Published in final edited form as:
J Abnorm Psychol. 2013 May ; 122(2): 542–557. doi:10.1037/a0031963.

Language Ability Predicts the Development of Behavior Problems in Children

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Abstract

Prior studies have suggested, but not fully established, that language ability is important for regulating attention and behavior. Language ability may have implications for understanding attention-deficit hyperactivity disorder (ADHD) and conduct disorders, as well as subclinical problems. This article reports findings from two longitudinal studies to test (a) whether language ability has an independent effect on behavior problems, and (b) the direction of effect between language ability and behavior problems. In Study 1 ($N = 585$), language ability was measured annually from ages 7 to 13 years by language subtests of standardized academic achievement tests administered at the children's schools. Inattentive-hyperactive (I-H) and externalizing (EXT) problems were reported annually by teachers and mothers. In Study 2 ($N = 11{,}506$), language ability (receptive vocabulary) and mother-rated I-H and EXT problems were measured biannually from ages 4 to 12 years. Analyses in both studies showed that language ability predicted within-individual variability in the development of I-H and EXT problems over and above the effects of sex, ethnicity, socioeconomic status (SES), and performance in other academic and intellectual domains (e.g., math, reading comprehension, reading recognition, and short-term memory [STM]). Even after controls for prior levels of behavior problems, language ability predicted later behavior problems more strongly than behavior problems predicted later language ability, suggesting that the direction of effect may be from language ability to behavior problems. The findings suggest

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that language ability may be a useful target for the prevention or even treatment of attention deficits and EXT problems in children.

Keywords

language and verbal ability; attentional problems; externalizing behavior problems; behavioral and self-regulation; child longitudinal

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As children's behavioral regulatory skills develop, they allow prosocial behavior (Rueda, Posner, & Rothbart, 2005). Deficits in attentional and behavioral regulation in children are commonly found to be associated with behavior problems, such as inattentive-hyperactive (I-H) and externalizing (EXT) problems. For example, attention-deficit hyperactivity disorder (ADHD) is a childhood disorder characterized by inattention, hyperactivity, and impulsivity. In 2000, ADHD was estimated to cost 31.6 billion dollars in the United States (Birnbaum et al., 2005), which probably only hints at the many costs to children, families, and society related to attention and behavior regulation problems. It is therefore important to identify the factors that lead to the development of attention and behavioral regulatory problems.

Associations Between Language and Behavior Problems

Language ability—defined here as language-related skills such as language mechanics, expression, and vocabulary—has consistently been found to be associated with behavior problems in children and adolescents. It may play a key role in the development of behavior problems. A meta-analysis found that language deficits are associated with ADHD and EXT problems (Yew & O'Kearney, in press). Deficits in language ability have been associated with later behavior problems (Beitchman et al., 2001; Silva, Williams, & McGee, 1987) and delinquency (Brownlie et al., 2004; Lynam, Moffitt, & Stouthamer-Loeber, 1993). Moreover, longitudinal studies of children with speech and language difficulties have demonstrated associations between language ability and later behavior problems, controlling for prior levels (Lindsay, Dockrell, & Strand, 2007; St Clair, Pickles, Durkin, & Conti-Ramsden, 2011).

Research on variations in first exposure to language among children with cochlear implants has shown that length of use of the implant, presumably marking language exposure, has been associated with the ability to regulate and delay behavioral responses (Horn, Davis, Pisoni, & Miyamoto, 2005). Moreover, differences in language abilities account for the difference in the amount of behavior problems between hearing children and children with hearing loss (Stevenson, McCann, Watkin, Worsfold, & Kennedy, 2010).

Co-Occurrence Between Language Impairments and Attention Deficits

There is substantial comorbidity between language and attentional disorders (Baker & Cantwell, 1992). Nearly half of children with ADHD have language problems (Tirosh & Cohen, 1998; but see Westby & Watson, 2004), with deficits in both language comprehension (Bruce, Thernlund, & Nettelbladt, 2006; Wassenberg et al., 2010) and expression (Humphries, Koltun, Malone, & Roberts, 1994). Moreover, Werry, Elkind, and Reeves (1987) found that many cognitive and behavioral differences between children with ADHD/conduct disorder and normal controls were eliminated when controlling for language ability (in addition to age and sex). From the complementary perspective, attention deficits are common in those with diagnosed language impairments. For example, children with specific language impairments have been shown to have deficits in selective and sustained attention, particularly to auditory stimuli (Noterdaeme, Amorosa, Mildenberger, Sitter, &

Minow, 2001; Spaulding, Plante, & Vance, 2008). In summary, previous studies have established that language deficits are associated with attention and behavior problems. However, studies have not established the developmental processes linking language to attention and behavior.

Possible Mechanisms Linking Language to Attention and Behavior Problems

Several possible mechanisms could explain why language may promote positive behavioral adjustment. One possible mechanism is that the use of language in the form of private (self-directed) speech may help guide behavior to facilitate problem solving (Luria, 1961; Vygotsky, 1962). In support of language as a regulator, studies have shown that private speech is associated with performance on problem-solving tasks (Berk, 1999). In addition, interventions that increase the use of private speech result in improved behavioral regulation (Barnett et al., 2008; Diamond, Barnett, Thomas, & Munro, 2007; Harris, 1986; Meichenbaum & Goodman, 1971; Winsler, Manfra, & Diaz, 2007; although the clinical utility of private speech interventions has been questioned; Hobbs, Moguin, Tyroler, & Lahey, 1980). Language ability has been associated with self-regulation (Vallotton & Ayoub, 2011), attentional regulation and delay of gratification among impulsive children (Rodriguez, Mischel, & Shoda, 1989), and with behavioral regulation among deaf children (Horn et al., 2005). Barkley (1997) has argued that the deficits in attention and self-regulation found in ADHD may, in part, arise from children's impairment in the ability to internalize language in the form of private speech that serves to guide behavior. Thus, language may be important for regulating attention and behavior.

Language ability could play a role in attentional and behavioral regulation for several biological reasons. First, motor and language systems are closely coupled in brain activation patterns and their development—processing action-related language activates motor and premotor cortices (van Elk, van Schie, Zwaan, & Bekkering, 2010), and research suggests that spoken language processing may influence the development of fine motor skills (Horn, Pisoni, & Miyamoto, 2006). As a result, language ability may be related to one's ability to regulate movements. Second, language processes are associated with neural circuits in the frontal lobe involving aspects of self-regulation (Pisoni et al., 2008). Third, children with specific language impairment have been shown to have neural deficits in early attention processing relating to selective attention (Stevens, Sanders, & Neville, 2006), and an intervention targeting language ability improved the neural deficits in selective attention associated with language impairments (Stevens, Fanning, Coch, Sanders, & Neuille, 2008). Language development, therefore, may directly influence attentional processing.

Language deficits may also influence behavior problems through mechanisms other than self-regulation. Keenan and Shaw (1997, 2003) proposed that language skills may influence the development of behavior problems because poor language and communication skills may interfere with socialization. Language skills may reduce children's frustration by effectively communicating their needs, and in response to misbehavior, parents might use more reasoning with children who have better language skills and more punishment with children with language difficulties. This mechanism might also partially account for some of the sex differences in the development of behavior problems, because boys are slower in language development than girls (Keenan & Shaw, 1997, 2003; Lahey & Waldman, 1999, 2005). Alternatively, language deficits may lead to the development of behavior problems as a consequence of peer rejection (Menting, van Lier, & Koot, 2011). The present study examined two questions about the role of language ability as a possible mechanism in the development of behavior problems.

Q1: Does Language Ability Have an Independent Effect on Behavior Problems?

It is important to consider alternative mechanisms linking language and behavioral adjustment as well. Researchers have proposed several plausible confounds that could account for the correlation of ADHD and language problems, including prior levels of working memory (Martinussen & Tannock, 2006), executive functioning (Oram, Fine, Okamoto, & Tannock, 1999), and subcomponents of general intelligence, including processing speed (Wassenberg et al., 2010) and capacity (Bruce et al., 2006). Attention deficits and behavioral dysregulation could be due to general intellectual delays and may not be specific to language impairments, which could mark general intelligence or neurodevelopmental deficits (Beitchman, Hood, & Inglis, 1990). To rule out such third-variable interpretations, studies are needed that examine whether language ability is associated with behavior problems over and above the effects of other intellectual domains. Despite the similarity of language ability to reading ability, language and reading ability were found to compose different dimensions of impairment in ADHD (Bruce et al., 2006). Moreover, verbal intelligence was found to be more strongly associated with delinquency than was general intelligence (Lynam et al., 1993). Thus, consistent with theory (Barkley, 1997; Keenan & Shaw, 1997; Vygotsky, 1962), language ability may have a contribution to attention and behavior problems that is independent of other intellectual domains. However, few studies have tested whether the effect of language ability on behavior exists above the effects of other intellectual domains.

It is also important to consider whether the association between language and attention or behavior problems owes to demographic characteristics, because ADHD, EXT problems, and language deficits are more common among children from families of lower socioeconomic status (SES; Keiley, Bates, Dodge, & Pettit, 2000; Scahill et al., 1999; Stanton-Chapman, Chapman, Bainbridge, & Scott, 2002) and among males compared with females (Costello, Mustillo, Erkanli, Keeler, & Angold, 2003; Keiley et al., 2000; Tomblin et al., 1997). Findings suggest that language ability may have an effect on behavior problems, controlling for SES (Stattin & Klackenberg-Larsson, 1993), but more studies are needed that control for SES, demographics, and other intellectual abilities. Further, if language ability does turn out to have a unique association with behavior problems, it would also be necessary to learn whether language ability is more likely the cause or the effect of behavior problems.

Q2: What Is the Direction of Effect Between Language Ability and Behavior Problems?

Cross-sectional studies have shown that language ability is associated with attentional and behavioral regulation and behavior problems (e.g., Rodriguez et al., 1989; Stevenson et al., 2010). A few studies have even shown prospective associations between language and later behavior problems (e.g., Brownlie et al., 2004; Lindsay et al., 2007). However, few studies have examined whether language ability predicts within-individual changes in behavior problems (Yew & O'Kearney, in press). Researchers have called for more longitudinal examinations of the association between language deficits and behavior problems to specify the developmental process (Conti-Ramsden, in press). It is important to examine within-individual changes over time to test underlying mechanisms and causal inferences. By examining withinindividual differences, we can use the individual as his or her own control to provide a stronger test of causal inferences by minimizing the possibility that the association owes to the opposite direction of effect.

Moreover, we have not seen any studies examining the direction of effect by testing whether language deficits predict the development of behavior problems more strongly than behavior problems predict language deficits. Because attentional processes are considered important for processing language (Scofield & Behrend, 2011; Toro, Sinnett, & Soto-Faraco, 2005), it is important not only to test whether language ability predicts subsequent changes in behavior problems but also the reverse. Perhaps deficits of attentional and behavioral regulation hinder the acquisition of language. For example, children with attention or behavioral regulatory deficits may have fewer opportunities to advance in language ability via social processes of joint attention. These considerations led us to examine the longitudinal association between language ability and behavior problems in ways that could elucidate the direction of effect. Determining the direction of effect between language ability and behavior problems would be an advance in the description of developmental processes.

Sex as a Possible Moderator of the Effect of Language Ability on Behavior Problems

Because the prevalence of ADHD, EXT disorders, and language impairments differ between males and females, it would also be important to examine sex differences in the association between language and behavior problems. Previous studies have suggested that the effect of language impairment on self-regulation and behavior problems is stronger for boys than for girls (Brownlie et al., 2004; Vallotton & Ayoub, 2011).

The Present Studies

We examined two questions: (a) Does language ability have an independent effect on behavior problems when controlling for demographic characteristics, SES, and performance in other intellectual domains? and (b) What is the direction of effect between language ability and behavior problems? A secondary, exploratory analysis examined whether the effect of language ability on behavior problems differed between males and females. We conducted two studies to address these questions, and focused on two types of behavior problems: I-H and general EXT problems.

Study 1 examined the trajectories of teacher- and motherreported I-H and EXT problems and language subtests of standardized academic achievement tests from ages 7 to 13 years. Based on the arguments of Vygotsky (1962) and others (Barkley, 1997; Keenan & Shaw, 1997), we hypothesized that fluctuations in language ability would predict within-individual variability in behavior problems over and above the effects of demographic characteristics (sex and ethnicity), SES, and performance in other intellectual domains (math and reading). Moreover, we hypothesized that language ability would predict later changes in behavior problems and that it would be stronger than the reverse direction of effect (behavior problems predicting later language ability). Study 2 attempted to cross-validate the findings from Study 1 in an independent sample of children followed from ages 4 to 12 years. The measures included vocabulary tests for language ability along with maternal ratings of I-H and EXT problems.

Study 1

Study 1 examined the association between language ability and I-H and EXT problems among children followed annually from ages 7 to 13 years as part of the Child Development Project (CDP; Dodge, Bates, & Pettit, 1990).

Method

Participants—Children (*N* = 585) in the CDP were recruited in 1987 and 1988 in Nashville and Knoxville, Tennessee, and Bloomington, Indiana. Children's parents were approached at random during kindergarten preregistration, on the first day of class, and by phone or mail. About 75% of parents approached agreed to participate. The schools and the composite sample reflected a broad range of socioeconomic status groups that were representative of the populations at the respective sites. The Hollingshead index of SES ranged from 8 to 66 for the original sample, reflecting a broad range. Of the 585 children recruited, 487 (83%) had scores for language ability and behavior problems. See Table 1 for demographic characteristics of the full community-based sample.

Data were missing at various follow-ups for some participants, in the common pattern for longitudinal studies. Children from lower SES families were more likely than higher SES children to be missing teacher-reported behavior problems, $t(1412.13) = -3.28$, $p = .001$, mother-reported behavior problems, $t(1685.83) = -4.52$, $p < .001$, and language ability scores, $t(2478.16) = -5.52$, $p < .001$. Males were more likely than females to be missing scores for teacher-reported behavior problems, $\chi^2(1) = 9.89$, $p = .001$, mother-reported behavior problems, $\chi^2(1) = 9.67$, $p = .001$, and language ability, $\chi^2(1) = 30.32$, $p < .001$. African Americans were less likely than European Americans to have language ability scores, $\chi^2(2) = 11.52$, $p = .003$. Moreover, individuals of "other" ethnicity were less likely than European Americans and African Americans to have scores for teacher-reported behavior problems, $\chi^2(2) = 6.68$, $p = .035$, mother-reported behavior problems, $\chi^2(2) = 11.75$, $p = .003$, and language ability, $\chi^2(2) = 11.52$, $p = .003$. The pattern of missing data would most likely reduce the range of language and behavior problems, working against our hypotheses, if the analyses did not address the concern. See Appendix 1 of the online supplemental material for rates of missingness in Study 1.

Measures

Behavior problems: Attention Problems and Externalizing subscales were reported by teachers on the Teacher Report Form (TRF; Achenbach, 1991b) and by mothers on the Child Behavior Checklist (CBCL; Achenbach, 1991a). Teacher reports were usually collected in winter to spring of the school year, whereas mother reports were usually collected in the preceding summer to fall. Teachers and mothers rated whether a behavior was *not true* (0) *somewhat or sometimes true* (1) or *very or often true* (2). We refer to the Attention Problems subscale as measuring I-H problems. Although the Attention Problems subscale is not a diagnostic checklist of ADHD symptoms, it has been interpreted by other researchers as a measure of ADHD symptoms because it includes items assessing the three dimensions of ADHD symptoms: inattention, hyperactivity, and impulsivity (Lifford, Harold, & Thapar, 2008). It is associated with other measures of ADHD, including the Conners rating scale (Conners, 1973) and *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; text rev.; *DSM– IV–TR*; American Psychiatric Association, 2000) symptoms of ADHD (also see Derks et al., 2008). Derks and colleagues have argued that the CBCL Attention Problems subscale measures ADHD as well as the Conners scale does. Moreover, it is an effective screening tool for ADHD, with strong sensitivity and specificity (Chen, Faraone, Biederman, & Tsuang, 1994). Means and standard deviations of measures are presented in Appendix 2 of the online supplemental materials.

The Attention Problems subscale of the teacher-reported TRF includes 20 summed items, including "inattentive," "fails to finish," and "fidgets," with a total possible score of 40. The Attention Problems subscale of the mother-reported CBCL includes 11 items, including "can't concentrate," "can't sit still," and "impulsive," with a total possible score of 22. Cronbach's alpha ranged from .94 to .95 for the teacher-reported I-H problems and from .79 to .84 for the mother-reported I-H problems, depending on the year measured.

The Externalizing subscale is a second-order factor composed of two first-order factors, the Aggression and Delinquency subscales. Example items include "lacks guilt," "steals outside home," "destroys others' things," "threatens," and "attacks people." The Externalizing subscale of the TRF includes 34 items, for a total possible score of 68. The Externalizing subscale of the CBCL includes 33 items for a total possible score of 66. Cronbach's alpha ranged from .95 to .96 for the teacher-reported EXT problems and from .88 to .90 for the mother-reported EXT problems, depending on the year measured. The within-time correlation between I-H and EXT problems ranged from .59 to .74 for teacher reports and .65 to .70 for mother reports ($p < .001$), depending on the year.

Language ability and other intellectual domains: Language ability was measured as the child's percentile score on the composite language sections of a nationally normed standardized academic achievement test, which was collected annually via official school records. The composite language ability score reflected the average of two types of subtests: language mechanics and language expression. Language mechanics assessed children's use of Standard English through correct grammar and conventions, usage of words and phrases, and sentence structure. Language expression assessed children's ability to communicate effectively through rules of writing. A school records form with achievement test scores for the participants was completed by a school administrator. The school records were collected at the end of the school year in the summer, but the standardized tests were administered during the school year. School records from ages 7 to 10 years were collected when the children were 10 years old, and school records from ages 11 to 13 years were collected in the summer after each school year. The correlations between language mechanics and language expression scores ranged from .59 to .71 ($p < .001$), depending on the year of data collection. Because the sample reflected students in different schools, school districts, and states, the actual standardized test administered differed between participants, but all students' scores were scaled according to national norms for their test. For a list of the tests and the percentage of times administered, see Appendix 3 of the online supplemental materials.

Other intellectual domains assessed were math and reading ability, as measured by the percentiles of their respective subtests on standardized tests. The composite math score percentile included subtests for mathematical computation and mathematical conceptual understanding and applications (α = .73 to .86). The composite reading score percentile reflected subtests including word analogies, vocabulary, and reading comprehension (α = .82 to .88). Possible scores ranged from 1 to 99. Although we refer to children's test performance as abilities, we recognize that scores are influenced by other, nonability sources of variance as well.

SES: SES was measured by the Hollingshead four-factor index (Hollingshead, 1975) when children were 5 years old. The index includes items related to parents' education and occupational status.

Statistical analysis—Models were initially built on teacherreported behavior problems because prior research suggests that language ability has a stronger association with teachers' than with parents' ratings of behavior problems (Lindsay et al., 2007). After selecting the models with the teacher-reported behavior problems, we tested the models with mother-reported behavior problems separately to attempt to replicate findings across raters. Two sets of models were fit to answer two questions.

Q1: Does language ability have an independent effect on behavior problems?: Individual growth models (IGMs) tested Question 1, whether language ability has an independent effect on behavior problems. IGMs included a model of concurrent predictors and outcomes examining whether language ability at each time point was associated with behavior problems controlling for individuals' linear trajectories of behavior problems, demographic characteristics, SES, and performance in other intellectual domains. The analyses examined whether language ability, a time-varying predictor, independently explained within-individual variability in behavior problems (Singer & Willett, 2003), which is a stronger test of a causal influence than models predicting only between-individual variability. IGMs included time-varying covariates representing other intellectual domains (math and reading ability) and time-invariant covariates for demographic information (sex and ethnicity) and SES. The time-invariant covariates were allowed to predict the intercepts and slopes. The time-varying predictors (language, math, and reading ability) were allowed to predict concurrent levels of behavior problems.

IGMs in hierarchical linear modeling (HLM) were fit using the lme function of the nlme package (Pinheiro, Bates, DebRoy, Sarkar, & the R Core Team, 2009) in R (R Development Core Team, 2009). Models used maximum likelihood estimation, except when testing whether effects should be fixed or random, in which case, restricted maximum likelihood was used, as suggested by Singer and Willett (2003). IGMs fit random intercepts and slopes, allowing children to have different starting values and slopes. Model fit was examined with pseudo-R^2, which was calculated by examining the squared correlation between the model's fitted and observed values (Singer & Willett, 2003). To determine the amount of within-individual variance in behavior problems explained independently by language ability, we calculated the proportional reduction in residual variance (similar to ΔR^2) between a model without language ability and a model with language ability as a predictor (Peugh, 2010).

To avoid systematic bias in model parameter estimates and inferences, we used multiple imputation, which is preferable in developmental studies when there is missingness (Jeličič, Phelps, & Lerner, 2009). For multiple imputation, we used Amelia II version 1.6.3 (Honaker, King, & Blackwell, 2011) in R 2.15 (R Development Core Team, 2009), which uses an expectation maximization with bootstrapping algorithm and is accurate for longitudinal data (Honaker & King, 2010). We included only the model variables in the imputation. We used a conservative tolerance level for convergence of the algorithm to ensure reliable estimates of missingness. We imputed 50 data sets to be used for the model analyses to provide adequate power (i.e., power falloff of about 1% with respect to full-information maximum likelihood estimates) for the rates of missingness in the present studies (Graham, Olchowski, & Gilreath, 2007). The conditional multilevel models were run on each imputed data set separately, and the results were combined using the mitools (Lumley, 2010) and mix (Schafer, 1997) packages in R, which use Rubin's (1987) rules for combining results of analyses on multiply imputed data sets. See Appendix 4 of the online supplemental materials for model equations. All of the descriptive statistics (means and standard deviations, Appendix 2 of the online supplemental materials; Pearson correlations, Appendix 5 of the online supplemental materials) and unconditional models are from the raw, nonimputed data set.

Q2: What is the direction of effect between language ability and behavior problems?: An autoregressive latent trajectory (ALT) model (Bollen & Curran, 2004; Curran & Bollen, 2001) tested Question 2, the direction of effect between language ability and behavior problems. ALT models provide rigorous estimates of the direction of effect between language ability and behavior problems because the models simultaneously take into account individual-specific random effects and time-specific lagged effects to specify accurately the developmental process. ALT models (see Figure 1) examined whether language ability predicted *later changes* in behavior problems 1 year later, controlling for individuals' trajectories *and* prior levels of behavior problems. It also examined the reverse direction of effect (i.e., whether behavior problems predicted later changes in language ability controlling for individuals' trajectories and prior levels of language ability). ALT models tested which direction of effect was stronger and did not include additional covariates.

ALT models were fit using structural equation modeling (SEM) in Mplus 6.12 (Muthén & Muthén, 2011). Mplus implements full information maximum likelihood (FIML) estimation, which is a robust estimation method when data are missing at random or completely at random. ALT models used maximum likelihood estimation with robust standard errors to account for the nonnormally distributed data. To test the direction of effect, we successively added paths corresponding to each direction of effect. We first tested a baseline ALT model without cross-lagged paths for either direction of effect. In a stepwise fashion, we added cross-lagged paths to the baseline model corresponding to direction (A) language ability to behavior problems, and (B) behavior problems to language ability. Then, we successively added paths to the baseline model in the reverse order (B then A). We then compared the nested models using chi-square change tests from Satorra-Bentler scaled chi-square statistics for non-normal outcomes (Satorra & Bentler, 1994) to determine which direction(s) of effect were necessary to account for the data. Because we had no hypotheses of developmental changes in the direction or magnitude of cross-lagged associations, we constrained cross-lagged paths within the same direction to be equal across time. We report parameter estimates of the full model, which fit the cross-lagged paths in both directions, to provide unbiased estimates of the magnitude of the relations.

Results

Unconditional means models showed similar levels of standardized within-individual variance for language ability ($\sigma_e^2=0.27, SD=0.52$), teacher- ($\sigma_e^2=0.45, SD=0.67$) and mother-reported ($\sigma_e^2=0.30, SD=0.55$) I-H problems and teacher- ($\sigma_e^2=0.47, SD=0.68$) and mother-reported ($\sigma_e^2=0.32, SD=0.57$) EXT problems, suggesting that we could compare each direction of effect. Models that allowed the slopes of teacher-reported I-H and EXT problems to have a quadratic form did not fit significantly better than linear models (I-H: $\chi^2[1] = 0.89$, $p = .344$; EXT: $\chi^2[1] = 2.51$, $p = .113$), so subsequent models examined linear change. Unconditional growth models found that I-H problems showed a nonsignificant increase over time for both teacher- ($B = 0.08$, $p = .190$) and mother- ($B = 0.03$, $p = .210$) reported problems. EXT problems increased over time for teacher reports ($B = 0.20$, $p = .007$) and showed trend-level decreases over time for mother reports ($B = -0.09$, $p = .063$).

Q1: Does language ability have an independent effect on behavior problems?

—We examined whether language ability predicted I-H and EXT problems using concurrent predictors and outcomes. The models with a random effect of language ability fit significantly better than models with a fixed effect of language ability, (I-H: $\chi^2[3] = 20.43$, $p < .001$; EXT: $\chi^2[3] = 52.14$, $p < .001$), suggesting that the effect of language ability on behavior problems differs between children, so the models included a random effect of language ability.

Inattentive-hyperactive (I-H) problems: Our prime interest was in the parameter estimates for teacher-reported child I-H problems. These are presented in Table 2. The findings for motherreported problems, regarded as confirmatory, are summarized in the text, and tabled in Appendix 6 of the online supplemental materials. There was a significant negative association between language ability and teacher-reported I-H problems ($\beta = -0.18$), and this held when controlling for covariates. Children with greater language ability were reported to exhibit fewer I-H problems. Nonetheless, greater math ability was also associated with fewer teacher-reported I-H problems. In addition, boys had higher initial values of teacher-reported I-H problems than did girls at age 7. Moreover, children from lower SES families showed higher initial values of I-H problems at age 7 compared with children from higher SES families. None of the person-level demographic covariates was significant, however, in predicting the change in I-H problems over time.

In the model of mother-reported I-H problems (see Appendix 6 of the online supplemental materials), language ability was significant in predicting I-H problems (β = −0.10, p = .002), over and above the effects of covariates. Similar to the findings in the teacher-reported model, boys had higher intercepts of I-H problems than did girls at age 7 (β = −0.13, p < .001). Math ability was also a significant predictor of mother-reported I-H problems (β = −0.09, p = .002), as children with greater math ability showed fewer I-H problems.

The pseudo-R^2 was .60 for teacher- and .65 for mother-reported I-H problems, suggesting that the models fit the data well. Language ability independently explained 3% of within-individual variability in teacher- and mother-reported I-H problems over time. Examination of the correlations suggested that language ability appeared to have stronger concurrent associations with teacher-reported (*rs* ranging from − .40 to − .55) than with mother-reported (*r*'s = −.11 to −.34) I-H problems. We tested this possibility using the Fisher *r*-to-*z* transformation, and found that language ability had a stronger association with teacher-reported than with mother-reported I-H problems at each age (z = −2.28 to −4.26, p < .05 to .001).

EXT problems: Predicting teacher-reported EXT problems (see Table 2), language ability was marginally significant after controlling for other covariates (β = −0.06). Language ability was significant in predicting mother-reported EXT problems (β = −0.07, p = .050; see Appendix 6 of the online supplemental materials).

Q2: What is the direction of effect between language ability and behavior problems?—We fit a series of ALT models (see Figure 1) testing Directions A (language ability predicting later behavior problems) and B (behavior problems predicting later language). The results of the chi-square change tests are in Table 3. The model fit statistics and cross-lagged parameter estimates from the full ALT models estimating both directions of effect are in Table 4. The full model parameter estimates are in Appendix 7 (teacher report) and Appendix 8 (mother report) of the online supplemental materials. Because the models fit better with autoregressive paths than without (teacher I-H: $\chi^2[12] = 32.41$, p = .001), we present results for models that included autoregressive paths.

Inattentive-hyperactive problems: For teacher-reported I-H problems, adding Direction A to the baseline model in the first step resulted in a significant improvement in model fit. In the second step, adding Direction B also resulted in a significant improvement. In the reverse order, adding Direction B first to the baseline model improved model fit to a trend level, and adding Direction A second significantly improved model fit. Cross-lagged parameter estimates from the full model showed that language ability was significantly associated with later teacher-reported I-H problems (β = −0.06), and teacher-reported I-H problems also predicted later language ability (β = −0.04), suggesting a bidirectional effect.

For mother-reported I-H problems, adding Direction A first to the baseline model improved model fit, whereas adding Direction B second did not. In the reverse order, adding Direction B first to the baseline model did not improve model fit, whereas adding Direction A second significantly improved model fit. Thus, the direction of effect was stronger from language ability to I-H problems than vice versa. Parameter estimates from the full model indicated that language ability predicted later mother-reported I-H problems (β = −0.07), but mother-reported I-H problems did not predict later language ability (β = −0.01).

EXT problems: For teacher-reported EXT problems, adding Direction A first to the baseline model improved model fit, whereas adding Direction B second did not. In the reverse order, adding Direction B first to the baseline model did not improve model fit, whereas adding Direction A second significantly improved model fit. Again, the parameter estimates indicated that language ability predicted later EXT problems (β = −0.04), but EXT problems did not predict later language ability (β = −0.01). Findings were similar for mother-reported EXT problems, suggesting that the direction of effect was stronger from language ability to EXT problems (β = −0.07) than from EXT problems to language ability (β = −0.03).

Secondary analyses—We fit autoregressive trajectory models in HLM, and the results were commensurate with the ALT models in SEM.[1] We also examined whether the effect of language ability on behavior problems differed by sex, testing Language Ability × Sex interaction effects in IGMs. It did not differ for either outcome or rater, with one exception. The effect of language ability on teacher-reported EXT problems tended to be stronger for boys than for girls ($B = .03$, $p = .055$).

Discussion

Study 1 tested (a) whether language ability has an independent association with behavior problems (I-H and EXT problems), and (b) the direction of effect between language ability and behavior problems. We found that language ability had an independent effect on I-H and EXT problems controlling for sex, ethnicity, SES, and math and reading ability. Children with poorer language ability were reported to show more I-H problems relative to peers with better language ability. In addition, although there was some evidence of a bidirectional association, the direction of effect was generally stronger from language ability to behavior problems than from behavior problems to language ability.

Study 2

Study 2 involved the Children of the National Longitudinal Survey of Youth study (CNLSY; Chase-Lansdale, Mott, Brooks-Gunn, & Phillips, 1991), in which children were followed every 2 years from ages 4 to 12 years. Study 2 attempted to cross-validate the findings from Study 1 by reexamining the association between language ability and behavior problems in an independent sample and with alternative measures.

Method

Participants—Participants included all biological children of the women in the National Longitudinal Survey of Youth (NLSY79), which was funded by the Bureau of Labor Statistics as a nationally representative sample, with a supplemental oversample of African American and Hispanic youth. The present study examined the children from the 2008 report ($N = 11{,}506$). Of the 6,283 women in the NLSY79, 4,925 (78%) had given birth to at least one child by the 2008 report. Of the 11,506 children recruited, 8,756 (76%) had scores for language ability and behavior problems. Most children were assessed every 2 years beginning in 1986 with newly born children in the following years added to the sample. A subsample was assessed on an annual basis. For those who had two assessments in a 2-year wave, their scores were averaged within wave. Participants' trajectories of behavior problems were analyzed from ages 4 to 12 years (the ages in which both language ability and behavior problems were measured). Because the 2008 report spans a wide age range of childbearing, the sample of children does not disproportionately represent children born to younger mothers (D'Onofrio et al., 2008). See Table 1 for demographic characteristics of the sample.

[1]Results of the autoregressive trajectory models in HLM are available upon request.

Measures

Behavior problems: Behavior problems included I-H and EXT problems, and were assessed at each wave by mothers' reports of the Behavior Problems Index (BPI). The BPI was developed by selecting items with the strongest correlations with CBCL (Achenbach & Edelbrock, 1981) factor scores, in addition to reliability and utility in the context of interviews (Peterson & Zill, 1986). The items were rated on a 3-point scale, where 1 = *not true*, 2 = *sometimes true*, and 3 = *often true*, and then were recoded to be on the same 0-to-2 scale as items on the CBCL. Items in the I-H problems scale included three items as determined by confirmatory factor analysis (D'Onofrio et al., 2008): (1) *has difficulty concentrating*, (2) *impulsive or acts without thinking*, and (3) *restless or overly active, cannot sit still*. Cronbach's alpha for the I-H problem composites ranged from .66 to .73, depending on the year. I-H problem composites were computed by averaging the items within-year, and multiplying them by a constant (3) to maintain the same possible range as the sum score (0 to 6). See Appendix 9 of the online supplemental materials for rates of missingness in Study 2.

EXT problems included two first-order factors from the BPI: antisocial conduct problems and oppositional problems (for support of first-order factor structure, see D'Onofrio et al., 2008).[2] The antisocial conduct problems subscale includes seven items (e.g., "cheats or lies," "does not feel sorry after misbehaving"), and oppositional problems include three items (e.g., "is stubborn, sullen, or irritable"). The items within each first-order factor were averaged, and then multiplied by a constant to retain the same possible range as the sum score. The correlation between antisocial conduct problems and oppositional problems ranged from .57 to .63 ($p < .001$), depending on the year. EXT problems were calculated as the sum of the two first-order factors. Cronbach's alpha for the EXT problem items ranged from .77 to .84 depending on the year.

Language ability: Language ability was measured by the agenormed composite score on the Peabody Picture Vocabulary Test–Revised (PPVT-R; Dunn & Dunn, 1981), a measure of receptive language and vocabulary. The test involves the examiner saying the name of an object, and the child picking the picture (out of four possible) that best matches the verbal description. There are 175 possible vocabulary items. The age-normed scores were computed according to a normed sample with a mean of 100 and standard deviation of 15, with higher values representing better language ability.

Other intellectual domains: Mathematics, reading comprehension, and reading recognition ability were measured by the Peabody Individual Achievement Test (PIAT; Dunn, Markwardt, & American Guidance Service, 1970) from ages 5 to 12. The mathematics subtest includes 84 multiple choice questions measuring attainment in early skills (number recognition) and more advanced concepts (geometry and trigonometry). The reading comprehension subtest includes 66 items, in which the child reads a sentence and selects one of four pictures that best corresponds to the meaning of the sentence. The reading recognition subtest includes 84 items measuring word recognition and pronunciation ability. All three subtests of the PIAT were age-normed to a normed sample ($M = 100$, $SD = 15$), with higher values representing better scores.

Short-term memory (STM) was measured by digit span, which was assessed from age-normed scores on the Wechsler Intelligence Scale for Children-Revised (WISC-R;

[2]Previous studies have referred to the first-order factors for I-H problems, antisocial conduct problems, and oppositional problems as attention-deficit/hyperactivity problems, conduct problems, and oppositional defiant problems, respectively (e.g., D'Onofrio et al., 2008).

Wechsler, 1974) Digit Span subtest at ages 7 to 12. The Digit Span subtest asks children to listen to a sequence of 14 numbers and to repeat them back to the interviewer. Then, the child listens to a different series of 14 numbers and is instructed to repeat the numbers in reverse order. Scores were age-normed ($M = 10$, $SD = 3$), with higher values representing better STM. Because the other intellectual domains were not measured at each of the ages of the present study (4 to 12 years), average scores of each intellectual domain (except language ability) across age were computed to be used as timeinvariant covariates.

Other risk factors: SES and other risk factors were measured by four indices: (a) the mother's highest grade completed in school (0 = *none*, 1 = *prekindergarten*, 2 = *kindergarten*, 3 = *first grade* … 20 = *eighth year of college*), (b) the mother's age at childbearing for the target child, (c) the mother's IQ, and (d) the total family income. Mothers' IQ scores were measured in 1980 (when mothers were 15 to 23 years old) as part of the Armed Forces Qualifications Test, which includes four subtests of the Armed Services Vocational Aptitude Battery, including Arithmetic Reasoning, Word Knowledge, Paragraph Comprehension, and Numerical Qualifications. Total family income was defined as the total income received by the mother's household when she was 30 years old (in inflation-adjusted 1986 dollars), including government support and food stamps. Because of skewness, total family income was log-transformed.

Statistical analysis—Two model sets, IGMs and ALT models, were fit similar to Study 1 with fewer time points ($n = 5$). IGMs included covariates for demographics (sex and ethnicity), SES, and other intellectual domains (math, reading comprehension, reading recognition, and STM). IGM variables were multiply imputed with the same procedure as in Study 1. Because of the oversampling of Hispanics and African Americans, we included sample weights as a covariate in the conditional IGMs and as a weight variable in the ALT models to help calculate unbiased parameter estimates that would be more representative of the general population of children in the United States. The sampling weights were proportional to the inverse of selection probability and were rescaled to have a mean of 1 to reflect the average weight or contribution of children relative to nationally representative children. Because multiple children (and mothers) were assessed in the same households, we fit three-level IGMs and ALT models with household as a cluster variable to account for the dependency of children within households. See Appendix 4 of the online supplemental materials for model equations.

Results

Unconditional means models showed similar levels of standardized within-individual variance for language ability (σ_e^2=0.36, SD=0.60), and I-H (σ_e^2=0.44, SD=0.66) and EXT (σ_e^2=0.46, SD=0.68) problems, suggesting that we could compare each direction of effect. (Note that only mother-reported problems were measured in Study 2.) An unconditional growth model found that I-H problems ($B = -0.09$, $p < .001$) and EXT problems ($B = -0.05, p < .001$) showed significant decreases with age. Models with random intercepts and slopes were fit to I-H problems and EXT problems. Language ability was modeled as a time-varying predictor with a fixed effect because it did not have sufficient variance in its association with I-H and EXT problems across individuals for model convergence (suggesting that the effect of language ability on behavior problems was similar across children). A correlation matrix of the variables, along with means and standard deviations is presented in Appendix 10 of the online supplemental materials.

Q1: Does language ability have an independent effect on behavior problems?

Inattentive-hyperactive problems: Parameter and pseudo-R^2 estimates are presented in Table 5. Controlling for covariates, language ability was significantly negatively associated with I-H problems. Children with poorer language ability showed more I-H problems (β = −0.02). Findings also suggested that girls had lower starting values of I-H problems than did boys at age 4. Moreover, Hispanics and African Americans had lower intercepts of I-H problems compared with non-Hispanic Whites. All of the SES and other risk factors except mother's IQ (mother's highest grade completed, mother's age at childbearing, total family income) were negatively associated with the intercepts of I-H problems. Mother's age at childbearing also predicted the slopes of I-H problems. Children of mothers who gave birth at an earlier age decreased more rapidly in I-H problems over time (although they started with higher intercepts). All of the intellectual domain covariates (math ability, reading comprehension, reading recognition, and STM) were negatively associated with the intercepts (not slopes) of I-H problems.

EXT problems: In the model of EXT problems (see Table 5), language ability was negatively associated with EXT problems controlling for covariates (β = −0.02). The following groups/ predictors were associated with higher intercepts of EXT problems: males, non-Hispanic Whites (compared with African Americans and Hispanics), children of mothers with fewer grades completed, *higher* IQ, lower family income, and of younger age at childbearing, and children with poorer math and reading comprehension scores. Mothers' highest grade completed and age at childbearing were the only predictors of the slopes (children of mothers with less education and an earlier age at childbearing declined more rapidly in EXT problems, although they started with higher intercepts).

Q2: What is the direction of effect between language ability and behavior problems?—ALT models were fit similar to Study 1, with 2-year lags testing Directions A (language ability predicting later behavior problems) and B (behavior problems predicting later language). The results of the chi-square change tests are in Table 6. The model fit statistics and cross-lagged parameter estimates from the full ALT models estimating both directions of effect are in Table 4. The full model parameter estimates are in Appendix 11 of the online supplemental materials.

Inattentive-hyperactive problems: For I-H problems, adding Direction A first to the baseline model improved model fit, whereas adding Direction B second did not. In the reverse order, adding Direction B first to the baseline model did not improve model fit, whereas adding Direction A second significantly improved model fit. Parameter estimates from the full model indicated that language ability predicted later I-H problems (β = −0.03), but I-H problems did not predict later language ability (β = 0.00). The findings suggested that the direction of effect was stronger from language ability to I-H problems than vice versa.

EXT problems: Findings for EXT problems were similar to findings for I-H problems, suggesting that the direction of effect was stronger from language ability to EXT problems (β = −0.03) than from EXT problems to language ability (β = 0.00).

Secondary analyses—We fit autoregressive trajectory models in HLM, and the results were commensurate with the ALT models in SEM (see Footnote 1). We also tested whether the effect of language ability on I-H problems differed by sex with Language Ability × Sex interaction effects in IGMs, and it did not. The effect of language ability on EXT problems tended to be stronger for boys than girls ($B = .003$, $p = .084$).

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Discussion

Study 2 attempted to replicate the findings from Study 1. Findings from Study 2 suggested that language ability had an independent effect on behavior problems controlling for sex, ethnicity, SES, and math, reading comprehension, reading recognition, and STM scores. Moreover, the effect of language ability on later behavior problems was stronger than the effect of behavior problems on later language ability, suggesting that the direction of effect is from language ability to behavior problems.

General Discussion

The present studies tested two questions: (a) Does language ability have an independent effect on behavior problems? and (b) What is the direction of effect between language ability and behavior problems? We hypothesized that language ability would have an independent effect on the development of behavior problems and that the direction of effect would be stronger from language ability to behavior problems than vice versa. Study 1 tested whether language ability, measured by language mechanics and expression, predicted the development of I-H and EXT problems in children from ages 7 to 13 years, and Study 2 tested the association between language ability, indexed by vocabulary, and behavior problems from ages 4 to 12 years. The longitudinal studies allowed using the child as his or her own control to test whether language ability predicts within-person changes in behavior problems. Findings from both studies supported the hypotheses that (a) language ability has an independent effect on the development of I-H and EXT problems, consistent with a meta-analysis (Yew & O'Kearney, in press), and that (b) the direction of effect is stronger from language ability to behavior problems than vice versa.

For I-H problems, both studies found that the association between language ability and I-H problems held, even after controlling for demographic characteristics (sex and ethnicity), SES, and performance in other intellectual domains (math, reading, and in Study 2, STM). In Study 1, this pattern also held across ratings by teachers and mothers. Moreover, children's language ability independently accounted for 3% of within-individual variability in I-H problems. These findings suggest that language ability has a unique effect on behavior problems. In addition, both studies found that language ability predicted *later changes* in I-H problems. Although teacher-reported I-H problems in Study 1 also predicted the development of later language ability, both studies found that the direction of effect was stronger from language ability to I-H problems than from I-H problems to language ability. Thus, although there is evidence of a bidirectional effect, the evidence is stronger in favor of the influence of language ability on I-H problems than the reverse. As for EXT problems, both studies found that language ability predicted the development of EXT problems controlling for demographic characteristics and performance in other intellectual domains. Moreover, both studies found that language ability predicted later changes in EXT problems more strongly than the reverse. The results are consistent with the causal hypothesis that language ability influences attentional and behavioral regulation.

The finding that poor language ability may lead to the development of attentional and EXT problems is consistent with prior findings showing that language ability is associated with attentional and behavioral regulation (Rodriguez et al., 1989). Children with better language ability may be more effective at using private speech as a self-guiding tool and may show earlier internalization of private speech and regulatory mechanisms, resulting in better self-regulation and adjustment. Language ability may be important for the development of attention regulation and for regulating behavior (Barkley, 1997). Alternatively, language ability may be important to the extent that it (a) allows children to communicate their needs and to elicit inductive parenting (Keenan & Shaw, 1997), or (b) facilitates social skills and prevents peer rejection (Menting et al., 2011). Although language ability has been hypothesized to account partially for gender differences in the development of behavior problems (Lahey & Waldman, 1999), our findings show that language ability appears to play an important role in the development of behavior problems even when controlling for gender differences.

Future studies should examine mechanisms by which language ability may influence behavior problems. A first step might be to identify what specific aspects of language (e.g., private speech, receptive language, expressive language) are important for the development of attentional and behavioral regulation. Studies should also examine whether poorer language skills elicit more parental punishment or whether language abilities are associated with individual differences in private speech and self-regulation. It may also be important for future studies to consider language ability in the context of dialects and second languages, because bilingual children may have better self-regulation than monolingual children (Bialystok & Viswanathan, 2009). Future studies should also consider how language ability contributes to behavior problems in adulthood.

In addition to language ability, there were other predictors of behavior problems as well. Boys had higher initial values of behavior problems than girls, which is unsurprising given the higher rates of ADHD and EXT problems among males than females (e.g., Costello et al., 2003). Moreover, children from lower SES families had higher initial values of behavior problems than did children from higher SES families, consistent with previous research (e.g., Scahill et al., 1999). Additionally, math ability predicted the development of I-H problems in Study 1, and math ability, reading ability, and STM were associated with I-H problems in Study 2. Finally, we tested whether the effect of language ability on the development of behavior problems differed by sex, and the effect mostly did not differ between boys and girls. For teacher-reported I-H problems in Study 1 and mother-reported EXT problems in Study 2, the effect of language tended to be stronger for boys than girls. To resolve the inconclusive Language × Sex effects, future studies are needed.

The effect of language ability did differ, however, based on the source of the ratings of I-H problems. Specifically, language ability had a stronger effect on teacher-reported compared with mother-reported I-H problems, which is consistent with prior findings (Lindsay et al., 2007). Although language ability predicted the development of both teacher- and mother-reported I-H problems in Study 1, the effect was stronger for teacher- than for motherreported problems. There are several possibilities for the stronger effect of language ability on teacher-reported I-H problems. One possibility is that language deficits may impair attentional regulation, particularly in the academic domain, during which difficult academic tasks may require greater language ability to focus and regulate behavior through self-directed speech or thought. Alternatively, children with poor language ability may not understand teachers' instructions in the classroom, or may take longer to process the instructions, which may lead them to lose interest, fidget, and show attention deficits. Thus, attention deficits may have different meanings in different contexts, and future studies should extend our findings with more direct measures of attention. Another possibility is that the teacher's knowledge of the child's academic performance may have influenced the ratings of I-H problems. Future studies should examine the effects of language ability on behavior problems in different contexts to determine the situations in which the functional impairment is greatest.

The present studies had several limitations. In Study 1, the rates of missingness in school records of language ability may have reflected nonrandom missingness, as suggested by the difference between the participants and nonparticipants in terms of sex, SES, and ethnicity. Nonrandom missingness and participation bias may have led to the high mean percentile score for language ability in the sample relative to the general population. Although one would expect a mean percentile around 50 for a random sample of a normal population, the mean percentile of language scores was higher (65), despite the fact that the percentiles were derived from nationally normed tests. Nevertheless, multiple imputation and FIML may have improved the generalizability of the findings. An alternative interpretation of the high average scores is that the norms for the standardized tests may have been out of date, similar to the general increase in a population's scores on intelligence tests over time (the Flynn effect, e.g., Neisser, 1997). In any case, the limitation in Study 1 was counterbalanced by below-average language scores in Study 2 (although within 1 *SD* of the mean for a normal population). Study 2 had considerable rates of attrition, yet this was counterbalanced by lower rates of missingness in Study 1. We also used multiple imputation and FIML to inform missingness and sample weights to make the findings in Study 2 more generalizable to the population.

A limitation in both studies was that the language ability scores were age-normed (Study 1: age-normed percentiles; Study 2: agenormed standardized scores). As a result, we could only examine age-normed differences rather than performance in the raw metric. Changes in a child's percentile and standardized score over time reflected changes relative to one's peers (similar to rank-order change), but did not reflect whether children were improving in their overall ability. Thus, we were unable to examine absolute, mean-level change in the test scores and whether mean-level changes corresponded to changes in behavior problems. In addition, because a difference in reliability between language ability and behavior problems could limit interpretation of the ALT models, we had to ask whether both variables had similar amounts of within-individual variability. The comparisons suggested that we could examine the direction of effect in the ALT models. Ultimately, multiple designs, including experiments, will be necessary to determine the precise causal role of language ability in the development of behavior problems.

Despite stronger evidence of the effect of language ability on later behavior problems than vice versa, the actual process of development between language ability and behavior problems may be bidirectional. Real development does not occur in a vacuum and could operate at different scales and in a transactional way. Resolution at this level of detail of the relation between language and behavior problems would require assessments on finer-grained time scales. The present study merely sheds light on one possible mechanism by which behavior problems develop. Future studies should examine other mechanisms for how language relates to attentional and behavioral regulation.

The present studies had several notable strengths. First, both studies examined multiple behavior problems to provide converging evidence of the effect of language ability on behavioral adjustment. Second, Study 1 measured behavior problems with multiple informants. This provided converging evidence of the effects of language ability on behavior problems from multiple perspectives and across different contexts. Third, the studies were longitudinal, which allowed us to predict the development of within-individual differences in behavior problems over time. Fourth, we tested whether language ability predicts *later changes* in behavior problems and tested the opposite direction of effect. Fifth, we found similar results across two analytical approaches, HLM and SEM. Finally, the findings were validated across independent samples. Although each study had its own limitations, the two studies used different measures, different methodologies, and incorporated different limitations that were in some cases addressed in the other study. For example, Study 1 incorporated stronger measurement of behavior problems, and Study 2 had more precise measurement of language ability. The replication of findings across both studies provides further confidence in the results.

Although not conclusive of a causal or directional effect, the ALT model provides a stronger test of the direction of effect from language ability to behavior problems than other cross-sectional and longitudinal correlational analyses, even though it does not eliminate the possibility that the association could owe to unmeasured variables. Nevertheless, the finding that language ability predicts later changes in I-H problems and EXT problems provides support for language ability as a plausible target of intervention for improving I-H or EXT problems. Because of the comorbidity of language problems with ADHD, researchers have already called for interventions that target language problems in children with ADHD (Wassenberg et al., 2010). The present results support that call in addition to a call for both finer-grained longitudinal and experimental tests of whether language ability would be a reasonable target of intervention for treating or preventing attention deficits and behavior problems in children.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors acknowledge Leslie Rutkowski for her multilevel modeling contributions, and Benjamin Lahey for his theoretical contributions to this paper. The Child Development Project has been funded by grants MH42498, MH56961, MH57024, and MH57095 from the National Institute of Mental Health; HD30572 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development; and DA016903 from the National Institute on Drug Abuse. This study was supported by the National Institute of Child Health and Human Development (HD061384). Isaac T. Petersen is supported by the National Institute of Health and National Research Service Award HD007475-17.

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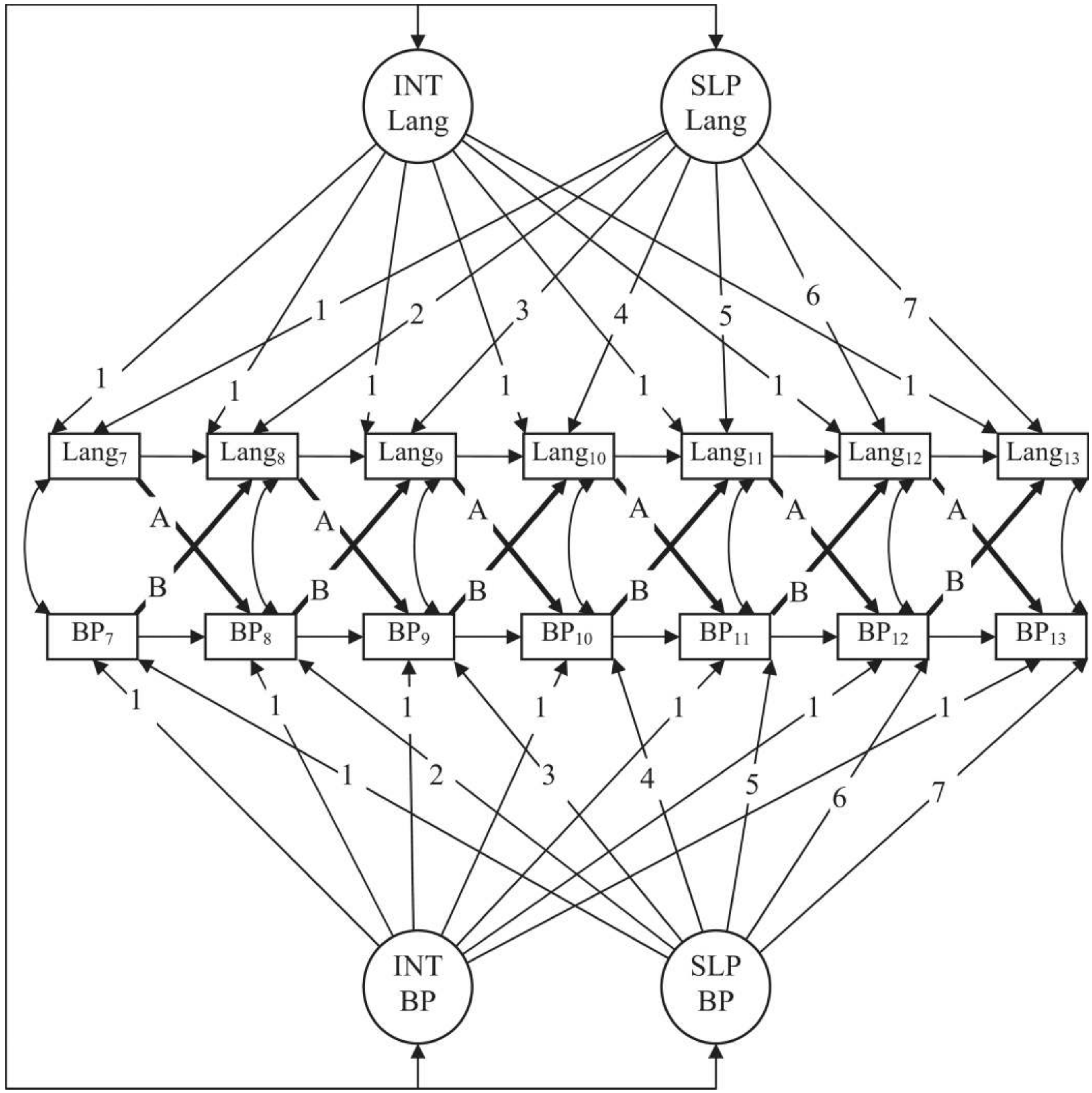

Figure 1.

Full autoregressive latent trajectory model in Study 1 (Q2: What is the direction of effect between language ability and behavior problems?). Successive addition of cross-lagged paths (A or B) tested the direction of effect between language ability and behavior problems. Path "A" tested the effect of language ability on later behavior problems (Direction A). Path "B" tested the effect of behavior problems on later language ability (Direction B). Paths of the same letter were constrained to be equal. See Table 4 for parameter estimates of the cross-lagged paths. Model parameters are in Appendix 7 (teacher report) and 8 (mother report) of the online supplemental materials. BP = behavior problems (I-H or EXT problems); INT = intercept; Lang = language ability; SLP = slope.

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Table 1

Studies 1 and 2: Demographic Information for the Participants

Study 1			Study 2		
Variable	***n***	**%**	**Variable**	***n***	**%**
Sample	CDP		Sample	CNLSY	
N	585		*N*	11506	
Males	304	52	Males	5,869	51
Females	281	48	Females	5,613	49
European Americans	477	82	Non-Hispanic Whites	6,091	51
African Americans	97	17	African Americans	3,184	28
"Other" ethnicity	11	2	Hispanics	2,208	19
	M	*SD*		*M*	*SD*
SES	39.53	14.01	Mother's highest grade	13.78	2.75
			Mother's IQ	35.61	27.29
			Mother's age at childbearing	25.20	5.91
			Total family income (log)	9.86	0.99

Note. CDP = Child Development Project; CNLSY = Children of the National Longitudinal Survey of Youth.

Table 2

Study 1: Language Ability Predicting the Development of Teacher-Reported Inattentive-Hyperactive and Externalizing Problems (Q1: Does Language Ability Have an Independent Effect on Behavior Problems?)

	Inattentive-hyperactive problems					Externalizing problems				
Variable	***B***	**β**	***SE***	***df***	***p***	***B***	**β**	***SE***	***df***	***p***
Intercept	19.43	−0.01	1.11	709.42	**<.001**	17.05	−0.01	1.33	2123.81	**<.001**
Time	0.28	0.01	0.23	543.78	.223	0.04	0.02	0.28	953.63	.893
Female	−3.65	−0.23	0.54	2527.22	**<.001**	−3.62	−0.16	0.65	9565.42	**<.001**
SES	−0.05	−0.10	0.02	765.45	**.030**	−0.10	−0.13	0.03	2467.35	**<.001**
African American	−0.80	−0.03	0.84	1474.24	.341	1.00	0.08	1.05	1825.96	.340
Other ethnicity	− 1.29	−0.01	2.07	1245.26	.534	0.42	−0.01	2.59	1605.59	.872
Female × Time	−0.08	−0.01	0.12	1738.29	.487	0.08	0.01	0.15	2164.92	.614
SES × Time	−0.01	−0.02	0.01	665.21	.284	0.00	0.00	0.01	1078.17	.958
African American × Time	0.02	0.00	0.18	858.03	.910	0.43	0.03	0.23	752.14	*.061*
Other Ethnicity × Time	0.14	0.00	0.49	457.58	.768	−0.32	−0.01	0.59	644.55	.592
Reading	−0.01	−0.03	0.01	122.20	.436	−0.02	−0.04	0.01	229.32	.166
Math	−0.06	−0.20	0.01	159.09	**<.001**	−0.04	−0.11	0.01	305.10	**<.001**
Language ability	−0.06	−0.18	0.01	187.56	**<.001**	−0.02	−0.06	0.01	462.94	*.062*
Pseudo-R^2	.60					.58				

Note. Time represents age in years centered on age 7. Interactions with time represent associations with the slopes of behavior problems. Parameters where $p < .05$ in bold, $p < .10$ in italics.

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Table 3

Study 1: Nested Model Comparisons of Autoregressive Latent Trajectory Model Successively Adding Each Direction of Effect Between Language Ability and Behavior Problems (Q2: What Is the Direction of Effect Between Language Ability and Behavior Problems?)

	Inattentive-Hyperactive				**Externalizing**			
	Teacher		**Mother**		**Teacher**		**Mother**	
Step	$\Delta\chi^2$	***p***	$\Delta\chi^2$	***p***	$\Delta\chi^2$	***p***	$\Delta\chi^2$	***p***
Testing language ability → Behavior problems								
1. Adding Lang → BP	10.92	**.001**	37.89	**<.001**	7.87	**.005**	15.96	**<.001**
2. Adding BP → Lang	4.52	**.034**	0.18	.667	0.53	.465	2.11	.147
Testing behavior problems → Language ability								
1. Adding BP → Lang	1.26	*.096*	1.10	.723	0.14	.710	1.24	.358
2. Adding Lang → BP	12.96	**<.001**	37.44	**<.001**	9.36	**.002**	17.58	**<.001**

Note. All chi-square tests had 1 *df.* Parameters where $p < .05$ in bold, $p < .10$ in italics. Teacher and mother refer to teacher and mother-reported behavior problems, respectively. BP = behavior problems; Lang = language ability.

Table 4

Studies 1 and 2: Full Autoregressive Latent Trajectory Model Fit Statistics and Standardized Cross-Lagged Parameter Estimates (Q2: What Is the Direction of Effect Between Language Ability and Behavior Problems?)

			Model fit				Lang → BP			BP → Lang		
BP	**Rater**	**Study**	**RMSEA**	**CFI**	χ^2	***df***		***SE***	***p***	**β**	***SE***	***p***
I-H	Teacher	1	.025	0.992	94.77	70	−0.06	0.02	**<.001**	−0.04	0.02	**.030**
I-H	Mother	1	.021	0.996	87.13	70	−0.07	0.01	**<.001**	−0.01	0.02	.671
I-H	Mother	2	.013	0.995	71.71	26	−0.03	0.01	**<.001**	0.00	0.01	.771
EXT	Teacher	1	.017	0.996	80.60	70	−0.04	0.01	**.005**	−0.01	0.02	.456
EXT	Mother	1	.008	0.999	72.52	70	−0.07	0.02	**<.001**	−0.03	0.02	.138
EXT	Mother	2	.013	0.996	67.85	26	−0.03	0.01	**<.001**	0.00	0.01	.966

Note. Parameters where $p < .05$ in bold. BP = behavior problems; CFI = comparative fit index; EXT = externalizing problems; I-H = inattentivehyperactive problems; Lang = language ability; RMSEA = root mean square error of approximation.

Table 5

Study 2: Language Ability Predicting the Development of Inattentive-Hyperactive and Externalizing Problems (Q1: Does Language Ability Have an Independent Effect on Behavior Problems?)

	Inattentive-hyperactive problems					Externalizing problems				
Variable	***B***	**β**	***SE***	***df***	***p***	***B***	**β**	***SE***	***df***	***p***
Intercept	6.594	0.01	0.212	144.91	**<.001**	13.795	0.00	0.494	104.68	**<.001**
Time	−0.238	−0.04	0.066	215.36	**<.001**	−0.432	−0.01	0.184	71.24	**.021**
Female	−0.419	−0.15	0.026	392.78	**<.001**	−0.619	−0.09	0.057	566.60	**<.001**
African American	−0.196	−0.07	0.040	531.45	**<.001**	−0.531	−0.06	0.101	191.59	**<.001**
Hispanic	−0.285	−0.09	0.043	497.95	**<.001**	−0.605	−0.07	0.104	355.86	**<.001**
Mother highest grade	−0.018	−0.03	0.006	707.85	**.001**	−0.046	−0.02	0.014	287.20	**.001**
Mother IQ	0.001	0.04	0.001	127.44	*.096*	0.004	0.03	0.002	130.36	**.016**
Mother age at birth	−0.035	−0.08	0.002	362.74	**<.001**	−0.070	−0.11	0.006	155.74	**<.001**
Family income	−0.071	−0.05	0.016	173.77	**<.001**	−0.291	−0.09	0.041	91.13	**<.001**
Sample weight	−0.139	−0.08	0.018	401.74	**<.001**	−0.218	−0.05	0.044	194.37	**<.001**
Math	−0.010	−0.09	0.002	384.42	**<.001**	−0.011	−0.03	0.004	191.68	**.006**
Reading comprehension	−0.007	−0.06	0.002	329.41	**<.001**	−0.012	−0.05	0.005	205.77	**.008**
Reading recognition	−0.004	−0.05	0.002	305.59	**.030**	−0.008	−0.03	0.005	111.22	*.094*
Short-term memory	−0.016	−0.03	0.005	329.05	**.003**	−0.007	−0.01	0.015	68.13	.671
Female × Time	−0.003	0.00	0.010	188.14	.753	0.004	0.00	0.023	148.17	.861
African American × Time	−0.018	−0.01	0.011	1179.56	*.087*	0.042	0.01	0.031	133.43	.169
Hispanic × Time	−0.014	−0.01	0.012	531.49	.248	0.024	0.01	0.033	121.85	.477
Mother Highest Grade × Time	0.003	0.01	0.002	339.07	.140	0.011	0.01	0.005	150.14	**.022**
Mother IQ × Time	0.000	0.01	0.000	122.32	.286	0.000	0.00	0.001	75.94	.856
Mother Age At Birth × Time	0.007	0.04	0.001	401.27	**<.001**	0.004	0.01	0.002	192.46	**.029**
Family Income × Time	0.000	0.00	0.006	150.58	.952	−0.002	0.00	0.015	66.96	.870
Math × Time	0.000	0.00	0.001	385.48	.869	0.001	0.01	0.001	160.75	.340
Reading Comprehension × Time	0.000	0.01	0.001	381.85	.643	0.000	0.00	0.002	143.01	.834
Reading Recognition × Time	0.000	−0.01	0.001	338.71	.503	0.000	0.01	0.002	120.21	.785
Short-Term Memory × Time	0.000	0.00	0.002	310.83	.949	−0.005	−0.01	0.005	165.11	.262
Language ability	−0.002	−0.02	0.001	82.01	**.008**	−0.004	−0.02	0.001	46.61	**.009**
Pseudo-R^2	.23					.22				

Note. Time represents age in years centered on age 4. Interactions with time represent associations with the slopes of behavior problems. Parameters where $p < .05$ in bold, $p < .10$ in italics.

Table 6

Study 2: Nested Model Comparisons of Autoregressive Latent Trajectory Model Successively Adding Each Direction of Effect Between Language Ability and Behavior Problems (Q2: What Is the Direction of Effect Between Language Ability and Behavior Problems?)

	I-H		EXT	
Step	$\Delta\chi^2$	***p***	$\Delta\chi^2$	***p***
Testing language ability → Behavior problems				
1. Adding Lang → BP	31.61	**<.001**	46.62	**<.001**
2. Adding BP → Lang	0.10	.750	0.00	.967
Testing behavior problems → Language ability				
1. Adding BP → Lang	0.96	.327	0.99	.320
2. Adding Lang → BP	31.30	**<.001**	40.87	**<.001**

Note. All chi-square tests had 1 *df*. Parameters where $p < .05$ in bold. BP = behavior problems; EXT = externalizing problems; I-H = inattentive-hyperactive problems; Lang = language ability.