad visit. Two children at T2 were matched with a same sex, same age child who had not been tested at the T1 visit because we were unable to align the schedules of these two children with any of the children tested at T1, and so a total of 64 children had T2 dyad data. The retention rate for children who returned to complete an individual visit at T2 rather than the dyadic portion at T2 was n = 71.

The children who did not complete the T2 dyadic portion did not differ from those children who did based on age ($t(102) = -.48$, p = .63), sex (χ^2 = 1.01, df = 1, p = .31), household income ($t(97) = -1.08$, p = .28), Flanker percentile ($t(85) = -.16$, p = .87), dinky toys coded behavior ($t(100) = -.51$, p = .61), or maternal report of inhibitory control ($t(101) = -.63$, p = .53).

Little's test of missing completely at random (MCAR) was not significant, χ^2 = 164.36, df = 509, p = 1.00,

suggesting that patterns of missing data did not violate the assumption that data were MCAR. To leverage the complete sample (N = 105) and avoid the biased parameter estimates that can occur with pairwise or listwise deletion (Schafer & Graham, 2002), children who did not return for the second visit were given a dyad pairing value based on same-sex matching and the date of their T1 visit, and then missing data were imputed using the expectation-maximization algorithm.

Statistical analyses

To derive latent factors of inhibitory control and observed social behaviors, we performed two CFAs in Mplus Version 8 using an MLR estimator. To account for the nested nature of the observed dyadic social behaviors where behaviors are nested within the child, and the child is nested within the dyad, we used the TYPE = COMPLEX function. This specification allowed us to control for the effect of the dyad (Huang, 2018). The cluster variable in our analyses was dyadic pairing. After specifying the measurement models for the latent factors, we built two structural equation models (SEM) that included the linear and quadratic influence of inhibitory control on either observed social behavior or mental health difficulties at T2 controlling for sex, household income at T1, and shyness at T1. Estimates are also provided without the covariates for completeness. Imputation was conducted in SPSS version 26, and the main analyses were conducted in MPlus Version 8.

RESULTS

Table 1 includes the means, standard deviations, and intercorrelations among all observed variables.

Measurement models

Inhibitory control (T1)

Figure 1a depicts the latent factor of inhibitory control supported by a CFA. T1 maternal ratings of inhibitory control, coded observations of children's behavior during the dinky toys task, and percentile scores from the Flanker Task were used as indicators of inhibitory control. To improve model fit, we constrained the three inhibitory control indicators to be equal. In order to justify the constrained model, we performed a Satorra–Bentler scaled chi-square difference test (Satorra & Bentler, 2001). This test is used to compare the fit of different models when an MLR estimator is used. We obtained a non-significant chi-square statistic, χ^2 = 0.11, df = 2, p = .948, and so we retained the more parsimonious constrained model with more degrees of freedom. The first factor was freed, and the latent factor was set to 1. The CFA for inhibitory control demonstrated acceptable fit (root mean square error of approximation [RMSEA] = 0, comparative fit index [CFI] = 1, standardized root mean square residual [SRMR] = .010), where Flanker percentile (B = 0.49, SE = 0.11, p < .001), dinky toys behavior (B = 0.43, SE = 0.12, p < .001), and maternal ratings of inhibitory control (B = 0.45, SE = 0.13, p = .001) all loaded significantly onto the latent factor.

Social behavior (T2)

Figure 1b depicts the latent factor of avoidant social behavior supported by a CFA. T2 scores of negative affect during free play with and without the mothers present and unoccupied/onlooking behaviors during free play without the mothers were used as indicators

TABLE 1 Pearson's correlations and descriptive statistics for study variables

Variables	2	3	4	5	6	7	8	*M* (*SD*)
1. Children's Behavior Questionnaire inhibitory control (T1)	.22*	.22*	.13	.01	−.09	−.09	−.47**	4.71 (0.72)
2. Dinky toys behavior (T1)	—	.20*	.09	.19*	.11	.16†	−.13	1.37 (1.63)
3. Flanker percentile (T1)	—	—	.07	.12	−.06	.08	.11	58.34 (27.03)
4. Negative affect during free play with the mother (T2)	—	—	—	.64***	.44**	.14	.13	6.17 (0.69)
5. Negative affect during free play without the mother (T2)	—	—	—	—	.64***	.13	.11	6.09 (0.65)
6. Unoccupied/onlooking during free play without the mother (T2)	—	—	—	—	—	.16†	.15	0.06 (0.22)
7. Internalizing difficulties (T2)	—	—	—	—	—	—	.48***	0.26 (0.16)
8. Externalizing difficulties (T2)	—	—	—	—	—	—	—	0.36 (0.27)

Note: T1 = Time 1, Age 3; T2 = Time 2, Age 4.

†p < .10; *p < .05; **p < .01; ***p < .001.

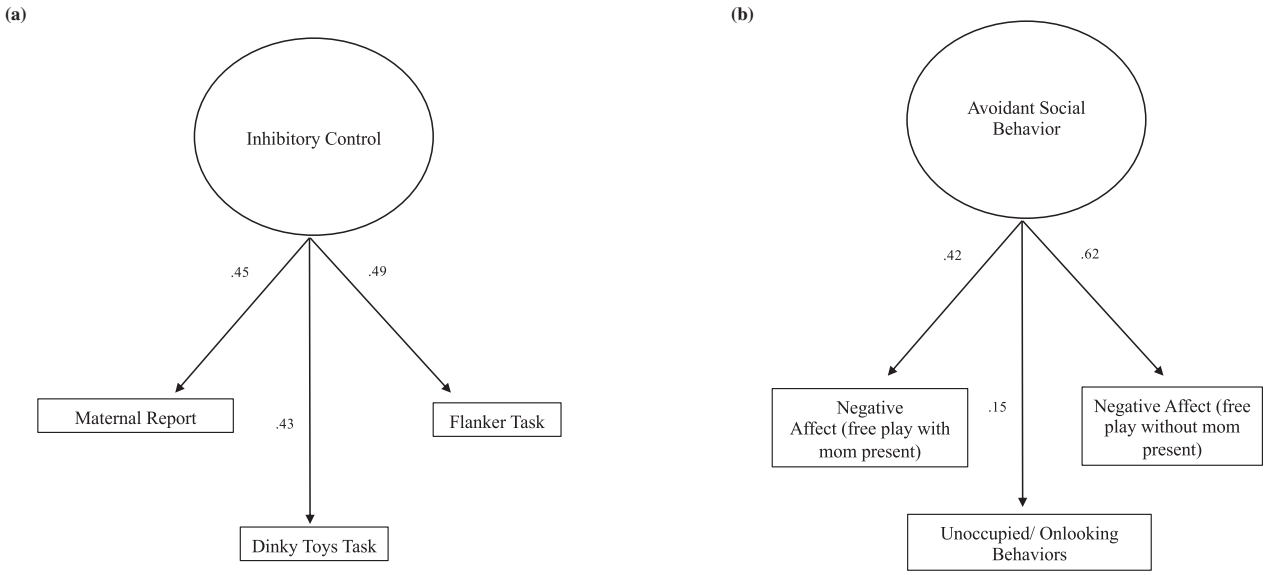

FIGURE 1 Confirmatory factor analysis supporting latent factors (a) inhibitory control at Time 1 (M_{age} = 3.50 years) and (b) avoidant social behavior during dyadic free play and at Time 2 (M_{age} = 4.76 years)
Note: All factor loadings are significant

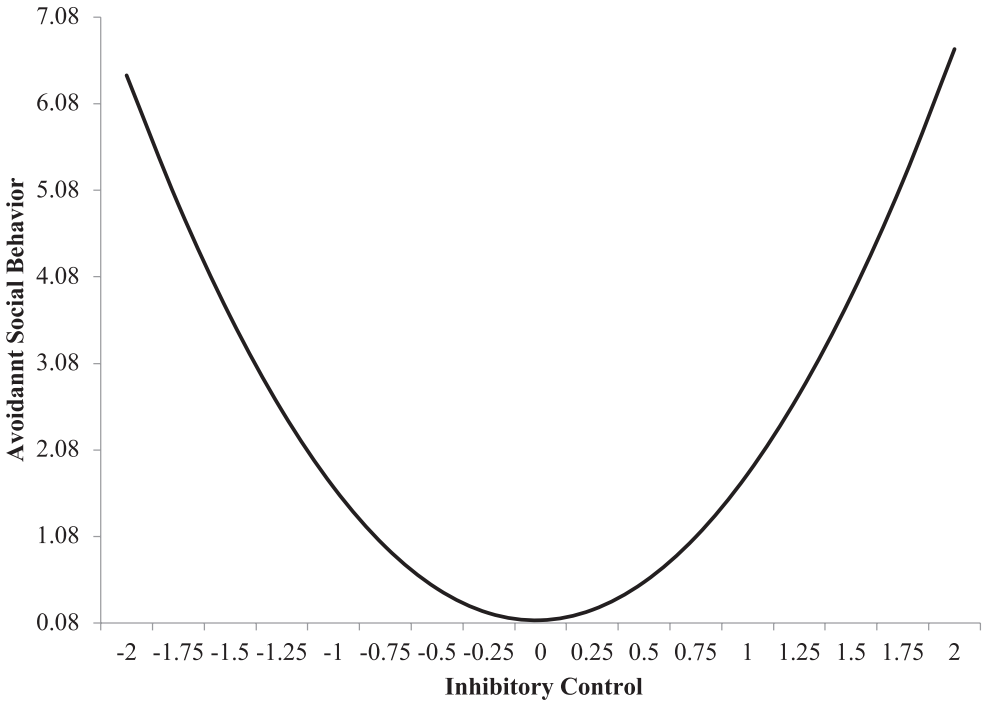

FIGURE 2 Quadratic influence of latent inhibitory control at Time 1 (M_{age} = 3.50 years) on avoidant social behavior during free play with an unfamiliar same sex peer at age 4 (M_{age} = 4.76 years)

of avoidant social behavior. To improve model fit, we constrained negative affect and unoccupied/onlooking behaviors without the mothers present to be equal. To justify the constrained model, we performed another Satorra–Bentler scaled chi-square difference test (Satorra & Bentler, 2001). We obtained a non-significant chi-square statistic, $\chi^2 = 0.18$, $df = 1$, $p = .665$, and so we retained the more parsimonious constrained model with more degrees of freedom. The first factor was freed, and the latent factor was set to 1. The CFA for avoidant social behavior demonstrated acceptable fit (RMSEA = 0, CFI = 1, SRMR = .008), and negative affect with ($B = 0.42$, $SE = 0.09$, $p < .001$) and without mothers present ($B = 0.62$, $SE = 0.12$, $p < .001$), and unoccupied/

onlooking behaviors (B = 0.15, SE = 0.04, p < .001) all loaded significantly onto the latent factor.

Influence of inhibitory control on prospective social behavior and mental health difficulties

Observed avoidant social behavior

The SEM included the linear and quadratic effects of the latent variable inhibitory control on the latent variable avoidant social behavior, controlling for sex, T1 household income, and T1 shyness (Akaike information criterion [AIC] = 1143.07, Bayesian information criteria [BIC] = 1193.35, sample size adjusted BIC = 1139.64). Both the linear (B = 0.65, SE = 0.34, p = .05) and quadratic (B = 2.52, SE = 1.12, p = .02) effects of inhibitory control were significantly related to prospective avoidant social behavior. Because the interaction (i.e., quadratic relation) is prioritized over the main effect (i.e., linear relation), we focused on interpreting the quadratic relation. Figure 2 visually depicts the nature of the U-shaped relation, and Figure 3 depicts the regions of significance. Consistent with our predictions, the relation between inhibitory control and avoidant social behavior during the dyadic interaction involving an unfamiliar peer was positive at both high and low levels of inhibitory control.

The model provided similar estimates when covariates were removed (AIC = 1151.31, BIC = 1196.75, sample size adjusted BIC = 1143.03), where both the linear (B = 0.74, SE = 0.26, p = .004) and quadratic (B = 2.07, SE = 0.26, p = .004) influence of inhibitory control were significantly related to prospective avoidant social behavior. The pattern of results also remained unchanged when we replaced the latent factor of observed social behavior with its individual indicators.

Internalizing difficulties

The second SEM included the linear and quadratic effects of the latent variable inhibitory control on internalizing difficulties, controlling for sex, T1 household income, and T1 shyness (AIC = 769.02, BIC = 806.32, sample size adjusted BIC = 762.08). The linear estimate of inhibitory control was non significantly related to internalizing difficulties (B = 0.02, SE = 0.02, p = .201) However, the quadratic (B = 0.08 SE = 0.01, p < .001) effect of inhibitory control was significantly related to prospective internalizing difficulties. Figure 4a visually depicts the nature of the U-shaped relation, and Figure 5a depicts the regions of significance. Consistent with our predictions, the relation between inhibitory control and internalizing difficulties was positive at both high and low levels of inhibitory control.

The model provided similar estimates when covariates were removed (AIC = 790.49, BIC = 819.89, sample size adjusted BIC = 785.14), where the linear estimate of inhibitory control was not significantly related to internalizing difficulties (B = 0.02, SE = 0.03, p = .489), but the quadratic influence of inhibitory control was significantly related to internalizing difficulties (B = 0.06 SE = 0.01, p < .001).

Externalizing difficulties

The third SEM included the linear and quadratic effects of the latent variable inhibitory control on externalizing difficulties, controlling for sex, T1 household

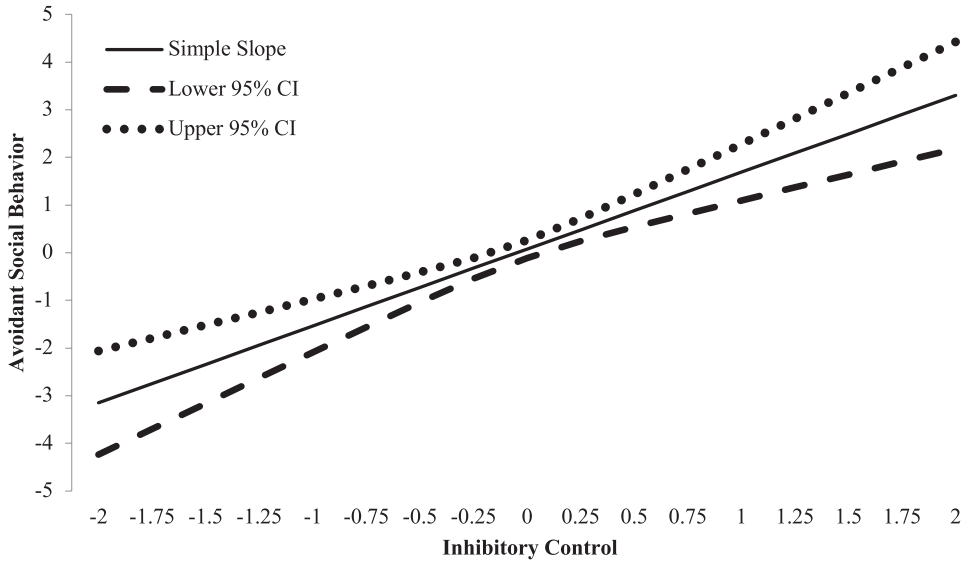

FIGURE 3 Regions of significance in the relation between latent inhibitory control at Time 1 (M_{age} = 3.50 years) and latent avoidant social behavior during free play with an unfamiliar same sex peer at Time 2 (M_{age} = 4.76 years)

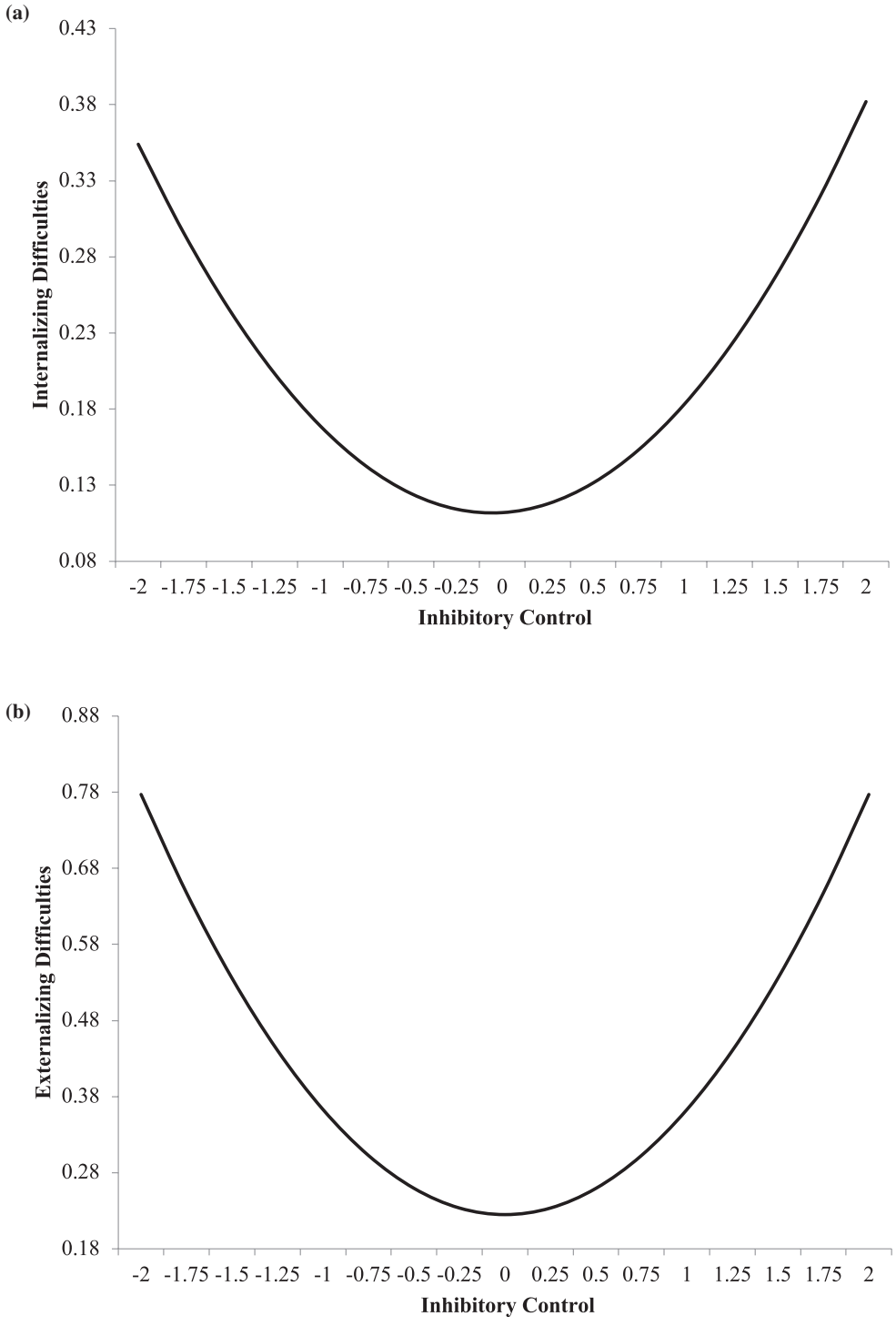

FIGURE 4 Quadratic influence of latent inhibitory control at Time 1 (M_{age} = 3.50 years) on internalizing (a) and externalizing (b) difficulties at Time 2 (M_{age} = 4.76 years)

income, and T1 shyness (AIC = 898.76, BIC = 936.05, sample size adjusted BIC = 891.92). Both the linear ($B = -0.15$, $SE = 0.38$, $p < .001$) and quadratic ($B = 0.09$ $SE = 0.02$, $p < .001$) effects of inhibitory control were significantly related to prospective externalizing difficulties. Figure 4b visually depicts the nature of the quadratic relation, and Figure 5b depicts the regions of significance. Consistent with our predictions, the relation between inhibitory control and externalizing problems was positive at both high and low levels of inhibitory control.

The model provided similar estimates when covariates were removed (AIC = 902.58, BIC = 931.99, sample size adjusted BIC = 897.23), where both the linear

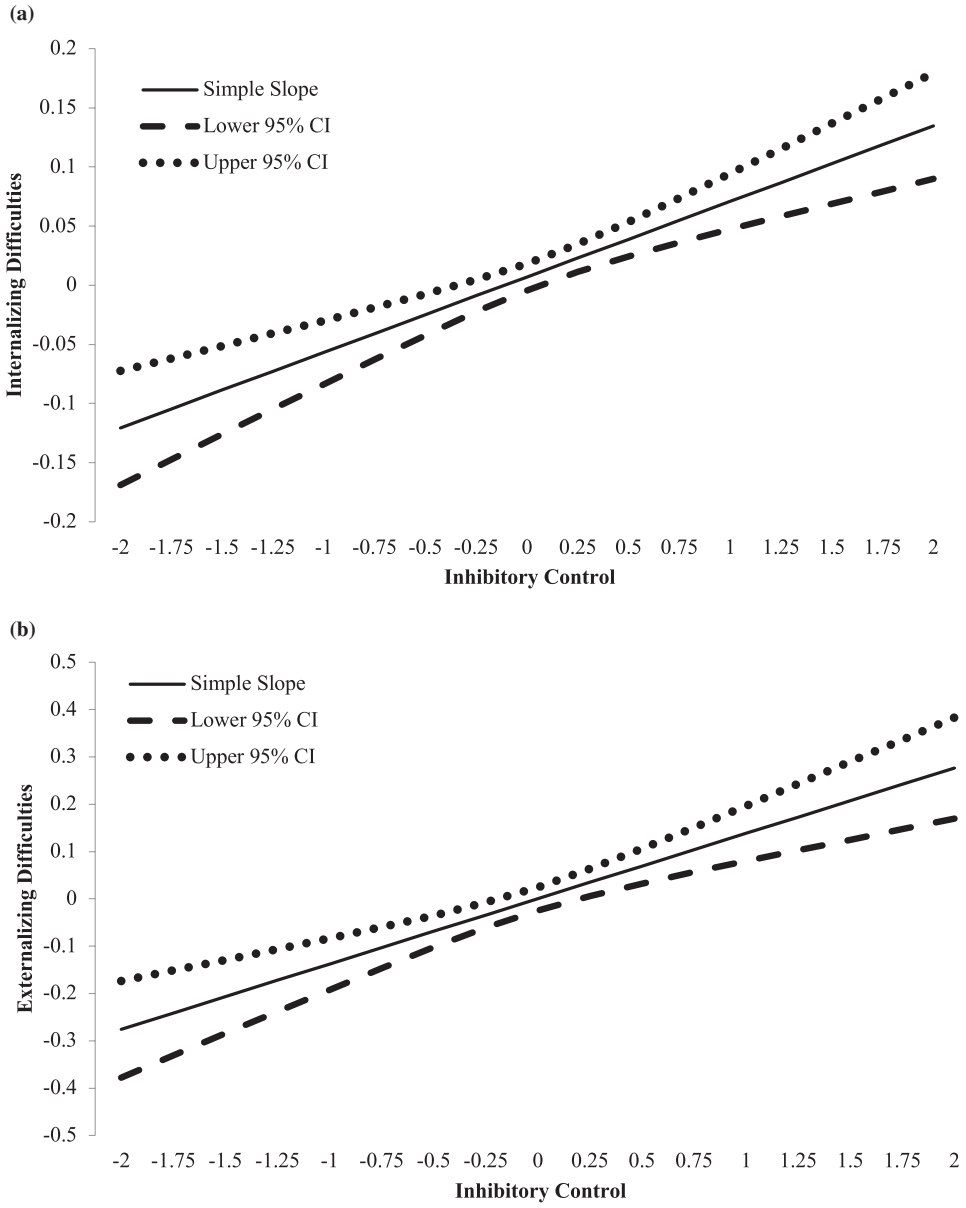

FIGURE 5 Regions of significance for the relation between latent inhibitory control at Time 1 (M_{age} = 3.50 years) and internalizing (a) and externalizing (b) difficulties at Time 2 (M_{age} = 4.76 years)

($B = -0.15$, $SE = 0.04$, $p < .001$) and quadratic ($B = 0.09$ $SE = 0.02$, $p < .001$) influence of inhibitory control were significantly related to prospective externalizing difficulties.

DISCUSSION

Using a longitudinal, multi-method approach, we examined whether inhibitory control displayed a U-shaped relation with prospective observed social behaviors with a same sex dyad and psychological difficulties as predicted by several theoretical frameworks (J. H. Block & Block, 1980; Derryberry & Rothbart, 1997; Eisenberg & Fabes, 1992; Henderson et al., 2015). We found that age 3 inhibitory control displayed a U-shaped relation with age 4 outcomes, where children with low and high inhibitory control had relatively higher levels of avoidant social behavior and mental health difficulties.

The results from the present study were in line with theoretical frameworks which have suggested both over and underregulation can have negative consequences for children (J. Block, 2002; Derryberry & Rothbart, 1997; Eisenberg & Fabes, 1992). These frameworks suggest that underregulation can be disadvantageous for children's social and psychological development because it can lead to be impulsivity, emotionally lability, and socially inappropriate behavior. Overregulation, on the other hand, may also be disadvantageous because it may lead to excessive and

unnecessary inhibition of impulses and desires, behavioral rigidity, and limited flexibility. The results from the present study support these theoretical assertions with empirical evidence, suggesting the U-shaped relation between inhibitory control and psychosocial difficulties was present across the preschool period in the context of inhibitory control, avoidant social behavior with an unfamiliar peer, and maternally reported psychological difficulties.

One notable strength of the present study was the inclusion of a free play session with an unfamiliar peer used to elicit social behaviors. To our knowledge, no study has examined the quadratic influence of inhibitory control on observed social behaviors in the peer context. Children with intermediate levels of inhibitory control appeared to engage in less prospective avoidant social behavior with an unfamiliar peer. We speculate low and high levels of inhibitory control prevent children from flexibility engaging in social interactions with their peers, potentially because of over and under control. These results have important psychosocial implications for children. While avoidant behaviors in and of themselves do not represent psychopathology, high levels of negative affect and unoccupied and onlooking behaviors have indeed been associated with more negative outcomes. For example, some studies have found associations between reticent play behaviors and higher internalizing difficulties (Degnan et al., 2014), higher negative emotionality (Coplan & Rubin, 2001), lower peer ratings of group acceptance (Hart et al., 2000), and lower social competence (Coplan et al., 2001). Children's ability to engage in positive social interactions contributes to the development of friendships (Rubin et al., 1995), and friendships are an important protective factor for children's psychological adjustment (Schmidt & Bagwell, 2007; Schwartz et al., 2000; Sette et al., 2017). Together, these studies highlight the importance of identifying factors contributing to children's engagement with a peer.

Children with intermediate levels of inhibitory control had lower prospective maternal ratings of internalizing and externalizing difficulties relative to children with low and high levels of inhibitory control. Like the relation between inhibitory control and avoidant social behaviors in the present study, the flexibility associated with intermediate inhibitory control may make children more resilient against developing mental health difficulties. Our results are particularly important considering the developmental period under investigation. Although some preschoolers' emotional and behavioral problems are transient, others are relatively stable or increase the risk for future internalizing and externalizing problems (Campbell & Ewing, 1990; Egeland et al., 1996; Fischer et al., 1984; Lavigne et al., 1998; Mesman & Koot, 2001; Rose et al., 1989), highlighting the importance of identifying early predictors of mental health difficulties in preschoolers.

An additional contribution of the present study was a multi-method, latent variable approach to self-regulation. We used behavioral, cognitive, and parent-reported indicators of inhibitory control, which we believe more accurately captures the multifaceted nature of inhibitory control than any one indicator alone. Although there is value in each of these measures independently, using multiple indicators of a multifaceted construct like inhibitory control allows for a more dynamic conceptualization of inhibitory control, moving beyond a single observation in time, and potentially reducing measurement error (Kline, 2015). Relying on behavioral, cognitive, and parent-reported indicators may, for example, account more effectively for a child who does not perform to his or her potential during the dinky toys task for reasons unrelated to underlying inhibitory control (e.g., disinterest in specific toys, sleepiness).

Strengths, limitations, and future directions

The present study had several strengths. These included a longitudinal design during a developmentally sensitive period for self-regulation (Dennis et al., 2007; Geeraerts et al., 2021; Klenberg et al., 2001; Kochanska et al., 1996; Schoemaker et al., 2014; Williams et al., 1999), the adoption of a latent variable approach to inhibitory control and social behavior, directly observed children's social behavior during dyadic peer interactions, and the examination of linear and non-linear effects.

The present study also had several limitations that warrant discussion. First, the number of participants lost to follow up in the present study was relatively high, which was partially accounted for by the difficulties associated with aligning the schedules of two families so that their children could be paired in same sex dyads who had been previously tested at T1. It is important to note, however, that missingness was not associated with any of the T1 variables of interest or sociodemographic information and the patterns of missing data did not violate the assumption that data were MCAR. As well, we used imputation techniques that should theoretically lead to less biased estimates than listwise deletion (Schafer & Graham, 2002).

Another important consideration in the present study was the free play context used to elicit social behaviors. Although the inclusion of two children and free play instructions may have some characteristics in common with how children behave in naturalistic settings, the laboratory context includes some demand characteristics that prevent us from generalizing to how children behave with their peers outside of the laboratory. However, the laboratory also has important benefits over a more naturalistic setting including greater environmental control and protocol standardization.

Related to generalizability, our sample was low risk and from the community, primarily White, and the mean household income was relatively high. Although we controlled for household income as a proxy for

socioeconomic status in the present study, because the mean household income was relatively high, it is possible that we simply did not have enough low-income families to fully account for the impact of household income. Consequently, our results might not be generalizable to children from more socioeconomically disadvantaged homes and ethnically diverse backgrounds.

Related to issues of measurement, the raw correlations between different facets of inhibitory control were significant but relatively weak. This is not surprising, because the unique sources of noise unrelated to inhibitory control are likely captured by each measurement modality. For example, scores on the dinky toys task may be influenced by the attractiveness of the toys to the child; Flanker percentiles may be impacted by the child's sleepiness; and parental reports of inhibitory control may be influenced by the temperament of the target child's siblings due to comparisons parents may make between children. Thus, correlations will be likely lower across modalities versus within modalities. For example, a correlation between different parental reports of inhibitory control will be likely higher than a correlation between a parent report and behavioral index of inhibitory control, because of the shared noise and measurement error within the parent reports. We believe the added benefit of using various indices capturing a more fulsome account of inhibitory control, accounting for measurement error using a latent variable, and excellent model fit outweighs the downside of relatively low correlations between and among the three inhibitory control indicators.

It is also important to note that there have been concerns raised recently about the use of regions of significance test to interpret a curvilinear relation because regions of significance tests may be biased in detecting a U-shaped over a linear relation (Simonsohn, 2018). A two-line approach has been suggested over a regions of significance test to probe a curvilinear relation (Simonsohn, 2018). To our knowledge, the two-line approach was not possible in the present study given the latent variable approach and so the results of the present study should be interpreted with this limitation in mind.

Although the present study was longitudinal in nature, we also cannot establish temporal precedence because inhibitory control was measured at T1, and social behavior and mental health difficulties were measured at T2. We cannot, therefore, determine that inhibitory control *leads* to avoidant social behaviors and mental health difficulties. It is possible that avoidant social behaviors and mental health difficulties were already present at T1. It is also possible that factors outside of inhibitory control and the scope of the present study may influence avoidant social behavior and mental health difficulties including parenting, temperament, and negative social experiences. Future work should consider examining repeated measures collected concurrently and prospectively.

Lastly, we used questionnaires to index children's mental health difficulties, which may be subject to more bias than clinical ratings. However, the CBCL is widely used and psychometrically sound (Achenbach & Rescorla, 2000). Within the limits of the present study, we believe the use of maternal report provides important convergent evidence with behavioral observation. Future studies should examine the curvilinear influence of inhibitory control on preschoolers' observed social behavioral and mental health difficulties in a more naturalistic setting such as the playground or school environment, using multiple measures of mental health difficulties, including teacher and child report, in a more socioeconomically and ethnically diverse sample.

CONCLUSION

We found a curvilinear relation between preschoolers' inhibitory control at age 3 and prospectively observed avoidant social behavior with an unfamiliar same sex peer and maternal reports of child mental health difficulties approximately at age 4. Children with intermediate levels of inhibitory control displayed relatively lower levels of avoidants social behaviors and mental health difficulties compared to children with relatively higher and lower levels of inhibitory control. The results from the present study support longstanding theoretical perspectives suggesting that over and under regulation may lead to socioemotional and psychological difficulties and have theoretical and practical implications to understanding socioemotional development before formal school entry.

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