The Impact of Birth Order on Language Development in Children with Autism Spectrum Disorder in Simplex Families

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ABSTRACT

The impact of birth order on language development has gained significant traction over the years, with contradictory evidence suggesting that lower birth order may hinder language development in typically-developing children (Nafissi & Vosoughi, 2015). However, results also suggest that when considering measures of social communication, second-born typically-developing children demonstrate a significant advantage (Kheirkhah & Cekaite, 2018). These findings have interesting ramifications when considering autistic children, as language impairments are characteristic of the disorder. The current study investigated the impact of birth order, in particular having an older, typically-developing sibling, on vocabulary and social language development in autistic youth. Participants included 1338 first-borns and 1049 second-borns (*M* age = 9.03 years, *SD* = 3.57; 86.4% male) with diagnoses of Autistic disorder, Aspergers, or PDD-NOS from the Simons Simplex Collection (Fischbach & Lord, 2010). Results indicated no significant differences in vocabulary or social language between first-borns and second-borns. Hierarchical linear regressions indicated no significant main effect of birth order; however, significant 2-way interactions with birth order x income and birth order x age predicted expressive vocabulary and inappropriate speech. Post-hoc simple slopes suggested that birth order may have a greater impact on language in younger autistic children, and lower-income families. This is the first work to date to investigate birth order and contextual factors on expressive language outcomes in autistic youth.

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GENERAL AUDIENCE ABSTRACT

Families provide an important context for important developmental milestones, such as language development (e.g., first words, firs phrases). Many parents and previous literature suggest that occasionally, older siblings can “speak on behalf” of their younger siblings, which reduces the number of opportunities second-born children have to practice important language skills. Previous literature in the field suggests that first-born siblings demonstrate stronger language skills when considering vocabulary, but that second-born siblings demonstrate stronger social language skills. The current dissertation evaluated these birth order findings in a clinical group of children and adolescents with Autism Spectrum Disorder (ASD), as language differences are key features of the disorder. Using a large, representative data set from the Simon Simplex Collection, nearly 3,000 youth with ASD were evaluated on vocabulary and social language skills, grouped by birth order status. Group comparisons suggested that there were no significant differences between first-borns and second-borns in vocabulary and language. When evaluating what factors predicted vocabulary and language, birth order was also not significant. However, some interaction effects emerged between birth order and income, suggesting that in lower-income families, birth order may make a meaningful difference in vocabulary and social language. This is the first work to evaluate the role of siblings on language in ASD, and has important implications for interventions, especially for lower-income families impacted by ASD.

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List of Abbreviations

ABC-IS………Aberrant Behavior Checklist- Inappropriate Speech

ADI-R ………Autism Diagnostic Interview-Revised

ADOS……… Autism Diagnostic Observation Schedule

ADOS-SS……Autism Diagnostic Observation Schedule- Stereotyped Speech

ANOVA…….Analysis of Variance

ASD…………Autism Spectrum Disorder

BF_{10}………….Bayes Factor

DAS-II………Differential Ability Scales- 2nd Edition

DSM-5………Diagnostic and Statistical Manual- 5th edition

DSM-IV………Diagnostic and Statistical Manual- 4th edition

FSIQ …………Full Scale Intelligence Quotient

GED…………General Educational Development degree

gs…………….Gradient Slope

H_0…………… Null Hypothesis

IQ……………Intelligent Quotient

MANCOVA…Multivariate Analysis of Covariance

mos………….Months

NVIQ……… Nonverbal Intelligence Quotient

OLL…………Overall Language Level

PDD-NOS……Pervasive Developmental Disorder- Not Otherwise Specified

PPVT-4………Peabody Picture Vocabulary Test-4th edition

SES………….Socioeconomic Status

SLI…………Specific Language Impairment

SSC………… Simon Simplex Collection

TD………… Typically-Developing

ToM…………Theory of Mind

VABS-II………Vineland Adaptive Behavior Scales- 2nd Edition

WASI-II………Wechsler Abbreviated Scale of Intelligence

WISC-IV………Wechsler Intelligence Scale for Children- 4th Edition

Introduction

Language comprises morphological, syntactic, semantic, and pragmatic features and is a crucial foundation for future cognitive and emotional development (Saxton, 2010). Language development is a significant predictor of academic achievement in elementary and middle school, and even higher educational attainment in early adulthood (Black et al., 2005). In atypically-developing children, such as children with autism spectrum disorder (ASD), or autistic children[1], language development is the single best predictor of overall functioning, including educational attainment, social skills, and adaptive functioning (e.g., Mayo et al., 2013). As such, predictors of language development are of continued interest in developmental and clinical research, including investigations into cognitive, behavioral, psychophysiological, temperamental, and contextual factors. One such contextual factor that has been debated over the decades is the impact of birth order and family size on language development (Nafissi & Vosoughi, 2015). Although birth order and family size have been studied in typically-developing samples, these contextual factors have yet to be investigated in autistic youth. The current study explores the impact of birth order and number of typically-developing siblings on measures of *vocabulary* (e.g., expressive vocabulary, receptive vocabulary, age of first words, and age of first phrases) and measures of *social language* (e.g., stereotyped/repetitive speech) in autistic children and adolescents.

In typically-developing children, the effects of birth order have revealed contradictory findings. Whereas some works have noted deleterious effects of being a later-born child in terms of language and academic outcomes (e.g., Westerlund & Lagerberg, 2008), others have noted social and linguistic benefits of growing up in a larger family with older siblings (Kheirkhah &

[1] Identity-first language is used throughout to be consistent with clinical and research recommendations (Kenny et al., 2016).

Cekaite, 2018). There are important distinctions here that are often not discussed in these works: namely, the linguistic dependent variable. Language development can be described in many ways, and in the current work, is divided into *vocabulary,* including the number of words produced or understood, and *social language*, including idiosyncratic or odd use of speech, repetitive speech, and stereotyped language. Using these two categories to understand language development may provide some clarity to the contradictory birth-order findings.

Vocabulary

The impact of birth-order on measures of vocabulary has been investigated as early as 9-12 months of age. Pine (1995) reported that first-born children reach expressive vocabulary milestones of first-50-words faster than second-born children. However, these birth order differences reportedly dissipate by the first-100-word milestone (Pine, 1995). Contradictory findings suggest that the effects of birth order may last beyond the first-100-word milestone. Berglund et al. (2005) reported that by 18-months of age, first-borns continued to score significantly higher than second-borns in terms of vocabulary production and comprehension. In these 18-month-olds, birth order was also a significant predictor of gestures, vocabulary comprehension, and vocabulary production (Berglund et al., 2005). Similarly, by 20-months of age, first-borns' expressive vocabulary exceeded that of second-borns' by maternal report, but interestingly not by standardized measures (Bornstein et al., 2004). In the second postnatal year of life (24mos), birth order can be considered a risk factor for late language emergence, or "late talkers", suggesting that second-borns may demonstrate a relative deficit in vocabulary compared to their first-born peers (Zubrick et al., 2007).

Results further suggest that even as children age, first-born children demonstrate stronger grammatical and lexical development than second-born children (Hoff-Ginsberg, 1998), demonstrate significant advantages on measures of verbal ability and verbal achievement (Polit & Falbo, 1988), and demonstrate significantly greater educational attainment (Black et al., 2005). These results suggest that when considering measures of vocabulary size, such as expressive language level, grammar, and lexical knowledge, first-borns reliably demonstrate a consistent advantage starting in early infancy and continuing through adulthood, compared to second-borns.

Although several reasons for first-born advantages have been postulated, the most-commonly agreed upon theory is the *Resource Dilution Theory* (Nafissi & Vosoughi, 2015), which hypothesizes that as more children enter the family, the family's finite resources are re-divided between the dependents, thus diluting the available resources for any one child as family size increases. Anecdotally, resources also differ with only-children compared to later-borns, as they then have to compete for maternal attention and resources, including financial and physical resources (e.g., school tuition, toys). This theory has gained support when investigating caregiver patterns of interactions with typically-developing children between first-borns and second-borns in dyadic (mother-child) vs triadic (mother-child-child) interactions. Whereas in dyadic interactions, caregivers use the same number of utterances and the same mean length of utterance, when engaging in triadic interactions, caregivers use fewer vocalizations directed towards the younger child (Oshima-Takane & Robbins, 2003). Triadic interactions may not only vary in the quantity of language directed towards younger children, but in the semantics and content of the language directed towards each child. In triadic contexts, mothers reportedly use more language centered around activities and social exchanges. In dyadic contexts, mothers use more language about language (e.g., conversations about switching languages in bilingual households; corrections about tenses or language use), which is an advanced meta-linguistic skill that is positively related to subsequent language development (Oshima-Takane & Robbins, 2003). The *Resource Dilution Theory* is generally supported in many works demonstrating that due to linguistic input differences, later-borns may be at a disadvantage when it comes to language quantity.

Although there are numerous works documenting a first-born advantage for measures of vocabulary, numerous other works take issue with the interpretation of these findings (e.g., Stewart, 2012), or present contradictory evidence. In fact, not all research has demonstrated a first-born advantage. Work conducted by Oshima-Takane et al. (1996) demonstrated no significant differences between first-borns and second-borns in terms of mean length of utterance, total vocabulary, and words (tokens) at 21-months of age. Follow-up results at 24-months still suggested no significant differences due to birth order. Others have argued that birth order simply "catches" remaining variance due to within-family factors, such as maternal education or socioeconomic status, but does not hold any true variance once these factors are properly accounted for (Liang & Sugawara, 1996; Zajonc & Sulloway, 2007).

Large-scale epidemiological studies predicting language outcomes between ages 18-24 months suggest that birth variables (e.g., order, weight, delivery complications) account for only a "modest" percentage of the variance (Rescorla, 2013; p. 144), ranging from 5-7% (Reilly et al., 2009). When isolating birth order specifically, effect sizes are generally small with overall explained variance of 1.7% in expressive vocabulary and 0.5% in receptive vocabulary (Berglund et al., 2005). Investigations into impacts on standardized tests and measures of verbal intelligence (IQ) suggest that birth order may only account for 1-3 standard points on these measures, which have been argued to be negligible as they still reside within the 95% confidence interval (Heiland, 2009; Zajonc & Sulloway, 2007). Although there are some findings that suggest birth order does not impact vocabulary*,* the majority of published work with typically-development youth demonstrate a significant, albeit small, effect of birth order.

Factors Influencing Birth Order Effects on Vocabulary in TD Children

There are numerous factors that contribute to differences in reported findings, including sex of the child and sex of the siblings (e.g., Steelman et al., 2002), age differences between siblings (e.g., Bornstein et al., 2004; Havron et al., 2019; Steelman et al., 2002), number of siblings/family size (e.g., Keller et al., 2015), caregiver setting (e.g., day-care versus home-care, Berglund et al., 2005), socioeconomic status (e.g., Hoff-Ginsberg, 1998) and form of measurement (i.e., maternal report versus behavioral observation; Bornstein et al., 2004). Due to limitations of variables available to investigate in the current data set, only sex, number of siblings, and socioeconomic status will be further discussed here.

Psycholinguistic research has demonstrated a consistent, female advantage in most areas of language development. For example, females globally outperform males at 18-months of age in gestures, vocabulary comprehension, and vocabulary production (Berglund et al., 2005). Given this advantage, it reasons that being a second-born may not be as disadvantageous for females. Some results support the idea that being a female may be a protective factor against the negative effects of birth order. For example, Bornstein et al. (2004) reported that second-born girls outperformed boys (regardless of first- or second-born) on all measures of language mastery. These results of a female-advantage have been replicated in non-English samples as well (e.g., for pragmatic development in Turkish-speaking families, Kesli, 2006). However, whereas being a female may provide a significant language advantage, it may be that the sex of the child is not as influential as the sex of the sibling. Havron et al. (2019) reported that children with an older sister had better language than children with an older brother; these findings are in alignment with the “liability of having brothers” theory, where having a brother negatively impacts overall achievement regardless of the sibling’s sex (Steelman et al., 2002). However, results are not always in the predicted direction when it comes to sibling sex. Other researchers have argued that it is not the sex of the sibling that matters, but instead whether the sibling pairs are same- or opposite-sex that may have a larger impact on sibling dynamics, and accordingly, impacts on language development (Steelman et al., 2002). Despite inconsistent differences, sibling sex is an important variable to explore when considering whether birth order significantly impacts language development.

Consistent with the *Resource Dilution Theory*, numerous results have indicated a negative relationship between the size of the sibling group and academic achievement (Karwath et al., 2014; for review, see Steelman et al., 2002). The effect size for this relationship is described as “robust”, although numeric average effect sizes are consistently around 0.2 (i.e., a “small” effect; Cohen, 1988). Still, this average effect size is reportedly larger than other contextual variables, such as socioeconomic status, family status, and rural status (Steelman et al., 2002). With regard to language specifically, the number of siblings is consistently more negatively related to verbal IQ than nonverbal IQ, suggesting there may be an experiential component to verbal IQ (and subsequent language skills) more so than nonverbal IQ (Peyre et al., 2016). Within verbal IQ, Keller et al. (2015) reported an inverse relationship between the number of siblings and second language skills. Their results indicated more siblings resulted in lower language scores after controlling for age, sex, number of books at home, and family/parental language skills. These results were partially replicated in a longitudinal study of Australian children ages four to eight years. When considering receptive vocabulary abilities at the age of four to eight years, having one or more sibling was not a significant risk factor for low receptive language (Christensen et al., 2014). However, when considering the *rate* of receptive vocabulary growth, having four or more siblings was established as a significant risk factor (Taylor et al., 2013). Combined, results suggested that having more siblings may not contribute to current levels of receptive language but may in fact contribute to slower rates of growth in receptive vocabulary from 4-8 years (Christensen et al., 2014; Taylor et al., 2013).

The relationship between socioeconomic status (SES) and language development has been a long-researched topic with consistent results demonstrating a significant relationship with SES and expressive and receptive vocabulary (e.g., Hoff, 2006). Previous works have noted significant interactions between SES and birth order, especially in the realm of language development. Hoff-Ginsberg (1998) demonstrated that both birth order and household income (reflecting SES) were predictors of expressive language at 18- and 29-months of age; however, these relationships were moderated by maternal vocabulary size. Further, Zambrana et al. (2012) investigated the impact of sex, maternal education, and birth order on language comprehension in toddlers ages 18-36 months. Their results indicated a main effect of sex (females in all birth orders and with all levels of maternal education outperformed males in all categories), and an effect of birth order (children with older siblings demonstrated significantly lower scores on language comprehension). However, interaction effects indicated that maternal education was a stronger predictor of language comprehension than birth order effects, regardless of sex. Together, results suggest that socioeconomic status, measured multiple ways (e.g., maternal education, maternal vocabulary, household income) may act as a powerful moderator of the birth order effects on expressive and receptive vocabulary.

It is clear then that numerous factors contribute to, and possibly moderate, sibling birth order effects. Despite these moderation effects, results are overall consistent in their indication of a second-born disadvantage when it comes to metrics of language quantity in typically-developing youth. However, when one considers other measures of language development apart from standardized assessments, the later-born "disadvantage" may, instead, be a later-born "difference" (Steelman et al., 2002). When considering language mastery in terms of conversational skills and social use of language, later-borns may, in fact, be advantaged compared to their first-born siblings.

Social Language

Although later-born children may hear less speech directed towards them from caregivers, the presence of older siblings may create a unique and diverse language environment that is qualitatively and quantitatively different from that of a firstborn child (Hoff-Ginsberg, 1998; Oshima-Takane & Robbins, 2003). In fact, Kheirkhah and Cekaite (2018) argue that siblings act as "socialization agents" that can help younger siblings in how they appropriately use their acquired language by providing linguistic corrections, requests, and language shifts. Results from Oshima-Takane and Robbins (2003) suggest that older siblings communicate to younger siblings (when in triadic contexts) via social-regulative phrases and clauses (e.g., directing or maintaining sensory attention: "Look at Big Bird!", expressing emotions about the context: "Good job playing nicely!", or maintaining or ending a communicative act by indicating a message was coming, being received, or over: "okay", "um"; Oshima-Takane & Robbins, 2003). In this way, older siblings help younger ones regulate emotions, engage socially in a small group, and play more pro-socially. This work has been further elucidated in bilingual families, where there is a positive impact of having an older sibling on social conversational skills of later-borns (Lauro et al., 2020; Oshima-Takane & Robbins, 2003). These unique linguistic and social environments may contribute to improved social use of language in second-borns compared to first-borns.

In fact, later-born children consistently score higher in measures of social language, although they may be scoring lower in vocabulary measures. For instance, Hoff-Ginsberg (1998) reported that whereas second-borns were less proficient in lexical and grammatical production, second-borns were more advanced in terms of conversational skill compared to first-borns at the same chronological age. Second-borns also scored higher in "frozen phrases", or the use of two or more words that had not previously occurred alone in a child's vocabulary (e.g., using the phrase "cookie gone" without previously using "gone" alone), thus demonstrating a significant advantage in creating unique phrases (Pine, 1995). Pine (1995) also found interesting results in pronoun usage; second-borns produced a higher percentage of diectic (personal) pronouns (e.g. "mine", "yours", "i", "you") in their first words compared to first-borns, although there was no significant difference in the number of common nouns. These pronoun differences have been replicated and extended in young toddlers: second-borns produced more first-person pronouns at 21-months than their first-born sibling. By 24-months, second-borns produced more first- and second-person pronouns than their older siblings when measured at the same age (Oshima-Takane et al., 1996).

These advanced social-communication skills of second-borns may also contribute to greater social skills, especially when considering theory of mind (ToM), or the understanding of others' mental states (de Veld et al., 2020). In fact, results suggest second-borns score higher on false-belief tasks and perform better on theory of mind (ToM) tasks, even after controlling for verbal IQ (Farhadian et al., 2010; Jenkins & Astington, 1996). Interestingly, sibling configuration has also been related to effectiveness of ToM interventions (de Veld et al., 2020).

In a randomized control trial ToM intervention for children with ASD, having more siblings and having an older sibling was related to better outcomes on ToM behavior and social cognition. The authors suggested that having older siblings allowed for greater practice and generalization of practical ToM skills outside of the intervention. These potential social language impacts as a result of birth order have clinical significance and relevance when considering atypical populations that may struggle with ToM, social language use, or language development, such as ASD. The impact of birth order in clinical populations will be discussed more below.

Birth Order Effects in Atypical Populations

The effects of birth order on language development have not been extensively studied in clinical samples. Some works have used the phenomenon of "late talkers" and specific language impairments/developmental language disorders as a platform to investigate predictors of heterogeneous language outcomes. When considering birth order as a continuous predictor among other demographic factors to account for variation in late talker status, research suggests that birth order can be considered a "risk factor" that contributes to expressive language delays (Zubrick et al., 2007), or that being a nonsingleton (e.g., a twin or triplet) could also contribute to being a late talker (Hammer et al., 2016).

When considering birth order as a categorical variable (first-born, second-born) predicting a categorical outcome, these results do not replicate. For example, In an unpublished dissertation, Souhlas (2014) investigated whether birth order impacts a parent's ability to identify a language delay by using a clinical sample at a language disorders clinic. Relying on retrospective reports, results suggested that birth order was not significantly related to age of detection. Second, in an earlier published study, Tomblin (1990) investigated the impact of birth order on language development in children with and without SLI. Using chi-square analyses, results indicated that birth order was not significantly related to language impairment classification. Tomblin (1990) argued that birth order may not be an experiential factor that contributes to language impairment in terms of diagnoses of SLI. These results are not surprising, as there is evidence for a strong genetic component to SLI (Moyle et al., 2013), and relying on a dichotomization of birth order may be missing some subtle variation. However, in more heterogeneous clinical presentations, or in the case of "late talkers", experiential factors, such as birth order, does reportedly contribute to atypical language development.

Autism Spectrum Disorder

ASD is a neurodevelopmental disorder marked by socio-emotional and socio-communicative impairments with the presence of clinically interfering restricted and repetitive behaviors and interests (American Psychiatric Association, 2013). Language has been noted to be an important feature of ASD since Kanner's (1946) early description of "infantile autism", including both impaired pragmatic communication and atypical language development. Whereas some have argued that deficits in language may be a reflection of a lack of social motivation, more recent considerations understand language to be a core deficit of ASD and unrelated to social motivation (Eigsti, 2011).

Although portions of language remain intact in ASD (e.g., phonology, syntax, articulation; Jordan, 1993), autistic individuals across the range of intellectual functioning typically demonstrate deficits and differences in language acquisition. Estimates suggest as many as 25% of autistic individuals never develop functional speech (Tager-Flusberg et al., 2005), but for those who do, many individuals demonstrate substantial expressive language delays, developmental scatter (e.g., grammatical structures that are not predicted based on previous vocalizations), and pragmatic deficits (Eigsti et al., 2007; Howlin, 2003). Autistic individuals may also demonstrate an atypical comprehension to production ratio (Gernsbacher et al., 2016). In typically-developing samples, almost all children demonstrate a significantly larger receptive vocabulary (words they understand) compared to expressive vocabulary (words they produce). However, in ASD, individuals may not have the same ratio; in fact, they may produce more words than they understand, or only begin to understand the words once they have mastered producing them (Goodwin et al., 2012).

Autistic individuals also demonstrate markedly atypical development in how they use the expressive language they do develop (i.e., their *social language*). Autistic youth often demonstrate pronominal reversals (e.g., incorrect usage of deictic pronouns “I” and “you”), overly repetitive speech, and use of idiosyncratic (e.g., overly formal, markedly odd) language (Gernsbacher et al., 2016). Language production in ASD is also characterized by the addition of some unusual features including echolalia (i.e., specific or exact verbal repetitions from other sources) and neologisms (i.e., the invention of novel words; Eigsti, 2011). Although there are differences in the degree of atypicality each individual demonstrates, ASD does remain one of the most interesting presentations of atypical language development. As such, a better understanding of the predictors of the atypical language trajectory in this disorder remains a crucial endeavor.

In ASD, birth order has been studied as a predictor of receiving an ASD diagnosis (e.g., Turner et al., 2011), ASD symptom severity (Reichenberg et al., 2007), internalizing and externalizing problems (Vaudrey, 2015), cognitive and adaptive functioning (Alvares et al., 2020; Upreti & Singh, 2017), but has not been thoroughly investigated as a predictor of language development. Only three previous studies have reported findings relating to birth order and language within ASD multiplex families. Multiplex families refer to families with more than one child with an ASD diagnosis. First, Spiker et al. (2001) reported that second-borns with ASD had lower non-verbal IQ scores, which was independent of sex and the sibling age gap. Martin and Horriat (2012) replicated these findings with a larger sample and extended Spiker et al.'s (2001) findings. Martin and Horriat (2012) reported that within multiplex families with ASD, second-borns with ASD had lower nonverbal IQ (replication) and lower verbal IQ (extension; as measured by the Peabody Picture Vocabulary Test, 4th Edition; Dunn & Dunn, 2007) compared to first-borns with ASD. Again, these effects remained after controlling for age differences between siblings and sex of the child and siblings. Lastly, Reichenberg et al. (2007) reported that first-born children with ASD had better useful speech than their second-born ASD siblings as determined by the Autism Diagnostic Interview-Revised (ADI-R; Rutter et al., 2003). From these three studies, there is evidence of birth order effects in families with multiple children with ASD. Although interesting, these multiplex studies confound diagnostic status and birth order, and cannot directly address the questions of how having a typically-developing older sibling may impact language of later-born autistic children.

Aims and Hypotheses

The current dissertation aims to address the following questions: (1) how does having a typically-developing, older sibling impact *vocabulary* and *social language* for autistic youth, (2) does birth order (first-born versus second-born status) predict *vocabulary* and *social language* above and beyond demographic factors, and (3), what other variables (e.g., age, number of siblings, sex, SES) potentially moderate the relationship between birth order and language development? In addition to these three primary aims, exploratory aims will investigate the role of the sex dyads and the role of only children versus eldest children.

In accordance with the typically-developing literature demonstrating a second-born disadvantage in measures of expressive and receptive language, it is predicted that (1a) second-born autistic children will demonstrate a detriment in *vocabulary* compared to first-born autistic children. However, given the typically-developing literature regarding siblings as "socialization agents" (Kheirkhah & Cekaite, 2018), it is predicted that (1b) autistic second-borns will demonstrate an advantage in *social language* as a result of having a typically-developing older sibling. It is also predicted that (2) birth order will account for significant variability in measures of *vocabulary* and *social language* above and beyond age, nonverbal IQ, sex, and income. Lastly, it is predicted that (3) the relationships between birth order and language will be moderated by SES, age, and number of siblings, insofar as individuals who are younger, who have a higher number of siblings, and who have a lower socioeconomic status will demonstrate the greatest detriment in *vocabulary* and *social language* due to having an older sibling. These predictions are based in the typically-developing literature demonstrating that sex (being a male), age (being younger), number of siblings, and lower income have all been significantly and negatively related to language development in the birth-order literature (e.g., Hoff, 2006).

Method

The current study utilizes a large sample of children with ASD (*N* = 2888) from the Simons Simplex Collection (SSC; Fischbach & Lord, 2010). Participants and their families were recruited as part of a multi-site genetic consortium resulting in a repository dataset that is publicly available by the Simons Foundation Autism Research Initiative. Recruitment for the SSC dataset was conducted at 12 different universities in the United States (Michigan, Yale, Emory, Columbia, Vanderbilt, Children's Hospital of Boston, University of Washington, Illinois- Chicago, Missouri, UCLA, and Baylor College of Medicine) from 2008 to 2010 (Fischbach & Lord, 2010). Principal investigators at each site included a geneticist and psychologist, as both blood samples (genetic information) and comprehensive psychological evaluation data was collected. Measures collected for the SSC phenotypic data included core autism symptoms, intellectual ability, adaptive behavior, emotional/behavioral problems, motor function, language, and data from a comprehensive medical evaluation and family history interview. Psychologist consultants who conducted training at all recruitment sites ensured outstanding validity and reliability, with error rates reported at 0.5/100 (Fischbach & Lord, 2010). Exclusion criteria included not meeting diagnosis for ASD, primary relatives being on the autism spectrum (i.e., not simplex families), having medically significant perinatal events, having low mental age (< 18 months nonverbal age), or genetic evidence of Fragile X or Down syndromes (Fischbach & Lord, 2010).

Participants

Participants included youth ages 4-18 years (*M* = 9.03 yrs, *SD* = 3.57; 86.4% male) with a DSM-IV diagnosis of Autistic disorder, Aspergers, or PDD-NOS. The sample was predominantly white (75.8%) with mean reported income of $78,180 (*SD* = $24,080); thus, the sample was also predominantly middle class. Participants had from zero to nine biological siblings, with missing sibling/birth order data for 103 participants. In the analyses that follow, participants were either grouped by birth-order, such as first-borns (*n* = 1338) and second-borns (*n* = 1049), or participant birth order was used as a continuous variable in predicting outcomes.

Measures

Measures of *vocabulary* are operationalized by expressive and receptive abilities as captured by the Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4), Vineland Adaptive Behavior Scales- Second Edition (VABS-II), and the Autism Diagnostic Interview-Revised (ADI-R). Measures of *social language* are defined as atypical verbal social communication as measured by the Autism Diagnostic Observation Schedule (ADOS) and Aberrant Behavior Checklist (ABC). Demographic variables, including birth order, sex, family income, child race/ethnicity, maternal education, and family size are all included in the SSC database.

Vocabulary

Given previously reported differences in findings due to measurement and informant (e.g., Bornstein et al., 2004; differences between maternal-report and standardized assessment), dependent variables of vocabulary were chosen to reflect two different measurements: standardized assessment (PPVT-4, VABS-II Expressive subdomain) and parent/clinician report (ADI-R age at first words, ADI-R age at first phrases, and ADI-R overall language level). Largely, these measures depict an individual's verbal expressive and receptive language abilities.

Peabody Picture Vocabulary Test, 4th Edition (Dunn & Dunn, 2007). The PPVT-4 is a measure of receptive language ability that comprises 228-items and is estimated to take 15-30 minutes to administer. The 228 items are divided into 19, 12-item sets that increase in difficulty. Starting location is dependent on the participant's chronological age, and the test proceeds according to basal (10 correct items in a set) and ceiling (8 incorrect items in a set) rules. Participants are asked to identify the correct image out of four possible images depicting the prompted word (including noun, adjectives, and verbs). Each participant's raw score is converted to an age- and sex-normed standard score (*M* = 100, *SD* = 15), which is used in the following analyses. The PPVT-4 has been demonstrated to reflect verbal IQ in the current data set (Krasileva et al., 2017) and possesses strong internal consistency (α = .97) and test-retest reliability (*r* = .92; Dunn & Dunn, 2007).

Vineland Adaptive Behavior Scales, 2nd Edition (Sparrow et al., 2005). The VABS-II is a semi-structured interview conducted with a child's caregiver to assess for current adaptive behaviors in four primary domains: Communication, Daily Living Skills, Socialization, and Motor Skills. The VABS-II demonstrates excellent validity and reliability (*r* = .94, Sparrow et al., 2005). Each domain produces a standard score (*M* = 100, *SD* = 15) and comprises two to three subscales that yield a v-scale score (*M* = 15, *SD* = 3). The current study investigated the Expressive subscale of the Communication domain[2]. The Expressive subscale has a variable number of items, depending on age start point and subsequent basal and ceiling rules, and assesses the frequency of behaviors on a three-point Likert scale: 0 (*never*), 1 (*sometimes*), and 2 (*usually*). The Expressive subscale has demonstrated excellent convergent validity with other standardized measures of expressive language (e.g., Bayley Scales; Scattone et al., 2011). To account for age and sex, the Expressive subscale *v*-score is used in subsequent analyses.

Autism Diagnostic Interview - Revised (Rutter et al., 2003). The ADI-R is a semi-structured interview administered to caregivers of children to assess for current and past

[2] The other two subscales in the Communication Domain (i.e., Receptive Language and Written Language) were not included in the current study. Items on the receptive subdomain contain questions that map onto abilities beyond the structural quantity of language development such as following directions and attending to others. Written language was not a primary aim of the current paper.

behaviors related to ASD. The ADI-R consists of 93 items in four subscales: Communication, Socioemotional Reciprocity, Restricted/Repetitive Behaviors, and Age of Abnormality. Three items in the ADI-R are used in the current project, including age of first words (item #9), age of first phrases (item #10), and overall language level (OLL, item #30). All three items are based on caregiver-report and clinician judgment. Age(s) of first words and phrases records the age, in months, of the child's first meaningful words and first use of phrases, as defined by using two words together meaningfully, including a verb. The OLL categorizes the child's current level of expressive language as: 0 (*functional use of phrases including verbs*), 1 (*uses at least five words daily, but no functional use of phrases*), and 2 (*uses fewer than five words daily*). For the overall level of current language (ADI-R item #30), age of first words (ADI-R item #9) and age of first phrases (ADI-R item #10), scores indicating the item was not administered or parents could not recall (scores 994-999) were coded as missing. The OLL as a categorical measure of broad language has demonstrated good agreement with other language measures (e.g., Bal et al., 2016).

Social Use of Language

Language quality was captured by specific scores from the ADOS and ABC. Again, as described above in the vocabulary section, two dependent measures were chosen to reflect possible differences in measurement (parent-report on the ABC; standardized observation on the ADOS). These specific scores describe the verbal social-communicative aspect of language.

Autism Diagnostic Observation Schedule (Lord et al., 2012). The ADOS is a semi-structured behavioral assessment of ASD symptoms, grouped into three domains: communication, social reciprocity, and restricted/repetitive behaviors. The ADOS has five modules, based on chronological age and expressive language level (toddler and modules 1-4). In the current project, only modules 1-4 were administered given the youngest age was 48 months. For the current project, item-level codes for "stereotyped speech and inappropriate language" (Module 1: A5, Modules 2-4: A4) were used as a measure of atypical social communication. Clinicians coded the participant's speech on a 4-point Likert scale: 0 (*no use of stereotyped or idiosyncratic speech*), 1 (*words or phrases tend to be more repetitive than others with the same expressive language level but is not obviously stereotyped*), 2 (*often uses stereotyped speech with some other non-stereotyped speech*), and 3 (*speech is mainly stereotyped or idiosyncratic*). Only scores in the continuous range from 0-3 were included; scores assigned values of 8 were coded as missing, as this reflects a lack of language as opposed to an atypical use of language. The code(s) for stereotyped language have demonstrated significant relationships to age, nonverbal IQ, and global scores of conversation skills (Kim & Lord, 2010).

Aberrant Behavior Checklist (Aman et al., 1985). The ABC is a 58-item parent-report measure, originally designed to assess treatment-related changes in psychiatric populations. The ABC comprises five subscales, including Irritability, Lethargy, Stereotypy, Hyperactivity, and Inappropriate Speech. The Inappropriate Speech (IS) subscale is used as a measure of atypical language. The IS subscale includes four items: "repeats words", "talks excessively", "talks to self", and "repetitive speech". Each item is scored on a four-point Likert scale with higher scores indicating higher severity: 0 (*not at all a problem*), 1 (*slight problem*), 2 (*moderately serious*), and 3 (*severe*). The maximum score on the IS subscale is 12; average scores in autistic samples range from 3.4 (*SD* = 3.1) to 3.9 (*SD* = 3.0) depending on IQ (Norris et al., 2019). The IS subscale has demonstrated acceptable internal consistency (α = .77, Kaat et al., 2014).

Verbal and Nonverbal Intelligence

Depending on the age and verbal abilities of the participant, full-scale intelligence quotients (FSIQ) were assessed by the Wechsler Abbreviated Scale of Intelligence (WASI-II;

Wechsler, 2011), Wechsler Intelligence Scale for Children - 4th Edition (WISC-IV; Wechsler, 2003), Mullen Scales of Early Learning (Mullen, 1995), or Differential Ability Scales- II (DAS-II early years or school age; Elliot, 2007). These assessments reported on both verbal and nonverbal IQ and report acceptable reliability and validity. Standard scores (*M* = 100, *SD* = 15) accounting for age and sex were used for each measure.

Demographics

Demographic information, including family-reported household income, maternal-reported years of education, number of children in the family, birth order, child sex, race and ethnicity were variables collected by the SSC and were available for each participant. Child age was recorded as the age the ADOS was administered, in months.

Data Analytic Plan

For analyses, *vocabulary* dependent variables included: (1) PPVT-4 receptive language, (2) VABS-II expressive language, (3) age of first words, (4) age of first phrases, and (5) overall language level. *Social language* dependent variables included: (1) ABC- inappropriate speech and (2) ADOS- stereotyped speech. Results were analyzed using IBM SPSS (Version 26) and JASP (Version 0.13.1; JASP Team, 2020). Descriptive statistics and correlations between main study variables were first examined. Due to the number of correlations, Bonferroni corrections were applied, and the significant p value was set at $p < .0005$ ($p = .05/91$ variable pairs; Curtin & Schulz, 1998).

For aim 1, a multivariate analysis of covariance (MANCOVA) was conducted with birth order and sex as independent variables and *vocabulary* and *social language* as dependent variables, controlling for child age. In the event of null main effects, Bayes Factors were analyzed to evaluate the confidence of interpreting the null hypothesis using interpretation guidelines from Lee and Wagenmakers (2014). Next, to evaluate the variance accounted for in *vocabulary* and *social language* (aim 2), hierarchical linear regressions were conducted controlling for demographic variables (models 1 & 2) and included two-way interaction terms (model 3; aim 3) to test for moderation. Categorical interaction terms were dummy-coded and continuous interaction variables were mean-centered for moderations. Standardized coefficients, which can be used to gauge relative importance, are presented and can be interpreted as *r*-values (Durlak, 2009). Values of .10 to .29 indicate a small effect, between .30 and .49 indicate a medium effect, and values greater than or equal to .50 indicate a large effect. Post-hoc analyses and simple slope calculations were conducted with unstandardized regression coefficients to determine the direction of interactions (Dawson, 2014).

Results

Preliminary Analyses

Descriptive statistics and correlations between all study variables are available in Table 1. Notably, birth order was only significantly related to number of siblings, $r = .555$, $p < .0003$. Number of siblings was not positively related to any other study variables. Child age was negatively related to expressive language, $r = -.193$, $p < .0003$, and overall language level, $r = -.082$, $p < .0003$, and positively related to age of first phrases, $r = .083$, $p < .0003$, which reflects the older individuals in the sample being lower in verbal skills. Income and maternal education were related to linguistic variables of interest insofar as higher years of maternal education and higher family income were related to better language. Looking at just first- and second-borns (Table 2), the two groups did not statistically differ on any demographic variable except number of siblings, $t(2357) = 10.97$, $p < .01$.

Group Differences Between First-borns and Second-borns

A 2 (birth order) x 2 (sex) MANCOVA controlling for child age was conducted with the five dependent measures of *vocabulary* (receptive, expressive, age of first words, age of first phrases, and overall language) and two dependent measures of *social language* (inappropriate speech, stereotyped speech). Results indicated a main effect of birth order for ABC-Inappropriate Speech subscale, $F(1,1910) = 6.460$, $p = .011$, $\eta_p^2 = .003$, where second-borns ($M = 3.57$, $SD = 2.88$) demonstrated a significantly lower score, indicating an overall better performance, compared to first-borns ($M = 3.89$, $SD = 2.91$). Birth order did not emerge as a significant main effect for any of the other six dependent variables[3]. Using a Bayesian multivariate analyses of variance, results suggested "extreme evidence" to "strong evidence" in

[3] These result patterns held when treating overall language level and stereotyped speech as dichotomous variables.

support of the null hypothesis, $BF_{10} < .072$, for all dependent variables (see Table 3 for group means and Bayes Factors).

Results of the frequentist MANCOVA also indicated a significant effect of sex for PPVT-4 Receptive Language, $F(1,1910) = 7.932$, $p = .005$, $\eta_p^2 = .004$, and VABS-II Expressive Language, $F(1,1910) = 7.900$, $p = .005$, $\eta_p^2 = .004$. For both receptive and expressive language variables, the males scored higher than females, indicating males demonstrated better receptive and expressive language skills than females (PPVT-4: $M_{Males} = 88.84$, $SD = 26.18$, $M_{Females} = 83.61$, $SD = 28.15$; VABS-II: $M_{Males} = 10.65$, $SD = 3.15$, $M_{Females} = 10.04$, $SD = 2.79$). There were no significant interaction effects for any dependent variable, *p*s > .190.

Birth Order as a Predictor of Vocabulary and Social Language

Assumptions of homoscedasticity, normality, and multicollinearity were met prior to conducting regression analyses. As FSIQ demonstrated strong multicollinearity with PPVT-4 Receptive language as indicated by Pearson correlations ($r = .888$) and variance inflation factors ($VIF = 12.82$), nonverbal IQ was used in subsequent analyses. To replicate previous works, only receptive and expressive language were used as dependent variables in *vocabulary;* inappropriate speech and stereotyped speech remained as the two dependent variables of interest in *social language.* Due to the restricted range of stereotyped speech (0-3), it was dichotomized into *no-to-mild stereotypy* (0-1) and *moderate-to-severe stereotypy* (2-3) for a logistic regression.

Vocabulary

For PPVT-4 Receptive language, the final model was significant, $F(13, 2409) = 347.882$, $p < .001$ and accounted for 65% of the overall variance in receptive language, $Adj.R^2 = .651$ (Table 4a). In the final model, the only significant predictors at the $p < .05$ level included age, *ß*

= .030, maternal education, *ß* = .040, and nonverbal IQ, *ß* = .806. Birth order did not emerge as a significant main effect or interaction.

For VABS-II Expressive language, the final model was significant, $F(13, 2499) = 139.171$, $p < .001$ and accounted for 42% of the overall variance in expressive language, $Adj.R^2 = .418$ (Table 4b). In the final model, the significant predictors at the $p < .05$ level included age, *ß* = -.174, income, *ß* = .045, maternal education, *ß* = .051, and nonverbal IQ, *ß* = .604. In addition to the main effects, two significant interactions emerged including income x birth order, *ß* = .038, and age x birth order, *ß* = -.045. Using simple slopes to evaluate the nature of the interaction between income and birth order (Dawson, 2014), results suggested a first-born advantage in below-average income families but no significant difference in birth order in higher-income families (Figure 1). The slope gradient for first-borns was negative and significant, $m = -.064$, $t = -2.024$, $p = .043$, whereas the slope gradient for later-borns was positive and non-significant, $m = .200$, $t = 1.265$, $p = .206$. The interaction between age x birth order revealed statistically significant birth order differences at younger ages, wherein later-borns outperformed first-borns, but a nonsignificant effect of birth order at the later ages (Figure 2). Simple slopes indicated both slope gradients were negative, although non-significant, $m_{\text{first-born}} = -.006$, $m_{\text{later-born}} = -.026$, *p*s > .80.

Social Language

For ABC-IS inappropriate speech, the final model was significant, $F(13, 2498) = 4.893$, $p < .001$ and accounted for 2% of the overall variance in expressive language, $Adj.R^2 = .020$ (Table 5a). In the final model, the significant predictors at the $p < .05$ level included income, *ß* = -.056, and nonverbal IQ, *ß* = -.111. A significant interaction between income and birth order also emerged as significant, *ß* = .069. Simple slope analyses revealed a second-born advantage over first-borns in terms of inappropriate speech in below-average income families, but no significant differences in birth order in above-average income families (Figure 3). The slope gradient for first-borns was negative and significant, $m = -.179$, $t = -2.311$, $p = .02$, whereas the gradient for later-borns was positive and non-significant, $m = .133$, $t = .809$, $p = .418$.

For ADOS stereotyped speech, only the first model of the logistic regression was significant, $X^2(8) = 17.935$, $p = .022$ (Table 5b). The model explained .9% (Nagelkerke R^2) of the variance in stereotyped speech and correctly classified 70.8% of cases. Despite an overall significant first model, no individual predictor reached the $p = .05$ level of significance.

Exploratory Results

Although not primary aims of the current work, additional questions related to birth order emerged in the previous literature were addressed as exploratory, post-hoc analyses. First, previous research has noted the impact of the child's sex and sibling's sex on language development, including patterns emerging based on the sex match of the sibling dyads (e.g., male-male; male-female; female-female; Steelman et al., 2002). Using data from second-borns, where first-born sibling sex was available, a MANCOVA controlling for age indicated no significant difference between female-female, female-male, and male-male sibling dyads on all 7 dependent measures (5 *vocabulary,* 2 *social language*, *p*s > .089, see Supplementary Table 1). When investigating these patterns by the sex of the second-born child, a significant main effect of dyad for female children emerged for overall language level, $F(1,80) = 4.690$, $p = .033$, $\eta_p^2 = .055$. Means comparisons revealed that female-female dyads ($M = 0.00$, $SD = 0.00$) had lower scores, indicating better overall language, compared to male-female dyads ($M = .13$, $SD = .42$). The same pattern was not detected in males, suggesting that for female second-borns, having an older female sibling is advantageous in terms of overall language level.

Second, the *Resource Dilution Theory* distinguishes between different types of first-borns: first-borns with younger siblings (eldest siblings) and first-borns without siblings (only children). Whereas both are considered first-borns, only children do not have the same social and family environment as first-borns with younger children. Birth order status was coded as only children (having no siblings), eldest siblings (born first, with at least one younger sibling), and younger children (later-borns with at least one older sibling). A 3 (birth order: only children, eldest children, and younger children) x 2 (sex) MANCOVA controlling for child age was conducted with the five dependent measures of *vocabulary* and two dependent measures of *social language*. The main effects of sex reported previously held for the current analyses; there were no significant main effects of birth order, ps > .067, nor any significant birth order x sex interactions, ps > .114 (Supplementary Table 2).

Discussion

The current study sought to evaluate the impact of having an older, typically-developing sibling on language development in autistic youth. The study divided results into three distinct aims: (1) understanding group differences in *vocabulary* and *social language* as a function of first-born and second-born status for autistic youth, (2) understanding the predictive role of birth order for language development outcomes in ASD, and (3) understanding the potential moderating effect of birth order with demographic variables for language development outcomes in ASD. The results analyzed for each aim will be discussed sequentially.

Aim 1: Birth Order Group Differences

The primary hypothesis for aim one was that autistic second-borns would demonstrate a detriment in *vocabulary*, but a benefit in *social language*, compared to first-borns as a result of having an older, typically-developing sibling. The results provided partial support for the preliminary hypothesis with a main effect of birth order predicting inappropriate speech (ABC-IS). In this main effect, second-borns demonstrated the hypothesized benefit in *social language* compared to first-borns, although this effect was small. There were no significant main effects of birth order on *vocabulary* after accounting for sex and age. The results also suggested a main effect of sex wherein males outperformed females on receptive and expressive language. Additionally, despite previous research detailing differences between maternal report and objective assessment (e.g., Bornstein et al., 2004), the results provided no evidence to suggest there were methodological differences in language reporting or assessment for ASD in this study.

Although there was a significant difference between first-borns and second-borns in relation to inappropriate speech in the hypothesized direction, the overall effect size was below the interpretation for a "small" effect, $\eta_p^2 = .003$, suggesting birth order may not make a meaningful or practical difference in levels of inappropriate speech. For the other six measures of language development, Bayes Factors indicated that one could reliably interpret the null findings with “extreme” to “strong” support, suggesting that the lack of observed significant effects here reflect a true representation of the null. These lack of significant group differences between first-borns and second-borns were surprising given previous literature (e.g., Berglund et al., 2005; Bornstein et al., 2004; Pine, 1995). However, when considering why significant effects were not found, there are several methodological differences that did not replicate previous work. First, the overall age of the current sample was significantly older than previous birth-order studies. The previous literature reported birth-order differences as young as 9-mos through approximately the second post-natal year of life (e.g., Bornstein et al., 2004). Comparatively, the average age of the current sample was nine years, with the youngest cohort being 48-mos. This may explain why measures assessing current language did not detect significant differences. However, measures intended to capture early linguistic variability (e.g., in the first two postnatal years of life) were also used in the current study: age of first words and age of first phrases, which should have replicated previous work investigating age of first words milestones (e.g., Pine, 1995). Again, previous works that used age of first word milestones were using current reports of early language, not retrospective reports, as used in the current study. Despite the general validity of parent-report to assess a child’s language skills (Dale, 1991), retrospective accounts of age of first words and age of first phrases may have been biased. Retrospective report is often less accurate than current reports, especially for families who attended speech/language therapies (Russell et al., 2013), which was the case for 30.2% of the current sample. Future work should aim to characterize the impact of sibling status on early language development by implementing parent-report and objective assessments of current language skills in early childhood, ideally between the ages of 12-to-24-months.

The second methodological difference that may have contributed to a lack of significant findings involved the dependent variables. Whereas some measures replicated previous literature (e.g., age of first words; Pine, 1995), other commonly-used measures of language were not available in the current study, including grammatical/lexical skills (Hoff-Ginsberg, 1998), mean length of utterance, tokens, and preverbal gestures (Oshima-Takane et al., 1996). Overall, the majority of the measures used to assess language development were standardized assessments. Standardized language assessments, while crucial for clinical comparisons, often fail to capture more nuanced aspects of language such as appropriateness of language, use of morphemes, and the quantity of expressive language that a child may initiate (Bacon et al., 2018). Understanding these nuanced elements of speech is even more important in ASD, as these more subtle language variables are often compromised in children and adolescents with ASD (Eigsti, 2011). Future work would benefit from using naturalistic language samples and coded behavioral interactions in early childhood as a metric of language development in ASD.

Lastly, despite the aforementioned methodological differences, it is possible that the relationship between birth order and language development may be different in typically-developing and ASD samples. Autistic youth present with significant heterogeneity in language, including the age of onset, growth progression, and overall outcomes (Tager-Flusberg, 2016). Despite the inherent heterogeneity of language development in typically-developing children, there are common benchmarks that most children meet, including first words before the first birthday and first phrases before the second birthday (Visser-Bochane et al., 2020). Given the wide array of linguistic outcomes present in ASD, including a large percentage of autistic individuals that may never develop functional speech (Bacon et al., 2018), the contextual mechanisms and relationships between birth order and language may not be as prevalent or as meaningful in ASD as in typical development. Other variables may have a larger impact on language development such as social motivation, ASD severity (e.g., cognitive and adaptive functioning), and access to language interventions.

The other prominent finding that emerged in the first aim was a significant main effect of sex for PPVT-4 Receptive language and VABS-II Expressive language, wherein males outperformed females. These results are surprising given the large body of work demonstrating a significant female advantage in measures of language and social communication in typical development (e.g., Bornstein et al., 2004). These results also do not match with the current ASD literature demonstrating either no differences in social/language skills by sex in ASD (Mandy et al., 2011), or a female advantage in the areas of social communication (Howe et al., 2015). However, results from the SSC dataset indicate there were significant cognitive differences in FSIQ between males (M = 82.11, SD = 27.81) and females (M = 75.20, SD = 28.23), in the same direction as the language findings, $t(493.715) = -4.407$, $p < .001$. Given the strong correlation between language and FSIQ, $r = .888$, the sex differences obtained can be attributed to group cognitive differences in the current sample and may not reflect global sex differences in ASD once matched on FSIQ, yet further replications are warranted. Though it can be considered as a strength of the current study that a wide range of cognitive functioning was included, future work should aim to have well-balanced groups of males and females with ASD to equate for these cognitive and adaptive variables.

Aims 2 and 3: The Role of Birth Order in Predicting Language Outcomes

The secondary and tertiary aims of the current project were to evaluate the predictive variance accounted for by birth order in *vocabulary* and *social language*, including potential demographic moderations. The hypotheses for aims two and three were that birth order would account for significant variance in both *vocabulary* and *social language* after controlling for demographic factors, and the relationship between birth order and language would be moderated by maternal education, income, age, and number of siblings. Again, the results partially supported these hypotheses. Birth order, contrary to hypotheses, did not account for significant variance in any dependent variable as a main effect after accounting for demographic factors. The demographic factor with the strongest predictive validity was nonverbal IQ, which routinely demonstrated a medium-to-large effect. Other significant main effects included age, maternal education, and income. However, there were three instances of moderations where demographic variables interacted with birth order to significantly predict expressive language and inappropriate speech, suggesting birth order may play a role, especially in low-income families.

The lack of significant main effect of birth order was unexpected given the previous research that suggested birth order accounted for predictive variance in language development (Rescorla, 2013). Even with previous research demonstrating small to modest effects (e.g., Reilly et al., 2009), the current sample was sufficiently sized and powered to detect small effects. Our results, however, support the hypothesis that birth order may simply capture family variance otherwise unaccounted for by missing contextual variables in previous work (Liang & Sugawara, 1996; Zajonc & Sulloway, 2007). Zajonc and Sulloway highlighted that previous literature claiming a birth order effect frequently omitted important measures of SES, including maternal education and income. They postulated that once these important linguistic predictors were accounted for, the final model would render birth order nonsignificant. Our results are in full alignment with Zajonc and Sulloway's predictions. Despite our use of an ASD sample compared to Zajonc and Sulloway's typically-developing model, our results support their hypothesis that once family contextual variables were accounted for in the model, birth order would not emerge as significant.

Although birth order did not emerge as a significant main effect, birth order did significantly interact with income to predict VABS-II expressive language and ABC-inappropriate speech. For both dependent variables, the hypothesized birth-order effect emerged only in lower-income families. For expressive language, first-borns demonstrated higher scores than second-borns, but only in lower-income families; there was no significant difference in higher-income families. For inappropriate speech, second borns demonstrated less inappropriate speech only in lower-income families; there was no significant difference in higher-income families. These results replicate previous studies suggesting a first-born vocabulary advantage and second-born social advantage (e.g., Hoff-Ginsberg, 1998), and support our hypotheses regarding the impact of birth order on *vocabulary* and *social language*. Although previous works have implicated a main effect of income (i.e., lower-income families demonstrating less advanced lexical development; Hoff-Ginsberg, 1998), these are the first results to our knowledge purporting a birth order x income interaction.

When examining these results within the *Resource Dilution Theory*, the birth order x income interaction findings suggest that for families in which resources may already be limited (e.g., financial, time), birth order has a stronger impact on vocabulary and social language than in high-income families. Our expressive vocabulary results support this hypothesis put forth by Nafissi and Vosoughi (2015), suggesting second-borns would demonstrate a global disadvantage compared to first-borns, since they receive split resources with their first-born siblings. However, our results demonstrated a second-born *advantage* in the *social language* domain. To date, the *Resource Dilution Theory* has only been applied to measures of vocabulary (Oshima-Takane & Robbins, 2003). When considering measures of *social language,* perhaps familial resource allocation looks a bit different. In these lower-income families, older siblings are more likely to be involved in the child-rearing process, providing approximately 39% of after-school care for their younger siblings (Dodson & Dickert, 2008). This unique situation of older siblings providing caregiving could have a protective effect for younger siblings in the domains of social language, as older siblings may be modeling appropriate social interactions. Therefore, *Resource Dilution* may only be when considering quantitative metrics of language; older siblings may actually provide *Resource Enrichment* for younger children when considering social metrics of language development.

The other birth order interaction that emerged was a birth order x age interaction that predicted expressive language. Simple slopes revealed second-borns scored significantly higher than first-borns at younger ages (e.g., 4-years-old), but not at older ages (e.g., 15-years-old). These results are surprising considering previous research suggests a first-born advantage in early childhood (e.g., Bornstein et al., 2004). It was hypothesized that this first-born advantage would continue through the youngest age range in the current sample (e.g., 48-mos). However, results indicate the opposite finding to be found: later-borns demonstrated higher scores on VABS-II Expressive Language subscale compared to first-borns in young age; this finding becomes a nonsignificant difference with age. These results may be related to the unusual presentation in the current data related to age and verbal level. In the current sample, there was a main effect of age for expressive language, suggesting that as the sample aged, the expressive language abilities decreased. These results are especially surprising considering the dependent variable was already scaled for age and sex. This unexpected pattern highlights that the older children included in the current sample are not as verbal as the younger children, which is perhaps a reflection of the recruitment approach or difficulty enrolling older, more verbal teenagers. These results are especially unanticipated considering there was a second main effect of age for receptive language, wherein older participants had higher scores (scores already normed for age and sex). Thus, this sample is characterized by younger, verbal children with lower receptive language and older children with high receptive vocabularies but lower expressive skills, which may have driven this age x birth order moderation.

In addition to the main effects of age for expressive and receptive language, socioeconomic demographic factors also emerged as significant main effects: income and maternal education. These main effects replicate previous works suggesting that children from lower socioeconomic statuses (e.g., lower years of maternal education, lower household income) demonstrated less advanced language and lexical development (e.g., Hoff-Ginsberg, 1998). A strength of the current approach was the ability to include both income and maternal education, which helped elucidate some differential impacts of these variables, which are often used alone or summed together to create a composite variable of SES. Our results demonstrated that income predicted expressive language and inappropriate speech, whereas maternal education predicted receptive language and expressive language. These results suggest that maternal education may have a greater impact on measure of *vocabulary* than *social language*, whereas income may impact both *vocabulary* and *social language* processes. Interestingly, income was only related to parent-report metrics, suggesting that family income may play more of a role in a parent-reported instrument assessing language than in an objective measure or clinician-rated measure.

Lastly, it was hypothesized that the number of siblings would be a significant predictor and moderator of language development indices based on previous work by Christensen et al., (2014) and Taylor et al., (2013). In their works using the same Australian sample of children ages 4-8 years, their results demonstrated that after controlling for other demographic factors, number of siblings was significantly related to expressive language and receptive language growth rates. Given the current sample was comparable in demographics, it was anticipated that number of siblings would be a significant risk factor for receptive and expressive language. However, the current results revealed no significant main effect or interaction with number of siblings. Several possible reasons exist for why these findings were not replicated in an autistic sample around the same age. First, Christensen et al., (2014) and Taylor et al., (2013) used longitudinal data to evaluate rates of growth in expressive and receptive language; these metrics were not available in this cross-sectional data. Second, the theoretical model driving these hypotheses is only used with typically-developing youth, not with youth with neurodevelopmental disabilities. When considering the *Resource Dilution Theory*, (Nafissi & Vosoughi, 2015), it is postulated that having more siblings will serve as a risk factor for language given the familial resources would be divided between more people. When adding an ASD diagnosis into the picture, the *Resource Dilution Theory* may not be most appropriate to understand family resource allocation. Previous research suggests that compared to caregivers of typically-developing children and children with other identifiable disabilities, parents of children with ASD report higher levels of stress (e.g., Baker-Ericzén et al., 2005) and allocation of resources (e.g., time, finances; Ganz, 2007; Krakovich et al., 2016). The rates of stress and financial spending increased with lower levels of social and language skills (Baker-Ericzén et al., 2005), which suggests that the current ASD sample with heterogeneous language skills may require a unique allocation of resources that is not evenly divided among all family members.

A better model for family allocation in families with ASD may be the *ABCX Model of Family Stress* (McCubbin & Patterson, 1983), which highlights the interplay between stressful life events (e.g., an ASD diagnosis, as applied to this model in McStay et al., 2014), available resources, and the appraisal of the situation, all of which contribute to the family's adaptation. This model accounts for child-related factors (e.g., severity of problem-behaviors, social skills, language level) as well as external (e.g., services available in rural v urban areas) and internal family factors (e.g., education, income, race). When considering the impact of birth order and siblings from the *ABCX Model*, birth order and number of siblings are not captured explicitly in these factors. Instead, other factors emerge as more relevant to include, such as the aforementioned child-related factors, external, and internal family factors. Conceptualizing the current results in the *ABCX Model* also could explain why a main effect of birth order was not detected in the current work, but instead why it interacted with income (an internal family factor). Other factors implicated by the *ABCX Model* were not evaluated here, including external resources (rural v urban resources) and other child-related factors (e.g., social skills, problem-behaviors). These gaps allow for future work investigating predictors of language development in ASD to consider applying the *ABCX Model* framework to understand important predictors.

Lastly, of note, despite the regression models for receptive and expressive language having acceptable adjusted R^2 variance (65% and 42%, respectively), the models for the *social language* variables demonstrated poor overall fit, only accounting for 2% (inappropriate speech) and .9% (stereotyped speech). These results suggest several factors are missing from these models, which could include factors such as autism severity, expressive language scores, receptive language scores, and overall language. For the current analyses, dependent variables used in other models were not included as independent variables in the *social language* model. However, future work should include ASD-specific severity scores and language scores to understand predictive validity of social language metrics.

Exploratory Results

Although not included as primary aims, additional exploratory aims provide insight into other patterns at play involving birth order and language development. First, the sex dyads of siblings emerged in previous work as predictive of language development (e.g., Havron et al., 2019) especially with the aforementioned sex differences in social communication profiles. Our results identified no significant differences between second-borns residing in either of the three sibling dyads: female-female, female-male, and male-male. However, when taking into account the sex of the second-born child, results suggested that for female second-borns, having an older, female sibling was a significant advantage over having an older, male sibling for overall language level. Despite the small cell sizes of female-female dyads, these results lend some support to the "liability of having a brother" hypothesis (Havron et al., 2019; Steelman et al., 2002), which implies that having an older male sibling may negatively impact language growth. However, the same protective effect of having an older female sibling did not hold for male second-borns and did not extend beyond one language domain (overall language level). Taken together, these results suggest a typically-developing female: autistic female dyad may represent a unique sibling configuration with some protective effects for overall language fluency.

Second, exploratory analyses separated first-borns into three, unique groups: only children, eldest children, and younger children to evaluate the impact of having younger siblings on language development. Results revealed no significant differences between sibling groups on any dependent measure, which suggests no significant impact of having younger siblings on language development for autistic youth. Although some previous research suggests that only children report higher levels of verbal achievement and verbal IQ than children with siblings (e.g., Polit & Falbo, 1988), this work has not been heavily replicated and most birth-order work continues to focus on first-borns versus second-borns to equate for family size (e.g., Hoff-Ginsberg, 1998).

Neurobiology and Context

Although the majority of the current discussion emphasized the contextual and experiential components of language learning in autistic youth, it is important to note the neurobiological bases of ASD and subsequent implications. For example, in the current results, demographic factors accounted for little variance in the *social language* models (e.g., ABC-IS and ADOS-SS), despite including numerous predictors with a sufficiently powered sample. These results suggest that there may be other neurobiological factors contributing to the severity of the social communicative outcomes in ASD, including core features of the disorder that contribute to ASD severity, language outcomes, and adaptive functioning outcomes. For example, epidemiological data from 348 toddler twin pairs suggested that there are three, highly-heritable predictors of autism severity: variation in attention, motor coordination, and parental autistic trait burden (Pohl et al., 2019). These neurobiological factors inherent to ASD were unaccounted for in the current study and, if included in subsequent models, may emerge as significant predictors of *social language* above and beyond those addressed here.

Second, considering the neurobiology of ASD may aid in interpreting the unusual sex findings observed in the current study, and underscoring the predominantly male sample (7:1 male: female). A novel study investigating the genotype of the siblings in the SSC dataset confirmed that female autistic siblings convey higher rates of ASD than siblings of autistic males, and that mothers carried more polygenic risk for ASD than fathers. Results further suggested that female transmission of de novo variants was overly inherited at a rate three-times that of male transmission (Wigdor et al., 2021). These genetic results could explain the sex severity discrepancy in the SSC data, wherein males scored significantly higher on measures of FSIQ and language than females, which did not replicate previous literature regarding sex differences and language.

Taken together, whereas contextual and experiential factors contributing to language outcomes are crucial to consider, especially in the frame of designing intervention studies, it remains important to consider the neurobiological roots of ASD and the inherent genetic contributions that may remain unaccounted for in contextual studies.

Limitations and Strengths

The present study had several limitations. Due to limitations of the available data, several research questions could not be answered in the current sample, including the impact of the age gap between siblings on language development, the impact of being a nonsingleton (e.g., twin or triplet), the role of the caregiving setting (e.g., home, daycare), and the role of birth order in bilingual families. As discussed in greater detail above, the sample of children and adolescents was older, which could have impacted the ability to detect impacts of sibling status on early language development. The chosen language development variables, while diverse in their method (i.e., parent-report and direct-assessment), were standardized and did not include any naturalistic samples, which limited the degree of valid language variables such as tokens or mean length of utterance that could be used as metrics of expressive language. Third, in addition to the sample age, the sample was predominantly male. This is common in work with ASD, as the assumed male to female ratio is 4:1, although reported statistics are closer to 3:1 and hypothesized to be even closer to 1:1 (Loomes et al., 2017). However, the current sample's sex ratio was closer to 7:1 (2092:295), which could be a reflection of the date of the creation of the SSC dataset (2008-2010) and reliance on DSM-IV instead of DSM-5. Thus, these results may be an overemphasis on the male experience and may not generalize to females with ASD.

Related to the third limitation above about the sample being predominantly male, although the SSC dataset is well-characterized and large, it is slightly outdated (Fischbach & Lord, 2010). The SSC dataset used DSM-IV diagnostic classification for inclusion criteria in the study. As such, with diagnostic changes brought about by the DSM-5 (APA, 2013), the SSC may not reflect participants considered as autistic today. First, the current dataset may include participants who would otherwise not meet DSM-5 diagnostic criteria for ASD. Work by Huerta et al., (2012) suggested that the DSM-5 ASD diagnosis captured approximately 91% of the youth previously diagnosed with PDD-NOS but omitted approximately 9% of DSM-IV children as borderline or non-ASD determined by DSM-5 standards. Second, the reliance on DSM-IV in the current sample may have omitted participants who would otherwise be captured by the DSM-5 diagnoses; specifically, females with ASD who may be described as "higher functioning" with higher language levels and adaptive functioning levels (Peters & Matson, 2020). The potential exclusion of more verbal females is particularly relevant in the current study as the cognitive sex differences accounted for significant variability predicting language. As such, conducting the same study with a DSM-5 sample of cognitively-diverse autistic youth may reveal new differences in linguistic predictors, especially related to the sex main effect findings.

In addition to the aforementioned limitations of the older, predominantly male sample reliant on DSM-IV criteria, the SSC sample was predominantly white and middle-to-upper class.

Despite having a range of income and educational levels, the majority of the families and participants can be described as families with ample resources, which may limit the generalizability to under-resourced or lower-income families. Naturally, stringent controls were required for the genotypic and phenotype criteria of the SSC project. However, as a result, the autistic sample had limited comorbidities (genetically, medically, and psychiatrically). Given previous work suggesting at least 58% of autistic youth have another comorbid psychiatric disorder (van Steensel et al., 2013), the SSC collection does not reflect the larger demographic of autistic youth globally and may limit the generalizability of these findings.

Lastly, a core aim of the current study was to evaluate the impact of having an older, *typically-developing* sibling for youth with ASD. Previous works have used multiplex families where multiple children have ASD, so the emphasis on having an unaffected sibling in the current study was important and novel. Previous works have detailed a familial broader autism phenotype, which suggests that unaffected family members may also demonstrate social and communication deficits of a milder presentation (Piven et al., 1997). If the broader autism phenotype was present in the current study for some families, it is possible that the "typically-developing" siblings may have been atypical in regard to social communication, which could have impacted the sibling's language development. This potential methodological concern can be addressed in the SSC dataset. The siblings were required to have subclinical thresholds on all measures of ASD to be included as "unaffected siblings". Indeed, results suggested siblings were "unaffected" in terms of social communication as indicated by average t-scores on the Social Responsiveness Scale edition (M = 43.97, SD = 7.24). Although previous works have noted limitations of the SRS in isolation for ruling in or out ASD (see Capriola-Hall et al., 2020), the typically-developing siblings can largely be considered unaffected siblings by their social/communication score profiles and their medical/family history assessment.

Despite these limitations, the current study has numerous strengths, including a large, well-characterized sample and the inclusion of family demographic variables that had previously been missing in birth-order studies (e.g., maternal education, family income, sibling data, number of siblings, race/ethnicity; Liang & Sugawara, 1996; Zajonc & Sulloway, 2007). The current study included numerous metrics of language development, including parent-report and standardized assessment, and measures of different constructs including *vocabulary* (expressive/receptive language) and *social language* (atypical and repetitive speech). Importantly, the current study also included a range of language and cognitive functioning in ASD, which is often missing from literature investigating language in ASD (Koegel et al., 2020). The inclusion of non-verbal and minimally-verbal children with ASD focusing on verbal expressive communication is a clear strength.

Conclusion

To date, this is the first work to investigate the relationship between birth order and sibling configuration on language development in autistic children. Despite previous evidence suggesting a small, albeit significant, impact of birth order on expressive and receptive language in typical-development, the current results do not support the previous findings when extending them to autistic youth. The large sample size, paired with high-confidence Bayesian estimates, provide certainty in supporting the null hypothesis. Several reasons for the lack of significant findings related to birth order in ASD exist, including the heterogeneity of language outcomes in ASD, the lack of salience birth order has in terms of *Resource Dilution* for families impacted by an ASD diagnosis, and the use of an older sample with standardized language measures used for the current analyses.

Despite a lack of overall support for the impact of birth order on language development in youth with ASD, some interesting patterns did emerge that warrant further exploration. Birth order, in lower-income families with autistic children, may have a stronger impact on expressive, receptive, and social language skills. Specifically, autistic second-borns in lower-income families may be slower to develop expressive and receptive skills, but faster to develop more socially-appropriate language. These results replicate previous research highlighting the impact of income on language development (e.g., Hoff, 2006) and further underscore the importance of lower-income families impacted by ASD having access to speech and language intervention services. Interestingly, including siblings in social language interventions may have added benefits for lower-income families and is an area for future exploration.

Additionally, the sex dyad match may also play a role in language development for youth with ASD. The current exploratory results suggested that females with ASD who have older, female siblings have stronger overall language than females with ASD who have an older, male sibling. Our results did not fully support the “liability of having an older brother” hypothesis (Havron et al., 2019), as males with an older female sibling did not show the same benefit. However, given the field’s recent interest in the female phenotype of ASD, including social camouflaging (see Tubío-Fungueiriño et al., 2020, for a review), future work with a better sex-balanced sample could elucidate some mechanisms in sex dyad matches driving language development.

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Tables

Table 1

Descriptive Statistics and Correlations Between Study Variables (Entire Sample)

Variable	*N*	*M(SD) or mode*	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Birth Order	2753	1.69 (.83)	--												
2. Child Age (yrs)	2758	9.03 (3.57)	-.015	--											
3. Family Income	2600	$81,000-$100,000	.016	.024	--										
4. Maternal Education	2742	College graduate	-.007	-.052	.420**	--									
5. Number of Siblings	2856	1.40 (.90)	.555**	-.013	-.004	-.010	--								
6. Child FSIQ	2752	81.17 (27.96)	-.020	-.007	.098**	.122**	-.020	--							
7. Autism Severity	2683	7.44 (1.68)	-.027	-.010	.017	.014	-.029	-.185**	--						
8. Receptive Language	2725	84.70 (29.21)	-.009	-.021	.075**	.113**	-.012	.888**	-.185**	--					
9. Expressive Language	2850	10.13 (3.33)	-.017	-.193**	.112**	.127**	-.018	.657**	-.143**	.636**	--				
10. Overall Language Level	2853	.16 (.47)	.017	-.082**	-.089**	-.081**	.048	-.558**	-.009	-.507**	-.512**	--			
11. Age of First Words (mos)	2650	24.42 (14.90)	-.014	.034	-.103**	-.106**	-.002	-.277**	.024	-.293**	-.236**	.134**	--		
12. Age of First Phrases (mos)	2483	39.18 (18.40)	.006	.083**	-.064	-.113**	-.020	-.460**	.100**	-.513**	-.382**	.196**	.671**	--	
13. Inappropriate Speech	2753	3.63 (2.96)	-.034	-.013	-.071**	-.053	-.015	-.109**	.160**	-.124**	-.085**	-.136**	.058	.128**	--
14. Stereotyped Speech	2702	1.04 (.74)	-.006	-.012	-.022	-.011	.011	-.058	.020	-.063*	-.038	.041	.025	.059	-.007

Note. FSIQ = Full Scale Intelligence Quotient. Applying a Bonferroni correction for number of correlations (91), the asterisks reflect the adjusted significance value. ** = p < .0005, *p <.001

Table 2

Demographic Statistics for First-borns and Second-borns

	First-borns (N = 1338)	Second-borns (N = 1049)	X^2/t
Average age in years (*SD*)	8.99 (3.53)	9.08 (3.62)	-.595
Females (%)	173 (13.37)	122 (12.15)	.762
Race (n = 2290; %)			.381
White	1027 (76.8)	788 (75.1)	
Asian	51 (3.8)	40 (3.8)	
African American	50 (3.7)	38 (3.6)	
Multi-racial	99 (7.4)	81 (7.7)	
Other/not specified	63 (4.7)	53 (5.1)	
Average Income (n = 2162)	$81,000-$100,000	$81,000-$100,000	3.550
Maternal Education (%)			6.361
Graduate degree	331 (24.7)	251 (23.9)	
College graduate	459 (34.3)	350 (33.4)	
Associates degree	103 (7.7)	75 (7.1)	
Some college	283 (21.2)	221 (21.1)	
GED/High school graduate	93 (6.9)	93 (8.8)	
Some high school	14 (1.0)	7 (.7)	
Less than 9th grade	1 (.1)	2 (.2)	
Average number of siblings (*SD*)	1.08 (.72)	1.40 (.69)	-10.97*
Average child FSIQ (n = 2294)	81.63 (27.33)	81.75 (28.06)	-.105
Average ADOS Comparison Score (*SD*)	7.44 (1.69)	7.49 (1.68)	-.660

Note. GED = General Educational Development degree, FSIQ = Full Scale Intelligence Quotient, ADOS = Autism Diagnostic Observation Schedule. Where n is specified, only a subset of participants had valid data; otherwise, statistics are presented from the total sample size of N = 2387. * = p <.01

Table 3

Bayesian ANOVA to Evaluate Group Differences in Vocabulary and Social Language by Birth Order Status

	First-borns	Second-borns	BF_{10}	BF_{10} Interpretation
	M (*SD*)	*M* (*SD*)		
Vocabulary				
PPVT-4 receptive standard score	84.71 (28.73)	86.05 (29.35)	.002	Extreme evidence for H_0
VABS-II expressive v-score	10.20 (3.54)	10.14 (3.13)	.0001	Extreme evidence for H_0
ADI-R overall language score	.16 (.47)	.15 (.45)	.005	Extreme evidence for H_0
Age of 1st words	24.56 (14.82)	24.03 (15.16)	.003	Extreme evidence for H_0
Age of 1st phrases	39.22 (18.51)	38.19 (17.81)	.072	Strong evidence for H_0
Social Language				
ABC-IS subscale	3.72 (3.00)	3.54 (2.88)	.006	Extreme evidence for H_0
ADOS stereotyped speech	1.512 (.612)	1.512 (.627)	.004	Extreme evidence for H_0

Note. PPVT = Peabody Picture Vocabulary Test 4th Edition, VABS = Vineland Adaptive Behavior Scales 2nd Edition, ADI-R = Autism Diagnostic Interview-Revised, ABC-IS = Aberrant Behavior Checklist- Inappropriate Speech, ADOS = Autism Diagnostic Observation Schedule, BF_{10} = Bayes Factor giving evidence for H_1 over H_0, H_0 = null hypothesis.

Table 4

Standardized Coefficient Regression Models for Measures of Vocabulary: (a) Receptive and (b) Expressive Language

		PPVT-4: Receptive Language				VABS-II: Expressive Language			
Model		ß	t	Adj. R^2	F Change	ß	t	Adj. R^2	F Change
1	(Constant)		-.839	.651	905.42***		10.835***	.417	358.210***
	Sex	-.018	-1.504			.012	.787		
	Age	.030	2.460*			-.174	-11.376***		
	Income	.011	.806			.046	2.715**		
	Maternal Education	.041	3.088**			.051	3.015**		
	Nonverbal IQ	.805	66.391***			.603	39.040***		
2	(Constant)		-.991	.651	.203		10.268***	.416	.046
	Sex	-.018	-1.486			.012	.783		
	Age	.030	2.469*			-.174	-11.371***		
	Income	.010	.789			.046	2.717**		
	Maternal Education	.041	3.095**			.051	3.016**		
	Nonverbal IQ	.805	66.370***			.603	39.018***		
	Number of Siblings	.001	.046			.005	.290		
	Birth Order	.007	.504			-.004	-.232		
3	(Constant)		-1.340	.651	.533		8.301***	.418	2.256*
	Sex	-.018	-1.481			.011	.742		
	Age	.030	2.488*			-.174	-11.354***		
	Income	.011	.838			.045	2.664**		
	Maternal Education	.040	3.039***			.051	2.993**		
	Nonverbal IQ	.806	66.227***			.604	39.079***		
	Number of Siblings	.002	.148			.007	.362		
	Birth Order	.035	1.081			.003	.085		
	Sex * Birth Order	-.028	-.934			-.010	-.255		
	Age * Birth Order	-.009	-.775			-.045	-2.899**		
	Income * Birth Order	.018	1.275			.038	2.156*		
	Maternal Education * Birth Order	-.010	-.725			-.004	-.222		
	Nonverbal IQ * Birth Order	.006	.505			.000	.002		
	Number of Siblings * Birth Order	-.008	-.527			-.010	-.508		

Note. PPVT-4 = Peabody Picture Vocabulary Test, 4^{th} Edition. VABS-II = Vineland Adaptive Behavior Scales, 2^{nd} edition. *** = $p < .001$, ** = $p < .01$, * = $p < .05$

Table 5

Standardized Coefficient Regression Models for Measures of Social Language: (a) Inappropriate Speech and (b) Stereotyped Speech

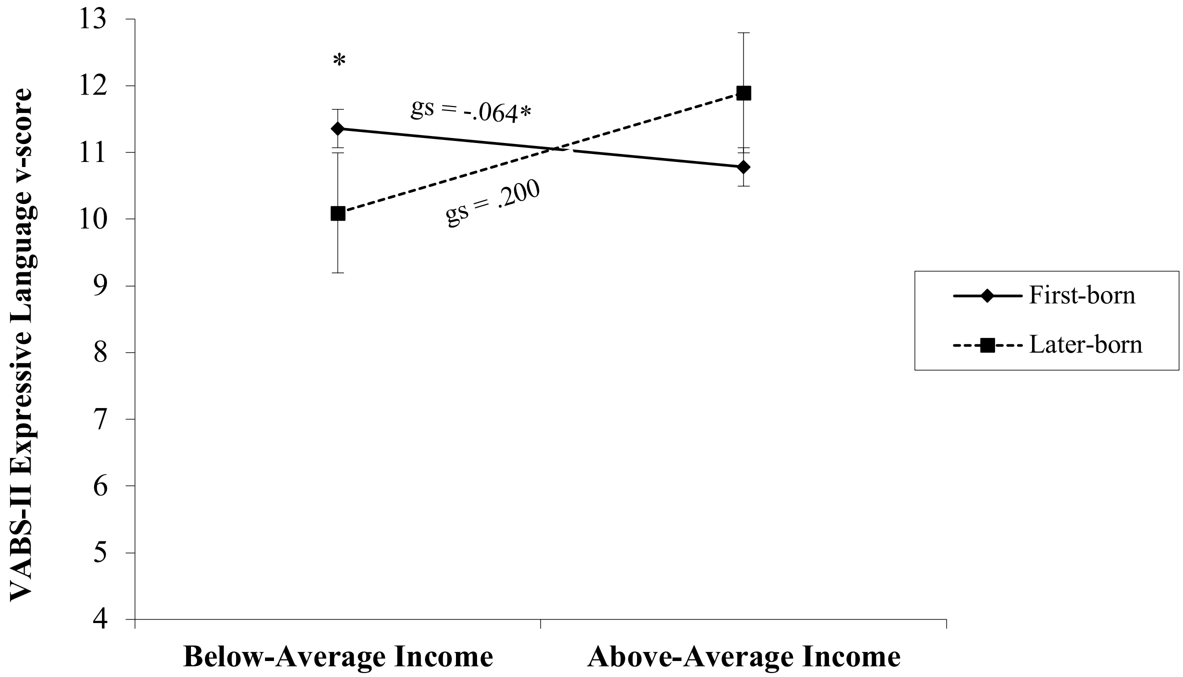
		ABC Inappropriate Speech				ADOS Stereotyped Speech			
Model		ß	t	Adj. R^2	F Change	ß	Wald	Nagelkerke R^2	X^2
1	(Constant)		14.325***	.017	9.871***		6.014*	.002	17.935*
	Sex	-.002	-.087			.032	.059		
	Age	-.023	-1.144			.001	2.055		
	Income	-.056	-2.531*			-.012	.296		
	Maternal Education	-.026	-1.160			-.026	.662		
	Nonverbal IQ	-.112	-5.579***			-.001	.359		
2	(Constant)		14.001***	.017	1.022		-.699*	.003	4.928
	Sex	-.003	-.128			.032	.059		
	Age	-.023	-1.170			.001	2.047		
	Income	-.055	-2.495*			-.012	.299		
	Maternal Education	-.026	-1.178			-.026	.677		
	Nonverbal IQ	-.112	-5.604***			-.001	.363		
	Number of Siblings	.004	.177			-.045	.572		
	Birth Order	-.031	-1.277			.023	.128		
3	(Constant)		12.238***	.020	2.015*		-.462	.009	15.409
	Sex	-.007	-.339			.026	.038		
	Age	-.022	-1.131			.001	1.900		
	Income	-.056	-2.564*			-.012	.292		
	Maternal Education	-.026	-1.204			-.026	.672		
	Nonverbal IQ	-.111	-5.522***			-.001	.407		
	Number of Siblings	.004	.154			-.029	.228		
	Birth Order	-.091	-1.716			-.110	.513		
	Sex * Birth Order	.062	1.225			.201	1.595		
	Age * Birth Order	-.006	-.293			.002	3.154		
	Income * Birth Order	.069	2.974**			-.015	.292		
	Maternal Education * Birth Order	-.010	-.431			-.059	2.060		
	Nonverbal IQ * Birth Order	-.008	-.400			.001	.085		
	Number of Siblings * Birth Order	.002	.081			-.052	1.829		

Note. ABC = Aberrant Behavior Checklist; ADOS = Autism Diagnostic Observation Schedule. *** = $p < .001$, ** = $p < .01$, * = $p < .05$

Figures

Figure 1

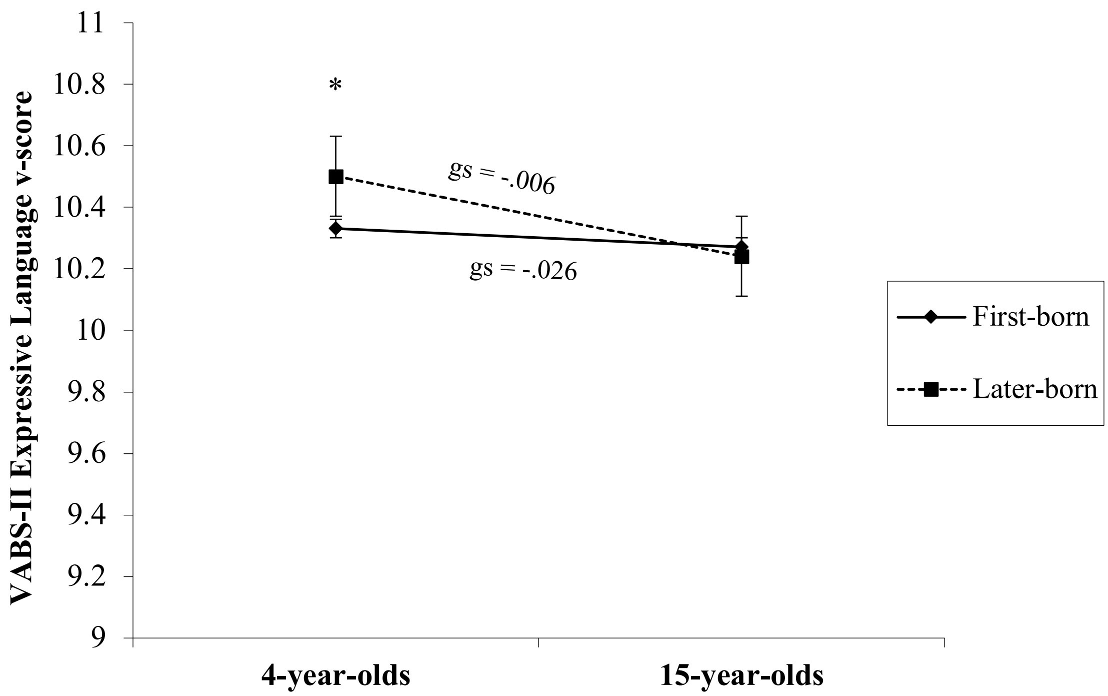
Birth Order x Income Interaction for Expressive Language



Note. Average VABS-II Expressive Language v-scores for first-borns and later-borns across below-average and above-average income families. "Average" income was determined by the average of the current sample, (~$78,000). Y-axis truncated to visibly present statistically significant results. Error bars show standard errors. VABS- II = Vineland Adaptive Behavior Scales, 2nd Edition, gs = gradient slope. * = $p < .05$

Figure 2

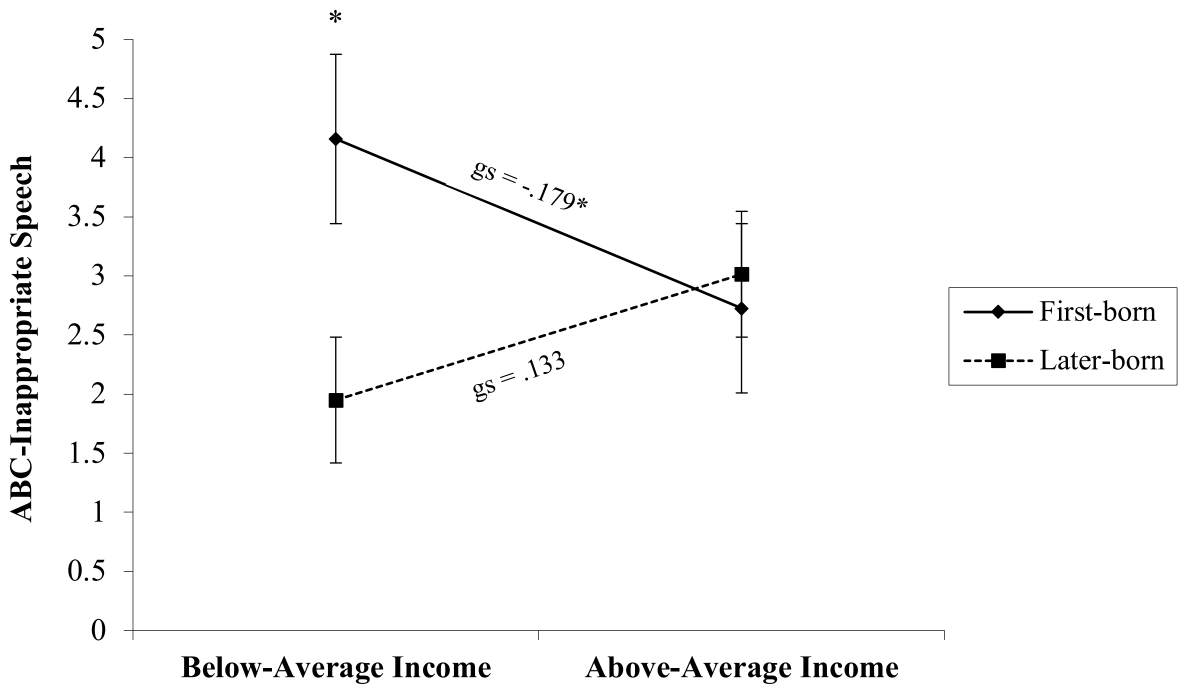
Birth Order x Age Interaction for Expressive Language



Note. Average VABS-II Expressive Language v-scores for first-borns and later-borns across age. Error bars show standard errors. Y-axis truncated to visibly present statistically significant results. VABS- II = Vineland Adaptive Behavior Scales, 2nd Edition, gs = gradient slope. * = $p < .05$

Figure 3

Birth Order x Income Interaction for Inappropriate Speech



Note. Average ABC-Inappropriate Speech subscale scores for first-borns and later-borns across below-average and above-average income families. "Average" income was determined by the average of the current sample, (~$78,000). Error bars show standard errors. ABC = Aberrant Behavior Checklist, gs = gradient slope. * = $p < .05$.

Appendix A: Supplementary Materials

Supplementary Table 1

Group Differences in Dependent Variables by Same- and Opposite-Sex Pairs in Second-borns

	Female-Female (N = 51)	Female-Male (N = 446)	Male-Male (N = 324)	F (df)	p
	M (SD)	M (SD)	M (SD)		
Vocabulary					
PPVT-4 receptive	81.35 (31.50)	86.74 (28.71)	84.68 (29.99)	1.032 (819)	.357
VABS-II expressive	9.71 (3.36)	10.03 (3.10)	9.95 (3.04)	.270 (819)	.763
Overall language	.10 (.36)	.15 (.45)	.14 (.42)	.406 (819)	.666
Age of 1st words	24.65 (17.75)	24.73 (14.70)	24.37 (16.42)	.050 (819)	.951
Age of 1st phrases	40.08 (18.601)	39.00 (18.71)	38.57 (18.59)	.152 (819)	.859
Social Language					
ABC-IS subscale	3.69 (2.65)	3.61 (2.95)	3.47 (2.82)	.278 (819)	.757
Stereotyped speech	1.71 (.54)	1.51 (.64)	1.53 (.61)	2.428 (819)	.089

Note. PPVT-4 = Peabody Picture Vocabulary Test- 4th Edition, VABS-II = Vineland Adaptive Behavior Scales- 2nd Edition, ADI-R = Autism Diagnostic Interview-Revised, ABC-IS = Aberrant Behavior Checklist- Inappropriate Speech, ADOS = Autism Diagnostic Observation Schedule.

Supplementary Table 2

Group Differences in Dependent Variables by Birth Order Status: Only Children, Eldest Children, and Youngest Children

	Only Children (N = 198)	Eldest Children (N = 929)	Younger Children (N = 1153)	F (df)	p
	M (SD)	M (SD)	M (SD)		
Vocabulary					
PPVT-4 receptive	86.80 (26.72)	88.43 (25.81)	87.37 (27.47)	.198 (2273)	.821
VABS-II expressive	10.57 (2.64)	10.60 (2.68)	10.46 (2.77)	.776 (2273)	.460
Overall language	.06 (.24)	.05 (.22)	.06 (.24)	1.306 (2273)	.274
Age of 1st words	24.48 (13.85)	24.21 (14.48)	23.42 (13.54)	.356 (2273)	.701
Age of 1st phrases	39.74 (17.61)	39.15 (18.76)	38.69 (18.12)	.233 (2273)	.792
Social Language					
ABC-IS subscale	3.97 (3.07)	3.86 (2.97)	3.65 (2.92)	2.707 (2273)	.067
Stereotyped speech	1.07 (.68)	1.11 (.73)	1.10 (.72)	.425 (2273)	.654

Note. PPVT-4 = Peabody Picture Vocabulary Test- 4th Edition, VABS-II = Vineland Adaptive Behavior Scales- 2nd Edition, ADI-R = Autism Diagnostic Interview-Revised, ABC-IS = Aberrant Behavior Checklist- Inappropriate Speech, ADOS = Autism Diagnostic Observation Schedule. MANCOVA controlling for child age.