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# Shyness and Inhibitory Control in Preschool Dyads: An Actor–Partner Model of Social Behavior

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The risk potentiation model of cognitive control posits that inhibitory control heightens children's risk for problematic outcomes in the context of shyness because it limits shy children's ability to engage flexibly with their environment. Although there is empirical support for the risk potentiation model, most studies have been restricted to parent report of children's outcomes and do not consider the influence of shyness and inhibitory control on other children's social behavior. In the present study, we used an actor–partner interdependence model to examine whether shyness and inhibitory control at Time 1 ($N = 105$, 52 girls, $M_{age} = 3.50$ years; 87% White; $M_{income}$ = between $75,000 and $100,000 in Canadian dollars) predicted children's own and their partner's observed social behavior with an unfamiliar peer at Time 2 ($M_{age} = 4.76$ years). When the child's own inhibitory control was high, the child's own shyness was negatively associated with their own approach behaviors but negatively associated with their partner's avoidance behaviors. However, when the child's own inhibitory control was low, the child's own shyness was unrelated to their own approach behaviors but positively associated with their partner's avoidance behaviors. Although inhibitory control was negatively associated with approach-related behavior for some shy children, this did not translate to more avoidance from the social partner. These results highlight the importance of examining the child's own behavior in addition to their partner's behavior when considering children's socioemotional development.

***Public Significance Statement***
During a free play interaction with an unfamiliar peer, shyness was negatively associated with the child's own approach behavior and the social partner's avoidance behavior when the child's own inhibitory control was high. In contrast to positive social perceptions of self-control, these results provide support for the growing notion that inhibitory control may only be beneficial for children under certain conditions. These results also highlight the dynamic nature of children's social interactions.

*Keywords:* shyness, inhibitory control, actor–partner independence model, social behavior, preschoolers

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Temperamental shyness refers to a tendency toward fear, inhibition, and avoidance in the face of social novelty (Kagan et al., 1988; Karevold et al., 2012; Sanson, 1996). Perhaps because of the ubiquity of shyness and its negative perceptions (Zimbardo, 1977), several studies have examined the social and interpersonal consequences of shyness across childhood. For example, in the context of a stranger approach task, shyness was associated with a high and steeply increasing trajectory of observed avoidance in preschool-aged children (Hassan & Schmidt, 2021) and displayed a curvilinear relation with gaze, where higher levels of shyness were associated with both low levels of gaze aversion (i.e., attentional vigilance) and high levels of gaze aversion (i.e., attentional

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avoidance) in 7–8-year-old children (Poole & Schmidt, 2021). Shyness has also been positively associated with reticent social behaviors in preschool-aged children (Coplan et al., 2001; Hane et al., 2008; Sette et al., 2022). Beyond nonverbal displays of avoidance, shy children also speak less in unfamiliar social situations (Asendorpf & Meier, 1993; Crozier & Perkins, 2002).

Higher levels of observed avoidance may also manifest in differences in shy children's social relationships. For example, in one study, shyness was positively associated with peer difficulties in school-aged children (Coplan et al., 2008), but another study failed to find a direct relation between shyness and peers' responses during childhood (Fordham & Stevenson-Hinde, 1999). Although these studies suggest shyness is associated with differences in observed social behavior and interpersonal relationships, not all shy children go on to develop social difficulties, so it is important to examine moderating factors that might help explain the heterogeneity in shy children's outcomes. Self-regulation may act as one such moderator.

## The Risk Potentiation Model of Control

Self-regulation broadly encompasses the affective, behavioral, cognitive, and physiological processes which function to modulate reactivity and support goal-directed behavior (McClelland et al., 2010; Rothbart & Bates, 2006). Typically, self-regulation is conceptualized as a helpful quality in childhood because it is positively associated with adaptive social (Eisenberg, Valiente, & Eggum, 2010; Wilson, 2003), academic (Graziano et al., 2007; Ponitz et al., 2009), and psychological (Eisenberg et al., 2009; Eisenberg, Valiente, & Eggum, 2010) adjustment. However, the risk potentiation model of control posits that some components of self-regulation may be maladaptive depending on individual differences in temperament (Henderson et al., 2015; Henderson & Wilson, 2017).

The risk potentiation model of control suggests that inhibitory control acts as a risk factor for temperamentally reactive children (Henderson et al., 2015; Henderson & Wilson, 2017). Inhibitory control refers to the ability to inhibit a dominant, easily accessible behavior in favor of a less dominant, less easily accessible behavior to achieve goals, and is one of three components of effortful control during the preschool period (Rothbart & Bates, 2006; Rothbart et al., 2001).

Henderson and her colleagues (Henderson et al., 2015; Henderson & Wilson, 2017) argue that children with temperamental styles characterized by novelty sensitivity (i.e., shyness) are marked by a reactive default mode of processing because they have a developmental history of automatically orienting toward perceived threat. To help regulate the negative emotions brought on by consistently orientating toward the perceived threat, controlled processing is frequently recruited (see Henderson et al., 2015, for a review of the controlled processing network). This functions to potentiate the fear already present. The combination of frequently activating both reactive and controlled modes of processing presumably creates a positive feedback loop where children with higher levels of reactive temperaments and inhibitory control may spend more time monitoring their environment and perceive higher levels of threat in benign social situations. Over-monitoring may lead to overregulated behavioral responses and negative cognitive perceptions, limiting children's ability to engage flexibly with their environment.

There has been empirical support for the risk potentiation model of control across childhood using different predictors, including behavioral inhibition, social fear, and shyness. Before reviewing the extant literature, it is important to highlight that theoretical accounts of the origins of shyness typically propose that shyness is rooted in early behavioral inhibition, which is characterized by fear of novelty in both nonsocial and social contexts (Fox et al., 2001; Kagan, 1999; Kagan et al., 1984). Like shyness, social fear refers to behavioral manifestations of fear in social contexts (Brooker et al., 2016; Walker et al., 2015). In addition to behavioral inhibition, other temperamental styles or behavioral/affective descriptions that share some conceptual overlap with shyness include dysregulated fear (Buss, 2011; Buss et al., 2013), fearful temperament (Morales et al., 2015), temperamental reactivity (Rothbart & Bates, 2006), social reticence (Asendorpf, 1990; Coplan et al., 1994), social withdrawal (Hane et al., 2008), and anxious solitude (Gazelle & Ladd, 2003). Most of the extant literature supporting the risk potentiation model of control has used behavioral inhibition as an index of reactive temperament.

In two studies, behavioral inhibition was only positively associated with symptoms of prospective social (Thorell et al., 2004) and general (White et al., 2011) anxiety when inhibitory control was relatively high during early childhood. Here, inhibitory control was indexed using cognitive laboratory tasks. A different study using a longitudinal index of inhibitory control operationalized as go/nogo task performance measured at 5, 7, and 10 years found that behavioral inhibition in toddlerhood was only positively associated with prospective symptoms of social anxiety at 12 years at a steep or moderately steep slope of inhibitory control performance (Troller-Renfree et al., 2019). Other studies have since used a longitudinal design and found that behavioral inhibition measured in toddlerhood was only associated with higher levels of prospective social reticence (Lamm et al., 2014) and higher social withdrawal and lower assertiveness at age 7 (Lahat et al., 2014) at relatively higher levels of the N2 amplitude (i.e., a neural correlate of cognitive control) in response to incongruent trials during a cognitive task.

Studies using social fear and negative emotionality provide converging evidence. For example, social fear was only positively associated with prospective anxious behaviors with peers at age 5 at relatively high levels of inhibitory control measured at age 2 (Brooker et al., 2016). Similarly, negative emotionality during the preschool period was only positively associated with prospective internalizing difficulties when children's percentile on a cognitive index of inhibitory control was relatively high (Rodrigues et al., 2022). Together, this collection of studies provides support for the risk potentiation model of control when conceptualizing reactive temperament as behavioral inhibition, social fear, or negative emotionality, and controlled cognitive processes as either inhibitory control or a neural correlate of cognitive control.

Studies focusing more specifically on shyness are largely in line with those using measures of behavioral inhibition, social fear, and negative emotionality. For example, shyness was negatively associated with parent-reported prosocial behaviors and popularity at high levels of parent-reported inhibitory control and positively associated with teacher-reported regulated school behaviors at low levels of inhibitory control in a sample of Italian preschoolers (Sette et al., 2018). A different cross-sectional study of 9–13-year-old children found that at relatively high levels of the N2 amplitude in response to incongruent trials during a cognitive task, shyness was associated with a negative attributional style, lower self-perceived peer acceptance, and symptoms of social anxiety (Henderson, 2010). Similarly, a more recent study conducted during early childhood

found when children exhibited relatively large baseline-to-task decreases in electroencephalogram theta/beta ratio from baseline to a social stressor, presumably indicative of high neurocognitive control, shyness was cross-sectionally related to trait and state social anxiety (Poole et al., 2021).

In a different recent cross-sectional study, preschoolers were observed during a model-building task that included either a familiar (i.e., with their mother) or unfamiliar (i.e., with a novel adult female) social partner (Hassan & Schmidt, 2023). In the unfamiliar context, shyness was only negatively associated with social support seeking at relatively low levels of inhibitory control, supporting the risk potential model of control. In the familiar context, however, shyness was only positively associated with social support seeking at relatively high levels of inhibitory control. The results from Hassan and Schmidt (2023) provide further support for the risk potentiation model of control and suggest contextual factors such as familiarity may influence these relations. It is important to note, however, that a different study using a sample of preschoolers failed to find that maternal report of inhibitory control moderated the association between shyness and observed social behavior in the laboratory (Hassan et al., 2020), which may be due to observed versus parent-reported inhibitory control and parent-reported versus observed social behavior.

Although the risk potentiation model was originally developed to explain the behavior of children who had an early developmental history of behavioral inhibition (Henderson et al., 2015; Henderson & Wilson, 2017), the studies which have provided support for the model have used samples of children selected for reactivity (Lahat et al., 2014; Lamm et al., 2014; Troller-Renfree et al., 2019; White et al., 2011), and unselected samples of children (Brooker et al., 2016; Hassan & Schmidt, 2023; Henderson, 2010; Poole et al., 2021; Rodrigues et al., 2022; Thorell et al., 2004). This suggests that the risk potentiation model of control can be used to make predictions about children's behavior in a normative and nonnormative, reactive sample of children. Together, these studies suggest that inhibitory control may increase the risk for psychosocial difficulties across childhood in the context of temperamental styles marked by reactive modes of responding, such as shyness.

## Gaps in the Extant Literature

There are several important limitations worth highlighting in the extant literature evaluating the risk potentiation model of control. First, most previous work relies on parent or teacher report of psychosocial outcomes rather than structured observed behavior (Henderson, 2010; Poole et al., 2021; Rodrigues et al., 2022; Thorell et al., 2004; Troller-Renfree et al., 2019; White et al., 2011) or direct observation of social behavior with adults rather than peers as social partners (Hassan et al., 2020; Hassan & Schmidt, 2023). Direct observation of social behavior, particularly with peers, is important to consider because the risk potentiation model of control suggests that one consequence of high levels of shyness and inhibitory control is restricted and nonflexible social behavior (Henderson et al., 2015; Henderson & Wilson, 2017). Further, parent report may not accurately align with children's social behavior in the real world (e.g., with peers at preschool).

A second gap is a lack of considering how shyness and inhibitory control influence the child's own behavior (i.e., actor effects) as well as their partner's social behavior (i.e., partner effects). An actor–partner independence model (APIM) allows for a focus on the dyad rather than the individual child as the unit of analysis and provides estimates of how variables of interest influence the child's own and the partner's behavior while accounting for dyadic interdependence (Cook & Kenny, 2005). While the extant literature does suggest that shyness and related constructs are negatively related to a child's own approach-related behaviors and positively related to the child's own levels of anxiety and avoidance-related behaviors (i.e., actor effects; Henderson, 2010; Lahat et al., 2014; Lamm et al., 2014; Poole et al., 2021; Rodrigues et al., 2022; Thorell et al., 2004; Troller-Renfree et al., 2019; White et al., 2011), it remains unclear if a child's shyness and inhibitory control influence their partner's social behavior (i.e., partner effect). One study did include a measure of coded social behavior in the presence of an unfamiliar peer, but only actor effects were included in the reported analyses (Lamm et al., 2014).

To our knowledge, only two previous studies have examined the influence of fearful temperament on actor and partner effects of social behavior. In a study where 39-month-old children were paired with an unfamiliar same-gender peer, children's parent-reported social fearfulness was negatively related to their own observed assertiveness, but not to their social partner's assertiveness (McElwain et al., 2014). In a more recent similarly designed study where children were paired with an unfamiliar same-gender peer, parent report of social fear at 24 months was negatively related to the child's own and their partner's social engagement, positively related to the child's own social wariness, and positively related to the partner's observed dysregulation at 36 months (Walker et al., 2015). Here, there is at least preliminary evidence suggesting that temperamental factors related to shyness are associated with differences in actor and partner effects on social behavior, but it remains unclear whether inhibitory control moderates these relations. If relatively high levels of shyness and inhibitory control are related to a target child's own inflexible behaviors, does this combination also influence the partner's social behavior in the same direction, or does the social partner adjust their behavior to compensate for the child's inflexibility?

## The Present Study

Using an APIM (Cook & Kenny, 2005), we examined whether inhibitory control at age 3 moderated the relation between shyness at age 3 and the child's own and their social partner's observed social approach and avoidance behaviors with an unfamiliar peer approximately 1.5 years later. We focused on preschoolers because of the increases in self-regulatory processes that are occurring during this period (Dennis et al., 2007; Geeraerts et al., 2021; Klenberg et al., 2001; Kochanska et al., 1996; Schoemaker et al., 2014; Williams et al., 1999) before formal school entry and to increase comparability with other studies examining the moderating role of inhibitory control on the relation between shyness or related constructs and psychosocial outcomes (Brooker et al., 2016; Hassan et al., 2020; Rodrigues et al., 2022; Sette et al., 2018; Thorell et al., 2004; White et al., 2011). We also focused on broad measures of social approach and social avoidance in the present study to mirror earlier work (Walker et al., 2015).

In line with previous studies (Brooker et al., 2016; Henderson, 2010; Lahat et al., 2014; Lamm et al., 2014; Rodrigues et al., 2022; Sette et al., 2018; Thorell et al., 2004; Troller-Renfree et al., 2019; White et al., 2011), we predicted that shyness would be positively related to the child's own social avoidance and negatively

related to social approach at relatively high levels of inhibitory control (i.e., actor effect). As such, this APIM was confirmatory. We did not make specific predictions about partner effects because, to our knowledge, no previous studies have examined the influence of the child's own shyness and inhibitory control on their social partner's observed behavior. As such, this APIM was exploratory.

# 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 parents who were recruited from the Child Database in the Department of Psychology, Neuroscience and Behaviour at McMaster University in Southern Ontario, Canada. This database contains the names and contact information of parents of healthy, full-term newborn infants recruited from hospitals across the greater Hamilton metropolitan area who agreed to be contacted in the future to participate in 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. Participants and procedures were identical to those used in a recent article examining the curvilinear relation between inhibitory control, mental health difficulties, and social behavior and will be described in the same way for consistency (Hassan & Schmidt, 2022).

## 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 parents visited the Child Emotion Laboratory at McMaster University at Time 1 (T1) when the children were 3 years old. At T1, the child, parent, and one female experimenter began in a room together. While the child played with a puzzle, the experimenter explained the study procedures to the parent. Once the child was acclimated to the laboratory room, the parent went into a separate room in the laboratory to complete a series of questionnaires. The parent could view the child on a closed-circuit computer monitor in the separate laboratory room while the child completed tasks. The child completed a Flanker task on an iPad from the National Institutes of Health (NIH) Toolbox Cognitive Battery for preschool-aged children (Zelazo et al., 2013) followed by a dinky toys task (Goldsmith et al., 1995).

Parents 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 gender and unfamiliar child who had also participated in the T1 visit ($M_{age}$ at T2 = 4.76 years, $SD_{age}$ = 0.38 years). The dyad met for the first time in the playroom and proceeded to engage in play activities. The parent was present for the first portion of the play activities, then left the room to complete a series of questionnaires. All families were provided with small toys, Junior Scientist certificates, and $30 gift cards as tokens of appreciation for their participation. Parents provided written permission for their children to participate and consented to participate themselves and children provided verbal assent for both visits. All procedures were approved by the McMaster Research Ethics Board (Title: Private Speech and Physiological Measures of Self-Regulation, Protocol: 2052).

## Measures

### *Shyness (T1)*

**Parent Report.** Parents completed the Children's Behavior Questionnaire (CBQ), which is a parent-rated questionnaire evaluating 3–7-year-old children's temperament. Of particular interest to the present study was the six-item shyness subscale from the CBQ. Statements were rated by parents on a scale ranging from 1 (*never*) to 7 (*always*). A sample item from this scale includes "Acts shy around new people." The shyness subscale demonstrated good internal consistency ($\alpha = .89$).

### *Inhibitory Control (T1)*

**Parent Report.** Parents reported on their child's inhibitory control on the CBQ (Rothbart et al., 2001). 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." The scale exhibited strong internal consistency ($\alpha = .82$).

**Dinky Toys Task.** This task is a measure of inhibitory control that was adapted from a previous study (Kochanska et al., 1996) and the preschool laboratory temperament assessment battery (Goldsmith et al., 1995). During this task, the experimenter and child were seated cross-legged across from each other on the floor. The child was presented with a box of attractive toys and told to indicate using their words which they would like while keeping their hands on their lap. Once the experimenter slid the box over to the child, she gave the child up to two reminders to keep their hands on their lap before the child either told the researcher what toy they wanted or grabbed the toy. This task was repeated once more for reliability purposes and children's performance was averaged across the two trials. The child was allowed to switch the toy at the end of the task if they wished.

Children's behavior was subsequently coded from videos by independent coders on a 0–5-point scale (Kochanska et al., 1996). A 0 represented the child grabbing a toy out of the container, a 1 represented the child touching the toys in the container, but not taking one out, a 2 represented the child pointing to the toys, a 3 represented the child removing their hands from the lap, a 4 represented the child's hands twitching or moving, but not leaving the lap, and a 5 represented the child not moving their hands from the lap at all during the task. Children displayed the full range of behaviors from 0 to 5, $M$ ($SD$) = 1.77 (1.79). The independent coders obtained good reliability on 15% of the total videos (ICC = .98).

**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, children were first presented with a row of fish and were 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. The Flanker task consisted of four teaching trials using fish as stimuli where two were congruent and two were incongruent, 25 trials using fish as stimuli where 16 were congruent and nine were incongruent, and 25 trials using arrows as stimuli where 16 were congruent and nine were incongruent. During the practice

trials, children had to correctly respond to three out of four trials to move to the fish testing trials. If they failed to meet this criterion, they were exposed to a maximum of three more practice trials, and testing was terminated if they did not meet the passing criteria during any of those practice trials. Of the 105 children, 18 failed to pass the teaching trials and therefore had missing data for the Flanker task. If the children responded correctly to five out of the nine incongruent trials using fish as stimuli, they advanced to the final testing phase where arrows were used instead of fish. Scores were automatically computed by the NIH Toolbox using a two-vector system incorporating accuracy and reaction time for those who were accurate ≥80% of the time. The scoring system is described in more detail elsewhere (Zelazo et al., 2013). Age-corrected percentiles computed by the NIH Toolbox were used for ease of interpretation where higher scores were indicative of relatively higher accuracy and speed compared to demographically matched peers.

**Composite Measure.** A composite measure of inhibitory control was derived that included CBQ maternal report of inhibitory control, coded behavior from the dinky toys task, and cognitive performance on the Flanker task. All three variables were significantly, positively correlated ($rs > .17$, $ps < .045$), so scores for all three measures were *z*-scored and a mean was computed. To reduce data loss and because the measures of inhibitory control were positively related, a mean was computed if children had scores on two out of three inhibitory control indicators. Higher values on this composite represented relatively higher levels of inhibitory control.

### *Observed Dyadic Social Behavior (T2)*

Children's approach and avoidance behaviors were observed in a free play context with an unfamiliar peer with the parent present and separately without the parent present. During these interactions, the research assistant 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. After 10 min, the research assistant returned to the room and told the children it was time for their next activity. Children's social behavior was unobtrusively digitally recorded and was subsequently coded by independent research assistants, and behavioral codes were adapted from the Play Observation Scale (Rubin, 2001). 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.

**Approach Behaviors.** Children's positive affect and prosocial acts/cooperation behaviors were coded every 10 s. Positive affect in both the free play session with and without the parents was based on facial (e.g., upturned lips, smiling), verbal (e.g., giggling, singing), and behavioral displays (e.g., skipping, dancing) 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*). Prosocial acts/cooperation were defined as positive and friendly actions that demonstrated one child understood or recognized the needs or intentions of the other child. Prosocial acts/cooperation included sharing, helping, comforting, giving, and cooperating and were coded on a scale of 1 (*none displayed*) to 4 (*three or more instances of the behavior occur, one or two behaviors occur, but they last for 5 or more seconds*) with the parent. Although prosocial acts/cooperation were also coded without the parent present, that variable was not significantly correlated with the other measures of positive affect and prosocial acts/cooperation with the parent ($ps = .076$ to $.807$), and so it was not included in the composite. Positive affect with (ICC = .81) and without the parent (ICC = .77) and prosocial acts/cooperation with the parent (ICC = .64) exhibited acceptable to good interrater reliability. All variables were either marginally or significantly related ($rs = .25$ to $.58$, $ps = .057$ to $<.001$), so scores were *z*-scored and a mean was computed. Higher values on this composite represented relatively higher levels of approach behavior.

**Avoidance Behaviors.** 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 parents 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*). Negative affect included displays of sadness rather than frustration and anger. 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 parents present, the instance was very low when the parents were present. As such, we focused only on unoccupied/onlooking behavior in the free play session without the parents present. Negative affect with (ICC = .76) and without the parent (ICC = .74) and unoccupied/onlooking without the parent (ICC = .75) exhibited acceptable interrater reliability. All variables were significantly correlated ($rs > .30$, $ps < .024$), so scores were *z*-scored and a mean was computed. Higher values on this composite represented relatively higher levels of avoidant behavior.

## Missing Data and Loss to Follow-Up

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 gender for the dyadic portion, of the 105 children at T1, 62 children returned for their T2 dyad visit. Two children at T2 were matched with a same-gender, 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, 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 $n = 71$. Of the 105 at T1, two were missing maternal report of shyness data because of refusal to participate.

The children who did not complete the T2 dyadic portion did not differ from those children that did based on age, $t(104) = 0.40$, $p = .693$, gender, $\chi^2(1, N = 105) = 1.01$, $p = .31$, household income, $t(98) = -0.48$, $p = .629$, Flanker percentile, $t(86) = -0.23$, $p = .824$, dinky toys coded behavior, $t(101) = -0.40$, $p = .693$, maternal report of inhibitory control, $t(102) = -0.42$, $p = .967$, or maternal report of shyness, $t(102) = 0.41$, $p = .682$.

Little's Test of Missing Completely at Random (MCAR) was not significant, $\chi^2(20) = 14.36$, $p = .811$, suggesting that patterns of missing data did not violate the assumption that data were MCAR. To leverage the full sample ($N = 105$), children who did not return for the second visit were given a dyad pairing value with a member of the same gender who also did not attend their T2 visit. Then, full information maximum likelihood (FIML) was used to account for missing data in the APIMs presented below. This approach uses all available raw data to simultaneously account for all of the missing data and estimates model parameters and standard errors, thus avoiding the biased parameter estimates that can occur with pairwise or listwise deletion (Schafer & Graham, 2002).

## Statistical Analyses

To examine the influence of a child's own shyness and inhibitory control at T1 on their own and their partner's approach and avoidant social behavior at T2, we used an APIM (Cook & Kenny, 2005) to account for conceptual and statistical interdependence.

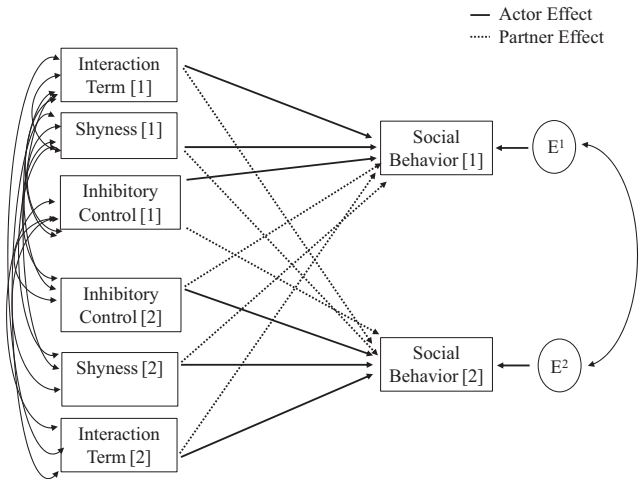
Sample size was justified using a power analysis in G*Power for linear regression (Faul et al., 2007). Although no study has examined the interaction between shyness and inhibitory control on children's observed social behavior using an APIM, we used the average effect size ($f^2 = 0.40$) from three previous studies that examined the moderating role of self-regulation in the relation between shyness and socioemotional outcomes and that reported effect sizes using nondyadic data (Henderson, 2010; Poole et al., 2021; Sette et al., 2018) to inform the power analysis. This power analysis revealed that for our objective of examining the two-way interaction between shyness and inhibitory control in predicting social behavior, we would require a minimum sample size of 35 participants (power = 0.80, $\alpha = .05$). However, the results should be interpreted with caution because G*Power does not provide estimates of power for dyadic analyses, which require more participants than nondyadic analyses.

Dyadic influence was modeled in Mplus Version 8 using two separate APIMs. Good and acceptable model fit to data were determined through several indices, including root-mean-square error of approximation (RMSEA) $\leq .060$ and $\leq .080$, comparative fit index (CFI) and Tucker–Lewis index (TLI) of $\geq .950$ and $\geq .900$, and standardized root-mean-square residual (SRMR) $\leq .050$ and $\leq .080$ (Browne & Cudeck, 1992; Hooper et al., 2008; Hu & Bentler, 1999; Kline, 2015).

In the present study, members of the dyads were considered conceptually indistinguishable because each member of the dyad was a part of a same-gender pair (Cook & Kenny, 2005; Walker et al., 2015). When dyad members are considered indistinguishable in a structural equation model, means and variances of actor and partner variables; actor–actor and partner–partner paths, and actor–partner and partner–actor paths are constrained to be equal (DeLay et al., 2021; Kenny et al., 2006; Olsen & Kenny, 2006). To confirm distinguishability statistically, we performed a Bryant–Satorra scaled difference chi-square test to compare the fit of a constrained model (for indistinguishable dyads) and a freely estimated model (for distinguishable dyads; Bryant & Satorra, 2012). We obtained a nonsignificant chi-square statistic for the approach, $\chi^2(18) = .007$, $p = 1.00$, and avoidance, $\chi^2(18) = .005$, $p = 1.00$, model, so we retained the more parsimonious constrained models (i.e., for indistinguishable dyads) with more degrees of freedom. Children were therefore included as both actors and partners in a pairwise data set.

**Figure 1**

*Conceptual Illustration of the APIM of Children's Shyness, Inhibitory Control, and Their Interaction at Time 1 ($M_{age}$ = 3.50 Years) Predicting Observed Social Behavior at Time 2 ($M_{age}$ = 4.76 Years)*




*Note.* Gender and household income were not depicted in the presented model for clarity but were included in the model. [1] = Child 1; [2] = Child 2; E = error residuals; APIM = actor–partner interdependence model.

Predictors were the partner and the actor's shyness, inhibitory control, and the interaction between shyness and inhibitory control. Predictors were centered at their mean before creating interaction terms. Given the many paths modeled in a moderated APIM, guidelines suggest only including theoretically meaningful interaction terms (Garcia et al., 2015). This also allows for the conservation of power given a limited sample size. Because the risk potentiation model of control focuses on the interaction between shyness and inhibitory control within individuals, we only included the actor's shyness by the actor's inhibitory control, and the partner's shyness by the partner's inhibitory control, as interaction terms in the two APIMs. We have included the two APIMs with all four possible interaction terms for completeness in the online supplemental materials. However, these results should be interpreted with caution given limited sample size. To further account for our limited sample size given the many paths modeled in an APIM, we also elected to use an observed rather than latent variables of inhibitory control, approach, and avoidance behaviors.

Because the dyads were indistinguishable, there were two possible interaction effects: actor's shyness by actor's inhibitory control and partner's shyness by partner's inhibitory control. The outcome was observed approach or avoidance-related behavior in the dyadic free play sessions. Figure 1 provides a visual representation of this theoretical model. Data that support the results reported in this article are available upon request. This study was not preregistered.

# Results

## Preliminary Analyses

Table 1 includes the means, standard deviations, and intercorrelations among study variables. Although gender was not related to mean level differences in shyness, observed approach, or observed

**Table 1**
*Intercorrelations, Means, and Ranges for All Study Variables*

| Variable | 2 | 3 | 4 | *M* (*SD*) | Range |
|---|---|---|---|---|---|
| 1. Shyness (T1) | −.07 | −.01 | −.08 | 3.51 (1.26) | 1 to 6.67 |
| 2. Inhibitory control (T1) | — | −.17 | .11 | −0.02 (0.69) | −1.75 to 1.71 |
| 3. Approach behavior (T2) | | — | −.05 | 0.06 (2.34) | −3.28 to 6.72 |
| 4. Avoidance behavior (T2) | | | — | −0.06 (2.52) | −2.65 to 9.08 |

*Note.* T1 = Time 1; T2 = Time 2.

avoidance ($ps \geq .126$), gender was associated with mean differences in inhibitory control, $t(101) = 1.59$, $p = .021$, where girls ($M = 0.13$, $SD = 0.73$) displayed significantly higher inhibitory control than boys ($M = -0.18$, $SD = 0.62$). Household income was only marginally related to inhibitory control ($r = .17$, $p = .094$), and unrelated to shyness, observed approach, or observed avoidance ($ps \geq .201$). Following a previous article published with the same data set examining a separate question related to inhibitory control (Hassan & Schmidt, 2022), we elected to control for gender and household income in the following analyses.

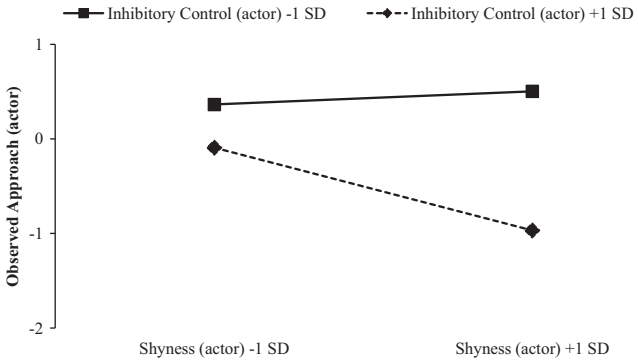
## APIM Analyses

### *Observed Approach*

The APIM including observed approach demonstrated good fit, $\chi^2(23) = 2.68$, $p = 1.00$, RMSEA = 0, CFI = 1, TLI = 1, SRMR = 0.03. All estimates presented controlled for gender and household income. The interaction between actor shyness and actor inhibitory control was a significant predictor of the actor's observed approach ($B = -0.30$, $SE = 0.15$, $p = .047$; Figure 2). Table 2 depicts the parameter estimates for the complete APIM.[1]

To decompose the interaction between shyness and inhibitory control, we conducted a simple slopes analysis where we examined the relation between the actor's shyness and the actor's observed approach at high (one standard deviation above the mean) and low (one standard deviation below the mean) values of the actor's inhibitory control (Dawson & Richter, 2006). At low values of the actor's inhibitory control, the child's own shyness was not significantly associated with their own observed approach behavior ($B = 0.06$, $SE = 0.19$, $p = .767$). At high values of the actor's inhibitory control, the child's own shyness was negatively associated with their own observed approach behavior ($B = -0.35$, $SE = 0.15$, $p = .017$). At average values of the actor's inhibitory control, the child's own shyness was not associated with the actor's observed approach behavior ($B = -0.15$, $SE = 0.13$, $p = .267$).

**Figure 2**
*Actor–Partner Interdependence Model Depicting the Influence of Children's Shyness, Inhibitory Control, and Their Interaction at Time 1 ($M_{age} = 3.50$ Years) on Actor's Observed Approach Behaviors During a Dyadic Free Play Session at Time 2 ($M_{age} = 4.76$ Years)*




### *Observed Avoidance*

The APIM including observed avoidance demonstrated good fit, $\chi^2(23) = 2.5$, $p = 1.00$, RMSEA = 0, CFI = 1, TLI = 1, SRMR = .03. All estimates presented controlled for gender and household income. The interaction between actor's shyness and actor's inhibitory control was a significant predictor of the partner's observed avoidance ($B = -0.80$, $SE = 0.26$, $p = .002$; Figure 3). Table 3 depicts the parameter estimates for the complete APIM.[2]

To decompose the partner effect of the interaction between shyness and inhibitory control, we conducted a simple slopes analysis where we examined the relation between the actor effect of shyness and partner's observed avoidance at high (one standard deviation above the mean) and low (one standard deviation below the mean) values of the actor effect of inhibitory control (Dawson & Richter, 2006). At low values of the actor's inhibitory control, the child's own shyness was positively associated with their partner's observed avoidance behavior ($B = 0.60$, $SE = 0.26$, $p = .021$). At high values of actor's inhibitory control, the child's own shyness was negatively associated with their partner's observed avoidance behavior ($B = -0.50$, $SE = 0.21$, $p = .019$). At mean values of the actor's inhibitory control, the child's own shyness was not associated with the partner's observed avoidance behavior ($B = 0.05$, $SE = 0.16$, $p = .749$).

## Discussion

Using an APIM and a longitudinal approach, we examined whether children's inhibitory control at age 3 moderated the relation between shyness at age 3 and observed social approach and social

[1] The main actor ($B = -0.70$, $SE = 0.25$, $p = .004$) and partner ($B = 0.75$, $SE = 0.27$, $p = .006$) effects of inhibitory control were also significant predictors of the actor's observed approach and remained significant in the same direction in a model without the interaction terms entered.

[2] The main actor effect of inhibitory control ($B = -0.61$, $SE = 0.29$, $p = .034$) was also a significant predictor partner's observed avoidance and remained significant in the same direction in a model without the interaction terms entered.

**Table 2**

*Actor–Partner Interdependence Model Depicting the Influence of Children's Shyness, Inhibitory Control, and Their Interaction at Time 1 ($M_{age} = 3.50$ Years) on Observed Approach Behaviors During a Dyadic Free Play Session at Time 2 ($M_{age} = 4.76$ Years)*

| Predictor | Unstandardized *B* (*SE*) | Standardized *B* (*SE*) | *p* |
|---|---|---|---|
| Shyness (A) | −0.15 (0.13) | −0.08 (0.07) | .267 |
| Shyness (P) | −0.16 (0.15) | −0.09 (0.08) | .305 |
| Inhibitory control (A) | −0.70 (0.25) | −0.21 (0.07) | .004 |
| Inhibitory control (P) | 0.75 (0.27) | 0.22 (0.09) | .006 |
| Shyness (A) × Inhibitory Control (A) | −0.30 (0.15) | −0.12 (0.06) | .047 |
| Shyness (P) × Inhibitory Control (P) | −0.34 (0.18) | −0.13 (0.07) | .062 |

*Note*. A = actor effect; P = partner effect.

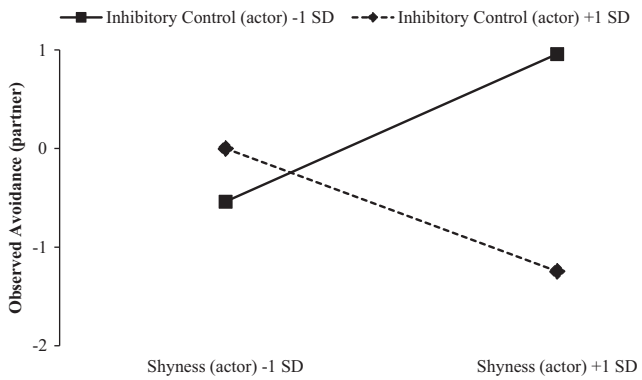


avoidance with an unfamiliar peer at age 4.5. When the actor's inhibitory control was high, the actor's shyness was negatively associated with the actor's observed approach and negatively associated with the partner's observed avoidance. When the actor's inhibitory control was low, the actor's shyness was not associated with the actor's observed approach and positively associated with the partner's observed avoidance.

The risk potentiation model of control predicts that relatively high levels of reactive temperament and inhibitory control would be related to more apprehension and less approach-related social behavior. As such, the finding that children's shyness was only negatively associated with their own observed approach behaviors with an unfamiliar peer when their own inhibitory control was relatively high was in line with predictions made by the risk potentiation model of control (Henderson et al., 2015; Henderson & Wilson, 2017). Empirically, our results are in line with previous studies suggesting that more reactive temperamental styles such as behavioral inhibition (Lahat et al., 2014; Lamm et al., 2014; Thorell et al., 2004; Troller-Renfree et al., 2019; White et al., 2011), shyness (Henderson, 2010; Poole et al., 2021; Sette et al., 2018), and negative emotionality (Rodrigues et al., 2022) are positively related to problematic emotional, social, and psychological difficulties in preschoolers, young children, and adolescents in the context of relatively high inhibitory control.

**Figure 3**

*Actor–Partner Interdependence Model Depicting the Influence of Children's Shyness, Inhibitory Control, and Their Interaction at Time 1 ($M_{age} = 3.50$ Years) on Partner's Observed Avoidance Behaviors During a Dyadic Free Play Session at Time 2 ($M_{age} = 4.76$ Years)*




Our results extend previous work by using a multifaceted measure of inhibitory control and a longitudinal design and move beyond parent reports of anxiety and social behavior to observed social behavior with an unfamiliar peer. In line with the risk potentiation model of control, we speculate that children with relatively high levels of shyness may have a developmental history of frequently and automatically orientating toward threat, and relatively high levels of inhibitory control lead to less approach-related behaviors by potentiating, rather than regulating, the social fear shy children are experiencing in unfamiliar social situations. Given that our measure of approach-related behaviors encompassed positive affect and prosociality, we speculate that the potentiation of fear may be related to higher levels of behavioral apprehension and inhibition possibly resulting in less positive affect and prosocial behaviors.

Inhibitory control is revered by parents and educators in North America. However, these results fit with the larger body of research suggesting that if a child is shy, inhibitory control may interfere with approach behaviors in a social context (Brooker et al., 2016; Hassan & Schmidt, 2023; Henderson, 2010; Lahat et al., 2014; Lamm et al., 2014; Poole et al., 2021; Rodrigues et al., 2022; Thorell et al., 2004; Troller-Renfree et al., 2019; White et al., 2011). Rather than considering inhibitory control a panacea, it may be more helpful for parents and educators to think about inhibitory control like any other individual differences factor that may be helpful in some contexts (e.g., when working on an assignment independently) or at a certain level (e.g., moderate levels of inhibitory control), and confer risk in other contexts (e.g., when combined with high levels of shyness in a social context) or at a different level (e.g., very low or very high levels of inhibitory control; Hassan & Schmidt, 2022).

We did not make specific predictions about partner effects in the present study because we know of no previous studies that have examined the risk potentiation model of control in the context of a dyadic interaction. It is reasonable to predict that a combination of high levels of reactive temperament and inhibitory control may lead to less approach and more avoidance in the social partner, given the higher levels of anxiety and lower levels of social approach observed in shy and overcontrolled children. However, it is also reasonable to predict that children may compensate behaviorally for their shy and overcontrolled social partner's rigidity and respond with more approach and less avoidance. In partial support for the latter prediction, we found that when children's inhibitory control was relatively low, children's shyness was positively related to their partner's observed avoidance behaviors, but when inhibitory control relatively high, children's shyness was negatively related to their partner's observed avoidance behaviors.

**Table 3**

*Actor–Partner Interdependence Model Depicting the Influence of Children's Shyness, Inhibitory Control, and Their Interaction at Time 1 ($M_{age} = 3.50$ Years) on Observed Avoidance Behaviors During a Dyadic Free Play Session at Time 2 ($M_{age} = 4.76$ Years)*

| Predictor | Unstandardized *B* (*SE*) | Standardized *B* (*SE*) | *p* |
|---|---|---|---|
| Shyness (A) | −0.10 (0.12) | −0.05 (0.06) | .438 |
| Shyness (P) | 0.05 (0.16) | 0.03 (0.08) | .749 |
| Inhibitory control (A) | 0.54 (0.30) | 0.15 (0.07) | .073 |
| Inhibitory control (P) | −0.61 (0.29) | −0.17 (0.09) | .034 |
| Shyness (A) × Inhibitory Control (A) | −0.42 (0.23) | −0.16 (0.08) | .068 |
| Shyness (P) × Inhibitory Control (P) | −0.80 (0.26) | −0.31 (0.08) | .002 |

*Note*. A = actor effect; P = partner effect.



The present findings are a particularly important extension of previous work because they suggest that the "negative" consequences of being highly shy and overcontrolled may be limited to the child's own behavior, and not necessarily reflected in how unfamiliar children respond to that child in a social context (Henderson et al., 2015; Henderson & Wilson, 2017). Consistent with more traditional or top-down views of regulatory processes (Henderson et al., 2015), high levels of inhibitory control may act as a protective factor against the typically negative associations observed between shyness and social outcomes (Asendorpf & Meier, 1993; Coplan et al., 2008; Crozier & Perkins, 2002; Hassan & Schmidt, 2021; Poole & Schmidt, 2021). We speculate that unfamiliar peers may compensate for the less approach-related behavioral patterns of their shy and overregulated counterparts by displaying less avoidance.

It is possible that shy and overcontrolled children are unable to benefit from the partner effects observed in the present study, as evidenced by their lower levels of approach observed and higher levels of anxiety observed in different studies (Brooker et al., 2016; Henderson, 2010; Poole et al., 2021; Rodrigues et al., 2022; Thorell et al., 2004; Troller-Renfree et al., 2019; White et al., 2011). If high levels of inhibitory control work to potentiate shy children's social fear (Henderson et al., 2015), these children may be spending more time attending to threat-related information rather than their social partner's behavior. Later, if these children ruminate or engage in postevent processing of the social interaction, they may selectively recall information that supports their negative, fear-based cognitions, thereby perpetuating their fear and apprehension in future social situations (Henderson et al., 2015; Schmitz et al., 2010; van Niekerk et al., 2017). To provide empirical support for these speculations, future studies can use a combination of eye-tracking technology during a social interaction to determine where children's attention is focused during a social interaction (Pérez-Edgar et al., 2020), and children can self-report how well they thought their social interaction went with an unfamiliar peer. The reported partner effects in the present study provide support for the dynamic nature of children's social development that depend on both the child's own characteristics and the context surrounding the child, including their peers (Wachs & Kohnstamm, 2001), and highlight the importance of examining the child's own behavior in addition to their social partner's behavior when considering children's social development.

Although not the focus of the present study, we did also find that inhibitory control was differentially associated with approach and avoidance in the actor and partner. In the actor, inhibitory control was negatively associated with approach and (marginally) positively associated with observed avoidance. In the partner, inhibitory control was positively associated with approach and negatively associated with avoidance. Although some studies have highlighted the positive association between inhibitory control and more approach-related social tendencies (Diener & Kim, 2004; Eisenberg et al., 1995, 1997; Rothbart et al., 2001), some theoretical accounts suggest that very high inhibitory control may lead to the excessive inhibition of behavior, impulses, emotions, and desires, interfering with approach-related social behavior (J. Block, 2002; J. H. Block & Block, 1980; Derryberry & Rothbart, 1997; Eisenberg & Fabes, 1992). In a previous study using the same sample, we recently found evidence for a U-shaped relation between inhibitory control and observed avoidance, such that very high and very low levels of inhibitory control were associated with more observed avoidance (Hassan & Schmidt, 2022). However, inhibitory control was also associated with more approach and less avoidance in the social partner, which we speculate may reflect the natural "push and pull" dynamics of a social interaction. If one child withdraws, it may sometimes draw the other child in. Future work can extend this line of research by identifying reasons underlying approach and avoidance behavior in the partner and actor such as social disinterest or fear.

## Strengths, Limitations, and Future Directions

The results of the present study should be interpreted within its strengths and limitations. Strengths of the present study included a longitudinal design during a developmentally sensitive period for self-regulation before formal school entry (Dennis et al., 2007; Geeraerts et al., 2021; Klenberg et al., 2001; Kochanska et al., 1996; Schoemaker et al., 2014; Williams et al., 1999), as well as an empirical test of the risk potentiation model of control (Henderson et al., 2015; Henderson & Wilson, 2017) using observed social behavior with an unfamiliar peer and a dyadic analytical approach.

With respect to limitations, the attrition in the present study was high. The high T2 attrition was in part because of difficulties associated with aligning the schedules of two children tested at T1. Importantly, missingness was not associated with any of the T1 variables of interest or sociodemographic variables, the patterns of missing data did not violate the assumption that data were MCAR, and the use of FIML should theoretically lead to less biased estimates than listwise deletion (Schafer & Graham, 2002). Beyond the high attrition rate, it is important to note that very shy children may have failed to present to the laboratory at all.

We also acknowledge that our sample size was limited given that our analyses used a dyadic approach. To conserve power, we used observed rather than latent variables, selected a missing data handling technique that maximized our sample size, and only included theoretically meaningful interactions in our model. Further, the actor effect reported in the present study providing support for the risk potentiation model of control is a well-founded effect (Brooker et al., 2016; Hassan & Schmidt, 2023; Henderson, 2010; Lahat et al., 2014; Lamm et al., 2014; Poole et al., 2021; Rodrigues et al., 2022; Thorell et al., 2004; Troller-Renfree et al., 2019; White et al., 2011), and the partner effects, though never previously demonstrated, were significant at $p < .001$, which suggests our results are not likely due to chance. However, given the complexity of the models presented and limited sample size, the results of the model fit and significance testing may be untrustworthy and caution should be exercised in interpreting the findings.

Although one important extension of the present study was a test of the risk potentiation model of control using a dyadic analytical approach, we do not know whether the actor and partner effects were specific to interactions with an unfamiliar social partner, or whether they would extend to a more familiar social partner. This is an important area for future search because at least one study has suggested that the predictions made by the risk potentiation model of control may be restricted to an unfamiliar social context (Hassan & Schmidt, 2023).

Finally, our sample was relatively homogenous as the families were primarily White and the mean household income was relatively high. To account for the impact of socioeconomic status, we controlled for household income. Given the relatively high mean household income, however, it is possible that we did not have a wide enough range of household incomes represented in the present study to fully account for the impact of household income on the results reported. The results from the present study may therefore not be generalizable to a more ethnically and socioeconomically diverse sample of children. This is important to highlight because previous work has suggested that shyness may have different meanings and be associated with different outcomes depending on cultural context (Kong et al., 2023; Xu et al., 2007, 2009).

Future studies should examine the reproducibility of the present results in more ethnically and economically diverse samples than those used herein. It would also be important to examine whether and how partner's social responses potentiate actors' shyness and inhibitory control to better understand the directionality of these relations across developmental time.

Further, although the direct relation between shyness and inhibitory control was not the focus of the present study, it is important to note that there are different theoretical perspectives about the relative independence/interdependence of reactive (e.g., shyness) and controlled processes (e.g., inhibitory control; Aksan & Kochanska, 2004; Eggum-Wilkens et al., 2016; Eisenberg et al., 2010; Henderson et al., 2015). Some studies have found no direct relation between shyness or related temperamental constructs and inhibitory control (Brooker et al., 2016; Hassan & Schmidt, 2023; Henderson, 2010; Lahat et al., 2014; Rudasill & Rimm-Kaufman, 2009; Troller-Renfree et al., 2019; White et al., 2011), whereas others have found a positive relation (Lamm et al., 2014; Thorell et al., 2004), and at least one study found that inhibitory control at 2 years was negatively associated with the development of shyness from 2 to 7 years (Eggum-Wilkens et al., 2016). Future studies should use cross-lagged analyses to examine the directionality of the relations between shyness and inhibitory control across developmental time.

## Conclusion

Guided by the risk potentiation model of control, we used an APIM to examine whether T1 inhibitory control moderated the association between T1 shyness and the actor and partner's T2 observed social approach and avoidance behavior. We found that shyness was negatively associated with the actor's own approach behavior and the partner's avoidance behavior at relatively high levels of inhibitory control. We speculate that unfamiliar social partners may compensate for the relatively lower levels of approach behaviors in some shy and overcontrolled children by displaying less avoidance. Accordingly, shy and overcontrolled children may not benefit from this social information because of a developmental history of threat sensitivity and excessive controlled processing.

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