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Language Experience, Cognitive Skills, and English and Spanish Semantic Abilities in Bilingual Children with Typical Development and Language Impairments.

Marika King¹, Nicole Lim², and MaryAnn Ronski³

¹Utah State University, USA

²International Institute for the Brain, USA

³Georgia State University, USA

Corresponding author: Marika King, Department of Communicative Disorders and Deaf Education, Utah State University, 1000 Old Main Hill, Logan, UT 84322-1400, USA.
Email: marika.king@usu.edu

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

Abstract

Purpose: The purpose of this study was to examine the relationships between language experience, nonverbal cognitive abilities, and English and Spanish semantics skills in 4-6 year old bilingual children with typical development compared to bilingual children with language impairments.

Methodology: Participants were 57 Spanish-English bilingual children (ages 4:0 – 6:11) with typical development ($n = 35$) or language impairments ($n = 22$). Parents provided demographic information and detailed information about their child's language input (exposure) and output (use). Children's nonverbal IQ and processing speed abilities and English and Spanish semantic abilities were measured using standardized assessments.

Data and Analysis: Nonparametric statistical analyses were used to examine relationships between variables across two groups (children with typical development and children with language impairments) and across Spanish and English semantic skills.

Findings: Processing speed showed a significant, moderate correlation with Spanish and English semantic abilities in both groups, however language experience variables showed weak, non-significant associations with semantic abilities.

Originality: This study is the first to investigate the relationships between both language experience factors as well as nonverbal cognitive and processing skills and the semantic abilities of bilingual children with typical development and language impairments.

Implications: This research furthers understanding of the environmental and child-internal influences on semantic abilities in bilingual children with and without language impairments.

Key words: Bilingualism, Language Impairment, Language Environment, Semantic Abilities

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

Language experience, cognitive skills, and English and Spanish semantic abilities in bilingual children with typical development and language impairments.

A key area of research in bilingualism is devoted to understanding lexical-semantic development in bilingual children. Lexical-semantic abilities can be considered in terms of vocabulary breadth and depth. Breadth corresponds to vocabulary size while depth describes the richness of word-knowledge and includes a multi-faceted understanding of the connections between words and their properties (Ordonez et al., 2002). Although related, depth and breadth are considered separable constructs with varying developmental trajectories (Schmitt, 2014; Van Goch et al., 2019).

A child's early years are a time of rapid vocabulary expansion (i.e., growth in vocabulary breadth). During the preschool years however, children begin to gain a deeper knowledge of the semantic relationships between words and concepts (i.e., vocabulary depth) as semantic networks increase in complexity and organization (Nelson, 1977; Nelson & Nelson, 1990; Wojcik, 2018; Wojcik & Kandhadai, 2020). In bilingual children, growth in vocabulary breadth generally parallels that of monolingual children when the children's vocabulary in both languages is considered (e.g., Bosch & Ramon-Casas, 2014; Core et al., 2013; Hoff et al., 2012; Patterson, 1998; Pearson & Fernandez, 1994). In terms of vocabulary depth, bilingual children appear to experience similar developmental changes in the organization of semantic networks (e.g., in category development and organization) when compared to monolingual peers (Peña, et al., 2003; Jardak & Byers-Heinlein, 2019). While both vocabulary size and organization are considered important predictors of lexical abilities (Schmitt, 2014), studies of preschool and school-aged bilingual children indicate that vocabulary depth uniquely contributes to academic

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

performance, specifically reading abilities (e.g., Leider et al., 2013; Proctor et al., 2012; Silverman et al., 2015).

The majority of studies in bilingual lexical-semantic development, however, have focused on measuring vocabulary growth in bilinguals by investigating the size of bilinguals' vocabulary across languages (e.g., Hoff et al. 2014; Leseman, 2000; Pearson et al., 1993; Thordardottir, 2011; Uchikoshi, 2006). Fewer studies have investigated semantic abilities in bilingual children by measuring vocabulary depth and fewer still have investigated these abilities in bilingual children with language impairments. Approximately 7 - 12% of children aged five to six have language impairments (Beitchman et al., 1986; Tomblin et al., 1997), yet historically bilingual children with language impairments have been excluded from research. Understanding the factors that drive semantic organization in bilingual children—including the relative importance of language experience and internal abilities—deepens our understanding of semantic development in bilingual children and importantly can inform clinical interventions for children with language impairments. The purpose of this study was to investigate semantic abilities in preschool-aged bilingual children with typical development and language impairments by examining the relationships between vocabulary depth and both internal and external factors.

Language Experience and Vocabulary Depth

For decades, researchers in bilingual language development have worked to disentangle the effects of language environment on language outcomes. Given the heterogeneity of the bilingual experience, this task is challenging, and to date there is not a consensus among scholars regarding the relationship between language experience (e.g., exposure and use) and language abilities. For example, studies of semantic priming in young bilinguals have yielded mixed

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

findings. Singh (2014) reported that in 2.5-year-old Mandarin-English speaking simultaneous bilinguals, language dominance was associated with increased lexical connections within and across languages. Singh found that a prime in the dominant language would increase recognition of the target in the non-dominant language but a prime in the non-dominant language did not boost recognition of a target in the dominant language. However, in two recent studies, Floccia and colleagues (2020) and Jardak & Byers-Heinlein (2019) found that 27- and 30-month-old simultaneous bilinguals (respectively) showed semantic priming within and across languages but with no effect of language dominance. Carroll (2017) suggested that perhaps inconsistencies across studies in the way language environment and language outcomes are measured may contribute to the mixed findings in this area. Thus, it may be most valuable to compare findings across studies that focused on similar outcomes and used parallel measures of language environment.

Few studies have specifically examined the effects of language environment on children's vocabulary depth, yet the available research suggests that a child's language experience (i.e., the languages they hear and use) is an important predictor of semantic abilities that indicate vocabulary depth in bilingual children (Bedore et al., 2012; Sheng et al., 2012, 2013). To measure language experience, Bedore, Sheng and colleagues relied on parent report, asking parents to detail the hour-by-hour language exposure and use of their children during a typical week. Language use was operationalized as the average language input and output. Sheng and colleagues (2013) investigated vocabulary associations in Spanish-English bilingual children (ages 7-9) with typical development, and found that the effect of language use was larger than that of age in predicting the number of semantic responses children produced and children consistently performed better in the language they used more frequently compared to their lesser

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

used language. In another study of over 1000 Spanish-English bilingual pre-kindergarteners in the United States, Bedore et al. (2012) found that different levels of language use predicted variation in performance on semantic tasks measuring vocabulary depth. When compared with age of exposure to English, the authors concluded that current language use was a stronger predictor of English and Spanish semantic abilities. Findings from these studies indicate that individual differences in language experience (determined by parent report) are associated with variability in semantic skills that measure vocabulary depth.

Child-Internal Factors and Vocabulary Depth

Although evidence points to a link between language environment and semantic depth in bilingual children, the contribution of child-internal factors to lexical-semantic development, cannot be overlooked. However, child-internal factors such as gender, age, and linguistic and cognitive abilities may influence and be influenced by external factors and trajectories of dual language development differ due to the various interacting internal and external influences. The bidirectional relationship between environmental factors and child internal factors is particularly apparent in the amount of dual language input a child receives at home. For instance, mothers talk more to older children than younger bilinguals (De Houwer, 2014) and mothers may stop using a particular language in response to a child's perceived difficulties with it (De Houwer & Bornstein, 2016). Despite the potential interactions between environmental and individual factors, individual differences in child internal factors such as language and cognitive abilities may uniquely contribute to variability in bilingual children's lexical outcomes (e.g., Paradis, 2011; Castilla-Earls et al., 2009). Given the variability in quality, quantity and timing of bilingual language exposure and use, understanding the role of internal factors such as cognitive

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

abilities and language impairment may be equally if not more important as the role of environmental factors in semantic development.

Cognitive abilities

Several studies indicate that a child's non-linguistic cognitive abilities such as nonverbal IQ and processing speed, impact bilingual language outcomes (e.g., Collins et al., 2014; Hurtado et al., 2014; Marchman et al., 2010; 2017). Most studies, however, have not specifically measured the impact of these cognitive skills on vocabulary depth. Collins et al. (2014) investigated environmental and child-internal factors that influenced dual language profiles of bilingual children from kindergarten to second grade. The authors found that nonverbal IQ significantly differentiated children whose dual language proficiency shifted from low performing to competent, from kindergarten to second grade.

Processing speed, or the efficiency with which a child performs basic cognitive functions, may also be related to lexical-semantic ability as basic lexical processing is necessary to access and recognize spoken words. A small number of studies have investigated the effects of lexical processing speed abilities on a child's bilingual language acquisition. Marchman et al. (2010) found that in 30-month old Spanish-English bilingual children, lexical processing speed and vocabulary knowledge within each of the child's languages were strongly related. In another study, Hurtado et al. (2014) found that in bilingual toddlers, processing speed predicted additional unique variance in vocabulary size in each language beyond relative language exposure. However, these studies used outcome measures of vocabulary breadth rather than vocabulary depth. Given that development of vocabulary depth likely recruits more global processing measures, it is important to investigate how global processing speed abilities might impact semantic development in bilingual children.

Language Impairment in Bilingual Children

Research investigating predictors of semantic abilities in bilingual children points to the effects of language experience as well individual cognitive and processing abilities. The research findings raise the question as to whether the same factors are important when considering the semantic abilities of bilingual children with language impairments. Deficits in semantic abilities have been identified as important markers of language impairment in bilingual children (Sheng et al., 2012, 2013) and assessments of semantic abilities may be used to accurately identify bilingual children with language impairments (Peña et al. 2016). Furthermore, compared to bilingual peers with typical development, bilingual children with language impairments demonstrate deficits in semantic convergence, or the degree with which their patterns of word use overlap with patterns used by adults from similar cultural and linguistic backgrounds (Sheng, et al., 2013; Shivabasappa et al., 2019). Thus, understanding the role of environmental and intrinsic factors that predict vocabulary depth is important for the development of effective clinical language interventions for children with language impairments.

To our knowledge only one study has specifically investigated factors that influence vocabulary depth in bilingual children with language impairments. Sheng et al. (2012) investigated child-internal and environmental factors that were related to semantic development in Spanish-English bilingual school-aged children with and without language impairments. Thirty-seven children with typical development were age-matched to 37 peers with language impairments. The children's responses on word-association tasks in English and Spanish were used to derive a semantic depth score. The authors found that current English use, but not socio-economic status, maternal education, or age of first exposure to English was related to vocabulary depth in English in children in both groups. Current English use was not significantly

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

related to Spanish vocabulary depth or to a conceptual measure of vocabulary depth that combined English and Spanish vocabulary depth scores. Sheng and colleagues found no difference in predictors of vocabulary depth across children with and without language impairments. However, in other areas of language (e.g., vocabulary breadth, grammatical abilities, and narrative abilities) studies indicate differential effects of predictors of language abilities across groups (Castilla-Earls et al., 2016; Gibson et al., 2014; Govindarajan & Paradis, 2019).

The Current Study

Few studies have systematically investigated predictors of semantic abilities in bilingual children by examining vocabulary depth and even fewer have included children with language impairments. While several studies have directly measured the effects of language experience on semantic outcomes in bilingual preschool and school-aged children, no studies have specifically measured the effect of nonverbal cognitive and processing abilities on bilingual children's semantic abilities. Understanding the role of language experience as well as child-internal abilities such as nonverbal IQ, and processing speed on semantic abilities is particularly important to inform theoretical understanding and clinical practice. Despite evidence that bilingualism does not appear to exacerbate language impairment (see Kay-Raining Bird et al., 2016), it is less clear whether environmental and child-internal factors that influence language outcomes for typically developing bilinguals similarly affect bilingual children with language impairments. Therefore, it is critical to investigate whether group differences exist between bilingual children with and without language impairments with regard to predictors of semantic abilities that indicate vocabulary depth. The aim of the current study was to identify the relationships between language experience (e.g., language exposure, language use, age of first

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

exposure to English) and nonverbal cognitive abilities (nonverbal IQ and processing speed) and English and Spanish semantics abilities in 4 - 6-year-old bilingual children with typical development and with language impairments. Children in the 4-6 age-range were included in this study because these years are an important period in the development of vocabulary depth as children gain metalinguistic awareness of the taxonomic and lexical properties of words (Hadley et al., 2016; 2019; Lucariello et al., 1992; Lam & Sheng, 2020). We hypothesized that the language experience variables would be more strongly related to semantic abilities in both groups than nonverbal cognitive abilities.

Method

Participants

Prior to beginning the study, parent participants provided written informed consent for participation and child participants gave either written or verbal assent according to the Georgia State University Institutional Review Board requirements. Participants were originally recruited for a study of bilingual language differentiation (King et al., 2021) and were recruited from elementary schools, community locations, and clinics in the metro Atlanta area.

Fifty-seven Spanish-English bilingual children and each child's parent participated in the study. Child participants were ages 4;0 – 6;11 ($M = 5.34$ years, $SD = .86$) and were exposed to Spanish and English (and no other language) at least 20% of the time as measured by parent report. All children passed a hearing screening at the time of testing (25dB at 1000, 2000, 4000 Hz bilaterally) or had passed a hearing screening within the six months prior to beginning the investigation. According to parent report, children's vision was within normal limits or children used corrective lenses ($n = 8$).

For analysis, we divided participants into two groups: children with typical development and children with language impairments. Using converging evidence (e.g., standardized test

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

scores, parent report) is best practice in identification of bilingual children with language impairment (Castilla-Earls et al., 2020; Sheng et al., 2012) and frequently a criteria threshold is used to operationalize language impairment in research with bilingual children (e.g., Gross & Kaushanskaya, 2020; Restrepo et al., 2013; Sheng et al., 2012). For the purpose of this research, we identified children with language impairment if they met two out of three of the following criteria: (1) received scores less than 85 (1 standard deviation from the mean) on the bilingual language index of the *Bilingual English-Spanish Assessment* (BESA; Peña et al., 2014), (2) had a previous diagnosis of language impairment from a speech-language pathologist, or (3) parents reported concern regarding their child's language development on a demographic information form. Twenty-two children (40%) met the criteria for language impairment, while 35 children (60%) were typically developing.

Fifty-three parents participated in the study as seven children were siblings. All children had at least one parent who identified as Hispanic and whose primary language was Spanish. Parents completed a questionnaire about their child's medical history and development, family history, as well as their own educational background. Forty-seven parents were female, six parents were male. Table 1 summarizes demographic information of the child and parent participants across children with typical development and children with language impairments. Over 60% of children attended kindergarten, preschool, or elementary school, 34% of children attended day-care, and 36% of the children remained at home with a caregiver during the day.

Procedures

Parents completed an interview about their child's past and current bilingual language environment and children completed standardized assessments of their English and Spanish language abilities and nonverbal cognitive abilities (nonverbal IQ, processing speed). The

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

primary investigator, who is a bilingual speech-language pathologist, administered all standardized language and cognitive assessments. Assessments were administered in a quiet, private room. Parent interviews were conducted in person or over the phone.

Language background. The *Bilingual Input-Output Survey* (BIOS; Peña et al., 2014) was used as a systematic tool to gather information about the children's past and current bilingual language exposure and use. The BIOS was administered as an interview during which parents were asked about their child's language history (i.e., age at which the child was exposed to English) and which language their child heard and used during a weekday and during a typical weekend day on an hour-by-hour basis. The hourly information was used to estimate the child's relative language exposure and use during a typical week and yielded an average percent of Spanish input (i.e., exposure) and average percent Spanish output (i.e., use) and an average percent of English input and average percent of English output.

Semantic Abilities. The BESA is a valid and reliable assessment of speech and language ability in English-Spanish bilingual children ages 4:0 – 6:11. The assessment includes three subtests that address morphosyntax, semantics, and phonology in English and Spanish. All subtests are norm-referenced and may be combined or used independently. Subtests yield scaled scores, standard scores, percentile ranks, and age equivalents. For the original study, the morphosyntax and semantics subtests were administered in English and Spanish although for the current study only the English and Spanish semantics subtests were used in analysis. We chose to use the semantic subtest as it provided a measure of vocabulary depth by assessing receptive and expressive semantic abilities across six key knowledge criteria: analogies, characteristic properties, categorization, functions, linguistic concepts, and similarities and differences.

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

Cognitive abilities. The *Leiter International Performance Scale, Third Edition* (Leiter-3; Roid et al., 2013) was used to evaluate nonverbal cognitive abilities. The administration of the Leiter-3 is nonverbal, instead relying on gestures, facial expressions and demonstrations, and thus is not language specific. It uses an engaging, format and was normed and validated with a diverse group of participants. The Leiter-3 yields individual subtest and composite scores that measure intelligence (including four subtests of fluid reasoning) as well as other discrete ability areas (i.e., nonverbal memory, processing speed). The following four subtests were administered to yield a composite measure of nonverbal IQ: Sequential Order, Form Completion, Classification and Analogies, and Figure Ground. In addition, the Attention Sustained and Nonverbal Stroop subtests were administered to yield a composite measure of Processing Speed.

Reliability

To establish inter-rater agreement for scoring of items on the BESA, two research assistants who were undergraduate students in communication disorders or psychology, listened to the audio recordings of 20% of the BESA sessions and documented participant responses on the morphosyntax subtests and expressive items on the English and Spanish semantics subtests. Inter-rater agreement for the Spanish BESA was conducted by a bilingual research assistant who was a native Spanish speaker. Interrater agreement for the Spanish BESA was 97.23% and 97.75% for the English BESA.

Results

All analyses were conducted using SPSS Statistics Version 25 (IBM Corp, 2017). The data were tested for normality of distribution prior to data analyses. The key variables, English semantic skills and Spanish semantic skills were not normally distributed, with skewness values ranging between -1.73 and -2.26 and kurtosis values between 3.88 and 7.62. Hence,

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

nonparametric tests were used. Descriptive statistics including the median, mean, standard deviation, and the minimum and maximum values for all key variables are indicated in Table 2.

Preliminary Analyses

Preliminary analyses were conducted using the Mann-Whitney U test to verify if the earliest age of exposure to English, the percent of English input and English output, and the proportion of English language input and output were similar between children with typical development and with language impairments. The Mann-Whitney U test is a nonparametric test that compares two independent groups without the assumption of normality of distribution. Results showed that there were no differences between the median age of exposure to English between children with typical development (Mdn = 2.00) and with language impairments (Mdn = 2.00), $U = 331.50$, $p = n.s.$ Another Mann-Whitney U test was used to determine if there were any differences in the percentage of English language input between the children with language impairments and with typical development. Even though the children were from English-Spanish bilingual backgrounds, only percent of English language input and output were utilized in the analyses as these values were the inverse of the percent of Spanish language input and output. The results of the Mann-Whitney U test showed that there were no significant differences in the median English language input in children with typical development (Mdn = 56.00) and with language impairments (Mdn = 54.00), $U = 341.00$, $p = n.s.$ There were no significant differences in the median English language output in children with typical development (Mdn = 63.00) and language impairments (Mdn = 66.00), $U = 323.50$, $p = n.s.$ There were also no significant differences in the proportion of English language input to English language output ($\frac{\text{input}}{\text{output}}$) between the children with typical development (Mdn = .99) and language impairments (Mdn = .99), $U = 372.50$, $p = n.s.$ A Spearman's rank correlation demonstrated that there was a moderate

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

and positive relationship between English language input and English language output for children with typical development ($r = 0.68, p < .001$) and language impairments ($r = 0.66, p < .001$).

Relationships between Key Variables and Semantic Abilities

A Spearman's rank correlation was used to explore how various factors were associated with semantic skills in English and in Spanish. Specifically, the relationships between the percentage of English language input and output, the age of first exposure to English, nonverbal IQ, processing speed, and English semantic skills and Spanish semantic skills were examined in both groups of children. The Spearman's rank correlation coefficients for all key variables are indicated in Table 3. In general, most of the correlations between the variables examined were found to be low and non-significant with correlations ranging from $r = -0.48$ to $r = 0.68$.

The results of the Spearman's rank correlation highlighted that processing speed was significantly correlated with English semantic skills for children with typical development, $r = 0.50, p < .001$, and children with language impairments, $r = 0.55, p < .001$. The analyses also showed a moderate-positive association between processing speed and Spanish semantic skills in children with language impairments, $r = 0.50, p < .05$, while the relationship between processing speed and Spanish semantic skills was not significant for children with typical development, $r = 0.09, p = n.s.$ The results also showed non-significant relationships between nonverbal IQ and semantic skills in children in both groups for English and Spanish semantic skills respectively; $r = 0.25, p = n.s.$, and $r = 0.23, p = n.s.$, for children with typical development, and $r = 0.30, p = n.s.$, and $r = 0.27, p = n.s.$, for children with language impairments.

In general, the Spearman's rank correlation highlighted that the language experience variables were not significantly related to English and Spanish semantic skills. The percent of

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

English language input was not significantly related to both English and Spanish semantic skills in children with typical development, $r = 0.03, p = n.s.$ and $r = -0.24, p = n.s.$, and children with language impairments, $r = 0.21, p = n.s.$ and $r = -0.24, p = n.s.$, for English and Spanish semantic skills, respectively. The results also showed that the percentage of English language output was not related to English and Spanish semantic skills in children with typical development, $r = 0.14, p = n.s.$ and $r = -0.32, p = n.s.$, and children with language impairments, $r = 0.20, p = n.s.$ and $r = -0.27, p = n.s.$, again for English and Spanish semantic skills respectively. Spearman's correlation also showed that age of exposure did not have a significant relationship with English ($r = 0.08, p = n.s.$) and Spanish ($r = 0.11, p = n.s.$) semantic skills in children with typical development and this was also true of children with language impairment, $r = 0.06, p = n.s.$ and $r = 0.32, p = n.s.$, for English and Spanish semantic skills respectively.

Discussion

In this study, we investigated the relationships between language experience and child-internal variables (language impairment group, cognitive abilities, and processing speed) on children's performance on semantic tasks assessing vocabulary depth in English and Spanish. Overall, we found a stronger effect for processing speed than language input and output on bilingual children's semantic abilities in English and Spanish for both children with typical development and children with language impairments.

Relationship between Cognitive Abilities, Language Experience, and Vocabulary Depth

Given the substantial body of research pointing to significant effects of language environment on language outcomes in bilingual and monolingual children (Grüter & Paradis 2014) and specifically on vocabulary depth (Bedore et al., 2012; Sheng et al., 2012; 2013), we hypothesized that in both groups, input and output would be more highly correlated with

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

semantic abilities than cognitive abilities. However, our hypothesis was not fully supported. Processing speed was significantly correlated with English and Spanish semantic abilities in bilingual children with typical development and language impairments. Nonverbal IQ on the other hand, was not related to semantic abilities when analyses included separate groups. Furthermore, there was no significant relationship between English input and output and children's English and Spanish semantic abilities when group analyses were used. Age of exposure to English was also not significantly related to semantic abilities.

Results of the current study indicated that individual differences in processing speed were significantly related to vocabulary depth in bilingual children, a finding previously demonstrated in studies of vocabulary breadth (Hurtado et al., 2014; Marchman et al., 2010). Unlike Hurtado et al. and Marchman et al., who used a measure of lexical processing speed, in our study we measured global processing speed. This finding supports a broad view of processing speed as a global construct that underlies many aspects of cognitive functioning (e.g., Kail, 1994; Kail & Salthouse, 1994; Shanahan et al., 2006). Furthermore, studies demonstrating that lexical-semantic organization in bilingual children parallels that of monolinguals, indicate that general cognitive factors are related to semantic organization (Peña et al., 2002, 2003; Sheng et al, 2006). In the current study, items on the semantics subtests (e.g., analogies, characteristic properties, categorization, functions, linguistic concepts, and similarities and differences) measured skills that presumably relied on processing speed as well as analytical and reasoning skills. Because the semantic measures used in this study likely drew more heavily on high-level cognitive skills than tests of expressive or receptive vocabulary size, it may not be surprising then that processing speed was significantly related to English and Spanish semantic abilities for both groups of children.

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

Findings from the current study indicated that parent reported language experience (i.e., English input, English output, age of exposure to English) was not significantly related to children's vocabulary depth in English and Spanish. The finding that age of exposure in English was not significantly associated with vocabulary depth, confirms results of Bedore et al. (2012) and Sheng et al. (2012) who also found that age of exposure was not significantly associated with semantic abilities in bilingual children. However, the finding that language input and output were not related to semantic abilities is more surprising and partially contradicts findings of Sheng et al. (2012, 2013) and Bedore et al. (2012). However, Sheng et al., 2013 found that English use was only significantly related to English vocabulary depth, not Spanish vocabulary depth or a combined measure of English and Spanish, suggesting that the relationship between language environment and vocabulary depth may be more nuanced. As recent studies of semantic priming in bilingual toddlers suggest (Floccia et al., 2020; Jardak & Byers-Heinlein, 2019), it is also possible that the development of depth of lexical networks is more resistant to individual variability in input effects than vocabulary size. However, as discussed later in the limitations section, variability and constraints in the way language environment is measured may confound or obscure the relationship between language environment and depth. Although preliminary, the findings from the current study suggest the relationship between language environment and vocabulary depth may not be as transparent as previously thought. This research underscores the importance of individual variability in child-internal factors in relationship to vocabulary depth. It is also important to acknowledge potential interactions between environmental factors such as language exposure and child-internal factors such as processing speed and language proficiency. For example, the amount of child directed speech has been found to influence language processing abilities in young children (Weisleder &

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

Fernald, 2010). However, given the challenges surrounding measurement of language environment, perhaps assessment of individual differences in language and cognitive abilities may be more straightforward and may offer clarifying information related to children's vocabulary depth. Clearly, the bidirectional effects of language environment on vocabulary depth in bilingual children warrant further exploration.

Bilingual Children with Language Impairment

The current study contributes to a growing body of research investigating the language and cognitive abilities of bilingual children with language impairments. Our results showed that the strength and direction of correlations between variables of language experience and cognitive skills were similar across groups, with the exception of the relationship between Spanish semantic abilities and processing speed. Overall, these findings support work by Sheng and colleagues (2012) indicating that factors that predict vocabulary depth in bilingual children are similar across bilingual children with typical development and with language impairments.

Processing speed deficits are thought to be associated with language impairments (e.g., Kail, 1994; Leonard, 2007; Miller et al., 2001, 2006) although some researchers have argued that children with language impairments do not differ from children with typical development on simple, speeded tasks (Kohnert & Windsor, 2004; Montgomery & Windsor, 2007, 2015). In the current study, the finding that processing speed was correlated with English semantic abilities for both groups (and for English and Spanish abilities in children with language impairments) supports the notion that general processing speed abilities may be related to language processing in children and corroborates research indicating that processing speed does not necessarily differentiate children with language impairments from those without language impairments (Windsor et al., 2001). These findings also suggest that individual differences in processing

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

speed are related to vocabulary depth in children with language impairments and typical development.

Limitations and Future Directions

A number of limitations are important to note regarding the current study. The sample size of this study was modest and a larger sample size would increase the power to detect significant effects. Furthermore, some researchers have raised concerns about the accuracy of parental questionnaires in measuring language exposure such as the one we used (Carroll, 2017; Marchman et al., 2017). Although the BIOS has been used in numerous studies as a measure of language experience (Bedore et al., 2010, 2012, 2016), the method for determining language exposure during dual-language contexts does not provide information about the quality or properties of language exposure (see Jia & Aaronson, 2003; Jia & Fuse, 2007; Paradis, 2011; Paradis & Jia, 2017; Place & Hoff, 2011). Furthermore, the BIOS describes the proportion of relative language exposure but does not capture the absolute amount of language exposure (i.e., the number of words a child hears in each language). Studies comparing parent report of bilingual language environment to observed language environment (which measures absolute exposure in each language) indicate a moderate to strong correlation when the proportion of language exposure in each language is considered (Marchman et al., 2017; Orena et al., 2019). However these studies also reported substantial heterogeneity in the absolute amount of language exposure, noting that the proportion of language exposure in a given language and the number of words the child heard in that language were highly variable across participants. Our findings may also be complicated by the fact that much of the children's language exposure was not purely in one language or the other and 50% of parents indicated that they either sometimes or frequently switched between English and Spanish when speaking to their children. Characterizing a

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

bilingual child's language environment is challenging due to the inherent heterogeneity in experience, the limitations of parent report, and the logistic and procedural challenges associated with direct observation of a child's language environment. Given the questions surrounding the role of language environment on children's bilingual outcomes, future research should continue to explore valid and efficient methods for capturing this complex variable.

Understanding the dynamic systems that impact the language outcomes of the bilingual child is inherently complex. Group comparison studies are important in understanding group differences and to the generalization of findings. It is critical, however, that researchers and clinicians remember that the complex interactions between language environment factors and child internal factors are unique to each bilingual child. The analyses used in this study allowed for measurement of the strength of association between the variables, however these analyses did not permit us to make causal inferences. This research provides preliminary evidence that processing speed may be related to vocabulary depth. Further research is needed to explore and confirm the differential effects of environment and internal factors on bilingual children's semantic abilities using larger sample sizes that allow for robust analyses.

Conclusion

This study investigated the associations between language experience and nonlinguistic cognitive variables in relation to Spanish and English semantic abilities in bilingual children with typical development and with language impairments. The results suggested that for both groups, processing speed was significantly related to vocabulary depth in English and Spanish although significant effects were not found for the language experience variables (i.e., age of exposure to English, language input, and language output). Findings from this study advance our understanding of the processes that influence bilingual language development indicating that the

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

relationships between the variables we measured were similar across bilingual children with typical development and language impairments.

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SEMANTIC ABILITIES IN BILINGUAL CHILDREN

Table 1. Demographic statistics for participants.

| Demographic Variable | Children with typical development | Children with language impairment |
|-------------------------------------|--------------------------------------|---|
| <i>N</i> | 35 | 22 |
| Child's Age Median | 67 | 57.5 |
| Child's Age <i>M</i> (<i>SD</i>) | 67.11 (1.66) | 59.52 (2.06) |
| Child's Age Range | 48 - 83 | 49 - 80 |
| Child's Sex Frequency | | |
| Male | 23 | 14 |
| Female | 12 | 8 |
| Child's Race Frequency (%) | | |
| Caucasian | 7 | 2 |
| Mixed Race | 5 | 2 |
| American Indian / Alaska Native | 2 | 1 |
| Other | 10 | 10 |
| Unknown | 1 | 1 |
| Did not indicate | 10 | 6 |
| Child's Ethnicity Frequency (%) | | |
| Non-Hispanic | 1 | 0 |
| Hispanic | 34 | 22 |
| Parent's Age Median | 36 | 34 |
| Parent's Age <i>M</i> (<i>SD</i>) | 35.32 (6.25) | 32.60 (6.46) |
| Parent's Age Range | 22 - 47 | 22 - 43 |
| Parent's Race Frequency | | |
| Caucasian | 7 | 3 |
| Mixed Race | 5 | 0 |
| American Indian / Alaska Native | 1 | 0 |
| Other | 14 | 8 |
| Did not indicate | 11 | 4 |
| Parent's Ethnicity Frequency | | |
| Non-Hispanic | 0 | 1 |
| Hispanic | 37 | 13 |
| Did not indicate | 1 | 1 |
| Parent's Education Frequency | | |
| Less than High School Diploma | 9 | 1 |
| High School Diploma | 6 | 6 |
| *College, no degree | 10 | 3 |
| Associate's Degree | 3 | 1 |
| Bachelor's Degree | 4 | 0 |

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

| | | |
|---------------------|---|---|
| Master's Degree | 1 | 0 |
| Professional Degree | 5 | 1 |
| Did not indicate | 0 | 3 |

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

Table 2. Descriptive statistic of variables.

| | Median | Mean (SD) | Range | Skewness (S.E.) | Kurtosis (S.E.) |
|--|--------|---------------|----------|-----------------|-----------------|
| Children with typical development (<i>N</i> = 35) | | | | | |
| Percentage of English Input | 56.00 | 53.49 (2.66) | 3 - 71 | -1.26 (0.40) | 1.95 (0.78) |
| Percentage of English Output | 63.00 | 58.31 (2.30) | 20 - 83 | -0.85 (0.40) | 0.50 (0.78) |
| Age of exposure to English | 2.00 | 2.06 (0.22) | 0 - 6 | 0.95 (0.40) | 1.29 (0.78) |
| Nonverbal IQ | 99.00 | 102.00 (1.31) | 87 - 125 | 0.96 (0.40) | 1.15 (0.78) |
| Processing Speed | 100.00 | 99.29 (1.82) | 82 - 126 | 0.70 (0.40) | 1.03 (0.78) |
| English Semantic Skills | 98.00 | 93.40 (2.95) | 23 - 118 | -2.04 (0.40) | 6.80 (0.78) |
| Spanish Semantic Skills | 103.00 | 99.09 (3.24) | 24 - 123 | -1.86 (0.40) | 5.74 (0.78) |
| Children with language impairment (<i>N</i> = 22) | | | | | |
| Percentage of English Input | 54.00 | 57.55 (2.97) | 30 - 80 | -0.09 (0.49) | -0.87 (0.95) |
| Percentage of English Output | 66.00 | 65.00 (4.58) | 25 - 100 | 0.53 (0.49) | -0.32 (0.95) |
| Age of exposure to English | 2.00 | 1.68 (0.25) | 0 - 4 | .30 (0.49) | -0.21 (0.95) |
| Nonverbal IQ | 98.00 | 96.27 (2.28) | 70 - 115 | -1.05 (0.49) | 1.36 (0.95) |
| Processing Speed | 84.00 | 83.10 (2.63) | 56 - 105 | -0.32 (0.50) | -0.17 (0.97) |
| English Semantic Skills | 78.00 | 73.76 (4.53) | 0 - 98 | -2.26 (0.50) | 7.62 (0.97) |
| Spanish Semantic Skills | 71.50 | 69.32 (4.89) | 0 - 103 | -1.73 (0.49) | 3.88 (0.95) |

Note. Age of exposure to English is indicated in years; IQ = Intelligence Quotient

SEMANTIC ABILITIES IN BILINGUAL CHILDREN

Table 3. Spearman's rank correlations between key variables.

| Children with typical development (<i>N</i> = 35) | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|--------|-------|-------|------|---------|------|---|
| 1. Percentage of English Input | 1 | | | | | | |
| 2. Percentage of English Output | .68*** | 1 | | | | | |
| 3. Age of exposure to English | 0.01 | -0.08 | 1 | | | | |
| 4. Nonverbal IQ | 0.23 | -0.04 | 0.19 | 1 | | | |
| 5. Processing Speed | 0.07 | 0.17 | -0.07 | 0.08 | 1 | | |
| 6. English Semantic Skills | 0.03 | 0.14 | 0.08 | 0.25 | 0.50*** | 1 | |
| 7. Spanish Semantic Skills | -0.24 | -0.32 | 0.11 | 0.23 | 0.09 | 0.14 | 1 |

| Children with language impairment (<i>N</i> = 22) | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|-------|--------|-------|-------|-------|------|---|
| 1. Percentage of English Input | 1 | | | | | | |
| 2. Percentage of English Output | .66** | 1 | | | | | |
| 3. Age of exposure to English | -0.06 | -0.48* | 1 | | | | |
| 4. Nonverbal IQ | 0.27 | 0.05 | 0.43* | 1 | | | |
| 5. Processing Speed | 0.21 | 0.04 | 0.47* | 0.49* | 1 | | |
| 6. English Semantic Skills | 0.21 | 0.20 | 0.06 | 0.30 | 0.55* | 1 | |
| 7. Spanish Semantic Skills | -0.24 | -0.27 | 0.32 | 0.27 | 0.50* | 0.30 | 1 |

Note. Age of exposure to English is indicated in years; IQ = Intelligence Quotient; * $p < .05$, ** $p < .01$, *** $p < .001$.