Published in final edited form as:

Child Dev. 2014 July ; 85(4): 1569–1585. doi:10.1111/cdev.12219.

Testing Alternative Hypotheses Regarding the Association Between Behavioral Inhibition and Language Development in Toddlerhood

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Abstract

Studies have reported an inverse association between language development and behavioral inhibition or shyness across childhood, but the direction of this association is unclear. The present study tested alternative hypotheses regarding this association in a large sample of toddlers. Data on behavioral inhibition and expressive and receptive language abilities were collected from 816 twins at ages 14, 20, and 24 months. Growth and regression models were fit to the data to assess the longitudinal associations between behavioral inhibition and language development from 14 to 24 months. Overall, there were significant associations between behavioral inhibition and expressive language, and minimal associations with receptive language, indicating that the association is better explained by reticence to respond rather than deficient language development.

Keywords

behavioral inhibition; toddler; shyness; language development; longitudinal study design; latent growth models

Temperamental behavioral inhibition reflects an underlying biological influence on the behaviors of shyness, fearfulness, and withdrawal (Kagan, Snidman, & Arcus, 1993). Behavioral inhibition is associated with withdrawal from novel situations and suppressed speech in social settings; for example, as early as age two to three, inhibited toddlers show less spontaneous vocalization and speech than uninhibited toddlers (Rezendes et al., 1993), which may have implications for language development. There is limited literature on the association between temperamental behavioral inhibition and language development, whereas there are numerous studies examining shyness (a component of behavioral inhibition) and language development, with many studies reporting an inverse association between shyness and language development (e.g., Crozier & Perkins, 2002; Cameron, 2009; Coplan & Evans, 2009; Coplan & Weeks, 2009). Although it is clear that shy children have

lower language abilities, the reasons for this association are not clear. Despite the ongoing interest in potential mechanisms underlying this association, there is a lack of studies that have tested specific alternative hypotheses explaining the association.

The purpose of the present study was to examine the development of behavioral inhibition and language development from 14 months to 24 months, when there is tremendous growth in language, to test alternative hypotheses regarding the developmental association between behavioral inhibition and language development. Given the lack of literature or theoretical framework on potential explanations for the association between behavioral inhibition and language development, a recent review by Coplan and Evans (2009) discussing four specific hypotheses explaining the association between shyness and language development was used as a guide. To our knowledge, this is one of the first studies to examine the prospective associations between behavioral inhibition and language development.

The term behavioral inhibition is used in the present study as a general term to encompass the range of constructs associated with inhibited response styles, including shyness, inhibition, and fearfulness (e.g., Kagan et al., 1984; Robinson, Kagan, Reznick, & Corley, 1992), whereas shyness has been defined as a hesitation to be a part of social interactions, despite the desire to be included (e.g., Cameron, 2009), which is often motivated by anxiety around social evaluation (Rubin & Asendorpf, 1993). Although most previous research has focused on the association between shyness and language development, the behavioral inhibition construct was used in the present study because it reflects a more general temperamental construct that encompasses other traits that are highly correlated with shyness, and because results of a previous study suggest that inhibition to various novel situations (including social situations) are manifestations of the same latent construct (Smith et al., 2012). Additionally, the availability of ratings from distinct sources and contexts to create a broader behavioral inhibition construct reduces measurement error. Behavioral inhibition is expected to have similar negative associations with language development, given the overlap between shyness and behavioral inhibition.

Understanding the mechanisms underlying the association between behavioral inhibition and language development more clearly may have practical implications for improving the language development of shy or behaviorally inhibited children. For example, Kubicek, Emde, and Schmitz (2001) suggest that specific temperamental characteristics such as shyness may influence language development because shy children may avoid initiating interactions with unfamiliar peers and limit the frequency and variety of their social and linguistic experiences. Also, variability in temperamental shyness may lead to variability in quality and quantity of social responses from caregivers, which may in turn lead to differences in outcomes in language development, suggesting that the association between shyness and language development may be diminished if caregivers provide more consistent encouragement of shy children's language development despite their natural tendency to be less interactive. Studies have demonstrated that inhibited behaviors are present in about 15% of healthy Caucasian toddlers from 12–24 months, and that around half of those with high inhibition in toddlerhood continue to be inhibited through the age of 8 years (Kagan, Snidman, & Arcus, 1993). Although behavioral inhibition is not a pathological trait, there is some evidence of negative long-term implications, and there are many important reasons for

studying behavioral inhibition in children. There are associations between traits of shyness and/or behavioral inhibition and deficits in social competence (e.g., Bohlin, Hagekull, & Andersson, 2005; Rimm-Kaufman & Kagan, 2005), decreased quality of peer relationships (Perren & Alsaker, 2006), social withdrawal (Fox & Reeb-Sutherland, 2010), and later quality of life (Caspi, Elder, & Bem, 1988). Similarly, other studies have reported that traits of shyness and/or behavioral inhibition are associated with internalizing problems (e.g., symptoms of anxiety and depression) in childhood (Mian, Wainwright, Briggs-Gowan, & Carter, 2011; Volbrecht & Goldsmith, 2010) and increased risk for developing anxiety disorders later in life (Chronis-Tuscano et al., 2009; McDermott et al., 2009; White, McDermott, Degnan, Henderson, & Fox, 2011; Schwartz, Snidman, & Kagan, 1999).

Behavioral inhibition may lead to negative outcomes, and language development may be an important factor in the associations between behavioral inhibition and these negative outcomes. Delayed language development has implications for children's functioning in several domains, such as poor self-regulation and behavioral adjustment (Prior, Bavin, Cini, Eadie, & Reilly, 2011) and later socio-emotional and learning difficulties (Desmarais, Sylvestre, Meyer, Bairati, & Rouleau, 2008). The combination of shyness or behavioral inhibition and poor language development might be particularly problematic for children's socio-emotional development (Coplan & Armer, 2005), although effects on academic achievement appear to be minimal (Cameron, 2009). The combination of behavioral inhibition and negative peer interactions at 24 months was associated with decreased Theory of Mind at 36 months in one study, which suggests that co-occurring behavioral inhibition and social difficulties at an early age have implications for cognitive and social development (Suway, Degnan, Sussman, & Fox, 2012).

Four Hypotheses for the Relation Between Shyness and Language Development

Coplan and Evans (2009) recently reviewed multiple hypotheses regarding the potential reasons for the association between shyness and language development. Although these hypotheses refer to the association between shyness and language development in preschool and early childhood, they provide a useful guide for examining the associations between behavioral inhibition and language development during toddlerhood. All four alternative hypotheses are compelling, and there is some corroborating evidence for each hypothesis; however, additional research testing these hypotheses is needed, as this is still a somewhat novel research area (Coplan & Evans, 2009). Also, the research to date is largely based on cross-sectional correlational data and examination of associations with related constructs such as fewer verbal utterances rather than language development. The present study examined each hypothesis using latent growth modeling techniques in a longitudinal prospective study, which gets us one step closer to examining directionality of the association (as discussed below), and used a standard measure of language development.

The first hypothesis explaining the association between shyness and language development is a "lack of practice makes lack of perfect" model (Coplan & Evans, 2009), which was suggested by Evans (1996). That is, shy children are less likely to engage in social interactions and participate in verbal activities, which leads to slower language development.

Although researchers have not found definitive evidence supporting this hypothesis, several studies have suggested that shy children do engage in fewer social interactions and verbal activities. Crozier and Badawood (2009) examined a sample of children (with a mean age of 5 years) and found that shy children engaged in more private activities during a free-play activity and had shorter verbal utterances during a show-and-tell activity compared to non-shy children. Furthermore, Asendorpf and Meier (1993) found that shy children in the second grade tended to speak less when they interacted with unfamiliar peers. Evans (1993) suggests that decreased language/communication competence may be part of the vicious cycle for shy individuals, in which engaging in fewer social interactions (which typically afford opportunities to “observe, try out, and practice interactional strategies”) further reduces ability to communicate effectively. If the “lack of practice makes lack of perfect” model is correct, behavioral inhibition should be associated with both expressive and receptive language abilities, as the model suggests less participation in social interactions would lead to slower development of language (Coplan & Evans, 2009). Also, results from latent growth modeling indicating that higher initial behavioral inhibition is associated with both lower initial language abilities and less growth in language abilities from age 14 to 24 months would support this model.

The second hypothesis explaining the association between shyness and language development is the “I know it but won’t say it” model (Coplan & Evans, 2009), which was suggested by Coplan, Wichmann, and Lagace-Seguin (2001) and Crozier and Perkins (2002). That is, shy children have problems in performance, not in capability, when speaking with others. As noted by Coplan and Weeks (2009), shy children perform worse than their non-shy counterparts on a variety of tests of language ability, but expressive language is affected to a greater extent than receptive language (e.g., Crozier & Perkins, 2002; Evans, 1996; Spere, Schmidt, Theall-Honey, & Martin-Chang, 2004). These associations between shyness and expressive language abilities are consistent with the idea that shy children’s quietness is not due to a lack of verbal knowledge, but is better explained by inhibition. For example, Crozier and Hostettler (2003) found that shy fifth graders performed more poorly than their less shy peers in face-to-face testing situations, but did not show deficits when tested in an anonymous group setting. However, some researchers have shown results conflicting with this hypothesis and report that shy children have significantly slower receptive *and* expressive language development than their non-shy peers (e.g., Spere & Evans, 2009). If the “I know it but won’t say it” model is correct, the present study should find a greater association between behavioral inhibition and expressive language development than between behavioral inhibition and receptive language development.

A third hypothesis explaining the association between shyness and language development is the “lower language skills lead to shyness” model (Coplan & Evans, 2009). Coplan and Weeks (2009) suggest that restraints in speech, specifically difficulty with verbal communication, are a fundamental trait of shy children, which may indicate that it is the lower language abilities that lead to the shyness, rather than vice versa. Children with poorer expressive language may have greater difficulty communicating effectively, which may in turn lead to lower-quality social interactions and shyness. For example, Coplan and Armer (2005) found a significant effect of expressive verbal abilities on social behavior among shy

preschoolers, in which shy children with lower expressive verbal abilities were less likely to initiate social contact and tended to withdraw from peer interactions, whereas shy children with better expressive verbal abilities were more likely to engage in prosocial behavior. In the present study, we are less likely to find support for this hypothesis given the ages of our sample. Behavioral inhibition is measurable by 6 months of age, whereas language begins developing later in the first year, so in developmental terms, it seems unlikely that early levels of behavioral inhibition would be influenced by later-developing language. If poorer language leads to increased behavioral inhibition, the effect may not be present as early as 14–24 months. It is possible, however, that early delays in developing language could have an effect on changes in behavioral inhibition during this critical development period. A finding that lower initial levels of language abilities at 14 months lead to an increase of behavioral inhibition over time in the latent growth modeling would be consistent with this model.

A fourth hypothesis explaining the association between shyness and language development is the “bold is better” model (Coplan and Evans, 2009). This hypothesis is unique because it proposes that shy children do not have deficits in language development, but that non-shy children have above-average language development. That is, being shy is not a disadvantage, but being very outgoing yields an advantage. For example, Spere and colleagues (2004) reported that shy children obtain normatively average scores on language tests, whereas their non-shy peers score higher than expected given their age. They also found that, although there were significant differences between shy and non-shy children, the shy children were still performing at age-appropriate levels, whereas the non-shy children’s language abilities were higher than that expected by their age (Spere et al., 2004). Similarly, Slomkowski, Nelson, Dunn, and Plomin (1992) found that extraverted temperament at age 2 predicted more advanced expressive and receptive linguistic abilities at ages 2, 3, and 7; one possibility is that extraverted children engage their environments in a way that increases their exposure to language. If this model is correct, inhibited toddlers will have similar language abilities as toddlers who are in the “average” or moderate range of the behavioral inhibition continuum, whereas their non-inhibited counterparts will have better developed language abilities across time points.

Sex Differences

In examining the association between behavioral inhibition and language development, it is important to consider that there may be sex differences in the magnitude of the association, with inhibited boys potentially being at greater risk for language problems than inhibited girls, largely because shyness in girls is more socially accepted than shyness in boys (Rubin & Coplan, 2004). Durkin (2009) agrees that shyness may be more problematic for boys, and suspects a greater risk of developmental difficulties in boys. In addition, Prior and colleagues (2007) found that although girls had higher scores on their measure of shyness than boys, shy girls had fewer behavioral problems and had higher speech/social scores than shy boys at 12 and 24 months of age. Additionally, there is evidence that boys have somewhat slower or delayed language development than girls, particularly during toddlerhood (e.g., Fenson et al., 1994; Van Hulle, Goldsmith, & Lemery, 2004). Given some researchers’ suggestions that the consequences of shyness may be more serious for boys

than girls (e.g., Rubin & Coplan, 2004; Durkin, 2009; Prior et al., 2007), and the findings that boys on average have delayed development of language compared to girls (e.g., Van Hulle, Goldsmith, & Lemery, 2004), we hypothesized that the association between behavioral inhibition and slower language development will be greater in boys than in girls.

The Present Study

The rationale of the present study was to test four specific alternative hypotheses to examine the association between behavioral inhibition and language development. Although there is a large literature examining different aspects of language development in relation to temperament factors (e.g., Dixon & Smith, 2000; Salley & Dixon, 2007; Slomkowski, Nelson, Dunn, & Plomin, 1992), the present study focused on behavioral inhibition to increase understanding regarding how an inhibited temperament might be associated with language development. We examined the association at an early age (i.e., 14 to 24 months) because it will get us one step closer to understanding (1) the underlying developmental mechanisms in the association and (2) potential areas for interventions at an earlier age. There are previous studies demonstrating that the associations are present at an early age, but to our knowledge, studies examining the prospective associations between behavioral inhibition and language development have not been conducted.

Longitudinal design gets us one step closer than cross-sectional approaches in evaluating the directionality of the association between behavioral inhibition and language development, and allows a more substantive evaluation of the hypotheses. For example, with longitudinal data, it is possible to examine whether children with high behavioral inhibition experience later delayed language development (or vice versa). The present study used latent growth curve models to examine the associations between initial levels *and* growth of language and behavioral inhibition during toddlerhood, which helps us test the directionality of the association between language development and behavioral inhibition.

Method

Sample

For the present study, 408 families with same-sex twin pairs born between 1986 and 1990 were recruited through the Colorado Department of Health as part of a larger study. The ethnicity of the families was 86.6% Caucasian, 8.5% Hispanic, 0.7% African-American, 1.2% Asian, and 2.9% other, which corresponds well to that reported for Boulder County, CO, in the 1990 United States Census. The mean number of years of education was 14.29 years for mothers and 14.42 years for fathers. Data used in the present study were collected from 408 same-sex twin pairs (50% female) at 14, 20, and 24 months (a total of 816 individuals). Average age at assessment was as follows: 14 month visit: $M = 14.29$ months, $SD = .38$; 20 month visit: $M = 20.34$ months, $SD = .43$; 24 month visit: $M = 24.48$ months, $SD = .68$. Behavioral inhibition and language data were collected as part of a larger research protocol during home and lab visits (occurring within two weeks of each other); individuals included in the analyses had data available for at least one of the behavioral inhibition or language measures, which resulted in only four individuals being excluded from the analyses due to complete missing data. Table 1 displays the number of children with

available data for expressive and receptive language and observed and parent-reported behavioral inhibition at each age. In the statistical analyses, non-independence of the data from twin pairs was addressed. All data collection procedures were approved by the Institutional Review Board of University of Colorado.

Assessments

Parent-reported and observational measures of behavioral inhibition and observational tests of language abilities were examined during the study. At age 14, 20, and 24 months, the participants were assessed in two different settings (home and laboratory). Home visits and lab visits were scheduled at a time when mothers believed their children would be alert and amenable to the testing situation. Laboratory visits took place within two weeks of the home visit. The home and laboratory visits were videotaped by separate examiner assistants, and then rated by trained research assistants.

Observed Behavioral Inhibition

There were four behavioral indicators of observed behavioral inhibition: “approach,” “cling,” “fearfulness,” and “lab visit shyness” assessed in either the home or lab contexts. To assess each twin’s level of inhibition around the examiners and research equipment (video camera, identifying vests, and toys), the first five minutes of the home visit was recorded by one examiner while the other examiner interacted with the twins and mother. Every minute, data were recorded on behaviors including approaching the examiner, approaching an offered toy, proximity to mother, clinging to mother, self-soothing (e.g., nervous behaviors of sucking thumb and fiddling with ear/hair), vocalizing, and crying. The examiners introduced themselves, presented two toys, and placed identifying vests on each twin. Each twin was given scores to assess shyness during the first five minutes of the home visit based on later review of the videos by trained research staff who established inter-rater reliability. Confirmatory factor analyses (CFA) were conducted in Mplus (Muthén & Muthén, 1998–2010) to examine the structure of the shyness variables captured in the first five minutes of the home visit. The variables loading on the “Approach” factor were average shyness, proximity to the researcher, and playing with the novel toy. The variables loading on the “Cling” factor were proximity to mother, touching mother, and clinging to mother. All variable loadings were statistically significant ($p < .001$) and ranged from .57-.96. Based on the significant factor loadings, composite scores were created for the “Approach” and “Cling” variables by summing the variables, and then categorizing from low to high based on distribution of the data (Approach: 1 = quick Approach, 4 = slow Approach; Cling: 1 = low Cling, 3 = high cling).

Examiners assessed each twin’s behavior, including level of fearfulness, using the Infant Behavior Record (IBR: Matheny, 1980) during the Bayley Scales of Infant Development (Bayley, 1969) and over the course of other lab procedures. In this study, the “IBR Fearfulness” item used was the average of the toddler’s reaction to the new strangers, strange surroundings, and test materials on a 9-point scale across the Bayley ratings and the sum across all other lab procedures (1 = low fearfulness, 9 = high fearfulness). Finally, “lab visit shyness” was the examiners’ global ratings of shyness and hesitation towards strangers (i.e., research staff) during the lab visit (1 = not shy, 4 = very shy). Inter-rater reliability

between raters was high, and values have been reported elsewhere, with kappas ranging from .86 to greater than .95 (Emde et al., 1992) and intraclass correlation coefficients ranging from .77 to .99 (Emde et al., 1992).

Each variable was categorized based on the distribution of the variables and to avoid zero cells in the analyses: low (1), medium (2), and high (3) behavioral inhibition. IBR Fearfulness scores ranged from 1–9, and were categorized as follows: scores of 1–2 = low, 2.5–3.5 = medium, and 4–9 = high. Lab visit shyness scores ranged from 1–4, and were categorized as follows: 1 = low, 2 = medium, 3–4 = high. The home shyness factor scores were categorized as follows: Approach: 0–3 = low, 3.01–8 = medium, 8.01–12 = high; Cling: 0 = low, 1–3 = medium, 4–5 = high. At each age, an observed behavioral inhibition composite score was calculated as the mean of the four observed behavioral inhibition measures (i.e., “approach,” “cling,” “fearfulness,” and “lab visit shyness”). The behavioral inhibition composite score was normally distributed at each age.

Parent-Reported Behavioral Inhibition

Parent report measures of behavioral inhibition included the averages of mother and father ratings on the “shyness” 5-point scale (assessing 5 items regarding child’s behavior with strangers) of the Colorado Childhood Temperament Inventory (CCTI; Rowe & Plomin, 1977), the average of mother and father ratings on the “approach” six-point scale of the Toddler Temperament Scale (TTS; Carey & McDevit, 1978), and mother ratings of “fearfulness” on a five-point scale on the Differential Emotions Scale (DES; Izard et al., 1980). Each score on the scales was converted to proportions of the maximum score to put the scores on the same scale, then a composite parent-rated behavioral inhibition score was formed by averaging the three proportions. The composite scores were calculated in the same way at each age, and were normally distributed at each age.

An earlier study using the same sample showed that all measures of behavioral inhibition had statistically significant factor loadings at each time point (ranging from .33–.73 for the observational factor and .57–.90 for the parent-reported factor; $p < .01$ for all loadings) in confirmatory factor analyses (Smith et al., 2012). Observational and parent-reported behavioral inhibition measures were also significantly associated. Cross-visit correlations of the behavioral inhibition composite scores used in the present study ranged from $r = .64$ –.67 (parent reported behavioral inhibition) and $r = .41$ –.54 (observed behavioral inhibition), all significant at the $p < .001$ level; this is an estimate of the lower limit of reliability, as change is expected across time.

Although there was evidence suggesting that observational and parent-reported behavioral inhibition measure the same underlying construct, they also capture unique aspects of the behavioral inhibition temperament (Smith et al., 2012). Observational measures are based on a small window of observable behavior, whereas parent reports assess a broader scope of behavior (but are potentially more affected by other variables, such as parental characteristics). Based on this earlier research, observational and parent-reported behavioral inhibition scores were examined separately in the present study.

Assessment of Language Development

Expressive and receptive language abilities were measured via the Sequenced Inventory of Communication Development (SICD; see Hedrick, Prather, & Tobin, 1975 for psychometric properties of the instrument) at age 14, 20, and 24 months. At age 14 months, the same set of items was given to all the children. At 20 and 24 months, testers first gave children the items that they had failed at the earlier age, and then items of increasing difficulty were added. Assessment of expressive language consisted of imitation or production of sounds and words, with increasing difficulty requiring more complex responses or correct use of grammar (e.g., adverbs, past tense verbs). For example, examiners asked children to imitate certain sounds and words (e.g., /ai/ and “mama”), and as the items became more difficult, asked “If you wanted a cookie, what would you do?” Assessment of receptive language included the ability to understand words and comments, again with increasing difficulty. For example, an examiner would ask a child to follow instructions, such as “Give me the cup and ball,” and as the difficulty of the task increases, later ask the child to respond to different colors or textures.

Raw expressive and receptive language scores were negatively skewed, so were subjected to a reflected square root transformation: each score was subtracted from the maximum score +1 and square-root transformed to obtain a normal distribution. To maintain the directionality of scores (i.e., higher scores reflecting better performance), the scores were multiplied by -1 after transformation. Skewness and kurtosis values were below 1 after transformations (with the exception of expressive language at 14 months, which had a kurtosis of 1.01 and skewness of .39).

Statistical Analyses

To examine the associations between behavioral inhibition and language development, we conducted a series of latent growth models and regression analyses. Univariate latent growth models were conducted to examine individual differences in the intercept and slope of language development and behavioral inhibition. Bivariate latent growth models were conducted to examine the associations between behavioral inhibition and language development. We also conducted regression analyses using specific contrasts to test the hypothesis that individuals with low behavioral inhibition will have better language development. Due to the numerous different analyses, general analytic issues will be discussed in this section, and detailed descriptions of the analyses will be presented with the results. Statistical analyses examining the association between behavioral inhibition and language development were conducted in Mplus (Muthén & Muthén, 1998–2010).

An advantage of Mplus is that it takes into account non-independence of observations when computing regressions, standard errors, and model fit (e.g., a scaled χ^2 that takes non-independence into account; Satorra & Bentler, 2001). Because the data from the two twins in each pair are correlated, the data were treated as non-independent and the twins were considered nested within twin pairs in Mplus using the type=COMPLEX option. Statistical significance was determined by the p-value of the z-statistic, which is the ratio of each parameter estimate to its standard error, but when there were inconsistencies between the conclusion regarding parameter significance from the result of the chi-square difference test

(between the full model and the reduced model where the parameter estimate was dropped) and the p-value, parameter significance was determined by chi-square difference tests. Maximum likelihood with robust standard errors (MLR) estimation was used in the latent growth curve modeling. Mplus treats missing data as missing at random by utilizing the expectation-maximization (EM) algorithm (Little & Rubin, 2002) when MLR is used. This allows the missing data to be a function of observed covariates and outcomes.

Results

Sex Difference in Means of Variables

T-tests were conducted in MPlus to assess sex differences in the mean level of observed behavioral inhibition, parent-reported behavioral inhibition, expressive language, and receptive language variables (Table 1). In general, girls had higher behavioral inhibition scores than boys at 14 and 20 months, but the differences were no longer statistically significant by age 24 months. Girls had significantly higher expressive and receptive language mean scores than boys at all ages. Given the significant sex differences in the means of variables, multiple group analyses were conducted, with all following analyses allowing sex differences in the means of behavioral inhibition and language.

Individual Growth Models

Figure 1 illustrates the four univariate growth models run in MPlus for observed behavioral inhibition, parent-reported behavioral inhibition, expressive language abilities, and receptive language abilities. The latent Intercept's loadings on all time points are fixed at 1.0 given the assumption that the Intercept influences behavior across all time points. The latent Slope in the model had loadings at 14 months fixed at 0, loadings at 20 months free, and loadings at 24 months fixed at 1. With this parameterization, the Intercept reflects the variance stable with the initial level of the variable and the Slope represents change from the initial time point. By freeing the Slope loading at 20 months, the model can have a non-linear pattern. In Figure 1, the free loadings for the latent Slope indicate the proportion of the total change. For example, in the observed behavioral inhibition model in girls (Figure 1a), 87.8% of the total change occurs by 20 months.

Table 2 presents the parameters for the growth models for boys and girls. In the four models, the variances of the Intercept variable were all significantly greater than zero, indicating that there are significant individual differences in the initial levels of behavioral inhibition, expressive language, and receptive language. For expressive and receptive language, the positive and significant means of the Slope suggest significant increases with time, and the significant variances of the Slope suggest significant individual differences in the rates of change. For observed behavioral inhibition, the variance of the slope was significant for both boys and girls, indicating individual differences in the rate of change.

For parent-reported behavioral inhibition in boys, both the mean and variance of the slope were significant, indicating significant increases and individual differences in the rates of change. In girls, the mean of the Slope of observed behavioral inhibition was small and not statistically significant ($p = .39$), suggesting that behavioral inhibition did not increase over

time, and the Slope had a small, non-significant negative variance ($p = .73$); that is, there were no significant individual differences in the rate of change in parent-reported behavioral inhibition in girls. In MPlus, negative residual variance suggests model overfitting or nonconvergence. When the parameter is small and nonsignificant, it can be fixed to zero to allow the model to run. Therefore, the variance of the Slope was fixed to zero for parent-reported behavioral inhibition in girls.

The correlations between the Intercept and Slope of the variables are also shown in Table 2. For both girls and boys, there was a significant negative correlation between the Intercept and Slope of observed behavioral inhibition. These results suggest that individuals with high initial levels of observed behavioral inhibition have less growth over time for those variables.

Associations Between Behavioral Inhibition and Language Development

To test the “lack of practice leads to lack of perfect,” “I know it but won’t say it,” and “lower language skills leads to shyness” models, we examined the relations between growth in language abilities and growth in behavioral inhibition. Four sets of latent growth curves were estimated: observed behavioral inhibition with expressive language, observed behavioral inhibition with receptive language, parent-reported behavioral inhibition with expressive language, and parent-reported behavioral inhibition with receptive language (Figure 2). Results from latent growth modeling indicating that higher initial behavioral inhibition is associated with both lower initial language abilities and less growth in language abilities from age 14 to 24 months would support the “lack of practice leads to lack of perfect” model. Results indicating a greater association between behavioral inhibition and expressive language development relative to the association between behavioral inhibition and receptive language development would support the “I know it but won’t say it” model. A finding that lower initial levels of language abilities at 14 months lead to an increase of behavioral inhibition over time would be consistent with the “lower language skills leads to shyness” model.

The correlation between Intercepts indicates whether the association between behavioral inhibition and language was present at 14 months. The expressive language Intercept was significantly and negatively associated with the observed behavioral inhibition Intercept (Figure 2a) and parent-reported behavioral inhibition in girls only (Figure 2b), demonstrating that the inverse association was present as early as 14 months. This result suggests that initial levels of expressive language are associated with initial levels of observed behavioral inhibition. In contrast, the receptive language Intercept was not significantly associated with either observed behavioral inhibition or parent-reported Intercepts. This result provides support for the “I know it but won’t say it” model, as the association was present for expressive, but not receptive, language.

The cross-paths from the Intercepts to Slopes show the extent to which the individual differences in the variance that are stable with initial levels of the variables influence the rate of change in the other, after controlling for the correlation between the Intercepts of the two traits. The Slopes for behavioral inhibition and language were regressed on the Intercepts for behavioral inhibition and language. The cross-paths were used to test the “lower language

skills lead to shyness” (i.e., cross-path from Intercept for language to Slope for behavioral inhibition) and “lack of practice makes lack of perfect” (i.e., cross-path from Intercept for behavioral inhibition to Slope for language) hypotheses. There was one significant cross-path between the Intercept for parent-reported behavioral inhibition and the Slope for expressive language in girls, suggesting that higher initial behavioral inhibition leads to less growth in expressive language, and one significant cross-path between the Intercept for expressive language and the Slope for parent-reported behavioral inhibition in boys, suggesting that lower initial expressive language leads to increased growth in behavioral inhibition. Overall, these results provide marginal evidence for the “lack of practice makes lack of perfect” model in girls and the “lower language skills lead to shyness” model in boys. It is important to note that these same cross-paths were not significant in the model examining observed behavioral inhibition and language. Generally, the results indicate that most of the regression parameters are not statistically significant, and the significant cross-paths were not consistent between observed and parent-reported behavioral inhibition.

Associations between High vs. Low Behavioral Inhibition and Language Development

To test the “bold is better model”, the sample was divided into those with “low” behavioral inhibition (i.e., greater than one standard deviation below the mean), “moderate” behavioral inhibition (i.e., ± 1 standard deviations around the mean), and “high” behavioral inhibition (i.e., greater than one standard deviations above the mean). Table 3 shows the means, standard deviations, and results from the regression analyses examining whether the mean language abilities differ among the low, moderate, and high behavioral inhibition groups.

Three sets of orthogonal contrast codes were tested at each time point to examine the association between the behavioral inhibition groups and language abilities (see Table 3). No contrast effects were statistically significant when examining the association between behavioral inhibition and receptive language, but there were several significant differences among the low, moderate, and high behavioral inhibitions groups in expressive language. The “bold is better” model would be supported if the significant differences were limited to comparisons between the “low” group and the other groups. However, significant differences between the “low” group and other groups only occurred at 20 months, providing little support for the “bold is better” model.

In general, results comparing high, moderate, and low behavioral inhibition groups suggested a linear association between behavioral inhibition and expressive language, and the group low on behavioral inhibition did not have consistently higher language abilities than the moderate behavioral inhibition group. Therefore, there was little support for the “bold is better” model.

Additional Findings from Growth Models

Results from the growth models indicated several significant paths from the Intercept to Slope of the same variable. These negative paths were significant for parent-reported behavioral inhibition (only in boys; Figures 2b and 2d) and in the models examining receptive language (Figures 2c and 2d). For example, high initial parent-reported behavioral inhibition was associated with less change or growth in parent-reported behavioral

inhibition. Most likely, these findings indicate a “ceiling effect;” that is, those with high initial levels of any trait may have less room to grow.

The correlations between the residual variances in the Slopes show whether the changes in language parallel the changes in behavioral inhibition, after controlling for association between the Intercepts. This correlation was significantly negative for observed behavioral inhibition and expressive language in both genders (Figure 2a), indicating that for children whose observed behavioral inhibition increased from age 14 to 24 months, there was less growth in expressive language. The correlations between the Slope for parent-reported behavioral inhibition and the Slopes for both receptive and expressive language were significant in boys (Figures 2b and 2d), suggesting that for boys whose parent-reported behavioral inhibition increased, there was less growth in language development. Although informative, these correlations do not provide direct support of either the “lack of practice makes lack of perfect” or the “lower language skills lead to shyness” hypotheses, as they do not indicate directionality of the association.

Sex Differences in the Associations between Behavioral inhibition and Language Development

We conducted a series of one-degree-of-freedom tests to examine the statistical significance of sex differences in each parameter of the bivariate models in Figure 2. Results suggest that fixing parameters to be the same across boys and girls for the analyses examining observed behavioral inhibition and language did not result in a significant decrement in model fit. Significant sex differences were found in the models examining parent-reported behavioral inhibition and language; parameters that were significantly different across the sexes are indicated by bolded font in Figure 2. Additionally, the variance of the Slope of parent-reported behavioral inhibition in girls had to be fixed to zero due to a non-significant, negative residual variance. Chi-square difference tests indicated that equating all parameters that were not significantly different across the sexes in the one-degree-of-freedom tests to be equal did not lead to a significant decrement in the fit of the model (all $\chi^2 < 6.00, p > .30$; results available upon request).

As described above, the results shown in Figure 2 are from analyses where all parameters with non-significant sex differences were fixed to be equal across boys and girls. However, because all models had sex-specific means and variances for the latent Intercept and Slope variables, the standardized parameters, which are shown in Figure 2, are different for boys and girls. Overall, there were not consistent sex differences indicating a greater association between language and behavioral inhibition in one gender or the other.

Discussion

Evidence for Alternative Models

Overall, the results support the “I know it but won't say it” model; that is, the results suggest that the association between behavioral inhibition and language development is likely due to reticence than language delays/deficits. Latent growth curve modeling results indicated that the associations between language development and behavioral inhibition were more

consistent for expressive than receptive language, which was the evidence needed to support the “I know it but won’t say it” hypothesis. Also, results of regression analyses indicated significant linear mean differences in expressive language development, but not receptive language development, among the low, moderate, and high behavioral inhibition groups, which further supported the “I know it but won’t say it” hypothesis. These results are consistent with previous research among children of diverse ages indicating that shy children perform worse than their non-shy counterparts on tests of expressive language in particular (e.g., Crozier & Hostettler, 2003; Crozier & Perkins, 2002; Evans, 1996; Spere et al., 2004).

The other hypotheses garnered mixed support. For example, the finding that lower initial expressive language was associated with higher growth of behavioral inhibition supported “lack of practice leads to lack of perfect” (i.e., behavioral inhibition leads to delays in language development) in girls only, whereas the finding that higher initial behavioral inhibition was associated with decreased growth of expressive language supported “lower language skills leads to shyness” (i.e., delayed language development leads to increased behavioral inhibition) in boys only. These results did not replicate with observed behavioral inhibition, which weakens the evidence. The discrepant findings between parent-reported and observed behavioral inhibition possibly reflect chance findings or rater-driven differences in the measured behaviors. For example, it is possible that parents rely on expressive language abilities as indicators of behavioral inhibition, whereas the observational measures relied primarily on behaviors (e.g., time to approach) not directly associated with expressive language. As noted in the Introduction, “lack of practice leads to lack of perfect” hypothesis has not been directly tested to our knowledge, but was based on earlier findings that shy children tend to engage in more private activities and talk less in social settings (e.g., Crozier & Badawood, 2009; Asendorpf & Meier, 1993). Similarly, “lower language skills leads to shyness” was based on the findings that individuals with language deficits tend to engage less in social settings (Coplan & Armer, 2005) and have lower popularity ratings (Gertner, Rice, & Hadley, 1994) in preschool, and have lower-quality friendships in adolescence (Durkin & Conti-Ramsden, 2007). We did find that the growth parameters of behavioral inhibition and language abilities are negatively associated, suggesting that toddlers who become more behaviorally inhibited over time have less growth of language (especially for expressive language). Although this result is consistent with the general finding that shy children tend to speak less, and/or children with language deficits tend to be shyer, it is not possible to ascertain the direction of the effect from these correlations.

“Bold is better” (i.e., extroverted children outperform children who are moderate or high on behavioral inhibition) was not supported by our results. Spere and colleagues (2004) found that in children (age 5–7-years-old), those who were rated as high and average on shyness characteristics scored within the normal range on a test of language abilities, whereas extroverted children scored above average. It is possible that the benefits of boldness develop over time, and the association may not be present as early as toddlerhood. Examining the developmental trajectories of the present sample is an important future direction to increase understanding of later outcomes in the association between behavioral inhibition and language development.

Sex Differences

Some researchers have suggested that shyness may predict different trajectories for boys and girls because shyness in girls is more culturally accepted than shyness in boys (e.g., Durkin, 2009). We found that there were significant sex differences in the mean level of both behavioral inhibition and language abilities, with girls having higher behavioral inhibition levels and higher language levels than boys during toddlerhood, consistent with earlier studies of children of diverse ages (e.g., Prior et al., 2007). Although the negative correlation between growth of parent-reported behavioral inhibition and growth of both expressive and receptive language was significant only in boys, there was not a similar sex difference in analyses examining observed behavioral inhibition. In general, the results from the present study suggest little evidence for consistent sex differences in the developmental association between behavioral inhibition and language development in toddlerhood. It is important to note that sex differences may not appear until older ages, when the social effects of shyness may be greater for boys than girls, as previous research indicates (e.g., Coplan & Weeks, 2009; Rubin & Coplan, 2004; Durkin, 2009). The present study was limited to ages 14 to 24 months, when gender differences in language ability become pronounced and differences in the way parents treat boys and girls are just beginning (Keenan & Shaw, 1997). Some studies have found differences in maternal responses to shyness as early as 33 months, with a harmonious mother–daughter relationship predicted by shyness in girls, and less maternal sensitivity predicted by shyness in boys (Engfer, 1993). It is possible that gender differences may become more pronounced at later ages, as the effects of differential parental treatment (and other social factors) between boys and girls likely intensify over time.

Strengths and Limitations

It is important to consider the strengths and weaknesses of the present study when interpreting its results. The primary strength of this study was its longitudinal design, which allowed us to use latent growth curve modeling, a strong analytical technique for studying within–individual change, individual variation in growth over time, and identifying potential factors that explain the variation (Curran, Harford, & Muthén, 1996). The longitudinal design and the use of latent growth curve modeling allowed us to test alternative hypotheses regarding the direction of the association between behavioral inhibition and language development. Additionally, examining the association between behavioral inhibition and language in toddlerhood is a unique strength, as there is tremendous growth in language development during this period (Durkin, 2009). On the other hand, our results suggest that there are significant associations between behavioral inhibition and language as early as 14 months, making the direction of the association between behavioral inhibition and language development difficult to determine.

Another strength of the present study was the availability of multiple measures in the sample. For example, we were able to test the “I know it but won’t say it” model because both expressive and receptive language were measured. Also, we examined two different measures of behavioral inhibition (observed and parent-reported), which have been shown to be significantly associated but distinct in an earlier study using the present sample (Smith et al., 2012). Some of the associations between behavioral inhibition and language development were limited to parent-reported behavioral inhibition, which may reflect the

rater-driven differences specific to parent-reported behavioral inhibition (e.g., DiLalla & Caraway, 2004); for example, parents have a larger sampling of behavioral observations on which to rate their children's behavior, and likely use different reference points for comparisons (e.g., other children in their family). We also had multiple measures of observed and parent-reported behavioral inhibition, which reduced measurement error and led to a more reliable assessment.

One limitation of the present study was the study design, which relied on correlational data and thus has limited ability to establish causality regarding mechanisms and etiological explanations for the association between behavioral inhibition and language development. However, it is important to note that the longitudinal design of the present study brings us one step closer to testing the alternative hypotheses directly by allowing examination of the directionality of the association. Additionally, the present study examined a general population sample of same-sex twins, and prior studies have reported that twins have higher incidence of language delay than singletons at early ages (e.g., Rutter et al., 2003; Thorpe, 2008) and are more behaviorally inhibited compared to singletons in a preschool sample (DiLalla & Caraway, 2004). If these mean differences between twins and singletons are accompanied by differences in how behavioral inhibition and language relate to each other, it will be important to replicate the results in other samples to determine generalizability. Another limitation is that the present study only examined data collected during toddlerhood. Future longitudinal studies examining longer developmental periods would provide stronger tests of the hypotheses. The longitudinal approach of the present study allowed us to examine potential pathways for the associations between behavioral inhibition and language development. Although this study design provided more depth than traditional cross-sectional designs, the inability to make causal statements remains. Examining the etiology of this association beyond the correlational study design is an important future direction. For example, a treatment study examining the effects of language remediation among shy children may help clarify causal mechanisms in the associations between behavioral inhibition and language development. This area of research would also benefit from replication across samples (e.g., non-twins, individuals selected for language developmental delay or selective mutism/extreme shyness to assess whether similar associations can be demonstrated in clinical samples), and time points (i.e., assessing association at later ages).

Summary

The present study examined the assumptions of four hypotheses regarding the association between behavioral inhibition and language development. There were more consistent associations between higher behavioral inhibition and lower expressive language than lower receptive language, suggesting support for the "I know it but won't say it" model. These results suggest that behavioral inhibition does not inhibit language acquisition, but that behaviorally inhibited children may be helped by greater attention to support developing their expressive verbal abilities.

Acknowledgments

This research was supported by grants from MacArthur Foundation, NICHD, and NIH HD010333, HD050346, HD007289, MH063207.

The authors thank the participants and research assistants for their participation and assistance with this project.

References

- Asendorpf JB, Meier GH. Personality effects on children's speech in everyday life: Sociability-mediated exposure and shyness-mediated reactivity to social situations. *Journal of Personality and Social Psychology*. 1993; 64:1072–1083. [PubMed: 8326470]
- Bayley, N. *Manual for the Bayley Scales of Infant Development*. New York: Psychological Corporation; 1969.
- Bohlin G, Hagekull B, Andersson K. Behavioral Inhibition as a Precursor of Peer Social Competence in Early School Age: The Interplay With Attachment and Nonparental Care. *Merrill-Palmer Quarterly*. 2005; 51:1–19.
- Cameron CA. Associations between shyness, reluctance to engage, and academic performance. *Infant and Child Development*. 2009; 18:299–305. [PubMed: 21048885]
- Carey WB, McDevitt SC. Stability and change in individual temperament diagnoses from infancy to early childhood. *American Academy of Child Psychiatry*. 1978; 17:331–337.
- Caspi A, Elder GH, Bern D. Moving away from the world: Life-course patterns of shy children. *Developmental Psychology*. 1988; 24:824–831.
- Chronis-Tuscano A, Degnan KA, Pine DS, Perez-Edgar K, Henderson HA, Diaz Y, Raggi VL, et al. Stable early maternal report of behavioral inhibition predicts lifetime social anxiety disorder in adolescence. *Journal American Academy Child Adolescent Psychiatry*. 2009; 48:928–935.
- Coplan RJ, Armer M. Talking yourself out of being shy: Shyness, expressive vocabulary, and socioemotional adjustment in preschool. *Merrill-Palmer Quarterly*. 2005; 51:20–41.
- Coplan RJ, Evans MA. At a loss for words? Introduction to the special issue on shyness and language in childhood. *Infant and Child Development*. 2009; 18:211–215.
- Coplan RJ, Schneider BH, Matheson A, Graham AA. "Play skills" for shy children: Development of a social skills-facilitated play early intervention program for extremely inhibited preschoolers. *Infant and Child Development*. 2010; 19:223–237.
- Coplan RJ, Weeks M. Shy and soft-spoken: Shyness, pragmatic language, and socioemotional adjustment in early childhood. *Infant and Child Development*. 2009; 18:238–254.
- Coplan RJ, Wichmann C, Lagace-Seguin DG. Solitary-active play behavior: A marker variable for maladjustment in the preschool? *Journal of Research in Childhood Education*. 2001; 15:164–172.
- Crozier WR, Badawoods A. Shyness, vocabulary and children's reticence in Saudi Arabian preschools. *Infant and Child Development*. 2009; 18:255–270.
- Crozier WR, Hostettler K. The influence of shyness on children's test performance. *British Journal of Educational Psychology*. 2003; 73:317–328. [PubMed: 14672146]
- Crozier WR, Perkins P. Shyness as a factor when assessing children. *Educational Psychology in Practice*. 2002; 18:239–244.
- Curran PJ, Harford TC, Muthén BO. The relation between heavy alcohol use and bar patronage: A latent growth model. *Journal of studies on alcohol*. 1996; 57:410–418. [PubMed: 8776683]
- Desmarais C, Sylvestre A, Meyer F, Bairati I, Rouleau N. Systematic review of the literature on characteristics of late-talking toddlers. *International Journal of Language & Communication Disorders*. 2008; 43:361–389. [PubMed: 17885825]
- DiLalla LF, Caraway RA. Behavioral inhibition as a function of relationship in preschool twins and siblings. *Twin Research*. 2004; 7:449–455. [PubMed: 15527660]
- Dixon WE, Smith PH. Links between early temperament and language acquisition. *Merrill-Palmer Quarterly*. 2000; 46:417–440.
- Durkin K. Language, shyness, and social contexts: Commentary. *Infant and Child Development*. 2009; 18:291–298.

- Durkin K, Conti-Ramsden G. Language, social behavior and the quality of friendships in adolescents with and without a history of Specific Language Impairment. *Child Development*. 2007; 78:1441–1457. [PubMed: 17883441]
- Emde RN, Plomin R, Robinson Ja, Corley R, DeFries J, Fulker DW, Reznick JS, Campos J, Kagan J, Zahn-Waxler C. Temperament, emotion, and cognition at fourteen months: the MacArthur Longitudinal Twin Study. *Child Development*. 1992; 63:1437–1455. [PubMed: 1446561]
- Engfer, A. Antecedents and consequences of shyness in boys and girls: A 6-year longitudinal study. In: Rubin, KH.; Asendorpf, JB., editors. *Social Withdrawal, Inhibition, and Shyness in Childhood*. Hillsdale, NJ: Lawrence Erlbaum Associations, Inc., Publishers; 1993. p. 49-79.
- Evans, MA. Communicative competence as a dimension of shyness. In: Rubin, KH.; Asendorpf, JB., editors. *Social Withdrawal, Inhibition, and Shyness in Childhood*. Hillsdale, NJ: Lawrence Erlbaum Associations, Inc., Publishers; 1993. p. 49-79.
- Evans MA. Reticent primary grade children and their more talkative peers: Verbal, nonverbal, and self-concept characteristics. *Journal of Educational Psychology*. 1996; 88:739–749.
- Fenson L, Dale PS, Reznick JS, Bates E, Thal DJ, Pethick SJ, Tomasello M, Mervis CB, Stiles J. Variability in early communicative development. *Monographs of the Society for Research in Child Development*. 1994; 59:1–185. [PubMed: 7845413]
- Fox, NA.; Reeb-Sutherland, BC. Biological moderators of infant temperament and its relation to social withdrawal. In: Rubin, KH.; Coplan, RJ., editors. *The Development of Shyness and Social Withdrawal*. New York, NY: Guilford Press; 2010. p. 84-103.
- Gertner BL, Rice MK, Hadley PA. Influence of communicative competence on peer preferences in a preschool classroom. *Journal of Speech and Hearing Research*. 1994; 37:913–923. [PubMed: 7967575]
- Hedrick, DL.; Prather, EM.; Tobin, AR. *Sequenced Inventory of Communication Development*. Seattle: University of Washington Press; 1975.
- Izard CE, Huebner R, Risser D, McGinnes GC, Dougherty L. The young infant's ability to produce discrete emotional expressions. *Developmental Psychology*. 1980; 16:132–140.
- Kagan J, Reznick JS, Clarke C, Snidman N, Garcia-Coll C. Behavioral inhibition to the unfamiliar. *Child Development*. 1984; 55:2212–2225.
- Kagan, J.; Snidman, N.; Arcus, D. On the temperamental categories of inhibited and uninhibited children. In: Rubin, KH.; Asendorpf, JB., editors. *Social Withdrawal, Inhibition, and Shyness in Childhood*. Hillsdale, NJ: Lawrence Erlbaum Associations, Inc., Publishers; 1993. p. 19-28.
- Keenan K, Shaw D. Developmental and social influences on young girls' early problem behavior. *Psychological Bulletin*. 1997; 121:95–113. [PubMed: 9000893]
- Kubicek, LF.; Emde, RN.; Schmitz, S. Temperament, mental development, and language in the transition from infancy to early childhood. In: Hewitt, RN.; Emde, JK., editors. *Infancy to Early Childhood*. New York, NY: Oxford University Press; 2001. p. 307-328.
- Little, RJ.; Rubin, DB. *Statistical analysis with missing data*. Second ed. New York: John Wiley & Sons; 2002.
- Matheny AP. Bayley's Infant Behavior Record: Behavioral components and twin analyses. *Child Development*. 1980; 51:1157–1167. [PubMed: 7193557]
- McDermott JM, Perez-Edgar K, Henderson H, Chronis-Tuscano A, Pine DS, Fox Na. A history of childhood behavioral inhibition and enhanced response monitoring in adolescence are linked to clinical anxiety. *Biological Psychiatry*. 2009; 65:445–448. [PubMed: 19108817]
- Mian ND, Wainwright L, Briggs-Gowan MJ, Carter AS. An ecological risk model for early childhood anxiety: The importance of early child symptoms and temperament. *Journal of Abnormal Child Psychology*. 2011; 39:501–512. [PubMed: 21153696]
- Miller SR, Coll E. From social withdrawal to social confidence: Evidence for possible pathways. *Current Psychology*. 2007; 26:86–101.
- Muthén, LK.; Muthén, BO. *Mplus User's Guide*. 6th ed. Los Angeles, CA: Muthén & Muthén; 1998–2010.
- Perren S, Alsaker FD. Social behavior and peer relationships of victims, bullyvictims, and bullies in kindergarten. *Journal of Child Psychology and Psychiatry*. 2006; 47:45–57. [PubMed: 16405640]

- Robinson JL, Kagan J, Reznick JS, Corley R. The heritability of inhibited and uninhibited behavior: A twin study. *Developmental Psychology*. 1992; 28:1030–1037.
- Prior M, Bavin EL, Cini E, Reilly S, Bretherton L, Wake M, Eadie P. Influences on communicative development at 24 months of age: Child temperament, behavior problems, and maternal factors. *Infant Behavior & Development*. 2007; 31:270–279. [PubMed: 18190967]
- Prior M, Bavin E, Cini E, Eadie P, Reilly S. Relationships between language impairment, temperament, behavioural adjustment and maternal factors in a community sample of preschool children. *International Journal of Language & Communication Disorders*. 2011; 46:489–494. [PubMed: 21771224]
- Rezendes, M.; Snidman, N.; Kagan, J.; Gibbons, J. Features of speech in inhibited and uninhibited children. In: Rubin, KH.; Asendorpf, J., editors. *Social Withdrawal, Inhibition and Shyness in Childhood*. Hillsdale, NJ: Erlbaum; 1993. p. 177–187.
- Rhea SA, Gross AA, Haberstick BC, Corley RP. Colorado Twin Registry. *Twin Research and Human Genetics*. 2006; 9:941–949. [PubMed: 17254434]
- Rimm-kaufman SE, Kagan J. Infant predictors of kindergarten behavior : The contribution of inhibited and uninhibited temperament types. *Behavior Disorders*. 2005; 30:331–347.
- Robinson JL, Kagan J, Reznick JS, Corley R. The heritability of inhibited and uninhibited behavior: A twin study. *Developmental Psychology*. 1992; 28:1030–1037.
- Rowe DC, Plomin R. Temperament in early childhood. *Journal of Personality Assessment*. 1977; 41:150–156. [PubMed: 856967]
- Rubin, KH.; Asendorpf, JB. Social withdrawal, inhibition, and shyness in childhood: Conceptual and definitional issues. In: Rubin, KH.; Asendorpf, JB., editors. *Social Withdrawal, Inhibition, and Shyness in Childhood*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc., Publishers; 1993. p. 3–17.
- Rubin KH, Coplan RJ. Paying attention to and not neglecting social withdrawal and social isolation. *Merrill-Palmer Quarterly*. 2004; 50:506–534.
- Rutter M, Thorpe K, Greenwood R, Northstone K, Golding J. Twins as a natural experiment to study the causes of mild language delay: I: Design; twin-singleton differences in language, and obstetric risks. *Journal of Child Psychology and Psychiatry*. 2003; 44:326–341. [PubMed: 12635964]
- Salley BJ, Dixon WE. Temperamental and joint attentional predictors of language development. *Merrill-Palmer Quarterly*. 2007; 53:131–154. [PubMed: 18080005]
- Satorra A, Bentler PM. A scaled difference chi-square test statistic for moment structure analysis. *Psychometrika*. 2001; 66:507–514.
- Schwartz CE, Snidman N, Kagan J. Adolescent social anxiety as an outcome of inhibited temperament in childhood. *Journal of the American Academy of Child and Adolescent Psychiatry*. 1999; 38:1008–1015. [PubMed: 10434493]
- Slomkowski CL, Nelson K, Dunn J, Plomin R. Temperament and language: Relations from toddlerhood to middle childhood. *Developmental Psychology*. 1992; 28:1090–1095.
- Smith AK, Rhee SH, Friedman NP, Robinson JL, Corley RP, Hewitt JK. The magnitude of genetic and environment influences in parental and observational measures of behavioral inhibition in toddlerhood. *Behavior Genetics*. 2012; 42:764–777. [PubMed: 22806186]
- Spre KA, Evans MA. Shyness as a continuous dimension and emergent literacy in young children: Is there a relation? *Infant and Child Development*. 2009; 18:216–237.
- Spre KA, Schmidt LA, Theall-Honey LA, Martin-Chang S. Expressive and receptive language skills of temperamentally shy preschoolers. *Infant and Child Development*. 2004; 13:123–133.
- Suway JG, Degnan K, Sussman AL, Fox N. The relations among theory of mind, behavioral inhibition, and peer interactions in early childhood. *Social Development*. 2012; 21:331–342. [PubMed: 22639494]
- Thorpe K. Twin children's language development. *Early Human Development*. 2006; 82:387–395. [PubMed: 16690234]
- Van Hulle CA, Goldsmith HH, Lemery KS. Genetic, environmental, and gender effects on individual differences in toddler expressive language. *Journal of Speech, Language, and Hearing Research*. 2004; 47:904–912.

- Volbrecht MM, Goldsmith HH. Early temperamental and family predictors of shyness and anxiety. *Developmental Psychology*. 2010; 46:1192–1205. [PubMed: 20822232]
- White LK, McDermott JM, Degnan KA, Henderson HA, Fox NA. Behavioral inhibition and anxiety: The moderating roles of inhibitory control and attention shifting. *Journal of Abnormal Child Psychology*. 2011; 39:735–747. [PubMed: 21301953]

A. Observed Behavioral Inhibition **B. Parent-Reported Behavioral Inhibition** **C. Expressive Language Skills** **D. Receptive Language Skills** **Figure 1.**

Results from growth models observed behavioral inhibition, parent-reported behavioral inhibition, expressive language, and receptive language. Unstandardized parameters are shown, with the exception of the standardized correlation between Intercept and Slope. Parameter estimates for girls are shown on the left, and those for boys are shown on the right (girl/boy). Note. + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

Figure 2.

Results for growth analyses examining the relations between language and behavioral inhibition. Parameter estimates for girls are shown on the left, and those for boys are shown on the right (girl/boy). The variances of bolded parameter estimates were allowed to vary across sex. Standardized parameters are shown. Note. + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, # parameters that could not be estimated due to non-significant negative residual variance of parent-reported behavioral inhibition Slope in the bivariate model (in girls only).

Table 1

Results of t-tests Examining Sex Differences in Mean Level of Behavioral Inhibition and Language Abilities.

	Girl <i>n</i>	Boy <i>n</i>	Girl Mean(SD)	Boy Mean(SD)	<i>t</i> -value
<i>Observed Behavioral</i>					
<i>Inhibition (range: 1–3)</i>					
14 month	390	400	1.94(.49)	1.83(.49)	–2.51*
20 month	348	365	1.98(.54)	1.87(.51)	–2.29*
24 month	352	362	1.96(.51)	1.91(.51)	–1.21
<i>Parent-Reported</i>					
<i>Behavioral Inhibition</i>					
<i>(range: 0–1)</i>					
14 month	359	366	.49(.13)	.47(.13)	–2.29*
20 month	318	326	.51(.13)	.49(.14)	–1.48
24 month	335	341	.50(.13)	.49(.14)	–0.99
<i>Expressive Language</i>					
14 month (range: 6–35)	386	391	21.11(3.86)	20.14(3.64)	–2.90**
20 month (range: 12–44)	340	358	31.20(5.86)	28.96(5.74)	–3.96**
24 month (range: 16–50)	339	344	39.08(6.76)	36.34(6.64)	–4.24**
<i>Receptive Language</i>					
14 month (range: 3–38)	386	393	19.03(5.89)	15.97(5.69)	–5.28**
20 month (range: 12–46)	341	351	36.33(5.77)	33.67(6.94)	–4.09**
24 month (range: 22–54)	332	333	45.63(4.08)	43.72(4.98)	–4.37**

Note.

+ $p < 0.10$,* $p < 0.05$,** $p < 0.01$.

Analyses corrected for nonindependence of twin data.

SD = standard deviation. Expressive and receptive language raw means are displayed for ease of interpretation; analyses were conducted on transformed scores due to non-normality of data.

Table 2

Results From Growth Models

Girls	Variance of Intercept	Mean of Slope	Variance of Slope	Correlation between Intercept and Slope
Behavioral inhibition				
Observed	0.24 ^{**}	0.03	0.19 ^{**}	−0.65 ^{**}
Parent-Reported	0.01 ^{**}	0.01	NA [#]	NA [#]
Language				
Expressive	0.08 ^{**}	2.14 ^{**}	0.63 ^{**}	0.11
Receptive	0.16 ^{**}	2.97 ^{**}	0.27 ^{**}	−0.18
Boys	Variance of Intercept	Mean of Slope	Variance of Slope	Correlation between Intercept and Slope
Behavioral inhibition				
Observed	0.24 ^{**}	0.05	0.24 ^{**}	−0.77 ^{**}
Parent-Reported	0.01 [*]	0.02 ^{**}	0.01 [*]	−0.36
Language				
Expressive	0.08 ^{**}	1.83 ^{**}	0.52 ^{**}	0.18
Receptive	0.22 ^{**}	2.93 ^{**}	0.36 ^{**}	−0.13 ⁺

Note.

⁺ p < 0.10,^{*} p < 0.05,^{**} p < 0.01,

[#] parameters that were not estimated due to nonsignificant negative variance of parent-reported behavioral inhibition Slope (in girls only). Unstandardized parameters are shown, with the exception of standardized correlations between Intercept and Slope.

Table 3
Regression Analyses Comparing Language Abilities Across Low-, Moderate-, and High-behavioral Inhibition Groups

		Low Behavioral Inhibition		Moderate Behavioral Inhibition		High Behavioral Inhibition		Standardized Regression Coefficients (β)					
		n	mean(SD)	n	mean(SD)	n	mean(SD)	Linear ^a	Low vs. Mod.+ High ^b	Mod. vs. High ^b	Low+ Mod. vs. High ^c	Low vs. Mod. ^c	
Expressive Language	14 months	Parent report	124	-5.49(.36)	480	-5.51(.35)	112	-5.54(.33)	-0.06	-0.05	-0.03	-0.07	0.01
		Observation	153	-5.43(.35)	498	-5.51(.35)	126	-5.55(.33)	-0.12 *	-0.13 *	-0.01	-0.10	0.07
	20 months	Parent report	109	-4.34(.69)	416	-4.55(.69)	99	-4.61(.67)	-0.13 **	-0.18 **	0.03	-0.08	0.11 *
		Observation	126	-4.43(.74)	437	-4.54(.67)	134	-4.57(.63)	-0.08	-0.10	0.01	-0.05	0.06
	24 months	Parent report	108	-3.18(.65)	419	-3.10(.73)	92	-3.16(.69)	-0.14 **	-0.07	-0.13 *	-0.22 **	-0.04
		Observation	113	-3.42(.96)	439	-3.48(.97)	131	-3.72(.99)	-0.11 *	-0.07	-0.09 +	-0.15 *	-0.02
	14 months	Parent report	124	-6.09(.53)	481	-6.10(.50)	111	-6.13(.50)	-0.02	-0.02	-0.01	-0.03	0.01
		Observation	153	-6.14(.50)	499	-6.10(.51)	127	-6.07(.48)	0.05	0.05	0.01	0.04	-0.02
Receptive Language	20 months	Parent report	108	-4.31(.62)	413	-4.44(.72)	97	-4.45(.71)	-0.07	-0.11	0.03	-0.03	0.07
		Observation	125	-4.46(.71)	433	-4.41(.70)	133	-4.43(.70)	0.01	0.03	-0.02	-0.01	-0.03
	24 months	Parent report	108	-3.18(.66)	419	-3.10(.73)	92	-3.16(.69)	0.01	0.05	-0.05	-0.03	-0.06
		Observation	113	-3.15(.66)	425	-3.12(.72)	127	-3.17(.70)	-0.02	0.01	-0.04	-0.04	-0.03

Note.

+ p < 0.10,

* p < 0.05,

** p < 0.01. n = sample size. SD = standard deviation.

^a Orthogonal contrast codes entered into first regression analysis (linear: low = -1, moderate = 0, high = +1; quadratic: low = -1, moderate = +2, high = -1).

^b Orthogonal contrast codes entered into second regression analysis (low vs. high/moderate: low = -2, moderate = +1, high = +1; moderate vs. high: low = 0, moderate = -1, high = +1).

^c Orthogonal contrast codes entered into third regression analysis (low/moderate vs. high: low = -1, moderate = -1, high = +2; low vs. moderate: low = +1, moderate = -1, high = 0).