Theory of Mind as a Mechanism That Accounts for the Continuity or Discontinuity of Behavioral Inhibition: A Developmentally Informed Model of Risk for Social Anxiety

Danming An[1] · Grazyna Kochanska[1]

Abstract

Research has established that children with high levels of early behavioral inhibition (BI) – a subdued, timid, fearful response to novel or mildly challenging stimuli or events – are at an elevated risk for social anxiety in later childhood and adolescence. Yet, substantial heterogeneity has been documented in those developmental trajectories; consequently, understanding factors that moderate children's paths from early BI to social anxiety is an important goal. We proposed that the association between children's BI at toddler age and social anxiety at early school age is (a) mediated by their BI at preschool age, and (b) moderated by the level of social understanding, or Theory of Mind (ToM). In 102 typically developing community children, we observed BI in the laboratory at age 2 and 4.5 in "Risk Room" paradigms and assessed ToM at age 4.5 and 5.5 using false belief tasks. Mothers and fathers rated children's social anxiety symptoms at age 6.5. We supported the proposed moderated mediation model, with the path from BI at age 2 to BI at age 4.5 to social anxiety at age 6.5 unfolding only for children whose ToM abilities were relatively low, but not for those whose ToM abilities were relatively high. Results also supported a curvilinear relation between ToM and social anxiety, which highlights the risk of elevated social anxiety for children with extremely low ToM abilities. Taken together, proficiency in mindreading may help inhibited children navigate social environments and thus reduce risks for social anxiety.

Keywords Behavioral inhibition · Social anxiety · Theory of mind · Social information processing

A voluminous body of research in developmental psychology and psychopathology has demonstrated that many of young children's temperament traits are quite stable and that some of them may forecast a variety of future internalizing and externalizing behavior problems (Rothbart & Bates, 2006; Thomas & Chess, 1977). Inspired by the pioneering, heuristically productive research program by Kagan and colleagues on children's temperament (Kagan & Fox, 2006; Kagan & Snidman, 2004; Kagan et al., 1984, 1989), multiple research groups have focused on a very salient trait of behavioral inhibition (BI), manifested as shy, reticent, wary, timid, subdued, fearful, withdrawn, or affectively constrained response to unfamiliar, novel, unusual, mildly stressful events or stimuli. Many longitudinal studies have since revealed

that behaviorally inhibited young children are more likely to develop symptoms of anxiety, particularly social anxiety, over the course of development, compared to their uninhibited peers (Biederman et al., 2001; Clauss & Blackford, 2012; Degnan et al., 2010; Kagan & Fox, 2006; Kagan & Snidman, 1999; Nikolić et al., 2020; Rapee & Spence, 2004; Schwartz et al., 1999; Troller-Renfree et al., 2019). Many of those studies have identified neurobehavioral mechanisms underlying such trajectory (e.g., Buzzell et al., 2017; Fox et al., 1996; Schwartz et al., 2010). Together, research has firmly supported a view of BI as a developmental antecedent, diathesis for, or bias toward the development of anxiety disorders.

At the same time, however, consistent with the principle of multifinality (Cicchetti & Rogosch, 1996), a broad consensus emerged that only some of the inhibited children embark on a trajectory toward sub-clinical or clinical level of anxiety (Degnan & Fox, 2007; Fox et al., 2005; Murray et al., 2009; Rapee & Spence, 2004; Rapee et al., 2009; Rubin et al., 2009). Consequently, researchers have strongly argued for the need to study potential moderators of the

✉ Danming An
  danming-an@uiowa.edu

[1] Department of Psychological and Brain Sciences, The
   University of Iowa, Iowa, USA

association between early BI and later anxiety symptoms to elucidate the factors that either strengthen or weaken that path.

Children's cognitive and social information processing has also been implicated in research on origins of social anxiety. Scholars have theorized that children with impaired information processing skills may be at elevated risk for developing social anxiety because they have difficulty appraising and interpreting social cues (Lau & Waters, 2017; Nikolić, 2020). In particular, children's skills in understanding other people's mental states, intentions, and perspectives, or mindreading, known as Theory of Mind (ToM), have been increasingly emphasized in the development of anxiety, particularly social anxiety. Those links appear complex, and findings are mixed. It is interesting that research on cognitive and temperament factors in the development of anxiety has progressed largely in parallel, with relatively little integration (Muris et al., 2007; Nikolić, 2020).

Generally, better ToM skills have been associated with lower social anxiety (Banejee & Henderson, 2001; Hezel & McNally, 2014; Pearcey et al., 2020; Ronchi et al., 2020), but some studies have failed to find the relation. For example, Broeren et al. (2013) reported that ToM did not predict a social anxiety trajectory in children from 4 to 9 years of age. Yet some other studies have indicated that both low and high levels of ToM may relate to heightened anxiety (Nikolić et al., 2019).

The relatively few studies on associations between children's ToM and BI, the presumed antecedent of social anxiety, have produced mixed findings. Some studies have shown that inhibited children tend to have worse ToM skills (Broeren & Morris, 2009; Suway et al., 2012). By contrast, other studies reported the opposite findings, with parent-rated inhibition or shyness positively associated with ToM skills, concurrently or longitudinally (LaBounty et al., 2017; Mink et al., 2014; Wellman et al., 2011). Lane et al. (2013) reported no association between ToM and parent-rated BI among preschoolers, but they found that the combination of high social withdrawal and high emotional reactivity (which likely reflects heightened and dysregulated social fearfulness) was associated with poor ToM. Similarly, Suway et al. (2012) found that high levels of observed BI, combined with negative peer interaction behaviors, predicted lower ToM.

Several issues should be considered when interpreting the mixed findings about the associations among ToM, BI, and social anxiety. First, various tasks have been used to measure ToM. The tasks often capture different aspects of ToM, such as cognitive ToM (LaBounty et al., 2017; Lane et al., 2013; Suway et al., 2012; Wellman et al., 2011), affective ToM (Hezel & McNally, 2014; Nikolić et al., 2019), or a mix of both (Banerjee & Henderson, 2001; Broeren et al., 2013; Mink et al., 2014; Ronchi et al., 2020). How various types of ToM tasks relate to social anxiety is not clear. However,

a meta-analysis that focused on the broader associations between social cognition and social anxiety suggested that those relations may depend, in part, on the type of social cognitive tasks used (Pearcey et al., 2020). A study that separated cognitive and affective ToM showed that inhibition to novelty was positively related to cognitive, but not affective ToM among preschoolers (Longobardi et al., 2017), suggesting that it may be necessary to examine the effects of different types of ToM separately.

Second, researchers have often assumed linear associations between ToM and BI/social anxiety, without examining other forms of relations. Having included a quadratic term of ToM skills (measured as reading facial expressions) in their model, Nikolić et al. (2019) found a curvilinear relation between ToM and concurrent social anxiety: Whereas children with low mindreading skills tended to have higher levels of social anxiety, those with an advanced understanding of other people's mental states were also at elevated risk for anxiety. The authors concluded that children with advanced ToM skills can be overly sensitive to social cues and highly self-conscious. Failure to account for such higher-order effects of ToM may result in biased estimations and lead to inconsistent findings. The potential curvilinear association, however, needs to be replicated in other studies.

Third, whereas researchers have often focused on the direct associations between ToM and BI and between ToM and social anxiety, very few studies examined the interplay among the three variables, taking into account moderation and mediation effects. Recently, Nikolić (2020) presented a cogent summary of research on social information processing and the development of social anxiety and provided a conceptual agenda for the path forward. Specifically, Nikolić argued that the association between ToM and social anxiety should be understood in the context of other distant factors, such as early fearful temperament. To our knowledge, there has been one study that addressed the intersection among BI (conceptualized as shyness), ToM, and children's social anxiety. Colonessi and colleagues (Colonnesi et al., 2017) examined concurrent relations among ToM, positive and negative shyness, coded from facial expressions during a performance (singing) and then watching its videorecording, and mother- and father-rated social anxiety in 4-year-olds. The findings revealed complex relations between ToM and social anxiety, depending on the type of shyness expression. Specifically, social anxiety was associated with higher negative shyness (similar to the social fear displayed by high BI children), lower positive shyness (coy smile), and lower levels of ToM skills. In addition, low ToM reduced social anxiety among children with higher levels of positive shyness. The findings supported both positive and negative roles of ToM, and suggested ToM may moderate the relation between temperament and social anxiety. However, so far, no study

has adopted a longitudinal design to examine the interplay between ToM and the developmental sequelae from BI to social anxiety.

Fourth, studies of the associations between social information processing and BI/social anxiety have utilized samples with various age ranges, with inhibited temperament measured from infancy to preschool age, and social anxiety measured from preschool age to adolescence. Whereas there does not seem to be an age-specific pattern, it may be useful to address those relations from a developmentally informed perspective, with an emphasis on the critical time points on the developmental trajectory. Although social anxiety disorder is typically diagnosed in late childhood to adolescence, first signs of social anxiety can be observed in early to middle childhood (Nikolić, 2020; Rapee & Spence, 2004). Therefore, it is necessary to examine the early manifestations of social anxiety in relation to temperament and cognitive factors.

In the present study, utilizing robust behavioral measures, we examined the trajectory from BI to social anxiety, followed from toddlerhood (when children gain awareness of their fearful and self-conscious emotions; see Kagan, 2018) to preschool age and to early school age (when children increasingly engage in peer interactions and show signs of social anxiety; Rapee & Spence, 2004). Further, we asked what, if any, role the ToM skills can play in the longitudinal trajectory of inhibited children, once those skills emerge between age 4 and 5. Generally speaking, children with better ToM abilities may acquire more successful social experiences, whereas those with poor ToM skills may encounter difficulty navigating the social world (Capage & Watson, 2001; Devine et al., 2016; Lecce et al., 2017; Slaughter et al., 2015; Watson et al., 1999). Consequently, strong ToM skills may reduce behaviorally inhibited children's social wariness, whereas poor ToM skills may consolidate their trajectory to social anxiety. However, very high ToM may involve oversensitivity to social cues and potential social evaluations, which might also put some children, especially those with high BI, at elevated risk of developing social anxiety (Colonessi et al., 2017; Nikolić et al., 2019). Although the question of the specific impact of ToM abilities is unsettled, nevertheless, once they emerge in development, ToM skills may be a mechanism that can alter or moderate the course of children's BI after preschool age, and the direction of the potential direct as well as moderating effects of ToM needs to be examined.

A view of the ToM skills as a "turning" or "inflection" point in the trajectory from early BI to future social anxiety is consistent with the construct of multifinality in development (Cicchetti & Rogosch, 1996), and with the focus on continuity and change in developmental psychopathology. Further, it offers an account of a potential mechanism that can maintain or deflect a maladaptive developmental trajectory.

Method

Participants and Overview

One-hundred and two two-parent, intact families in Midwestern United States participated in our longitudinal study in response to mass advertisements broadly disseminated in the surrounding community (a college town, a small city, and rural areas). Children in the study were mostly born in 2001. Annual incomes of the families were as follows: 8% earned less than $20,000 per year, 17% between $20,000 and $40,000, 26% between $40,000 and $60,000, and 49% more than $60,000. Parental education varied: 25% of mothers and 30% of fathers had no more than a high school education, 54% of mothers and 51% of fathers had an associate or college degree, and 21% of mothers and 20% of fathers had a postgraduate education. In terms of race and ethnicity, 90% of mothers and 84% of fathers were White, 3% of mothers and 8% of fathers Hispanic, 2% of mothers and 3% of fathers African American, 1% of mothers and 3% of fathers Asian, 1% of mothers Pacific Islander, and 2% of mothers and fathers reported Other. In 20% of families, at least one parent was not White. The University of Iowa IRB approved the study (Developmental Pathways to Antisocial Behavior: A Translational Research Program, 200107049). We obtained parents' informed consents at the entry to the study.

At each time point of the longitudinal study, female experimenters (Es) conducted lengthy behavioral sessions (2–4 h), separately for the child with each parent. The sessions were videotaped for future coding. In addition, parents completed questionnaires about the child's behavior. In this article, we present data from the ages 2 ($N = 100$, 50 girls), 4.5 ($N = 99$, 49 girls), 5.5 ($N = 90$, 45 girls), and 6.5 years ($N = 90$, 43 girls).

Children's BI was observed at ages 2 and 4.5 years; their ToM was assessed at 4.5 and 5.5 years. At 6.5 years, mothers and fathers reported on the child's social anxiety. All behavioral data were coded from videotapes, with about 15–20% of cases used for reliability, followed by frequent realignments. Note that the best practices in reliability have evolved over the last 20 years. Consequently, most statistics deployed in this study included kappas and alphas.

Measures

Behavioral Inhibition (BI), Ages 2 and 4.5 Years. We assessed the child's BI at ages 2 and 4.5 years. At each age, BI was assessed in two "Risk Room" paradigms, each lasting 7–8 min, one with each parent. This paradigm was inspired by the original work by Kagan and colleagues (e.g., Kagan et al., 1989; Reznick et al., 1989); we have adapted and expanded

the procedure, and used it in several longitudinal studies (e.g., Kochanska, 1995; Kochanska et al., 2007). The child was observed in an unfamiliar lab room decorated with many odd-looking and slightly frightening objects (e.g., Halloween masks, witch poster, bats, rats, worms) and objects that could potentially involve mildly challenging physical activities (e.g., a strange big black box, tunnel, trampoline). At the beginning of the session, the child explored the room briefly. Then, a female stranger entered and attempted to engage the child in a conversation, following a standard script (e.g., asking "isn't this a fun room?", "what's your favorite toy here?", "can you show me how your favorite toy works?"). The stranger encouraged the child, using standard prompts, to engage in four scripted "Risky Acts" (e.g., jump on a trampoline, climb a strangely decorated ladder, walk across a balance beam, crawl through a tunnel, insert a hand into an odd box, touch a moving odd dinosaur or spider toy; at age 4.5, the last "Risky Act" involved a person in a witch or clown costume entering the room briefly). The parent was asked to remain neutral and work on questionnaires during these tasks.

Coding and data aggregation were parallel at ages 2 and 4.5 years. We coded proximity to the parent for every 30 s (within arm's length, hovering close by, more than 1/3 room away); latency to explore; presence/absence of exploration for every 30 s, including extra credits for exploring particularly threatening objects, and reluctance to perform each Risky Act (0 = *act performed immediately after the demonstration and before the first prompt*, 1 = *after the first prompt*, 2 = *after the second prompt*, 3 = *after the third prompt*, 4 = *never performed, but child touches or approaches object*, 5 = *never performed and no approach*), plus an extra point if the child showed distress. We also coded the child's response to the stranger's conversation overtures (0 = *initiates interaction*, 1 = *gives verbal response*, 2 = *does not give verbal response, but smiles or points to an object*, 3 = *does not respond*, 4 = *does not respond and shows distress*), and proximity to the stranger (close contact, some distance, far away). Inter-coder reliability, alphas, ranged from 0.74 to 1.00 at age 2 and 0.84 to 1.00 at age 4.5.

For the session with each parent (mother listed first, father second), the number of segments within arm's length to the parent, latency to explore, reversed exploration score, and the scores for each Risky Act were standardized and averaged (Cronbach's alphas 0.85 and 0.82 at age 2, 0.85 and 0.83 at age 4.5). The proximity to and response to the stranger were also standardized and averaged (Cronbach's alphas 0.77 and 0.76 at age 2, 0.83 and 0.78 at age 4.5). Higher scores reflected higher BI. The four composites (two for each parent) cohered strongly at both times (*r*s among the composites were 0.36 to 0.72 at age 2 and 0.55 to 0.78 at age 4.5, *p*s < 0.001) and were averaged into one overall BI score for each age.

Table 2 Correlations among the Study Variables

	BI, 2 years	BI, 4.5 years	ToM, 4.5–5.5 years	Social Anxiety, 6.5 years
BI, 2 years	–	0.27**	0.05	0.30**
BI, 4.5 years		–	0.11	0.34**
ToM, 4.5–5.5 years			–	-0.06

BI Behavioral Inhibition. *ToM* Theory of Mind. Gender was coded 0 = girls, 1 = boys

*p < 0.05; **p < 0.01

Theory of Mind (ToM), Age 4.5–5.5 Years. Children's ToM was assessed at 4.5 and 5.5 years using false belief tasks (for details, see Goffin et al., 2020). E presented the child with well-established tasks (unexpected contents, unexpected location, and belief–desire; Hughes et al., 2005), using pictures, puppets, and props (e.g., a Band-Aid box) as appropriate. At 4.5 years, there were four tasks: unexpected contents (Band-Aid Box story), unexpected location (Andy's Apple and Chocolate stories), and belief–desire (Coke Can story). At 5.5 years, there were five tasks: unexpected contents (Cookie Box story), unexpected location (Boris Banana story, New Toy story, and Mom and Baby story), and belief-desire (Hot Chocolate story).

Coding of ToM followed the conventions described by Hughes et al. (2005, pp. 369–370). Coders assigned scores of either 0 (incorrect answer) or 1 (correct answer) to each

Table 1 Descriptive Statistics of the Study Variables

	M	SD	Range	N
BI, age 2 years[a]	0.00	0.61	-1.04 – 1.20	100
BI, age 4.5 years[a]	0.01	0.69	-0.86 – 1.69	99
ToM				
Age 4.5 years	3.00	2.64	0 – 8	98
Age 5.5 years	6.27	2.50	1 – 11	90
Aggregated, age 4.5–5.5 years[a]	-0.01	0.90	-1.62 – 1.90	98
Social Anxiety, age 6.5 years				
Mothers' Ratings				
Social Phobia, CSI	0.30	0.36	0.00 – 1.33	88
Social Anxiety, HBQ	1.66	0.48	1.00 – 3.00	88
Fathers' Ratings				
Social Phobia, CSI	0.45	0.45	0.00 – 2.00	86
Social Anxiety, HBQ	1.72	0.49	1.00 – 3.00	86
Overall Social Anxiety, aggregated across parents[a]	0.02	0.76	-1.17 – 2.39	90

BI Behavioral Inhibition measured using the "Risk Room" paradigm. *ToM* Theory of Mind measured using a series of false belief tasks. *CSI* Child Symptom Inventory. *HBQ* Health Behavior Questionnaire

[a] Composite of standardized constituent variables. Variables in bold are the final constructs used in the analyses

critical test question asked per story. To earn a point, the child needed to respond correctly to both the critical test question (false belief question, e.g., "Where does Simon think Mary will look for the chocolate?") and the accompanying control question(s) (e.g., "Where is the chocolate really?"). Children did not earn any points if they did not respond correctly to the control question(s). Reliability (kappa) was 1.00 for all stories.

We summed ToM scores across tasks. At 4.5 years, the possible range was 0 to 8, and at 5.5 years the possible range was 0 to 11. The two scores correlated, $r(88) = 0.56$, $p < 0.001$, and were standardized and averaged into an overall ToM score from 4.5 to 5.5 years.

Parent-Reported Social Anxiety, Age 6.5 Years. Mothers and fathers reported the child's social anxiety using the Social Phobia subscale from the Child Symptom Inventory (CSI-4; Gadow & Sprafkin, 2002) and the Social Inhibition subscale from the Macarthur Health Behavior Inventory (HBQ, Boyce et al., 2002; Essex et al., 2002) that targets socially anxious behaviors. The Social Phobia subscale contained four items (e.g., "Tries to avoid contact with strangers; abnormally shy"). The parent rated the child's symptom severity using a 4-point scale (0 = *never*, 1 = *sometimes*, 2 = *often*, 3 = *very often*). Following the suggestion in the CSI-4 manual for calculating the symptom severity score (Gadow & Sprafkin, 2002), we omitted one screening item from analysis ("warm and outgoing with family members and familiar adults"). Cronbach's alphas of the three items were 0.59 and 0.58, for mothers and fathers, respectively. The HBQ Social Inhibition subscale contained three items (e.g., "Is afraid of strangers"), and was rated by parents using a 3-point scale (1 = *never/not true*, 2 = *sometimes/somewhat true*, 3 = *often/very true*). Cronbach's alphas were 0.68 and 0.73, for mothers and fathers, respectively.

We calculated subscale means and standardized them to account for differences in rating scales. The four standardized composites (two for each parent) cohered, alpha = 0.73, and were averaged into one social anxiety score.

Results

Preliminary Analysis: Attrition Analysis and Descriptive Statistics

We first inspected the missing data. T-tests suggested no differences in the study variables between children who stayed in the study and those who dropped out. Little's MCAR test (Little, 1988) indicated that data were missing completely at random, $\chi^2(20) = 20.37$, $p = 0.44$.

Next, we inspected the descriptive statistics (Table 1) and correlations among the variables (Table 2). BI at 2 years, BI at 4.5 years, and social anxiety at 6.5 years were correlated positively with each other, but they were not correlated with

Fig. 1 The moderated mediation model of the developmental cascade from the predictor, BI at age 2 years, to the mediator, BI at age 4.5 years, to the outcome, parent-reported social anxiety at age 6.5 years. Linear and quadratic terms of children's ToM at age 4.5–5.5 years were modeled as predictors of social anxiety at 6.5 years as well as moderators of the path from BI at 4.5 years to social anxiety at 6.5 years. Although not depicted, the child's gender was included as a covariate for both the mediator and the outcome. The models were saturated; covariances between predictors were not depicted for clarity. Solid lines represent significant paths, and dashed lines represent non-significant paths. See Table 3 for the path coefficients and the supplementary materials for covariances. BI = Behavioral Inhibition. ToM = Theory of Mind
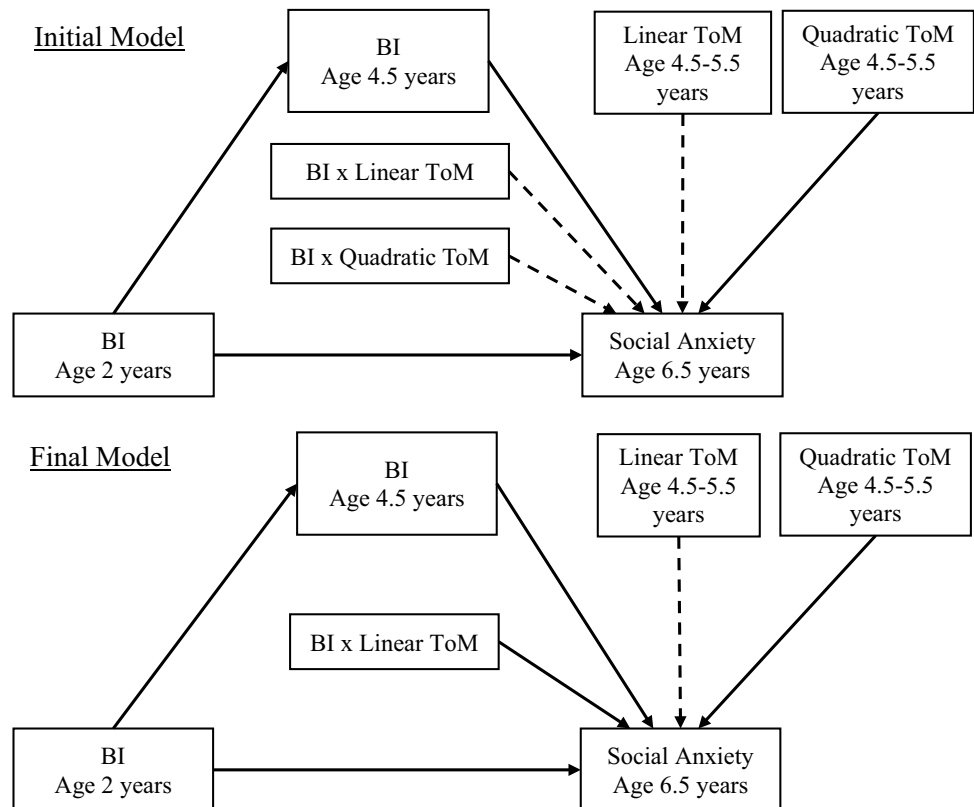
ToM. Girls were more behaviorally inhibited at age 2 and more socially anxious at age 6.5 than boys, $t(98) = 2.34$ and $t(88) = 2.06$, respectively, $ps < 0.05$.

Main Analyses: The Moderated Mediation Model

Model Specification. We examined a moderated mediation model with BI at age 2 as the predictor, BI at 4.5 as the mediator, and parent-reported social anxiety at 6.5 as the outcome. To inspect the moderating effect of ToM on the association between BI and social anxiety, as well as the potential curvilinear relation between ToM and social anxiety, we included linear and quadratic terms of ToM at ages 4.5 – 5.5, as well as their interaction terms with BI at age 4.5, as predictors of social anxiety at 6.5. Child gender was included as a covariate. All predictors were already mean-centered before the analysis and were allowed to covary, resulting in a saturated model. The initial model configuration is illustrated in Fig. 1. Of note, we examined additional models in which BI at age 2 was estimated as predicting the linear and quadratic terms of ToM at age 4.5 – 5.5 instead, but the path coefficients from BI to ToM were non-significant. Considering that such additional models were beyond the scope of this paper, we only reported the series of models in which BI and ToM were specified as covarying with each other.

We tested the moderated mediation effect in Mplus (Muthén & Muthén, 1998–2020), using codes adapted from Stride et al., (2015). The syntax corresponds to the framework of PROCESS (Hayes, 2017) and allows for unbiased missing data treatment using the full information maximum likelihood (FIML) method. To account for the non-normal distribution of the indirect effect and provide accurate estimations for the moderate sample size, we estimated the mediation effect by deriving the 95% confidence intervals (CI) using bias-corrected bootstrapping with 10,000 resamples drawn (MacKinnon et al., 2004; Preacher et al., 2007; Shrout & Bolger, 2002).

Results of the initial model are listed in Table 3. Children's BI at age 2 was associated positively with BI at age 4.5, $B = 0.29$, $SE = 0.12$, $p = 0.021$, 95% CI [0.04, 0.52]; BI at 4.5, in turn, was associated positively with social anxiety at age 6.5, $B = 0.36$, $SE = 0.13$, $p = 0.005$, 95% CI [0.13, 0.62]. In addition, the linear term of ToM was not associated, whereas the quadratic term of ToM was positively associated with social anxiety, $B = -0.15$, $SE = 0.11$, $p = 0.162$, 95% CI [-0.35, 0.09], and $B = 0.25$, $SE = 0.11$, $p = 0.022$, 95% CI [0.02, 0.44], respectively. Further, the linear term of ToM marginally moderated the relation between BI at age 4.5 and social anxiety at age 6.5, $B = -0.29$, $SE = 0.16$, $p = 0.061$, 95% CI [-0.57, 0.03]; whereas the interaction term between quadratic ToM and BI was not significant, $B = -0.09$, $SE = 0.15$, $p = 0.571$, 95% CI [-0.47, 0.20]. We further examined a model in which the path from the quadratic interaction term to social anxiety was

Table 3 Path Coefficients of the Initial and Final Moderated Mediation Models

Predictors	Initial Model						Final Model					
	BI at Age 4.5			Social Anxiety at Age 6.5			BI at Age 4.5			Social Anxiety at Age 6.5		
	B	SE	95% CI	B	SE	95% CI	B	SE	95% CI	B	SE	95% CI
Gender	-0.12	0.14	[-0.39, 0.14]	-0.29+	0.16	[-0.59, 0.03]	-0.12	0.14	[-0.39, 0.14]	-0.27+	0.16	[-0.58, 0.05]
BI at Age 2	0.29*	0.12	[0.04, 0.52]	0.25*	0.12	[0.03, 0.50]	0.29*	0.12	[0.04, 0.52]	0.26*	0.12	[0.05, 0.51]
BI at Age 4.5	-	-	-	0.36**	0.13	[0.13, 0.62]	-	-	-	0.29**	0.10	[0.09, 0.49]
ToM at Age 4.5–5.5, Lin	-	-	-	-0.15	0.11	[-0.35, 0.09]	-	-	-	-0.15	0.10	[-0.34, 0.06]
ToM at Age 4.5–5.5, Qua	-	-	-	0.25*	0.11	[0.02, 0.44]	-	-	-	0.24*	0.10	[0.03, 0.43]
BI at Age 4.5×Lin ToM	-	-	-	-0.29+	0.16	[-0.57, 0.03]	-	-	-	-0.27*	0.14	[-0.55, -0.01]
BI at Age 4.5×Qua ToM	-	-	-	-0.09	0.15	[-0.47, 0.20]	-	-	-	-	-	-

BI Behavioral Inhibition, *ToM* Theory of Mind, *Lin* Linear, *Qua* Quadratic. Gender was coded 0 = girls, 1 = boys. See Fig. 1 for model configurations. Unstandardized coefficients are reported. See the supplementary materials for covariances among the predictors.

$^+ p < 0.10$; $^* p < 0.05$; $^{**} p < 0.01$

constrained at zero ($\chi^2[1]=0.515$, $p=0.473$; RMSEA$=0.00$; CFI$=1.00$; SRMR$=0.007$). Constraining the path coefficient at zero did not change model fit, $\triangle\chi^2(1)=0.515$, $p=0.473$ as compared to the initial model. Thus, in the final model (saturated), we omitted the quadratic interaction term for parsimony and ease of interpretation.

The final model (Table 3 and Fig. 1) yielded similar results as the initial model: Children's BI at age 2 was associated positively with BI at age 4.5, $B=0.29$, $SE=0.12$, $p=0.021$, 95% CI [0.04, 0.52]. BI at 4.5 then significantly predicted social anxiety at 6.5 years, $B=0.29$, $SE=0.10$, $p=0.005$, 95% CI [0.09, 0.49]. The linear term of ToM was not associated, whereas the quadratic term of ToM was positively associated with social anxiety, $B=-0.15$, $SE=0.10$, $p=0.144$, 95% CI [-0.34, 0.06], and $B=0.24$, $SE=0.10$, $p=0.020$, 95% CI [0.03, 0.43], respectively. Further, the association between BI at age 4.5 and social anxiety at age 6.5 was qualified by a significant interaction between BI at age 4.5 and the linear term of ToM skills at age 4.5 – 5.5, $B=-0.27$, $SE=0.14$, $p=0.049$, 95% CI [-0.55, -0.01]. Following the significant moderating and quadratic effects of ToM, we proceeded to examine the moderated mediation effect, as well as the curvilinear relation between ToM and social anxiety.

Moderated Mediation. We first inspected the simple slopes of social anxiety on BI at age 4.5 at low (-1 SD), average (0 SD), and high (+ 1 SD) levels of ToM skills (Aiken & West, 1991). For children with low (-1 SD) to average (0 SD) ToM skills, BI at age 4.5 was associated positively with social anxiety at age 6.5, $B=0.53$, $SE=0.16$, $p=0.001$, 95% CI [0.24, 0.88], and $B=0.29$, $SE=0.10$, $p=0.005$, 95% CI [0.09, 0.49], respectively. By

contrast, for children with high (+ 1 SD) ToM skills, BI at age 4.5 was unrelated to social anxiety at age 6.5, $B=0.05$, $SE=0.16$, $p=0.764$, 95% CI [-0.26, 0.37]. The respective simple slopes are depicted in Fig. 2.

Consequently, the proposed moderated mediation model was supported; index of moderated mediation (Hayes, 2015) $=-0.08$, $SE=0.05$, 95% CI [-0.23, -0.01]. The indirect effect from BI at age 2 year to BI at age 4.5 to social anxiety at age 6.5 was present for children who had low (-1 SD) to average (0 SD) ToM skills, $B=0.15$, $SE=0.09$, 95% CI [0.03, 0.39], and $B=0.08$, $SE=0.06$, 95% CI [0.01, 0.23], respectively. By contrast, for children who had high (+ 1 SD) ToM skills, the indirect effect was absent, $B=0.01$, $SE=0.05$, 95% CI [-0.06, 0.15]. In addition, there was a direct effect from BI at age 2 to social anxiety at age 6.5, $B=0.26$, $SE=0.12$, $p=0.026$, 95% CI [0.05, 0.51], supporting a partial mediation model.

Curvilinear Effect of ToM. Because a significant quadratic term provides little information about the actual shape of the curvilinear relation (Simonsohn, 2018), we examined the association between ToM and social anxiety using the two-lines approach (Simonsohn, 2018). The two-lines test utilizes two linear regressions, one for the "low" values of the predictor, and the other for the "high" values of the predictor. The relation between the predictor and the outcome takes a U-shaped form if both regression lines are significant but with opposite signs. Following the approach of Nikolić et al. (2019), we formed two extreme groups based on sample statistics: The low-ToM group consisted of children whose ToM was in the lowest 30% ($\leq$ -0.46; $N=30$), and the high-ToM group consisted of children whose ToM was in the highest 30% ($\geq$ 0.53; $N=31$). We then conducted a

Fig. 2 Simple slopes of BI at age 4.5 years predicting parent-rated social anxiety at age 6.5 years at low (-1 SD), mean (0 SD), and high (+ 1 SD) values of ToM skills. Solid lines represent significant simple slopes, and dashed lines represent non-significant simple slopes. BI$=$Behavioral Inhibition. ToM$=$Theory of Mind
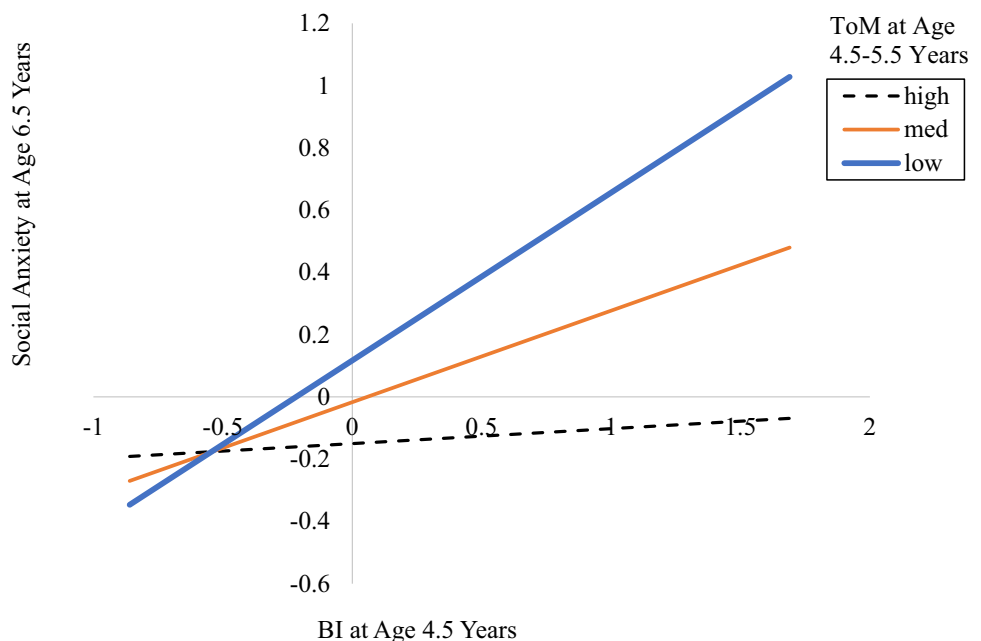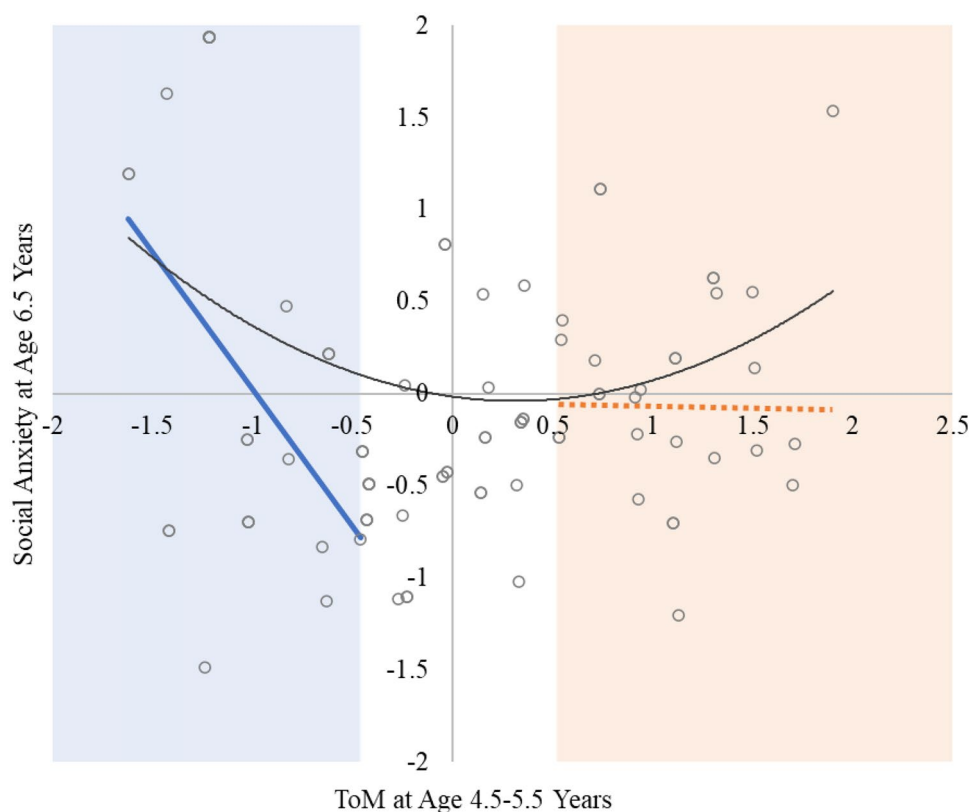
Fig. 3 The relation between ToM at age 4.5 – 5.5 years and parent-rated social anxiety at age 6.5 years. The model suggested a curvilinear relation between ToM and social anxiety (black quadratic curve). We used the two-line test to further examine the shape of the curve by estimating two linear models for children with low ToM skills (lowest 30% of the sample; left shaded area) and high ToM skills (highest 30% of the sample; right shaded area). ToM was associated neg-

atively with social anxiety for children in the low-ToM group (solid straight line), but not associated with social anxiety for children in the high-ToM group (dashed straight line), supporting a L-shaped curvilinear relation between ToM and social anxiety. Data points in gray circles represent the residualized scores of social anxiety after controlling for gender and previous BI at ages 2 and 4.5 years. BI = Behavioral Inhibition. ToM = Theory of Mind

multigroup analysis in Mplus with the two extreme groups. Note that we examined alternative ways to split the sample, such as a median split, as well as the data-driven split as suggested by the online tool developed by Simonsohn (2018), and the different approaches yielded similar results. As aforementioned, we used bias-corrected bootstrapping with 10,000 resamples to provide accurate estimations for the limited sample sizes in each group. We specified the model for each group in the same way as the moderated mediation model, but without the quadratic term of ToM or the interaction term (as the purpose was to replicate the findings in Nikolić et al., 2019, or to describe the shape of the curvilinear relation using the two linear regressions in the full sample). Path coefficients were constrained to be the same across the two groups, except for the intercepts of social anxiety and the slopes of ToM predicting social anxiety, which were allowed to differ across groups.

Results are illustrated in Fig. 3. For children in the low-ToM group, ToM skills were associated negatively with social anxiety, $B = -1.49$, $SE = 0.53$, $p = 0.005$, 95% CI [-2.49, -0.39]. However, for children in the high-ToM

group, the association between ToM and social anxiety was absent, $B = -0.02$, $SE = 0.28$, $p = 0.944$, 95% CI [-0.55, 0.58]. In other words, the results suggested a L-shaped association between ToM and social anxiety.

Discussion

A critical goal in developmental psychology and psychopathology is to understand what accounts for continuity versus discontinuity of both adaptive and maladaptive developmental trajectories. Research has shown that behaviorally inhibited toddlers tend to remain inhibited, fearful, and shy over the course of development, and they are often at risk for developing social anxiety. Yet, despite the often-described continuity of this temperament trait, only some, but not all behaviorally inhibited children remain on the trajectory to social anxiety at school age and adolescence (Clauss & Blackford, 2012). Understanding the potential mechanisms that moderate that trajectory, particularly those that attenuate developmental risks by disrupting progress from early

BI to future anxiety symptoms, would inform translational research on effective interventions for anxiety disorders (Chronis-Tuscano et al., 2018).

We examined one such mechanism – children's social information processing skills, specifically ToM skills, emerging generally at preschool age. Our focus is consistent with the recent emphasis on a rapprochement between research on young children's temperament and their social-cognitive skills in the origins of social anxiety, explicitly proposed as an agenda for the future (Nikolić, 2020). Our findings suggest that strong ToM abilities may be one of the factors that underlie discontinuity of the developmental trajectory from early fearful, inhibited temperament to social anxiety at early school age. Our main findings were straight-forward. The maladaptive developmental cascade – from early BI at toddler age to social anxiety symptoms at school age, mediated by BI at preschool age – was present only for children who had relatively poor skills of understanding others' mental states. By contrast, for the good mind readers, the indirect effect was absent, and preschool BI did not predict social anxiety at school age.

These findings correspond with the literature that has shown that impoverished or biased understanding of other people's beliefs, intentions, and attitudes often maintains or worsens social anxiety (Banerjee & Henderson, 2001; Pearcey et al., 2020; Rapee & Spence, 2004; Spence et al., 1999). Children with poor ToM may have difficulty interpreting social cues and engaging in social interactions effectively (Capage & Watson, 2001; Devine et al., 2016; Lecce et al., 2017; Slaughter et al., 2015; Watson et al., 1999). Social difficulties and negative social experiences, combined with an inhibited, fearful temperament, may contribute to negative interpretations of social cues and deepen social withdrawal, avoidance, and ultimately, social anxiety. By contrast, behaviorally inhibited children who are proficient mind readers may be skillful when navigating their social environments; the temperamental sensitivity to novelty and uncertainty, combined with accurate social understanding, may, in fact, make these children good observers and interpreters of the surrounding social world (LaBounty et al., 2017; Wellman et al., 2011). Consequently, even if these children remain reticent, they are less likely to develop social anxiety symptoms.

Of note, highly inhibited toddlers remained at risk for future elevated social anxiety. Although we confirmed the presence of an indirect effect of toddler-age BI to social anxiety via preschool-age BI (moderated by ToM), toddler-age BI continued to exert a direct effect on social anxiety in the final model. This suggests partial mediation; toddler-age fearful temperament may be associated with future social anxiety through mechanisms other than fearfulness at preschool age, not measured in the current study, including evocative effects on parenting and parental emotion socialization and negative peer relationships (Affrunti et al., 2014; Degnan et al., 2010;

Kiel & Buss, 2014; Lewis-Morrarty et al., 2012; Rubin et al., 2009).

Our study also produced additional, more nuanced findings, when we inspected the curvilinear relation between ToM and social anxiety. Lower levels of ToM skills were associated with higher levels of social anxiety, but only for children whose ToM was in the lower range. For children with relatively good ToM skills, preschool-age ToM was unrelated to future social anxiety. These findings are consistent with the notion that the relation between ToM and social anxiety may be curvilinear (Nikolić et al., 2019). However, instead of the U-shaped curve described by Nikolić et al. (2019), our findings support a L-shaped relation: ToM was associated negatively with social anxiety among children with relatively poor ToM skills, but not associated with social anxiety among children with relatively good ToM skills. We were not able to replicate the positive association between mindreading abilities and concurrent social anxiety among advanced mind readers (Nikolić et al., 2019). Perhaps this was due to the differences in the measurement of ToM and the age range of the samples. Our false belief tasks primarily focused on cognitive ToM. It is possible that heightened affective ToM, such as the sensitivity to facial expressions (Nikolić et al., 2019), may increase the risk for social anxiety. Further, we only inspected the relation between ToM at age 4.5 – 5.5 and social anxiety at age 6.5. As social anxiety symptoms increase during early adolescence, the relation between ToM and social anxiety assessed at later ages may be different. Alternatively, ToM skills of advanced mind readers may not be associated with future social anxiety after controlling for early temperament. Future studies should systematically examine the effects of different aspects of ToM on the developmental psychopathology of social anxiety from childhood to adolescence.

This study has limitations. The families came from a low-risk community sample, limiting generalizability to at-risk and diverse populations. The ethnic diversity was limited (although we note that in 20% of families, one or both parents were non-White). Children were typically developing and not selected for early BI; their social anxiety symptoms were generally low. To our knowledge, most studies on the associations among BI, ToM, and social anxiety also utilized normative community samples, with most children's social anxiety being below clinical levels. In future studies, it will be important to include both normative samples and at-risk samples. As well, including young children who represent the broad spectrum of BI would be useful. Multiple robust parent-reported screening instruments and well-established observational procedures are available. Such designs would inform researchers' and clinicians' understanding of the potential importance of ToM (and perhaps other social-cognitive skills) as factors that may protect vulnerable children from developing severe forms of anxiety disorders.

Further, deficits in ToM may be associated with other problems in social information processing, such as attentional biases, memory biases, and biased appraisal of ambiguous stimuli. Those information-processing mechanisms have been known to be associated with elevated risk of social anxiety (Abend et al., 2021; Lau & Waters, 2017). Future studies should examine a broad scope of various information-processing deficits and their relations with social anxiety.

In sum, our findings elucidate the role of social cognitive skills, particularly ToM, in mitigating the maladaptive developmental trajectory from early BI to social anxiety at school age. Although BI often forecasts future social anxiety, researchers have found that such path can be deflected, and that inhibited children can become relatively well adjusted if aided by good regulative abilities and supportive ecological systems (Degnan & Fox, 2007; Pérez-Edgar et al., 2014; Poole et al., 2018). Our findings dovetail with extant evidence that behaviorally inhibited children can embark on heterogeneous developmental trajectories. Further, we highlight the role of ToM as one potential protective mechanism. Researchers and clinicians may consider ToM as a potential target in future prevention and intervention programs for childhood social anxiety.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval The University of Iowa IRB approved the study (Developmental Pathways to Antisocial Behavior: A Translational Research Program, 200107049). The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards

Informed Consent We obtained parents' informed consents at the entry to the study.

References

Abend, R., Bajaj, M. A., Matsumoto, C., Yetter, M., Harrewijn, A., Cardinale, E. M., & Pine, D. S. (2021). Converging multi-modal evidence for implicit threat-related bias in pediatric anxiety disorders. *Research on Child and Adolescent Psychopathology, 49*, 227–240. https://doi.org/10.1007/s10802-020-00712-w

Affrunti, N. W., Geronimi, E. M., & Woodruff-Borden, J. (2014). Temperament, peer victimization, and nurturing parenting in child anxiety: A moderated mediation model. *Child Psychiatry & Human Development, 45*(4), 483–492. https://doi.org/10.1007/s10578-013-0418-2

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Sage.

Banerjee, R., & Henderson, L. (2001). Social-cognitive factors in childhood social anxiety: A preliminary investigation. *Social Development, 10*(4), 558–572. https://doi.org/10.1111/1467-9507.00180

Biederman, J., Hirshfeld-Becker, D. R., Rosenbaum, J. F., Hérot, C., Friedman, D., Snidman, N., & Faraone, S. V. (2001). Further evidence of association between behavioral inhibition and social anxiety in children. *American Journal of Psychiatry, 158*(10), 1673–1679. https://doi.org/10.1176/appi.ajp.158.10.1673

Boyce, W. T., Essex, M. J., Woodward, H. R., Measelle, J. R., Ablow, J. C., Kupfer, D. J., & MacArthur Assessment Battery Working Group. (2002). The confluence of mental, physical, social, and academic difficulties in middle childhood. I. Exploring the "headwaters" of early life morbidities. *Journal of the American Academy of Child & Adolescent Psychiatry, 41*(5), 580–587. https://doi.org/10.1097/00004583-200205000-00016

Broeren, S., & Muris, P. (2009). The relation between cognitive development and anxiety phenomena in children. *Journal of Child and Family Studies, 18*(6), 702–709. https://doi.org/10.1007/s10826-009-9276-8

Broeren, S., Muris, P., Diamantopoulou, S., & Baker, J. R. (2013). The course of childhood anxiety symptoms: Developmental trajectories and child-related factors in normal children. *Journal of Abnormal Child Psychology, 41*(1), 81–95. https://doi.org/10.1007/s10802-012-9669-9

Buzzell, G. A., Troller-Renfree, S. V., Barker, T. V., Bowman, L. C., Chronis-Tuscano, A., Henderson, H. A., & Fox, N. A. (2017). A neurobehavioral mechanism linking behaviorally inhibited temperament and later adolescent social anxiety. *Journal of the American Academy of Child & Adolescent Psychiatry, 56*(12), 1097–1105. https://doi.org/10.1016/j.jaac.2017.10.007

Capage, L., & Watson, A. C. (2001). Individual differences in theory of mind, aggressive behavior, and social skills in young children. *Early Education and Development, 12*(4), 613–628. https://doi.org/10.1207/s15566935eed1204_7

Cicchetti, D., & Rogosch, F. A. (1996). Equifinality and multifinality in developmental psychopathology. *Development and Psychopathology, 8*(4), 597–600. https://doi.org/10.1017/s0954579400007318

Chronis-Tuscano, A., Danko, C. M., Rubin, K. H., Coplan, R. J., & Novick, D. R. (2018). Future directions for research on early intervention for young children at risk for social anxiety. *Journal of Clinical Child & Adolescent Psychology, 47*(4), 655–667. https://doi.org/10.1080/15374416.2018.1426006

Clauss, J. A., & Blackford, J. U. (2012). Behavioral inhibition and risk for developing social anxiety disorder: A meta-analytic study. *Journal of the American Academy of Child and Adolescent Psychiatry, 51*(10), 1066–1075. https://doi.org/10.1016/j.jaac.2012.08.002

Colonnesi, C., Nikolić, M., de Vente, W., & Bögels, S. M. (2017). Social anxiety symptoms in young children: Investigating the interplay of theory of mind and expressions of shyness. *Journal of Abnormal Child Psychology, 45*(5), 997–1011. https://doi.org/10.1007/s10802-016-0206-0

Degnan, K. A., Almas, A. N., & Fox, N. A. (2010). Temperament and the environment in the etiology of childhood anxiety. *Journal of Child Psychology and Psychiatry, 51*(4), 497–517. https://doi.org/10.1111/j.1469-7610.2010.02228.x

Degnan, K. A., & Fox, N. A. (2007). Behavioral inhibition and anxiety disorders: Multiple levels of a resilience process. *Development*

and Psychopathology, 19(3), 729–746. https://doi.org/10.1017/s0954579407000363

Devine, R. T., White, N., Ensor, R., & Hughes, C. (2016). Theory of mind in middle childhood: longitudinal associations with executive function and social competence. *Developmental Psychology, 52*(5), 758–771. https://doi.org/10.1037/dev0000105

Essex, M. J., Boyce, W. T., Goldstein, L. H., Armstrong, J. M., Kraemer, H. C., Kupfer, D. J., & MacArthur Assessment Battery Working Group. (2002). The confluence of mental, physical, social, and academic difficulties in middle childhood. II. Developing the MacArthur Health and Behavior Questionnaire. *Journal of the American Academy of Child & Adolescent Psychiatry, 41*(5), 588–603. https://doi.org/10.1097/00004583-200205000-00017

Fox, N. A., Henderson, H. A., Marshall, P. J., Nichols, K. E., & Ghera, M. M. (2005). Behavioral inhibition: Linking biology and behavior within a developmental framework. *Annual Review of Psychology, 56*, 235–262. https://doi.org/10.1146/annurev.psych.55.090902.141532

Fox, N. A., Schmidt, L. A., Calkins, S. D., Rubin, K. H., & Coplan, R. J. (1996). The role of frontal activation in the regulation and dysregulation of social behavior during the preschool year. *Development and Psychopathology, 8*(1), 89–102. https://doi.org/10.1017/s0954579400006982

Hayes, A. F. (2017). *Introduction to mediation, moderation, and conditional process analysis* (2nd ed.). The Guilford Press.

Hayes, A. F. (2015). An index and test of linear moderated mediation. *Multivariate Behavioral Research, 50*(1), 1–22. https://doi.org/10.1080/00273171.2014.962683

Hezel, D. M., & McNally, R. J. (2014). Theory of mind impairments in social anxiety disorder. *Behavior Therapy, 45*(4), 530–540. https://doi.org/10.1016/j.beth.2014.02.010

Hughes, C., Jaffee, S. R., Happé, F., Taylor, A., Caspi, A., & Moffitt, T. E. (2005). Origins of individual differences in theory of mind: From nature or nurture? *Child Development, 76*(2), 356–370. https://doi.org/10.1111/j.1467-8624.2005.00850_a.x

Gadow, K. D., & Sprafkin, J. N. (2002). *Child Symptom Inventory 4: Screening and norms manual.* Checkmate Plus.

Goffin, K. C., Kochanska, G., & Yoon, J. E. (2020). Children's theory of mind as a mechanism linking parents' mind-mindedness in infancy with children's conscience. *Journal of Experimental Child Psychology, 193*, 104784. https://doi.org/10.1016/j.jecp.2019.104784

Kagan, J. (2018). The history and theory of behavioral inhibition. In K. Pérez-Edgar & N. A. Fox (Eds.), *Behavioral inhibition* (pp. 1–15). Springer.

Kagan, J. & Fox, N. (2006). Biology, culture, and temperamental biases. In W. Damon & R. Lerner (Series Eds.), & N. Eisenberg (Vol. Ed.), *Handbook of child psychology, Vol. 3. Social, emotional, and personality development* (6th ed., pp. 167–225). New York, NY: Wiley.

Kagan, J., Reznick, J. S., Clarke, C., Snidman, N., & Garcia Coll, C. (1984). Behavioral inhibition to the unfamiliar. *Child Development, 55*(6), 2212–2225. https://doi.org/10.2307/1129793

Kagan, J., Reznick, J. S., & Gibbons, J. (1989). Inhibited and uninhibited types of children. *Child Development, 60*(4), 838–845. https://doi.org/10.2307/1131025

Kagan, J., & Snidman, N. (1999). Early childhood predictors of adult anxiety disorders. *Biological Psychiatry, 46*(11), 1536–1541. https://doi.org/10.1016/s0006-3223(99)00137-7

Kagan, J., & Snidman, N. (2004). *The long shadow of temperament.* Belknap Press/Harvard University Press.

Kiel, E. J., & Buss, K. A. (2014). Dysregulated fear in toddlerhood predicts kindergarten social withdrawal through protective parenting. *Infant and Child Development, 23*(3), 304–313. https://doi.org/10.1002/icd.1855

Kochanska, G. (1995). Children's temperament, mothers' discipline, and security of attachment: Multiple pathways to emerging internalization. *Child Development, 66*, 597–615. https://www.jstor.org/stable/1131937

Kochanska, G., Aksan, N., & Joy, M. E. (2007). Children's fearfulness as a moderator of parenting in early socialization: Two longitudinal studies. *Developmental Psychology, 43*(1), 222–237. https://doi.org/10.1037/0012-1649.43.1.222

LaBounty, J., Bosse, L., Savicki, S., King, J., & Eisenstat, S. (2017). Relationship between social cognition and temperament in preschool-aged children. *Infant and Child Development, 26*(2), e1981. https://doi.org/10.1002/icd.1981

Lane, J. D., Wellman, H. M., Olson, S. L., Miller, A. L., Wang, L., & Tardif, T. (2013). Relations between temperament and theory of mind development in the United States and China: biological and behavioral correlates of preschoolers' false-belief understanding. *Developmental Psychology, 49*(5), 825–836. https://doi.org/10.1037/a0028825

Lau, J. Y., & Waters, A. M. (2017). Annual Research Review: An expanded account of information-processing mechanisms in risk for child and adolescent anxiety and depression. *Journal of Child Psychology and Psychiatry, 58*(4), 387–407. https://doi.org/10.1111/jcpp.12653

Lecce, S., Caputi, M., Pagnin, A., & Banerjee, R. (2017). Theory of mind and school achievement: The mediating role of social competence. *Cognitive Development, 44*, 85–97. https://doi.org/10.1016/j.cogdev.2017.08.010

Lewis-Morrarty, E., Degnan, K. A., Chronis-Tuscano, A., Rubin, K. H., Cheah, C. S., Pine, D. S., & Fox, N. A. (2012). Maternal overcontrol moderates the association between early childhood behavioral inhibition and adolescent social anxiety symptoms. *Journal of Abnormal Child Psychology, 40*(8), 1363–1373. https://doi.org/10.1007/s10802-012-9663-2

Little, R. J. (1988). A test of missing completely at random for multivariate data with missing values. *Journal of the American Statistical Association, 83*(404), 1198–1202. https://doi.org/10.1080/01621459.1988.10478722

Longobardi, E., Spataro, P., D'Alessandro, M., & Cerutti, R. (2017). Temperament dimensions in preschool children: Links with cognitive and affective theory of mind. *Early Education and Development, 28*(4), 377–395. https://doi.org/10.1080/10409289.2016.1238673

MacKinnon, D. P., Lockwood, C. M., & Williams, J. (2004). Confidence limits for the indirect effect: Distribution of the product and resampling methods. *Multivariate Behavioral Research, 39*(1), 99–128. https://doi.org/10.1207/s15327906mbr3901_4

Mink, D., Henning, A., & Aschersleben, G. (2014). Infant shy temperament predicts preschoolers' theory of mind. *Infant Behavior and Development, 37*(1), 66–75. https://doi.org/10.1016/j.infbeh.2013.12.001

Muthén, L. K., & Muthén, B. O. (1998–2020). *Mplus user's guide.* Los Angeles, CA: Author.

Muris, P., Mayer, B., Vermeulen, L., & Hiemstra, H. (2007). Theory-of-mind, cognitive development, and children's interpretation of anxiety-related physical symptoms. *Behaviour Research and Therapy, 45*(9), 2121–2132. https://doi.org/10.1016/j.brat.2007.02.014

Murray, L., Creswell, C., & Cooper, P. J. (2009). The development of anxiety disorders in childhood: an integrative review. *Psychological Medicine, 39*(9), 1413–1423. https://doi.org/10.1017/s0033291709005157

Nikolić, M. (2020). Disturbed Social Information Processing as a Mechanism in the Development of Social Anxiety Disorder. *Child Development Perspectives, 14*(4), 258–264. https://doi.org/10.1111/cdep.12390

Nikolić, M., Majdandžić, M., Colonnesi, C., de Vente, W., Möller, E., & Bögels, S. (2020). The unique contribution of blushing to the development of social anxiety disorder symptoms: results from a longitudinal study. *Journal of Child Psychology and Psychiatry, 61*(12), 1339–1348. https://doi.org/10.1111/jcpp.13221

Nikolić, M., van der Storm, L., Colonnesi, C., Brummelman, E., Kan, K. J., & Bögels, S. (2019). Are socially anxious children poor or advanced mindreaders? *Child Development, 90*(4), 1424–1441. https://doi.org/10.1111/cdev.13248

Pearcey, S., Gordon, K., Chakrabarti, B., Dodd, H., Halldorsson, B., & Creswell, C. (2020). Research Review: The relationship between social anxiety and social cognition in children and adolescents: a systematic review and meta-analysis. *Journal of Child Psychology and Psychiatry*. Advance online publication. https://doi.org/10.1111/jcpp.13310

Pérez-Edgar, K., Taber-Thomas, B., Auday, E., & Morales, S. (2014). Temperament and attention as core mechanisms in the early emergence of anxiety. In K. Lagattuta (Ed.), *Children and Emotion: New Insights into Developmental Affective Science* (Vol. 26, pp. 42–56). Karger.

Poole, K. L., Tang, A., & Schmidt, L. A. (2018). The temperamentally shy child as the social adult: An exemplar of multifinality. In K. Pérez-Edgar & N. A. Fox (Eds.), *Behavioral Inhibition: Integrating theory, research, and clinical perspectives*. Cham, Switzerland: Springer.

Preacher, K. J., Rucker, D. D., & Hayes, A. F. (2007). Addressing moderated mediation hypotheses: Theory, methods, and prescriptions. *Multivariate Behavioral Research, 42*(1), 185–227. https://doi.org/10.1080/00273170701341316

Rapee, R. M., & Spence, S. H. (2004). The etiology of social phobia: Empirical evidence and an initial model. *Clinical Psychology Review, 24*(7), 737–767. https://doi.org/10.1016/j.cpr.2004.06.004

Rapee, R. M., Schniering, C. A., & Hudson, J. L. (2009). Anxiety disorders during childhood and adolescence: origins and treatment. *Annual Review of Clinical Psychology, 5*, 311–341. https://doi.org/10.1146/annurev.clinpsy.032408.153628

Reznick, J. S., Gibbons, J. L., Johnson, M. O., & McDonough, P. M. (1989). Behavioral inhibition in a normative sample. In J. S. Reznick (Ed.), *Perspectives on behavioral inhibition* (pp. 25–49). University of Chicago Press.

Ronchi, L., Banerjee, R., & Lecce, S. (2020). Theory of mind and peer relationships: The role of social anxiety. *Social Development, 29*(2), 478–493. https://doi.org/10.1111/sode.12417

Rothbart, M. K., & Bates, J. E. (2006). Temperament. In W. Damon & R. Lerner (Series Eds.), & N. Eisenberg (Vol. Ed.), *Handbook of child psychology, Vol. 3. Social, emotional, and personality development* (6th ed., pp. 99–166). New York: Wiley.

Rubin, K. H., Coplan, R. J., & Bowker, J. C. (2009). Social withdrawal in childhood. *Annual Review of Psychology, 60*, 141–171. https://doi.org/10.1146/annurev.psych.60.110707.163642

Schwartz, C. E., Kunwar, P. S., Greve, D. N., Moran, L. R., Viner, J. C., Covino, J. M., & Wallace, S. R. (2010). Structural differences in adult orbital and ventromedial prefrontal cortex predicted by infant temperament at 4 months of age. *Archives of General Psychiatry, 67*(1), 78–84. https://doi.org/10.1001/archgenpsychiatry.2009.171

Schwartz, C. E., Snidman, N., & Kagan, J. (1999). Adolescent social anxiety as an outcome of inhibited temperament in childhood. *Journal of the American Academy of Child and Adolescent Psychiatry, 38*(8), 1008–1015. https://doi.org/10.1097/00004583-199908000-00017

Shrout, P. E., & Bolger, N. (2002). Mediation in experimental and nonexperimental studies: new procedures and recommendations. *Psychological Methods, 7*(4), 422–445. https://doi.org/10.1037//1082-989X.7.4.422

Simonsohn, U. (2018). Two lines: A valid alternative to the invalid testing of U-shaped relationships with quadratic regressions. *Advances in Methods and Practices in Psychological Science, 1*(4), 538–555. https://doi.org/10.1177%2F2515245918805755

Slaughter, V., Imuta, K., Peterson, C. C., & Henry, J. D. (2015). Meta-analysis of theory of mind and peer popularity in the preschool and early school years. *Child Development, 86*(4), 1159–1174. https://doi.org/10.1111/cdev.12372

Spence, S. H., Donovan, C., & Brechman-Toussaint, M. (1999). Social skills, social outcomes, and cognitive features of childhood social phobia. *Journal of Abnormal Psychology, 108*(2), 211–221. https://doi.org/10.1037/0021-843x.108.2.211

Stride, C. B., Gardner, S., Catley, N. & Thomas, F. (2015). *Mplus code for the mediation, moderation, and moderated mediation model templates from Andrew Hayes' PROCESS analysis examples.* Retrieved from http://www.offbeat.group.shef.ac.uk/FIO/mplusmedmod.htm

Suway, J. G., Degnan, K. A., Sussman, A. L., & Fox, N. A. (2012). The relations among theory of mind, behavioral inhibition, and peer interactions in early childhood. *Social Development, 21*(2), 331–342. https://doi.org/10.1111/j.1467-9507.2011.00634.x

Thomas, A., & Chess, S. (1977). *Temperament and development.* Brunner/Mazel.

Troller-Renfree, S. V., Buzzell, G. A., Bowers, M. E., Salo, V. C., Forman-Alberti, A., Smith, E., & Fox, N. A. (2019). Development of inhibitory control during childhood and its relations to early temperament and later social anxiety: unique insights provided by latent growth modeling and signal detection theory. *Journal of Child Psychology and Psychiatry, 60*(6), 622–629. https://doi.org/10.1111/jcpp.13025

Watson, A. C., Nixon, C. L., Wilson, A., & Capage, L. (1999). Social interaction skills and theory of mind in young children. *Developmental Psychology, 35*(2), 386–391. https://doi.org/10.1037/0012-1649.35.2.386

Wellman, H. M., Lane, J. D., LaBounty, J., & Olson, S. L. (2011). Observant, nonaggressive temperament predicts theory-of-mind development. *Developmental Science, 14*(2), 319–326. https://doi.org/10.1111/j.1467-7687.2010.00977.x