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CHILD DEVELOPMENT

EMPIRICAL ARTICLE

Behavioral inhibition, negative parenting, and social withdrawal: Longitudinal associations with loneliness during early, middle, and late adolescence

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Abstract

Adolescent loneliness can have detrimental effects on physical and mental health, but there is limited understanding of its antecedents in infancy and childhood. A 20-year longitudinal, multi-informant, and multi-methods study (first data collection in 1998) was conducted to examine mechanisms underlying adolescent loneliness ($N = 128$, 52% boys, $M_{age\_baseline} = 1.23$, SD = 0.02, 99% White, recruitment in Dutch urban, healthcare centers). Structural equation modeling showed that high infant behavioral inhibition (BI) was indirectly associated with high loneliness during adolescence via high childhood social withdrawal. This indirect effect was equally strong during early, middle, and late adolescence. Contrary to expectations, infant parenting did not moderate the relation between BI and social withdrawal. The results suggest a developmental cascade with infant BI showing long-lasting indirect effects on adolescent loneliness up to 20 years later via childhood social withdrawal.

Loneliness refers to the negative emotional experience that arises when people perceive their relations to be of inadequate quality or lacking in size (network quantity; Perlman & Peplau, 1981). Evidence suggests that loneliness is high during adolescence (Qualter et al., 2013; van Roekel et al., 2011), with 20%–70% of adolescents reporting to feel lonely "sometimes" or "often" (Qualter et al., 2015). Loneliness can have detrimental effects on one's physical and mental health, including impaired immune functioning and poorer sleep quality (Hawkley & Cacioppo, 2010). Moreover, adolescent loneliness is associated with depression, with metabolic risk factors linked to cardiovascular disease during adulthood, and is predictive of poorer self-perceived health (Goosby et al., 2013). Given the negative effects on one's mental and physical health, it is important to understand the mechanisms that underlie adolescent loneliness.

Here, we adopt a developmental psychopathology framework in which we postulate that adolescent loneliness can have its roots in infancy, specifically in infant behavioral inhibition (BI). Specifically, based on the previous theoretical accounts (Fox et al., 2005; Rubin & Chronis-Tuscano, 2021; Rubin et al., 2009), we tested a developmental cascade model in which we hypothesized that higher levels of BI during infancy predisposes some children to loneliness during adolescence, partly because their high levels of BI put them at higher risk of becoming more socially withdrawn during middle childhood. Moreover, we hypothesized that this pathway would be stronger in the case of negative parenting during infancy.

Abbreviations: BI, behavioral inhibition; BQTP, Behavior Questionnaire for Toddlers and Preschoolers; CBCL, Child Behavior Checklist; CBQ, Child Behavior Questionnaire; CFI, comparative fit index; ITSEA, Infant-Toddler Social & Emotional Assessment; LLCA, Louvain Loneliness Scale for Children and Adolescents; LSDQ, Loneliness and Social Dissatisfaction Questionnaire; NLS, Nijmegen Longitudinal Study; RMSEA, root mean square error of approximation; SEM, structural equation modeling; SRMR, standardized root mean square residual; TBAQ, Toddler Behavior Assessment Questionnaire; TRF, Teacher Report Form.

Although some studies support how indicators of BI (e.g., negative reactivity) and social withdrawal (e.g., lower social skills and engagement) during childhood could have long-lasting effects on loneliness during adolescence (Qualter et al., 2013; Schinka et al., 2013), we are not aware of any study that has tested this complete developmental cascade from infant BI via childhood social withdrawal on early, middle, and late adolescent loneliness while making use of a multi-methods and multi-informant approach. To test this hypothesized developmental pathway, we made use of a prospective 20-year longitudinal study with multi-method and multi-informant measures of BI and negative parenting during infancy (ages 1 and 2), social withdrawal during middle childhood (ages 5, 7, 9, and 12) and loneliness during early (age 13), middle (age 16), and late adolescence (age 21). By understanding the early mechanisms of loneliness, strong theory-based prevention programs could be informed, which could ultimately prevent onset or deterioration of feelings of loneliness during adolescence.

BI during infancy as a predisposing factor for adolescent loneliness

BI is a biologically based temperamental style characterized by a relatively consistent pattern of overly cautious, fearful, and avoidant behavior to unfamiliar people, situations, and contexts (Fox et al., 2005; Kagan et al., 1984). Several theoretical models postulate that infant BI can—directly or indirectly—predispose one to experience loneliness later in life (e.g., Fox et al., 2005; Rubin & Chronis-Tuscano, 2021; Rubin et al., 2009). A possible direct pathway could be that infants and toddlers who are highly inhibited typically react with more restraint and caution to novel objects and situations, and are more anxious around unfamiliar people than their less inhibited peers (Kagan et al., 1984). This implies that highly inhibited individuals encounter fewer opportunities to connect with others which—over the long run—could predispose to the experience of loneliness. Indeed, findings from several longitudinal studies suggested that behaviorally inhibited children may have an increased risk of experiencing social isolation, resulting in feelings of loneliness (Fox et al., 2005).

Another rationale to include BI as a precursor in current theoretical models of loneliness is that similar cognitive biases may play a role in both BI and loneliness, namely a hypervigilance for threatening social cues and endorsing a prevention motivation instead of a promotion motivation (Fox et al., 2005; Park & Baumeister, 2015). Indeed, it has been shown that highly inhibited infants and toddlers react to novel situations and stimuli as if they are potentially threatening (Fox et al., 2005; Henderson et al., 2015). This hypervigilance toward social stimuli typically associated with BI shows a striking resemblance with the hypervigilance perspective thought to be vital in the emergence of loneliness (Qualter et al., 2015; Spithoven et al., 2017). Additionally, high BI might be associated with higher prevention motivation (Hane et al., 2008), which serves the goal of self-preservation while limiting one's opportunities for awarding social interactions. Because avoiding certain situations is associated with lower chances of experiencing negative social interactions, prevention behavior is reinforced. This may instigate a cascade of reduced experiences of social successes, less socially competent behaviors, less attempts at social reconnection, and probably more BI or feelings of loneliness (Rubin et al., 2018). Evidence for this idea of shared underlying mechanisms for childhood BI and adolescent loneliness (i.e., these cognitive biases) comes from a neurobiologically grounded framework (Shackman et al., 2016) suggesting that early age amygdala functioning is associated with attentional biases to threat and hypervigilance and plays a role in understanding the *maintenance* of psychopathology. That these cognitive biases contribute to heightened BI at young age and increased feelings of loneliness in later years may also explain the idea of heterotypic continuity (i.e., one trait or disorder predicting another at a later time point).

Based on these theoretical explanations, BI might be an important early risk factor for loneliness in later life. Indeed, a recent study found that BI at 14 months of age was predictive of lower social functioning (which included feelings of loneliness) at the age of 26 (Tang et al., 2020). However, little research has focused on this topic, and previous research never integrated different methods and informants or such a long time-window. Therefore, the first aim was to examine whether BI, measured in infancy with multiple methods and by questioning several informants, was predictive of loneliness during early, middle, and late adolescence.

Social withdrawal as an underlying factor between BI and loneliness

A possible indirect pathway through which high infant BI might predispose to adolescent loneliness is via social withdrawal during childhood (see Rubin & Chronis-Tuscano, 2021 for a review). Social withdrawal is defined as a consistent display of solitary behavior when encountering both familiar and unfamiliar peers (Coplan & Rubin, 2010). During childhood, peer relations are vital to a child's emotional and social development, for instance through learning moral reasoning, perspective taking, and self-understanding (Rubin et al., 2009). However, if children show high social withdrawal during this important developmental period, they might not receive such opportunities and be at higher risk for internalizing problems, including loneliness (Rubin & Chronis-Tuscano, 2021).

Indeed, several studies have found that infant BI can be an antecedent for social withdrawal during

childhood and adolescence (Booth-Laforce & Oxford, 2008; Degnan et al., 2014; Fox et al., 2005; Perez-Edgar et al., 2010). While social withdrawal might seemingly show overlap with BI, these are two distinct concepts (Fox et al., 2005; Rubin et al., 2018). Specifically, BI is used to describe a biologically based individual characteristic, which predisposes infants to behave in a fearful and avoidant manner when encountering both social and non-social unfamiliarity. As these children tend to engage in less socially competent behaviors than their peers, they may experience more peer-rejection. These unpleasant social experiences may trigger (dispositional) withdrawn behavior even more. Subsequently, this behavioral predisposition together with negative evaluations from others could increase the likelihood that the avoidant behavioral repertoire generalizes to familiar social situations as well, leading to social withdrawal (Rubin et al., 2018).

Social withdrawal, in turn, is thought to play a key role in the emergence and/or maintenance of loneliness (Qualter et al., 2015). First off, high levels of withdrawn behavior might undermine opportunities to experience meaningful social interaction, which, according to the evolutionary theory of loneliness is crucial for reconnection (Cacioppo et al., 2014). Second, avoiding social situations might prevent one from gaining valuable experiences that promote social interaction, which may lead to more deficient social skills over time (Qualter et al., 2015). Indeed, social withdrawal is concurrently and prospectively associated with increased feelings of loneliness (Booth-Laforce & Oxford, 2008; Jobe-Shields et al., 2011; Rubin et al., 1995). Drawing on these findings, social withdrawal might be relevant in understanding the hypothesized association between infant BI and adolescent loneliness. Therefore, the second goal was to examine whether childhood social withdrawal (partially) mediated the relation between infant BI and early, middle, and late adolescent loneliness.

Parenting as a moderating factor

Next to these internal factors, the caregiving environment is recognized as an important factor that can strengthen the effect that BI has on social behavior. Specifically, negative parenting is thought to moderate the stability of BI from infancy to childhood (Degnan & Fox, 2007; Fox et al., 2005; Rubin et al., 2009). Some parents might restrict their child's behavior, discourage independence, and control their child's activities, leading to fewer opportunities for them to learn how to behave in social situations and this has more pronounced effects in inhibited children (Rubin et al., 2002, 2009). Thus, for inhibited infants and toddlers, negative parenting might strengthen the earlier described association between BI and social withdrawal.

Indeed, if caregivers display high levels of control and derision (Rubin et al., 2002), or are insensitive and intrusive toward their behaviorally inhibited child (Booth-Laforce & Oxford, 2008), they are more likely to develop into withdrawn children. In turn, this increased likelihood to become withdrawn might be associated with more loneliness (Jobe-Shields et al., 2011; Oh et al., 2008). Using a developmental framework, the main focus of the current research was combining these individual (i.e., BI and social withdrawal) and environmental (i.e., negative parenting) frameworks to further understanding on the emergence of adolescent loneliness. The third goal was to examine the moderating role of negative parenting during infancy in the relation between infant BI and childhood social withdrawal.

Loneliness during different adolescent periods

One problem in the research field of loneliness is that "adolescence" has often been studied as if it were a homogeneous group. Research samples either show large variations in age and simply use group means (e.g., Teppers et al., 2013) or include just one specific age (e.g., Woodhouse et al., 2012). A drawback of existing longitudinal studies to loneliness is that these mainly describe loneliness trajectories, making it impossible to draw conclusions for different age groups. Current approaches thus neglect the vast amount of rapid biological, cognitive, emotional, and social transitions that characterize this developmental period. For example, biological changes might be more pronounced during early adolescence, whereas social transitions mainly happen during middle adolescence when adolescents gain autonomy from their parents and spend more time with their peers (Wang et al., 2007). Given these transitions, it could be possible that long-term effects of BI and social withdrawal vary over the course of development. It could also be possible that social withdrawal in childhood has a stronger effect on loneliness in early adolescence, because those developmental periods are closer in time than middle or late adolescence. During late adolescence, those individuals might have had a greater chance to grow out of higher social withdrawal. However, we are not aware of any prior literature that has tested how the influence of infant BI and childhood social withdrawal might differ across different periods of adolescence.

Following developmental psychologists, the current study explored whether the effects of BI, withdrawal, and parenting on loneliness differed between early, middle, and late adolescence. In the current study, we measured loneliness at approximately ages 13, 16, and 21, which converge with the general categorizations from Kimmel and Weiner (1985), who used the following age ranges to categorize adolescence into early (10–13 years), middle (14–17 years), and late adolescence (18–22 years).

The present study

In the current 20-year longitudinal study, a multi-informant (i.e., parents, teachers, adolescents, and their peers) and multi-methods (i.e., observations, parent and teacher reports, sociometric nominations, and self-reports) approach was used to investigate the role of BI and negative parenting during infancy, and social withdrawal during childhood in the development of loneliness during early, middle, and late adolescence. Specifically, the direct effect of infant BI on loneliness at the different ages, with childhood social withdrawal as a possible mediator in this relation was examined (aim 1). Additionally, the moderating effect of observed negative parenting in infancy on the relation between BI and social withdrawal was investigated (aim 2). Lastly, we were interested whether the indirect effect of infant BI on adolescent loneliness via childhood social withdrawal differed between early, middle, and late adolescence (aim 3).

First off, it was hypothesized that a high level of BI during infancy would be predictive of loneliness during early, middle, and late adolescence, given that (1) high BI may decrease the opportunities for social connection and (2) similar cognitive biases have been associated with BI and loneliness (Henderson et al., 2015; Spithoven et al., 2017). Moreover, it was expected that this relation would be partially mediated by social withdrawal (Booth-Laforce & Oxford, 2008; Degnan et al., 2014; Jobe-Shields et al., 2011; Perez-Edgar et al., 2010). Additionally, it was hypothesized that the relation between infant BI and childhood withdrawal would be moderated by negative parenting. More specifically, this relation would be stronger in the presence of negative parenting (Booth-Laforce & Oxford, 2008; Rubin et al., 2002). Lastly, with regard to age differences in loneliness, the hypothesized relations were tested in an exploratory manner in the different adolescent age periods and no specific hypotheses for that matter were formulated (given the lack of literature to base specific hypotheses on). Figure 1 depicts the visualization of the hypothesized theoretical model.

METHOD

Participants

Participants were part of the Nijmegen Longitudinal Study (NLS) on Infant and Child Development, which started in 1998 with a Dutch community-based sample of 129 healthy 15-month-old infants (52% boys, M_{age} = 14.88 months, SD = 0.25 months) and one of their primary caregivers (126 mothers and 3 fathers), representative of the Dutch population. The primary caregivers were between 22 and 47 years old (M = 32.9 years, SD = 4.42). Families were initially contacted using birth records from local, urban, healthcare centers in Nijmegen, the Netherlands. During nine consecutive months, all families with a 15-month-old baby (i.e., 639 families) were sent a recruitment letter explaining the goals of the research and were asked to respond if interested in participating. Of the 174 families that responded positively to this letter, 129 families that were randomly selected agreed to participate. For more information about the recruitment procedure and demographic characteristics, see Van Bakel and Riksen-Walraven (2004). For the current study, data were collected when participants were 1, 2, 5, 7, 9, 12, 13, 16, and 21 years old (see Table 1 for detailed information on age and years of data collection). One participant who did not have any data on the relevant measures was excluded from further analyses, meaning that the final sample consisted of 128 participants.

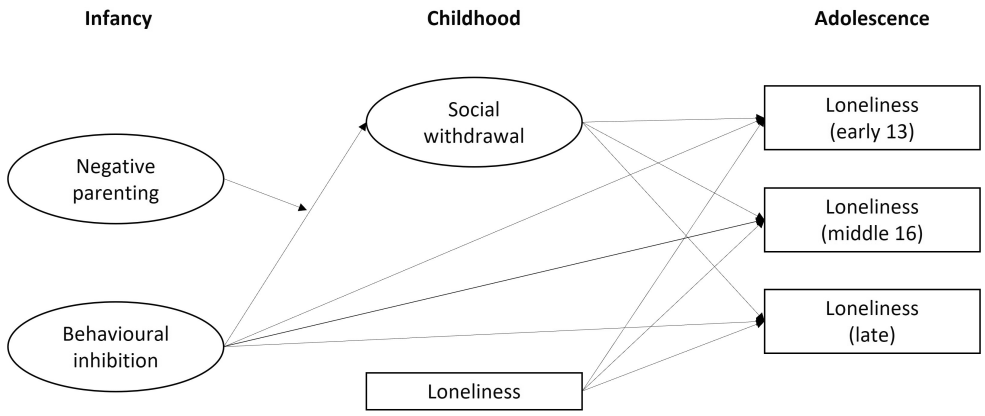

FIGURE 1 Hypothesized theoretical model. All depicted pathways present positive associations. Aim 1: Testing direct effect of infant behavioral inhibition (BI) on loneliness at the different ages, with childhood social withdrawal as a possible mediator. Aim 2: Testing the moderating effect of observed negative parenting in infancy on the relation between BI and social withdrawal. Aim 3: Testing whether the effect of BI via social withdrawal differed across early, middle, and late adolescence

TABLE 1 Descriptive information for age in years and years of assessment

	Infancy		Childhood				Adolescence		
Age	**Age 1**	**Age 2**	**Age 5**	**Age 7**	**Age 9**	**Age 12**	**Age 13**	**Age 16**	**Age 21**
Year	1998 1999	1999 2000	2002 2003	2005	2006 2007	2009 2010	2010 2011	2014	2018
M_{age}	1.23	2.35	5.32	7.67	8.96	12.58	13.52	16.27	20.50
SD_{age}	.02	.04	.14	.12	.21	.17	.24	.26	.15
Min_{age}	1.19	2.28	4.37	7.46	8.00	12.17	12.9	15.81	20.31
Max_{age}	1.28	2.49	5.86	8.07	9.99	13.00	14.08	16.82	21.02

TABLE 2 Overview of instruments per wave of behavioral inhibition, parenting, social withdrawal, and loneliness

	Construct	**Instrument**	**Informant**	**Cronbach's α**
Age 1	Behavioral inhibition	Stranger task	Observer	.73
		Robot task	Observer	.64
		TBAQ	Parent	.62
	Parenting	Interaction tasks	Observer	.84
Age 2	Behavioral inhibition	TBAQ	Parent	.78
		ITSEA	Parent	.79
		BQTP	Nursery teacher	.83
	Parenting	Interaction tasks	Observer	.86
Age 5	Withdrawal	CBCL	Parent	.59
		TRF	Teacher	.76
Age 7	Withdrawal	CBQ	Parent	.92
Age 9	Withdrawal	CBCL	Parent	.56
		TRF	Teacher	.73
		Sociometry	Classmates	.73
Age 9	Loneliness	LSDQ	Self-report	.76
Age 12	Withdrawal	CBCL	Parent	.70
		TRF	Teacher	.82
		Sociometry	Classmates	—
Age 13	Loneliness	LLCA	Self-report	.92
Age 16	Loneliness	LLCA	Self-report	.88
Age 21	Loneliness	UCLA	Self-report	.92

Abbreviations: BQTP, Behavior Questionnaire for Toddlers and Preschoolers; CBCL, Child Behavior Checklist; CBQ, Child Behavior Questionnaire; ITSEA, Infant Toddler Social Emotional Assessment; LLCA, Louvain Loneliness Scale for Children and Adolescents; LSDQ, Loneliness and Social Dissatisfaction Questionnaire; TBAQ, Toddler Behavior Assessment Questionnaire; TRF, Teacher Report Form; UCLA, UCLA Loneliness Scale.

Procedures and measures

Active informed consent was obtained from parents, and if applicable, the school board and teachers, when participants were 1, 2, 5, 7, 12, 13, and 16 years of age. In addition, at age 12, 13, and 16, the participant, and if applicable, the participant's classmates, provided informed assent. At age 21, the participants gave active informed consent for their participation. The following IRB approvals have been obtained for the NLS: ECSW20213-1811-157 and ECG 2013-1308-123.

For the current study, relevant measures of BI, parenting, social withdrawal, and loneliness were selected. Due to the longitudinal setup of the study, procedures and measures widely varied throughout the years. Data were collected during laboratory, home and school visits, and internet assessments. Measurements included child and parent–child interaction observations, parent reports, teacher reports, sociometric peer nominations by the child's classmates, and child self-reports. Table 2 provides an oversight of the instruments per wave that were included in the current study. A more detailed description of relevant procedures and measures per construct can be found below. Internal consistency (Cronbach's α) for each instrument is found in Table 2.

Behavioral inhibition

Stranger/robot observation

At age 1, BI was measured with a stranger/robot observation paradigm (Kagan et al., 1989). The parent–child dyads were invited to the university laboratory. During this laboratory visit, the infant was videotaped during a 14-min "stranger-robot procedure" (adapted from Kagan et al., 1989) during which the infant was first invited for some free play (3 min). After that, a female stranger entered the room and invited the child to play together (2 min) and subsequently the female stranger invited to child to play with a small robot (3 min). After this paradigm, the stranger left the room and the robot was stored. The parent was present during this procedure, and was asked to not actively engage with the child, and to respond as (s)he normally would. The idea of this task is to measure the initial reaction of the infant when confronted with unfamiliarity, both social (i.e., a female stranger) and non-social (i.e., a small robot). A detailed description of this procedure can be found in Van Bakel and Riksen-Walraven (2004) and Niermann et al. (2019).

The behaviors in the videotapes were coded by a trained observer. In total, six variables were coded (in seconds): (1) latency to vocalize to the stranger, (2) latency to approach the stranger, (3) time spent in proximity to caregiver during the stranger episode, (4) latency to vocalize to the robot, (5) latency to approach the robot, and (6) time spent in proximity to caregiver during the robot episode. The three variables for the stranger and the three variables for the robot were summed. The two summed indices were transformed in *z*-scores; one representing the infant's reaction to the stranger, and the other representing the infant's reaction to the robot. Higher *z*-scores indicate higher BI to social and to non-social cues.

Toddler Behavior Assessment Questionnaire

At ages 1 and 2, the primary caregiver completed the Toddler Behavior Assessment Questionnaire (TBAQ; Goldsmith, 1996) during a home visit. The TBAQ is a 111-item measure on which parents report the frequency of specific behaviors during the past month on a 7-point scale, ranging from 1 = never to 7 = always. For this study, the subscale *social fearfulness* consisting of 18 items was used to assess BI of the child. After reversing mirrored scores, the scores were averaged. A higher composite score indicates a higher level of inhibited behavior.

Infant-Toddler Social and Emotional Assessment

At age 2, the primary caregiver completed the Infant-Toddler Social & Emotional Assessment (ITSEA; Carter et al., 2003) during a home visit. The ITSEA is a 166-item parent-report questionnaire that assesses the child's socio-emotional (dis)functioning. Items are scored on a 3-point scale, ranging from 0 = not true/rarely to 2 = very true/often. The subscale *inhibition to novelty*, consisting of 5 items, was used to assess BI of the child. A single composite score was calculated by averaging item scores. A higher composite score indicates a higher level of inhibited behavior.

Behavior Questionnaire for Toddlers and Preschoolers

If the child attended nursery school at age 2, the child's nursery teacher completed the Behavior Questionnaire for Toddlers and Preschoolers (BQTP; Goossens et al., 2000). The BQTP is a 41-item questionnaire on which the nursery teacher reports on the child's social behavior on a 4-point scale, ranging from 1 = not true to 4 = very true. For this study, the subscale *anxious/withdrawn* was used to assess BI, which includes 12 items. A single composite score was calculated by averaging item scores. A higher composite score indicates a higher level of inhibited behavior.

Quality of parental interactive behavior

At ages 1 and 2, parent–child dyads were filmed during a home visit while they performed up to four age-appropriate interaction tasks lasting 3–4 min each, such as doing a jigsaw puzzle and putting a puppet together. Observers rated the following parental interaction quality on five 7-point scales (1 = very low to 7 = very high): (1) supportive presence, (2) respect for the child's autonomy, (3) effective structure and limit setting, (4) quality of instructions, and (5) hostility. The scales were developed by Erickson et al. (1985) to measure quality of parenting behavior (see Appendix A for details). After mirroring hostility scores, one composite score was calculated by averaging the raw scores. A higher composite score indicates higher quality parenting.

Social withdrawal

Child Behavior Checklist

At ages 5, 9, and 12, the primary caregiver completed the Child Behavior Checklist (CBCL; Achenbach, 1991). The CBCL is a 118-item checklist in which parents can report various emotional and behavioral problems of their child on a 3-point scale, ranging from 0 = never to 2 = occurs often. The subscale *withdrawn*, consisting of 9 (age 5) or 8 (ages 9 and 12) items, was used to measure social withdrawal of the child. A composite score was calculated by averaging item scores. A higher composite score indicates more social withdrawal.

Teacher Report Form

At ages 5, 9, and 12, the child's teacher was asked to complete the Teacher Report Form (TRF; Achenbach, 1991) during a school visit. The TRF is a 113-item checklist on which the teacher reports about socio-emotional problems of the child within the classroom. Items are scored on a 3-point scale, ranging from 0 = never to 2 = occurs often. The subscale *withdrawn*, consisting of 9 (age 5) or 8 (ages 9 and 12) items, was used to assess social withdrawal. A single composite score was calculated by averaging item scores. A higher composite score indicates more social withdrawal.

Child Behavior Questionnaire

At 7 years, the primary caregiver completed the Child Behavior Questionnaire (CBQ; Rothbart et al., 2001). The CBQ is a 195-item questionnaire on which parents can report on their child's typical behavior and reactions in various contexts. Items are scored on a 7-point scale, ranging from 1 = extremely untrue to 7 = extremely true. The subscale *shyness* was used to assess social withdrawal of the child, which consists of 13 items. After reversing mirrored scores, the scores were averaged. A higher composite score indicates a higher level of withdrawn behavior.

Sociometric peer nominations

At ages 9 and 12, the child and his/her classmates provided sociometric nominations during a school visit. These sociometric nominations measured multiple behaviors (e.g., relational aggression, victimization, withdrawn behavior). For the present study, we used the items regarding withdrawn behavior. The child and his/her classmates were asked which individual is most withdrawn in their classroom (e.g., "Who is quite shy?" and "Who speaks softly or does not say anything often?"). At both time points, they were asked to nominate at least one classmate. The number of nominations per individual was counted and standardized into *z*-scores within the classroom (i.e., also including non-participating children). A higher *z*-score indicates more withdrawn behavior.

Loneliness

Loneliness and Social Dissatisfaction Questionnaire

Loneliness at 9 years was assessed during a school visit with the Loneliness and Social Dissatisfaction Questionnaire (LSDQ; Asher & Wheeler, 1985), and included in the current research to control for the effects of pre-existing loneliness. The LSDQ is a 16-item questionnaire which measures feelings of loneliness and social dissatisfaction in peer relations at school. Items are scored on a 5-point scale, ranging from 1 = never true to 5 = always true. After reversing mirrored items, the scores were averaged. A higher composite score indicates more feelings of loneliness.

Louvain Loneliness Scale for children and adolescents

Loneliness at 13 and 16 years was assessed during a school visit with the Louvain Loneliness Scale (LLCA; Marcoen et al., 1987). The LLCA is a 48-item questionnaire which measures the participant's subjective experience of loneliness within various social contexts. Items are scored on a 4-point scale, ranging from 0 = never to 3 = often. For this study, the subscale *loneliness in peer relations*, consisting of 12 items was used. After reversing mirrored items, the scores were averaged. A higher composite score indicates more feelings of loneliness.

UCLA Loneliness Scale

To measure loneliness at age 21, participants completed the UCLA Loneliness Scale (Russell et al., 1980) through an internet assessment. The UCLA Loneliness Scale is a 20-item measure on which the participants report on their subjective experience of loneliness on a 5-point scale, ranging from 1 = very untrue to 5 = very true. After reversing mirrored items, the scores were averaged. A higher composite score indicates more loneliness.

Statistical analyses

All code and output can be accessed on the Open Science Framework via https://osf.io/yk7sc/?view_only=1dc569aa2cee44e6ad3a349c46414e44. To investigate the research questions concerning the effect of BI, parenting behavior and social withdrawal on adolescent loneliness, (moderated) mediation analyses within a structural equation modeling (SEM) framework were conducted. Due to the small sample size, we chose a two-step procedure of our SEM analyses where the measurement part is done separately from the structural part as suggested by Rosseel (2020). In the first part (measurement part), we used confirmatory factor analyses to construct latent scores of our study variables BI, negative parenting, and social withdrawal. In the second part (structural part), we addressed our main research questions with regard to the mediation (i.e., indirect effect of BI on loneliness via social withdrawal) and moderated mediation (i.e., moderation by parenting) using the saved latent factor scores from the first part. All analyses, including data

cleaning and descriptives, were conducted in *R* (R Core Team, 2017).

First, using confirmatory factor analyses, latent variables of BI, social withdrawal, and parenting were created based on the observed measures as described in Table 2 using the R package *lavaan* (Rosseel, 2012). Using latent factor scores allows one to test whether the observed variables provide a reliable latent construct, while increasing model parsimony (i.e., fewer parameters and higher degrees of freedom). Moreover, by using latent scores, a more comprehensive score of the measures, including different methods and informants could be constructed. Here, we shortly describe the approach and final models, which are depicted in Figure 2. More information is found in Appendix A. Higher latent factor scores indicate higher BI, more social withdrawal and higher quality of parenting behavior.

For BI, the base model with all manifest indicators indicated that all factor loadings were significant except for the robot task (p = .17) and the BQTP questionnaire (p = .31). It is likely that the robot task did not load significantly on the overall BI score, as it represents the initial reaction toward an unfamiliar *non-social* stimulus (in contrast to the infant's reactions towards unfamiliar *social* stimuli in the other tasks). Second, the score on the BQTP possibly did not load significantly on the overall BI latent score, because it was filled in by the infant's nursery teacher, whereas the other instruments were parent reports. To improve model fit, we removed both manifest indicators from the overall latent BI factor. After this, the model showed a good fit. This adjustment to the model makes that this factor mainly represents socially inhibited behavior as compared to overall BI. For parenting and socially withdrawn behaviors, no modifications to the model were needed, since all indicators significantly loaded on the latent factors and model fit was excellent. For the withdrawal latent factor, the different indicators (CBCL, TRF, CBQ, Sociometry) loaded more or less to a similar degree onto the withdrawal latent score (λ^* = .41–.71, all p's < .001), with the exception of sociometry at age 9, which loaded less high, but still significantly (λ^* = .29, p = .03). This might have to do with the fact that the CBCL, TRF, CBQ are all questionnaire measures and thus share more common method variance. The final factor scores were saved and used in the subsequent analyses.

Second, SEM was used to test the associations between the variables with BI as predictor, parenting as

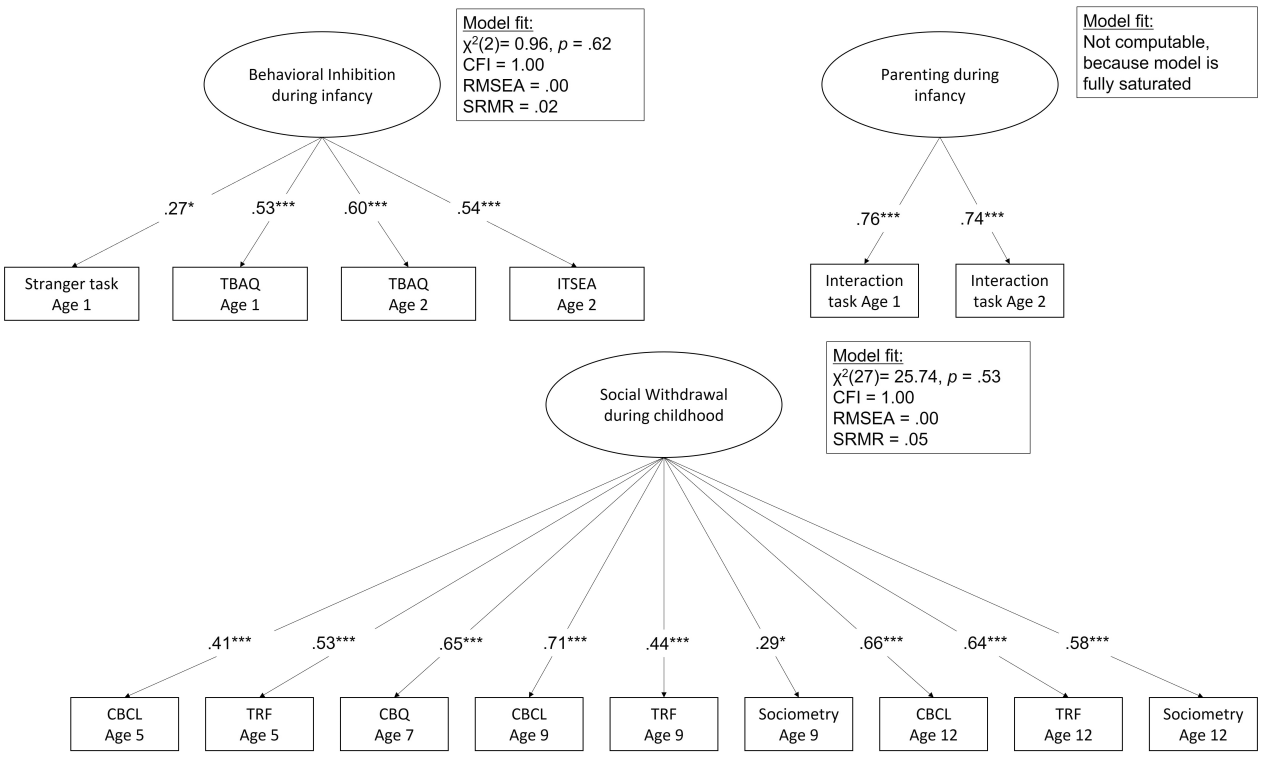

FIGURE 2 Final results of CFA for latent factors behavioral inhibition, parenting, and social withdrawal. For behavioral inhibition, the robot task and Behavior Questionnaire for Toddlers and Preschoolers did not significantly load onto the behavioral inhibition latent factor in an initial model and were removed. No adjustments were needed for the parenting and social withdrawal factors. The manifest indicators for the parenting latent variable were constrained to be equal and the latent factor was standardized for model identification purposes. That model is fully saturated (i.e., no model fit indices could be calculated). CBCL, Child Behavior Checklist; CBQ, Child Behavior Questionnaire; CFA, confirmatory factor analysis; CFI, comparative fit index; ITSEA, Infant Toddler Social Emotional Assessment; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual; TBAQ, Toddler Behavior Assessment Questionnaire; TRF, Teacher Report Form. *p < .05, ***p < .001

moderator, withdrawal as mediator, and loneliness during early, middle, and late adolescence as an outcome. The analyses controlled for earlier levels of loneliness to investigate whether BI and social withdrawal can predict adolescent loneliness above and beyond pre-existing levels of loneliness. We included loneliness at age 9 as a control variable, because we wanted to be certain that any associations between social withdrawal in childhood and loneliness in adolescence were due to interindividual differences in social withdrawal and was not confounded by loneliness in childhood. This was done by adding the standardized loneliness score at age 9 as a predictor for loneliness scores at age 13, 16 and 21 years in all models. Mediation analyses were performed in two steps using the package *lavaan* (Rosseel, 2012) in *R* (R Core Team, 2017).

In step 1, we tested whether social withdrawal mediated the relation between BI and loneliness (aim 1; models 1a–1c). Here, a mediational path model was constructed including the latent factor scores of BI and social withdrawal, and standardized scores of loneliness at age 13, 16, and 21 years (due to different instruments at age 21 compared to ages 13 and 16) to examine direct effects of BI and social withdrawal on loneliness and indirect effects from BI on loneliness via withdrawal. To improve model fit and increase parsimony, data-driven modifications to this model were made by deleting non-significant paths. Moreover, to increase model parsimony and to test whether effects of withdrawal significantly differed between loneliness scores at the different ages, paths from BI and social withdrawal to the three loneliness scores were constrained to be equal across time. This constrained model was then compared to the model with the freely estimated paths with a chi-square difference test to examine whether the effects of BI and withdrawal on loneliness differed over time. In case of a non-significant chi-square difference test, the more parsimonious model (i.e., with the constrained effects across time) was retained as the final mediation model.

In step 2, we tested whether negative parenting moderated the relation between BI and social withdrawal (aim 2; model 2). For that purpose, we fitted a moderated mediation model, where we used the best fitting model from the previous step and added the latent factor score of parenting as a moderator by multiplying the parenting factor score with the BI factor score. Here, the main effect of BI, the main effect of parenting, and the interaction effect on withdrawal were added to examine the interaction effect of BI and parenting on withdrawal.

Little's MCAR test (Little, 1988) was not significant, indicating that there was no evidence that the data violated the assumption of data being missing completely at random (χ^2 = 1183.09, *df* = 1169, *p* = .38). To account for non-normal distributions and missing data, bootstrapped standard errors (10,000 samples) and a full-information maximum likelihood criterion were applied. Additionally, bias-corrected confidence intervals for the indirect effects were calculated, using bootstrapping (10,000 samples). Model fit was evaluated using the chi-square statistic, the comparative fit index (CFI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). Hu and Bentler (1999) recommended a value larger than .95 for CFI, smaller than .06 for RMSEA, and .08 for SRMR to indicate good model fit. Moreover, a non-significant chi-square test is an indication of a good fitting model.

RESULTS

Descriptive statistics

Exploration of the data using boxplots revealed that several variables had scores that visually stood out (i.e., potential outliers). To retain statistical power and reduce effects of potential outliers, these values were winsorized to the ±3 SDs. In total, across all measures and participants, 29 scores were winsorized with this method. Table 3 provides descriptive statistics and missingness of all study variables before winsorizing. Descriptive statistics and correlations on post-winsorized scores, boxplots before and after winsorizing as well as which scores were winsorized can be found in the output via https://osf.io/yk7sc/?view_only=1dc569aa2cee44e6ad3a349c46414e44.

Correlations between study variables (i.e., factor scores and loneliness at all ages) are shown in Table 4, but associations between predictors and outcomes were also formally tested in the SEM analyses. The associations between all manifest indicators are shown in Appendix B, Table S1. Among several significant and non-significant correlations, only the correlations for loneliness at the different ages are described here. Loneliness at age 9 was positively associated with loneliness at ages 13, 16, and 21. Moreover, loneliness scores at age 13 and age 16 positively correlated as well; however, loneliness at age 21 was not associated with loneliness at age 13, nor age 16.

Mediation model

To test the first hypothesis regarding the indirect effect of BI on loneliness via withdrawal, a base model (model 1a) was defined, containing direct effects of BI on social withdrawal, direct effects of social withdrawal on loneliness and direct effects of BI on standardized scores of loneliness over time. This model showed poor fit (Table 5). Inspection of parameter estimates indicated that the direct paths from BI to loneliness were not significant at ages 13, 16, and 21 (see Appendix C, Table S2, for model estimates). To increase parsimony and improve model fit, those non-significant paths were removed (model 1b), which was associated with a

TABLE 3 Descriptive statistics of behavioral inhibition, parenting, social withdrawal and loneliness

	Construct	Instrument	*M* (SD)	Range	*N* (missing)
Age 1	Behavioral inhibition	Stranger task	0.00 (0.81)	−0.87 to 3.57	124 (4)
		Robot task	0.00 (0.76)	−1.08 to 2.82	124 (4)
		TBAQ	3.01 (0.72)	1.39 to 4.78	128 (0)
	Parenting	Interaction tasks	4.71 (1.01)	2.40 to 7.99	128 (0)
Age 2	Behavioral inhibition	TBAQ	2.92 (0.93)	0.47 to 5.74	110 (18)
		ITSEA	1.02 (0.52)	0.00 to 2.00	91 (37)
		BQTP	1.50 (0.41)	1.00 to 3.00	66 (62)
	Parenting	Interaction tasks	5.29 (1.04)	2.20 to 6.80	113 (15)
Age 5	Withdrawal	CBCL	0.22 (0.20)	0.00 to 1.11	115 (13)
		TRF	0.23 (0.26)	0.00 to 1.22	111 (17)
Age 7	Withdrawal	CBQ	3.24 (1.25)	1.00 to 6.46	109 (19)
Age 9	Withdrawal	CBCL	0.23 (0.22)	0.00 to 1.25	102 (26)
		TRF	0.28 (0.30)	0.00 to 1.38	108 (20)
		Sociometry	0.00 (0.79)	−1.04 to 3.18	113 (15)
Age 9	Loneliness	LSDQ	1.69 (0.45)	1.00 to 3.12	98 (30)
Age 12	Withdrawal	CBCL	0.29 (0.28)	0.00 to 1.38	109 (19)
		TRF	0.27 (0.36)	0.00 to 1.38	95 (33)
		Sociometry	−0.02 (0.88)	−0.79 to 3.70	105 (23)
Age 13	Loneliness	LLCA	0.64 (0.60)	0.00 to 2.50	99 (29)
Age 16	Loneliness	LLCA	0.49 (0.46)	0.00 to 1.92	100 (28)
Age 21	Loneliness	UCLA	1.67 (0.56)	1.00 to 3.45	95 (33)

Abbreviations: BQTP, Behavior Questionnaire for Toddlers and Preschoolers; CBCL, Child Behavior Checklist; CBQ, Child Behavior Questionnaire; ITSEA, Infant Toddler Social Emotional Assessment; LLCA, Louvain Loneliness Scale for Children and Adolescents; LSDQ, Loneliness and Social Dissatisfaction Questionnaire; TBAQ, Toddler Behavior Assessment Questionnaire; TRF, Teacher Report Form; UCLA, UCLA Loneliness Scale.

TABLE 4 Bivariate correlations between factor scores (FS) and loneliness measures

	1. FS BI	2. FS par	3. FS SW	4. L9	5. L13	6. L16
1. Behavioral inhibition during infancy (FS BI)						
2. Parenting during infancy (FS Par)	.23*					
3. Social withdrawal during childhood (FS SW)	.25**	−.13				
4. Loneliness at age 9 (L9)	.02	−.15	.18			
5. Loneliness at age 13 (L13)	−.03	−.07	.31**	.26*		
6. Loneliness at age 16 (L16)	.13	−.17	.26**	.27*	.34**	
7. Loneliness at age 21 (L21)	−.03	−.01	.30**	.28*	.12	.18

*$p < .05$; **$p < .01$

better model fit (Table 5; see Appendix C, Table S3, for parameter estimates).

Subsequently, in accordance with our exploratory hypothesis, we were interested in whether the effect of social withdrawal during childhood had different effects on loneliness across the different ages (13, 16, and 21). For that purpose, we fitted a model in which the paths from withdrawal to loneliness scores at the different ages were constrained to be equal across time (model 1c). A chi-square difference test between model 1b (i.e., freely estimated paths) and 1c (i.e., constrained paths across ages) was not significant ($\Delta\chi^2(2) = .47$, $p = .79$), which indicates that the effects of social withdrawal on loneliness were not significantly different across the different ages. Since model 1c was the most parsimonious mediation model, this model was set as the final model. Unstandardized and standardized estimates of model 1c are found in Table 6. The results indicated that BI significantly predicted higher levels of social withdrawal, and that social withdrawal predicted feelings of loneliness at 13, 16, and 21 years. Moreover, the indirect effects of BI on higher loneliness via higher levels of social withdrawal were

TABLE 5 Summary of goodness-of-fit indices

	χ^2	df	*p*	CFI	RMSEA	SRMR
Mediation models (aim 1)						
Model 1a: Base model with all paths (BI → loneliness; BI → withdrawal; withdrawal → loneliness)	3.44	1	.06	0.95	.14	.04
Model 1b: Model 1a without direct BI → loneliness paths	6.02	4	.20	0.96	.06	.05
Model 1c: Model 1b + withdrawal → loneliness paths constrained across ages	6.48	6	.37	0.99	.03	.05
Moderated mediation model (aim 2)						
Model 2: Model 1c + BI × parenting → withdrawal	15.43	12	.22	0.93	.05	.06

Note: In the table, loneliness as the outcome refers to loneliness measured at ages 13, 16, and 21 years. The base model contained all possible paths (i.e., direct paths from BI → withdrawal, withdrawal → loneliness ages 13, 16, and 21 years, BI → loneliness ages 13, 16, and 21 years). All models are controlled for loneliness at age 9. Correlations between residual variances of loneliness at age 13, 16, and 21 are included.

Abbreviations: BI, Behavioral inhibition; CFI, comparative fit index; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual.

TABLE 6 Parameter estimates of final mediation model (model 1c) for indirect effects of behavioral inhibition (BI) on loneliness scores through social withdrawal

	B [95% CI]	SE	*p*	*β*
Direct effects				
Behavioral inhibition → Social withdrawal	0.11 [0.04, 0.19]	.04	.002	.25
Social withdrawal → Loneliness (13)[a]	3.77 [1.72, 5.55]	.98	<.001	.26
Social withdrawal → Loneliness (16)[a]	3.77 [1.72, 5.55]	.98	<.001	.26
Social withdrawal → Loneliness (21)[a]	3.77 [1.72, 5.55]	.98	<.001	.26
Indirect effects				
BI → Social withdrawal → Loneliness (13)[b]	0.43 [0.14, 0.76]	.16	.007	.07
BI → Social withdrawal → Loneliness (16)[b]	0.43 [0.14, 0.76]	.16	.007	.07
BI → Social withdrawal → Loneliness (21)[b]	0.43 [0.14, 0.76]	.16	.007	.07

Note: Equal superscripts refer to equally constrained paths. Loneliness age 13 was controlled for by loneliness age 9 ($B = .23$, $SE = .12$, $p = .062$, $\beta = .23$). Loneliness age 16 was controlled for by loneliness age 9 ($B = .21$, SE = .09, $p = .025$, $\beta = .21$). Loneliness age 21 was controlled for by loneliness age 9 ($B = .26$, SE = .11, $p = .013$, $\beta = .27$). Note that in this model, the direct effect of BI on loneliness (path *c*′) had been removed based on model fitting steps described earlier (see Table 5). However, the removal of the *c*′ path could be associated with forcing all shared variance into the mediated pathway. To check consistency of the indirect effect, we re-ran the mediation model, in which direct paths from BI to loneliness were included. The indirect paths were virtually the same ($B = .44$, SE = .17, $p = .01$, $\beta = .07$), implicating that the indirect effect was not affected by including the *c*′ path.

significant (Table 6). Figure 3 depicts paths and standardized estimates of this final model.

Moderated mediation model

Next, it was tested whether parenting moderated the relation between BI and social withdrawal (hypothesis 2). The final mediation model from step 1 (model 1c) served as a starting point. The main effect of parenting and the interaction effect between BI and parenting on withdrawal (model 2) were added to this model. As shown in Table 5, model 2 showed acceptable, yet poorer model fit compared to model 1c. The interaction effect of BI and parenting did not significantly predict social withdrawal ($B = .05$, SE = .08, $p = .47$, $\beta = .08$), indicating no moderation of parenting (see Appendix C, Table S4, for model estimates and see Appendix E, Figure S1, for a scatterplot presenting the distribution of the two predictors in this interaction).

DISCUSSION

The main goal was to test a developmental cascade model examining longitudinal associations between infant BI (ages 1 and 2), negative parenting (moderator at ages 1 and 2), childhood social withdrawal (mediator at ages 5, 7, 9, and 12), and loneliness during early (10–13 years), middle (14–17 years), and late adolescence (18–22 years). In line with expectations, infant BI indirectly predicted adolescent loneliness years later via childhood social withdrawal. The effect of childhood social withdrawal seemed not to differ in strength for loneliness during early, middle, and late adolescence. As opposed to the expectations, BI was not a direct predictor of loneliness during adolescence. Moreover, negative parenting did not moderate the relation between infant BI and childhood social withdrawal.

Infant behavioral inhibition, childhood social withdrawal, and adolescent loneliness

Most importantly, it was found that infant BI had a significant indirect effect on adolescent loneliness (up to almost 20 years after the first BI assessment) through childhood social withdrawal, above and beyond what feelings of loneliness during childhood predicted.

These findings are in line with and built upon existing theory and research in important ways (Fox et al., 2005; Rubin et al., 2009; Rubin & Chronis-Tuscano, 2021). An abundance of research has demonstrated that early temperament is implicated in later socioemotional (dis)

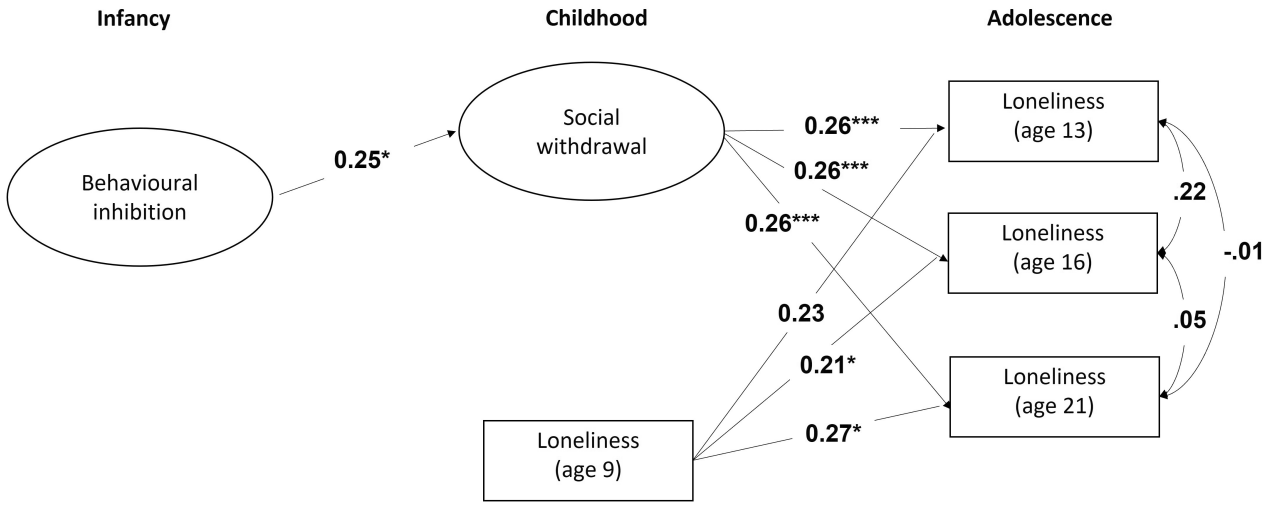

FIGURE 3 Final mediation model (model 1c) showing the relations among infant behavioral inhibition (BI), childhood social withdrawal, and loneliness at ages 13, 16, and 21, controlling for loneliness at age 9. Standardized estimates are presented. Effect of social withdrawal on loneliness was constrained across the ages. The indirect effect from BI on loneliness via social withdrawal was significant and not significantly different across all ages ($B = .43$, SE = .16, $p = .008$, $\beta = .07$). Please find exact values in Table 6. *$p < .05$, ***$p < .001$

functioning (for a review, see Clauss et al., 2015), but the current research is the first to test this developmental cascade (infant BI–childhood social withdrawal–adolescent loneliness) over such a long time span. Moreover, this study examined the effects for various adolescent age periods, which has never been done before. Furthermore, the findings indicate heterotypic continuity, implying that BI continues to impact socio-emotional development, beyond childhood, even up to middle and late adolescence. It is important to note here that, next to the commonly known outcomes such as anxiety disorders, this study suggests that loneliness could also be one of the later-life outcomes. The fact that this temperamental trait is indeed a direct predictor of social withdrawal, and an indirect predictor of loneliness, not only illustrates the importance of including early-life factors in theories on loneliness, but also helps in broadening our ideas on the widespread impact early BI might have and suggests to examine this phenomenon of heterotypic continuity later in life (e.g., in adulthood) as well (see also Klein & Mumper, 2018).

Contrary to expectations, it was found that infant BI was not directly predictive of adolescent loneliness. However, this finding is not necessarily novel, as several studies have failed to find direct links between infant BI and later adjustment (Degnan & Fox, 2007; Lewis-Morrarty et al., 2012). The absence of a direct effect could be explained in several ways. First off, the lack of direct effect might be the large time span between the measurement of BI (ages 1 and 2) and the measurements of loneliness (ages 13, 16, and 21). The effects of temperamental traits on socio-emotional functioning are likely to diminish as infants grow older; most inhibited infants might simply "grow out of it." This pattern of discontinuity could be explained by differences in the development of adaptive self-regulatory skills, including attentional control (Degnan & Fox, 2007), which can be defined as the degree to which one is able to flexibly monitor and shift attention (Rueda et al., 2004). This capacity develops mostly from early to middle childhood (Simonds et al., 2007).

Another explanation for the lack of direct effect might be that a community sample was included instead of a selected sample for BI. A previous study showed that the stability of BI was substantially higher in selected samples, compared to unselected samples (which was the case in our study; Degnan & Fox, 2007). Using selected samples would probably result in stronger relations with developmental outcomes. Next to that, BI was operationalized as a continuous construct. While this is an often adopted method to quantify BI (Lewis-Morrarty et al., 2012; Williams et al., 2009), it has been suggested that BI should be studied as a categorical construct instead. For example, Kagan et al. (1989) showed that, when extremely inhibited infants were compared to extremely uninhibited infants, significant differences in behavioral outcomes were observed, but not when BI was treated as a continuous measure. While it should be noted that continuous variables generally provide more statistical power (Altman & Royston, 2006), comparing more extremely inhibited individuals to uninhibited individuals on experienced loneliness could have led to different results.

However, using an extreme group approach raises a different issue; namely, whether such an uninhibited group effectively represents a standard "healthy control group" (Clauss et al., 2015). In fact, it has been found that highly uninhibited infants show more disruptive problem disorders and externalizing behaviors when they grow older (Degnan et al., 2014). Interestingly, Degnan et al. (2014) have suggested that this pattern of externalizing behavior might be a result of increased levels

of peer rejection and isolation due to their uninhibited nature. Possibly, both extreme ends of the BI spectrum might eventually result in loneliness. In conclusion, more research is needed to gain insight into more reliable differentiation between normative and non-normative levels of BI, leading to increased predictive value for adolescent socio-emotional adjustment, including loneliness.

Another finding of the current research is that BI was prospectively related to social withdrawal in childhood, which means that highly inhibited infants are more likely to develop into socially withdrawn children. This is in line with previous literature (Booth-Laforce & Oxford, 2008; Degnan et al., 2014; Perez-Edgar et al., 2010) and also links to the social-information processing model (Crick & Dodge, 1994), in which it is hypothesized that temperament and accompanying biases in attention and cognition heavily influence subsequent social behavior. In this case, BI might be linked to limited exposure to awarding social encounters. The associated cognitions of not feeling included or feeling rejected increase the likelihood of displaying social withdrawal behaviors to prevent further rejection (a prevention-oriented behavioral style; Park & Baumeister, 2015).

Also, it was found that the tendency to withdraw predicted feelings of adolescent' loneliness at all ages (except for age 9), which aligns with earlier studies (Fox et al., 2005; Jobe-Shields et al., 2011; Oh et al., 2008) and with existing theories which hypothesize that social withdrawal is positively associated with feelings of loneliness, possibly by reducing the likelihood of having positive social interactions and impairing social skills (Qualter et al., 2015).

Regarding our third aim, it was found that the effect of social withdrawal on feelings of loneliness did not seem to differ in strength during early, middle, and late adolescence. Given the vast amount of rapid biological, cognitive, emotional, and social transitions that occur during adolescence, and differ between the different developmental periods, we tested this in an exploratory manner. The fact that the effects between the latent factor of social withdrawal and loneliness at the ages of 13, 16, and 21 were more or less similar, evidences the long-lasting effects of infant and childhood precursors in explaining prospective loneliness, although the effects were not large. It could be that a certain default mode of emotions, cognitions, and behaviors is set in one's life which makes it difficult for individuals to "grow out" of high social withdrawal and sets an increased risk for experiencing loneliness across different developmental periods of adolescence. Another potential mechanism that could possibly explain these long-lasting effects is self-esteem. Social experiences with peers become important contributors to the development of self-esteem during childhood (Robins & Trzesniewski, 2005). Shy children might experience fewer positive interactions compared to their typical peers, leading to lower self-esteem (Rubin et al., 2009). Conversely, low self-esteem might decrease the likelihood of having positive social interactions, leading to more social withdrawal. Thus, high social withdrawal and low self-esteem might reinforce one another over time (Crozier, 1995). Since self-esteem has a fairly stable nature (Robins & Trzesniewski, 2005), these childhood experiences might have lasting negative effects on one's self-esteem during adolescence. In turn, low self-esteem is an important predictor of loneliness during adolescence (Geukens et al., 2020; Vanhalst et al., 2013). Intrapersonal factors such as self-esteem could possibly explain the enduring effect of social withdrawal on loneliness, and should be the target of further research.

Moderated-mediation: Negative parenting

As the caregiving environment is thought to affect the stability of BI (Degnan & Fox, 2007), negative parenting was included in the current research. However, findings were not in line with earlier findings describing that highly inhibited infants who experienced negative parenting, were more likely to become withdrawn 2 years later (Rubin et al., 2002). An explanation for this might be that parenting behavior was assessed in a relatively familiar and safe setting, namely during a parent–child play-session at their own homes, without that the child needed to engage with a stranger, or novel object. However, it is known that negative parenting behavior in potentially emotionally arousing situations might have the most impact on further development of the inhibited infant. Indeed, Rubin et al. (2002) found that when parents displayed controlling and derisive behavior during a more challenging situation, highly inhibited infants were more likely to become withdrawn during childhood. Thus, measuring parenting behavior during a task or setting that could actually be considered novel or unfamiliar might yield different results. Another explanation could be that the time-lag between the parenting assessments (ages 1 and 2) and social withdrawal assessments (ages 5–12) was too large to find a moderation effect. As parenting eminently is a dynamic concept which is in continuous interaction with offspring's development, needs, and demands, it may have been good to additionally include more proximal time intervals to capture the effects of negative parenting on social withdrawal in childhood and adolescence.

Strengths, limitations, and future directions

A strength of the present study is its longitudinal (spanning almost 20 years from infancy through late adolescence), multi-informant (parent, teacher, and child reports) and multi-method (observations, self-reports, laboratory tasks, internet assessments, home and school

visits) approach. Moreover, sophisticated statistical analytic procedures were used that suited the complexity of the data. Using this data, we were able to test a developmental cascade model explaining why some adolescents might be at higher risk for loneliness, which may have its roots in infancy.

This study had a number of methodological limitations, which should be considered in future research. First off, various problems concerning the research sample are being recognized. Specifically, the sample size was quite small, which reduced power to detect moderation effects. Future studies with a larger sample size are needed to detect such higher-order effects. Added to that, these findings were based on a Dutch urban sample and its characteristics were not diverse in terms of cultural background (which may be due to participation bias). Chen and French (2008) hypothesized that cultural norms and values strongly influence the effects of temperamental traits on later outcomes. Certain behaviors, like social withdrawal, might elicit different social evaluations and reactions across cultures, which, in turn, leads to different developmental patterns and socio-emotional outcomes. More research is needed to replicate the results of these study findings across different cultures.

A second limitation is that loneliness was measured with different instruments across adolescence. For early and middle adolescence, the subscale *loneliness in peer relations* from the Louvain Loneliness Scale for Children and Adolescents (Marcoen et al., 1987) was used, which is aimed to measure whether the adolescent experiences loneliness specifically in relationships with peers. For late adolescence, the UCLA Loneliness Scale (Russell et al., 1980) was used. This questionnaire measures the frequency of negative feelings associated with loneliness in general, and not necessarily in a specific type of relation. While the subscale *loneliness in peer relations* and the UCLA loneliness scale correlate highly ($r = .76$;Goossens et al., 2009), it cannot be ruled out that the scales tap into slightly different dimensions of loneliness. This should be taken into account when interpreting the findings.

Moreover, loneliness was measured only once at each time point, which means that it remains unclear to what extent the feelings of loneliness were persistent. Loneliness is a transient experience for most adolescents, but some remain lonely for extended periods of time (i.e., months to years; Hawkley & Cacioppo, 2010; Qualter et al., 2015). Such prolonged loneliness seems to be particularly detrimental to mental and physical health; adolescents who experience increasingly high or stable high levels of loneliness over the course of several years, report more depressive symptoms and suicidal ideation (Schinka et al., 2013), visit a doctor more often, and have lower self-perceived health (Qualter et al., 2013). Such findings indicate that it is of particular importance to investigate early life risk factors in relation to prolonged adolescent loneliness. Therefore, future studies should include multiple assessments of loneliness over shorter time intervals to capture different longitudinal loneliness trajectories.

Additionally, parenting behavior of the father was not measured. In the current study, the primary caregiver that participated was oftentimes the child's mother which neglects the fact that mothers and fathers each contribute uniquely to their child's development. Mothers generally take on the caregiving role, whereas fathers tend to engage more in playing activities (Paquette, 2004). Playing activities like rough-and-tumble play are novel and exciting for the child, and fathers play an important role in aiding the child in learning how to interpret and cope with such arousal effectively (Dumont & Paquette, 2013). Specifically, children may learn that this internal arousal should be perceived to be indicative of "fun" instead of "fear," making them less afraid of other (socially) challenging situations (Bogels & Perotti, 2011). Since the literature on the role of fathers in the development of inhibited children is scarce, this might be an interesting avenue for future research. Another interesting avenue to pursue is to examine whether *curvilinear* effects may effectively explain parenting effects on child development. This is important since previous studies have shown that parenting behaviors at the more positive extreme end (e.g., oversensitive or oversolicitous parenting) may also result in worse developmental outcomes for children with high BI (Degnan et al., 2015; Rubin et al., 1997; Suarez et al., 2021). As of now, we do not know whether, or to what extent, specific parenting styles are disadvantageous for children with BI. Also, it is essential to detect an "optimal" combination of parenting behaviors to mentor parents of BI children.

Something else that could be considered worthwhile to examine is how pubertal stage (next to chronological age) is associated with feelings of loneliness. Although there are reasons to believe that puberty may facilitate onset of feelings of loneliness (among others due to changes in circadian rhythms, sleep-related changes, physical maturation; Laursen & Hartl, 2013), studies have not examined, nor controlled, for pubertal stage (except for one study by Oldehinkel et al. (2011) showing that pubertal stage was not associated with feelings of loneliness, whereas early pubertal timing was). In our study, we were not able to control for pubertal stage since we did not have information available on pubertal status at the ages that loneliness was measured.

Lastly, little is known about whether loneliness refers to perceptions or actual low relationship quality with peers. While some studies indicate that adolescents have the tendency to perceive or interpret their social relationships more negatively (bias hypothesis), other studies indicate that the actual social environment is objectively less positive, due to low social standing or possible social skill deficits (deficit hypothesis; Lodder et al., 2016, 2017). Thus, for some adolescents, high loneliness might indicate an actual low relationship quality, whereas for others it might primarily refer to perceived

low relationship quality. Unfortunately, we are not aware of any studies that have addressed whether this differs as a function of BI.

CONCLUSION

This prospective, longitudinal study is one of the first to demonstrate that infant BI has long-lasting (over the course of 20 years) indirect predictive associations with loneliness during early, middle, and late adolescence via childhood social withdrawal. The current findings not only highlight the importance of including early life characteristics like infant BI in theories of loneliness, which currently lack sufficient predictive value, but also make a case for infant BI impacting on socio-emotional development in the form of heterotypic continuity. Moreover, these results are relevant for developing much needed effective preventions for loneliness that can be implemented at a young age. Specifically, BI and social withdrawal could aid in identifying children with high risk of becoming lonely. Intervention on such early predictors could play an important role in preventing the development of loneliness at a later age and protect adolescents from the detrimental mental and physical health consequences associated with loneliness.

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DATA AVAILABILITY STATEMENT

The data necessary to reproduce the analyses presented here are publicly accessible. The analytic code necessary to reproduce the analyses presented in this paper is publicly accessible via https://osf.io/yk7sc/. The materials necessary to attempt to replicate the findings presented here are publicly accessible. The analyses presented here were not preregistered.

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REFERENCES

Achenbach, T. M. (1991). *Manual for the Child Behavior Checklist/4–18 and the 1991 profile* [Unpublished manuscript]. Department of Psychiatry, University of Vermont.

Altman, D. G., & Royston, P. (2006). The cost of dichotomising continuous variables. *British medical journal*, *332*, 1080. https://doi.org/10.1136/bmj.332.7549.1080

Asher, S. R., & Wheeler, V. A. (1985). Children's loneliness: A comparison of rejected and neglected peer status. *Journal of Consulting and Clinical Psychology*, *53*, 500–505. https://doi.org/10.1037//0022-006x.53.4.500

Bogels, S. M., & Perotti, E. C. (2011). Does father know best? A formal model of the paternal influence on childhood social anxiety. *Journal of Child and Family Studies*, *20*, 171–181. https://doi.org/10.1007/s10826-010-9441-0

Booth-Laforce, C., & Oxford, M. L. (2008). Trajectories of social withdrawal from grades 1 to 6: Prediction from early parenting, attachment, and temperament. *Developmental Psychology*, *44*, 1298–1313. https://doi.org/10.1037/a0012954

Cacioppo, J. T., Cacioppo, S., & Boomsma, D. I. (2014). Evolutionary mechanisms for loneliness. *Cognition & Emotion*, *28*, 3–21. https://doi.org/10.1080/02699931.2013.837379

Carter, A. S., Briggs-Gowan, M. J., Jones, S. M., & Little, T. D. (2003). The infant-toddler social and emotional assessment (ITSEA): Factor structure, reliability, and validity. *Journal of Abnormal Child Psychology*, *31*, 495–514. https://doi.org/10.1023/a:1025449031360

Chen, X., & French, D. C. (2008). Children's social competence in cultural context. *Annual Review Psychology*, *59*, 591–616. https://doi.org/10.1146/annurev.psych.59.103006.093606

Clauss, J. A., Avery, S. N., & Blackford, J. U. (2015). The nature of individual differences in inhibited temperament and risk for psychiatric disease: A review and meta-analysis. *Progress in Neurobiology*, *127–128*, 23–45. https://doi.org/10.1016/j.pneurobio.2015.03.001

Coplan, R. J., & Rubin, K. H. (2010). Social withdrawal and shyness in childhood. In K. H. Rubin & R. J. Coplan (Eds.), *The development of shyness and social withdrawal* (pp. 3–20). Guilford Press.

Crick, N. R., & Dodge, K. A. (1994). A review and reformulation of social information-processing mechanisms in childrens social-adjustment. *Psychological Bulletin*, *115*, 74–101. https://doi.org/10.1037/0033-2909.115.1.74

Crozier, W. R. (1995). Shyness and self-esteem in middle childhood. *British Journal of Educational Psychology*, *65*, 85–95. https://doi.org/10.1111/j.2044-8279.1995.tb01133.x

Degnan, K. A., Almas, A. N., Henderson, H. A., Hane, A. A., Walker, O. L., & Fox, N. A. (2014). Longitudinal trajectories of social reticence with unfamiliar peers across early childhood. *Developmental Psychology*, *50*, 2311–2323. https://doi.org/10.1037/a003775125181648

Degnan, K. A., & Fox, N. A. (2007). Behavioral inhibition and anxiety disorders: Multiple levels of a resilience process. *Development and Psychopathology*, *19*, 729–746. https://doi.org/10.1017/S0954579407000363176059000

Degnan, K. A., Hane, A. A., Henderson, H. A., Walker, O. L., Ghera, M. M., & Fox, N. A. (2015). Emergent patterns of risk for psychopathology: The influence of infant avoidance and maternal caregiving on trajectories of social reticence. *Development and Psychopathology*, *27*, 1163–1178.

Dumont, C., & Paquette, D. (2013). What about the child's tie to the father? A new insight into fathering, father-child attachment, children's socio-emotional development and the activation relationship theory. *Early Child Development and Care*, *183*, 430–446. https://doi.org/10.1080/03004430.2012.711592

Erickson, M. F., Sroufe, L. A., & Egeland, B. (1985). The relationship between quality of attachment and behavior problems in preschool in a high-risk sample. *Monographs of the Society for Research in Child Development*, *50*, 147–166. https://doi.org/10.2307/33338314069126

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.55.090902.14153215709935

Geukens, F., Maes, M., Spithoven, A., Pouwels, J. L., Danneel, S., Cillessen, A. H. N., Van den Berg, Y. H., & Goossens, L. (2020). Changes in adolescent loneliness and concomitant changes in fear of negative evaluation and self-esteem. *International Journal of*

Behavioral Development, *46*, 10–17. https://doi.org/10.1177/0165025420958194

Goldsmith, H. H. (1996). Studying temperament via construction of the toddler behavior assessment questionnaire. *Child Development*, *67*, 218–235. https://doi.org/10.1111/j.1467-8624.1996.tb01730.x

Goosby, B. J., Bellatorre, A., Walsemann, K. M., & Cheadle, J. E. (2013). Adolescent loneliness and health in early adulthood. *Sociological Inquiry*, *83*, 505–536. https://doi.org/10.1111/soin.12018

Goossens, F. A., Dekker, P., Bruinsma, C., & De Ruyter, P. A. (2000). *The Behavior Questionnaire for Toddlers and Preschoolers (BQTP): Factor structure, reliability and validity* [Unpublished research report]. Free University Amsterdam.

Goossens, L., Lasgaard, M., Luyckx, K., Vanhalst, J., Mathias, S., & Masy, E. (2009). Loneliness and solitude in adolescence: A confirmatory factor analysis of alternative models. *Personality and Individual Differences*, *47*, 890–894. https://doi.org/10.1016/j.paid.2009.07.011

Hane, A. A., Fox, N. A., Henderson, H. A., & Marshall, P. J. (2008). Behavioral reactivity and approach-withdrawal bias in infancy. *Developmental Psychology*, *44*, 1491–1496. https://doi.org/10.1037/a0012855

Hawkley, L. C., & Cacioppo, J. T. (2010). Loneliness matters: A theoretical and empirical review of consequences and mechanisms. *Annals of Behavioral Medicine*, *40*, 218–227. https://doi.org/10.1007/s12160-010-9210-8

Henderson, H. A., Pine, D. S., & Fox, N. A. (2015). Behavioral inhibition and developmental risk: A dual-processing perspective. *Neuropsychopharmacology*, *40*, 207–224. https://doi.org/10.1038/npp.2014.18925065499

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*, 1–55. https://doi.org/10.1080/10705519909540118

Jobe-Shields, L., Cohen, R., & Parra, G. R. (2011). Patterns of change in children's loneliness: Trajectories from third through fifth grades. *Merrill-Palmer Quarterly*, *57*, 25–47. http://www.jstor.org/stable/23098054

Kagan, J., Reznick, J. S., Clarke, C., Snidman, N., & Garcia-Coll, C. (1984). Behavioral inhibition to the unfamiliar. *Child Development*, *55*, 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*, 838–845. https://doi.org/10.2307/11310252758880

Kimmel, D. C., & Weiner, L. B. (1985). *Adolescence: A developmental transition*. Lawrence Erlbaum Associates.

Klein, D. N., & Mumper, E. E. (2018). Behavioral inhibition as a precursor to psychopathology. In K. Pérez-Edgar & N. Fox (Eds.), *Behavioral inhibition. Integrating theory, research, and clinical perspectives* (pp. 283–308). Springer Nature.

Laursen, B., & Hartl, A. C. (2013). Understanding loneliness during adolescence: Developmental changes that increase the risk of perceived social isolation. *Journal of Adolescence*, *36*, 1261–1268. https://doi.org/10.1016/j.adolescence.2013.06.003

Lewis-Morrarty, E., Degnan, K. A., Chronis-Tuscano, A., Rubin, K. H., Cheah, C. S. L., Pine, D. S., Henderon, H. A., & Fox, N. A. (2012). Maternal over-control moderates the association between early childhood behavioral inhibition and adolescent social anxiety symptoms. *Journal of Abnormal Child Psychology*, *40*, 1363–1373. https://doi.org/10.1007/s10802-012-9663-222821448

Little, R. J. (1988). A test of missing completely at random for multivariate data with missing values. *Journal of the American Statistical Association*, *83*, 1198–1202. https://doi.org/10.2307/2290157

Lodder, G. M. A., Goossens, L., Scholte, R. H. J., Engels, R. C. M. E., & Verhagen, M. (2016). Adolescent loneliness and social skills: Agreement and discrepancies between self-, meta-, and peer-evaluations. *Journal of Youth and Adolescence*, *45*, 2406–2416. https://doi.org/10.1007/s10964-016-0461-y

Lodder, G. M. A., Scholte, R. H. J., Goossens, L., & Verhagen, M. (2017). Loneliness in early adolescence: Friendship quantity, friendship quality, and dyadic processes. *Journal of Clinical Child and Adolescent Psychology*, *46*, 709–720.

Marcoen, A., Goossens, L., & Caes, P. (1987). Loneliness in pre-through late adolescence: Exploring the contributions of a multidimensional approach. *Journal of Youth and Adolescence*, *16*, 561–577. https://doi.org/10.1007/BF02138821

Niermann, H. C. M., Tyborowska, A., Cillessen, A. H. N., van Donkelaar, M. M., Lammertink, F., Gunnar, M. R., Franke, B., Figner, B., & Roelofs, K. (2019). The relation between infant freezing and the development of internalizing symptoms in adolescence: A prospective longitudinal study. *Developmental Science*, *22*, 1–10. https://doi.org/10.1111/desc.12763

Oh, W., Rubin, K. H., Bowker, J. C., Booth-LaForce, C., Rose-Krasnor, L., & Laursen, B. (2008). Trajectories of social withdrawal from middle childhood to early adolescence. *Journal of Abnormal Child Psychology*, *36*, 553–566. https://doi.org/10.1007/s10802-007-9199-z18193479

Oldehinkel, A. J., Verhulst, F. C., & Ormel, J. (2011). Mental health problems during puberty: Tanner stage-related differences in specific symptoms. The TRAILS study. *Journal of Adolescence*, *34*, 73–85.

Paquette, D. (2004). Theorizing the father-child relationship: Mechanisms and developmental outcomes. *Human Development*, *47*, 193–219. https://doi.org/10.1159/000078723

Park, J., & Baumeister, R. F. (2015). Social exclusion causes a shift toward prevention motivation. *Journal of Experimental Social Psychology*, *56*, 153–159. https://doi.org/10.1016/j.jesp.2014.09.011

Perez-Edgar, K., Bar-Haim, Y., McDermott, J. M., Chronis-Tuscano, A., Pine, D. S., & Fox, N. A. (2010). Attention biases to threat and behavioral inhibition in early childhood shape adolescent social withdrawal. *Emotion*, *10*, 349–357. https://doi.org/10.1037/a001848620515224

Perlman, D., & Peplau, L. A. (1981). Toward a social psychology of loneliness. In R. Gillmour & S. W. Duck (Eds.), *Personal relationships 3: Personal relationships in disorder* (pp. 31–56). Academic Press.

Qualter, P., Brown, S. L., Rotenberg, K. J., Vanhalst, J., Harris, R. A., Goossens, L., Bangee, M., & Munn, P. (2013). Trajectories of loneliness during childhood and adolescence: Predictors and health outcomes. *Journal of Adolescence*, *36*, 1283–1293. https://doi.org/10.1016/j.adolescence.2013.01.005

Qualter, P., Vanhalst, J., Harris, R., Van Roekel, E., Lodder, G., Bangee, M., Maes, M., & Verhagen, M. (2015). Loneliness across the life span. *Perspectives on Psychological Science*, *10*, 250–264. https://doi.org/10.1177/1745691615568999

R Core Team. (2017). *R: A language and environment for statistical computing*. https://www.R-project.org/

Robins, R. W., & Trzesniewski, K. H. (2005). Self-esteem development across the lifespan. *Current Directions in Psychological Science*, *14*, 158–162. https://doi.org/10.1111/j.0963-7214.2005.00353.x

Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, *48*, 1–36. https://doi.org/10.18637/jss.v048.i02

Rosseel, Y. (2020). Small sample solutions for structural equation modeling. In R. Van de Schoot & M. Milocevic (Eds.), *Small sample size solutions: A guide for applied researchers and practitioners* (pp. 226–238). Routledge.

Rothbart, M. K., Ahadi, S. A., Hersey, K. L., & Fisher, P. (2001). Investigations of temperament at three to seven years: The Children's Behavior Questionnaire. *Child Development*, *72*, 1349–1408. https://doi.org/10.1111/1467-8624.0035511699677

Rubin, K. H., Barstead, M. G., Smith, K. A., & Bowker, J. C. (2018). Peer relations and the behaviorally inhibited child. In K.

Perez-Edgar & N. Fox (Eds.), *Behavioral inhibition* (pp. 157–184). https://doi.org/10.1111/1467-8624.00419

Rubin, K. H., Burgess, K. B., & Hastings, P. D. (2002). Stability and social-behavioral consequences of toddlers' inhibited temperament and parenting behaviors. *Child Development*, *73*, 483–495. https://doi.org/10.1111/1467-8624.0041911949904

Rubin, K. H., Chen, X. Y., Mcdougall, P., Bowker, A., & Mckinnon, J. (1995). The Waterloo longitudinal project—Predicting internalizing and externalizing problems in adolescence. *Development and Psychopathology*, *7*, 751–764. https://doi.org/10.1017/S0954579400006829

Rubin, K. H., & Chronis-Tuscano, A. (2021). Perspectives on social withdrawal in childhood: Past, present, and prospects. *Child Development Perspectives*, *15*, 160–167. https://doi.org/10.1111/cdep.12417

Rubin, K. H., Coplan, R. J., & Bowker, J. C. (2009). Social withdrawal in childhood. *Annual Review of Psychology*, *141-171*, 141–171. https://doi.org/10.1146/annurev.psych.60.110707.16364218851686

Rubin, K. H., Hastings, P. D., Stewart, S. L., Henderson, H. A., & Chen, X. Y. (1997). The consistency and concomitants of inhibition: Some of the children, all of the time. *Child Development*, *68*, 467–483.

Rueda, M. R., Posner, M. I., & Rothbart, M. K. (2004). Chapter: Attentional control and self-regulation. In *Handbook of self-regulation: Research, theory, and applications* (pp. 283–300). The Guilford Press.

Russell, D., Peplau, L. A., & Cutrona, C. E. (1980). The revised UCLA Loneliness Scale: Concurrent and discriminant validity evidence. *Journal of Personality and Social Psychology*, *39*, 472–480. https://doi.org/10.1037//0022-3514.39.3.472

Schinka, K. C., van Dulmen, M. H. M., Mata, A. D., Bossarte, R., & Swahn, M. (2013). Psychosocial predictors and outcomes of loneliness trajectories from childhood to early adolescence. *Journal of Adolescence*, *36*, 1251–1260. https://doi.org/10.1016/j.adolescence.2013.08.00224007942

Shackman, A. J., Stockbridge, M. D., Tillman, R. M., Kaplan, C. M., Tromp, D. P. M., Fox, A. S., & Gamer, M. (2016). The neurobiology of dispositional negativity and attentional biases to threat: Implications for understanding anxiety disorders in adults and youth. *Journal of Experimental Psychopathology*, *7*, 311–342.

Simonds, J., Kieras, J. E., Rueda, M. R., & Rothbart, M. K. (2007). Effortful control, executive attention, and emotional regulation in 7–10-year-old children. *Cognitive Development*, *22*, 474–488. https://doi.org/10.1016/j.cogdev.2007.08.009

Spithoven, A. W. M., Bijttebier, P., & Goossens, L. (2017). It is all in their mind: A review on information processing bias in lonely individuals. *Clinical Psychology Review*, *58*, 97–114. https://doi.org/10.1016/j.cpr.2017.10.003

Suarez, G. L., Morales, S., Miller, N. V., Penela, E. C., Chronis-Tuscano, A., Henderson, H. A., & Fox, N. A. (2021). Examining a developmental pathway from early behavioral inhibition to emotion regulation and social anxiety: The moderating role of parenting. *Developmental Psychology*, *57*, 1261–1273.

Tang, A., Crawford, H., Morales, S., Degnan, K. A., Pine, D. S., & Fox, N. A. (2020). Infant behavioral inhibition predicts personality and social outcomes three decades later. *Proceedings of the National Academy of Sciences of the United States of America*, *117*, 9800–9807. https://doi.org/10.1073/pnas.1917376117

Teppers, E., Klimstra, T. A., Damme, C. V., Luyckx, K., Vanhalst, J., & Goossens, L. (2013). Personality traits, loneliness, and attitudes toward aloneness in adolescence. *Journal of Social and Personal Relationships*, *30*, 1045–1063. https://doi.org/10.1177/0265407513481445

Van Bakel, H. J., & Riksen-Walraven, J. M. (2004). Stress reactivity in 15-month-old infants: Links with infant temperament, cognitive competence, and attachment security. *Developmental Psychobiology*, *44*, 157–167. https://doi.org/10.1002/dev.20001

van Roekel, E., Goossens, L., Scholte, R. H. J., Engels, R. C. M. E., & Verhagen, M. (2011). The dopamine D2 receptor gene, perceived parental support, and adolescent loneliness: Longitudinal evidence for gene-environment interactions. *Journal of Child Psychology and Psychiatry*, *52*, 1044–1051. https://doi.org/10.1111/j.1469-7610.2011.02424.x

Vanhalst, J., Luyckx, K., Scholte, R. H. J., Engels, R. C. M. E., & Goossens, L. (2013). Low self-esteem as a risk factor for loneliness in adolescence: Perceived-but not actual-social acceptance as an underlying mechanism. *Journal of Abnormal Child Psychology*, *41*, 1067–1081. https://doi.org/10.1007/s10802-013-9751-y

Wang, A., Peterson, G. W., & Morphey, L. K. (2007). Who is more important for early adolescents' developmental choices? Peers or parents? *Marriage & Family Review*, *42*, 95–122. https://doi.org/10.1300/J002v42n02_06

Williams, L. R., Degnan, K. A., Perez-Edgar, K. E., Henderson, H. A., Rubin, K. H., Pine, D. S., Steinberg, L., & Fox, N. A. (2009). Impact of behavioral inhibition and parenting style on internalizing and externalizing problems from early childhood through adolescence. *Journal of Abnormal Child Psychology*, *37*, 1063–1075. https://doi.org/10.1007/s10802-009-9331-319521761

Woodhouse, S. S., Dykas, M. J., & Cassidy, J. (2012). Loneliness and peer relations in adolescence. *Social Development*, *21*, 273–293. https://doi.org/10.1111/j.1467-9507.2011.00611.x

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