

PHONOLOGICAL MEMORY AND THE DEVELOPMENT OF VOCABULARY AND
GRAMMAR IN YOUNG SPANISH-ENGLISH BILINGUALS

by

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The Charles E. Schmidt College of Science
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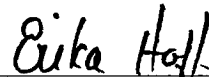
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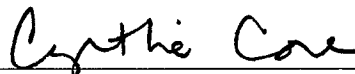
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This thesis was prepared under the direction of the candidate's thesis advisor, Dr. Erika Hoff, Department of Psychology, and has been approved by the members of her supervisory committee. It was submitted to the faculty of The Charles E. Schmidt College of Sciences and was accepted in partial fulfillment of the requirements for the degree of Master of Arts.

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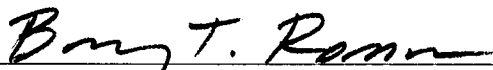
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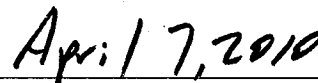
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ABSTRACT

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This study tested the hypotheses that phonological memory contributes to vocabulary and grammatical development in young Spanish-English bilinguals, and that the relation between phonological memory and both vocabulary and grammar is language-specific. Phonological memory skill was the percentage of consonants correctly repeated (PCC) in English, and Spanish Nonword Repetition (NWR) tasks at 22 months. Vocabulary size and grammatical complexity were measured at 25 months using the English and Spanish versions for the MacArthur-Bates Communicative Development Inventories. Nonword repetition accuracy was significantly related to both subsequent vocabulary size and grammatical complexity within and across languages after controlling for the percentage of input in English. The relations were not significantly higher within than between languages. The results suggest that in these young Spanish-

English simultaneous bilinguals phonological memory is a language-general ability that contributes to the development of vocabulary and grammar in both English and Spanish.

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INTRODUCTION

Learning a language involves the discrimination of the sounds of the language, the segmentation of these sounds into separate units, the creation of associations among units and meanings, and the assemblage of these meaningful units into meaningful strings. A system that temporarily stores the sounds of a language while they become permanently represented in long term memory must be important in these endeavors. This temporary storage is termed phonological short term memory, and it has been found to be important in early vocabulary development and grammatical development in both monolinguals and second language learners (e.g., Baddeley, Gathercole, & Papagno, 1998). The role of phonological memory in early bilingual development has not been tested so far. This was the first purpose of this study. Specifically, the present study examined whether phonological short term memory contributes to the development of vocabulary size and grammatical complexity in very young Spanish-English simultaneous bilinguals.

The analysis of the relations between phonological memory and both vocabulary development and grammatical development in young bilinguals entails the question of the language universality of phonological memory abilities. In the literature on bilingualism there is no agreement as to whether phonological memory is a language-general ability, or whether bilinguals develop two language-specific and independent phonological memory systems. In the former case, phonological memory would support

the development of both languages in a general way. In the latter, phonological memory in each language would contribute uniquely to the development of the corresponding language. The second purpose of this study was to investigate whether the relations between phonological memory and both vocabulary and grammar were language-specific, asking whether phonological memory skills in English and Spanish were independent, and whether they had independent effects on vocabulary development and grammatical development in English and Spanish.

Measures of Phonological Memory

Phonological memory is a component of the working memory system (Baddeley, 1986, as cited in Baddeley et al., 1998, p. 158) that is responsible for temporarily storing the speech sounds of the language. Different measures have been used to assess the phonological memory. They can be divided into those that measure the short term memory capacity and those that measure the accuracy of the phonological representations (e.g., Gathercole, Willis, Emslie & Baddeley, 1992). The most common measures of memory capacity are digit span, word span, and sentence span. The memory capacity is reflected in the maximum set length that is correctly repeated. The measures of the quality of the representations in phonological memory are real word, nonword, and sentence repetition. In repetition tasks, subjects must repeat back the word nonword, or sentence immediately after presentation.

The most commonly used measure of the accuracy of the phonological representations is the nonword repetition task (NWR). This task is argued to be the most sensitive measure of the quality of the representations in the phonological store because the repetition of nonwords is less likely to be aided by long term lexical information (e.g.,

Gathercole, & Adams, 1993; Gathercole, 2006). This is especially true when nonwords do not follow the phonological characteristics or phonotactics (i.e., constraints of the sequencing and combination of the sounds in a language) of a familiar language (Gathercole, 2006).

Phonological Memory and Vocabulary

Phonological short term memory has been demonstrated to be related to vocabulary knowledge and to vocabulary development in first and second language learning, even after considering the effects of age and nonverbal intelligence (e.g., French & O'Brien, 2008; Gathercole, Hitch, Service, and Martin 1997; Gathercole, et al., 1992; Masoura & Gathercole, 1999, 2005). It seems that phonological memory is more important at the early stages of vocabulary development and that the main role of the phonological short term memory is the acquisition of novel words (Baddeley et al., 1998). For instance, in English monolinguals, phonological memory as measured by a nonword repetition task was strongly associated with English receptive vocabulary knowledge at the ages of 4, 5 and 6. At the age of 8, although the relation was still significant, it was small. Cross lagged correlations indicated that until the age of 5 phonological memory was driving vocabulary acquisition. After this age, vocabulary paced the development of phonological memory (Gathercole, et al., 1992).

Short term phonological memory is important at the beginning of second language learning as well. For example, the phonological short term memory of school-age Greek children who had been learning English for 3 years on average, and whose English vocabulary knowledge was poor, was significantly related to their speed of learning new English words (Masoura & Gathercole, 2005). In the same vein, only for a

low vocabulary group of Cantonese children learning English at school was there a significant relation between phonological memory, measured with a nonword span task and vocabulary size (Cheung, 1996).

In order to explain the role of phonological memory in vocabulary acquisition it has been proposed that initial encounters with novel words are temporarily stored as individual exemplars in the short term store (Gathercole, 2006). These individual exemplars would constitute the basis for the gradual abstraction of the long term memory representations.

Phonological Memory and Grammar

Phonological short term memory has been also associated with grammatical development in first language acquisition and second language learning. For instance, Adams and Gathercole (1995) found that 3-year-olds with good nonword repetition skills differed from children poor at nonword repetition with respect to the variety of vocabulary, the length of the utterances, and the complexity of the syntax used in spontaneous speech (as cited in Adams & Gathercole, 1996, p. 218). Adams and Gathercole (1996) also found that non word repetition was associated with the length of the sentences, and the amount of detail in the narrations produced by 4- year- old children after they controlled for vocabulary knowledge, age, and nonverbal intelligence. Finally, Adams and Gathercole (2000) found that 4- year-old children with good nonword repetition abilities produced longer utterances, and more varied syntactic constructions relative to children of the same age and similar non verbal abilities, but with poor non word repetition abilities.

In the realm of second language learning, French and O'Brien (2008) examined the relation between phonological memory and grammar in a group of 11 year-old children enrolled in a 5- month intensive English program. They found that phonological memory measured at the beginning of the course explained a significant amount of variance in grammar above and beyond the variance explained by vocabulary knowledge, non verbal intelligence, and prior grammatical knowledge, and that the variance explained by phonological memory on grammar was greater than the variance explained by vocabulary knowledge.

Speidel (1993) explained these associations between phonological short term memory and grammatical development indicating that exemplars of the sentences are held in the short term memory store, and then they become part of a storehouse of adult-like sentence patterns that the child use to construct his/her own sentences.

Relations between Phonological Memory and both Vocabulary and Grammar

Vocabulary and grammar are linked in development (Conboy & Thal, 2006; Marchman, Martínez-Sussmann & Dale, 2004). One explanation for this is that vocabulary precedes and gives rise to the acquisition of particular grammatical structures (e.g., Marchman & Bates, 1994). An alternative explanation is that there is a third common influence, cognitive or environmental, that underlies the simultaneous development of both (Dixon & Marchman, 2007). Since phonological memory is associated with both vocabulary and grammatical development, it is also possible that phonological memory is either driving directly the simultaneous development of both vocabulary and grammar, or driving directly the development of vocabulary, and indirectly the development of grammar through vocabulary.

Relations between Phonological Memory and both Vocabulary and Grammar in Bilinguals.

The findings described so far indicate that phonological memory is associated with both vocabulary and grammar in first and second language development. The question that remains to be answered is what the patterns of these relations are in bilinguals. Are the associations between phonological memory and vocabulary and between phonological memory and grammar language-specific, or, does phonological memory reflect a general ability that equally affects the development of both languages? Separate studies on the specificity of the link between vocabulary and grammar, on one hand, and, on the specificity of the phonetic space in bilinguals, on the other, shed some light on this issue.

For instance, it has been found that the relation between vocabulary and grammar in very young Spanish-English bilinguals is language-specific (Conboy & Thal, 2006; Marchman, et al., 2004). That is, Spanish vocabulary is correlated with Spanish grammar and English vocabulary is correlated with English grammar. However, Spanish vocabulary is uncorrelated with English grammar and English vocabulary is uncorrelated with Spanish grammar. These findings suggest that the relation between vocabulary and grammatical development is driven by language-specific factors rather than by general cognitive or linguistic factors.

There is also evidence of independent phonological development in a bilingual child's development. For instance, Bosch and Sebastian-Gallés (2003) found that Spanish-Catalan bilinguals as young as 12 months were able to discriminate the vowel contrast /e/ / ε/ existing in Catalan but not in Spanish. In the same vein, French-English

simultaneous bilinguals at the age of 10 months were able to discriminate between sounds with a short and a long VOT (i.e., voice onset time) corresponding to French and English phonemes respectively (Burns, Yoshida, Hill, & Werker, 2007).

Evidence of distinct phonological representations in bilingual children has also been found in language production. For instance, the phonological development of two Cantonese-English bilingual children was assessed monthly, for 9 and 11 months respectively, after the children were exposed to the second language at the age of 2 (Holm & Dodd, 1999). Error patterns and phoneme simplification were specific to each of the languages. In addition, errors followed the phonotactic constraints of each of the languages; and shared phonemes were used first in one of the languages.

That bilingual children have two phonological systems, one for each language, speaks to the influence of language specific factors, such as language exposure, on the construction of the phonological representations. Taking all the results together, we can expect that in early bilinguals the relations between phonological memory and both vocabulary and grammar are affected by language-specific influences and thus are language specific.

The Present Study

To the best of my knowledge, no study has tested the contribution of phonological memory to vocabulary and grammatical development or the language-specificity of the relations between phonological memory and vocabulary, and phonological memory and grammar in very young simultaneous bilinguals. The present study was designed to accomplish that.

In line with the existing literature on young monolinguals and sequential bilinguals, phonological short term memory was expected to be significantly associated with both vocabulary and grammatical development. In addition, it was expected consistent with previous findings on early bilinguals, that these relations would be specific to each language.

As with phonological memory, language input has been associated with early language development as well. For instance, Pearson, Fernández, Lewedég, and Oller (1997) demonstrated that in very young Spanish-English bilinguals the amount of language input in each language was strongly associated with vocabulary size in the same language. In the statistical analyses performed in the current study the percent of input in English was held constant in order to control for the effects of this variable on vocabulary and grammatical development.

Method

Participants

Data were available from 41 Spanish-English bilinguals, 21 males and 20 females, who were born in the United States and were living in South Florida. The participants' ethnicity was distributed as follows: 92.7% were Hispanic white, 2.4% were Hispanic African, 2.4% were European American, and 2.4% belonged to other ethnicities. The participants had been exposed to both English and Spanish at least 10% of the time since birth. Spanish was the native language of 50% of the mothers and 52% of the fathers; English was the native language of 35.4% of the mothers, and 37.5% of the fathers; 12.5% of the mothers, and 8.33% of the fathers were bilingual; and 2.08% of mothers and 2.08% of the fathers of the participants spoke a language other than English

or Spanish. The socioeconomic status as assessed by the parents' educational level was high, 89.5% of the mothers and 64.58% of the fathers had at least a 4-year college degree.

Participants were all full term at birth and had no history of medical or sensory problems. In addition, they had normal language development according to the criterion that they were above the recommended cutoff value of 35 for language delay in the communication section of the Ages and Stages Questionnaire (Squires, Potter, & Bricker, 1999), and were at least at the 10th percentile in the vocabulary section of a standardized measure in one language.

Design

This study was part of a short-term longitudinal design in which phonological memory, language input at home, vocabulary size, and grammatical complexity were measured at 22 months, and vocabulary size and grammatical development were measured again at the age of 25 months. In this particular study, the focus was on the relation between phonological memory measured at 22 months and vocabulary size and grammatical complexity measured at 25 months after controlling for English language input at 22 months.

Procedure

At 22 months, the nonword tasks in English and Spanish were administered within a week of each other. Bilingual examiners presented the nonwords orally in a standard way for the children to repeat back. The procedure was as follows: after a warm up period, children were presented with nonwords one at a time. The nonwords were accompanied by toys representing animals or people. They were told that the nonwords were the names of these toys. For instance, children were told: "This guy is named Kog,

can you say Kog?” The session started with two training trials, after two successful repetitions, the test stimuli were presented. Each nonword was presented a maximum of three times to encourage children’s repetitions. The children’s productions were recorded for later transcription. When children failed to repeat six words the session was terminated.

The primary caregivers were contacted later when their children were 25 months to complete the *MacArthur- Bates Communicative Development Inventory* (Fenson, Dale, Reznick, Thal, Bates, Hartung, et al., 1993) and its Spanish version, *Inventario del Desarrollo de las Habilidades Comunicativas* (Jackson-Maldonado, Thal, Fenson, Marchman, Newton, & Conboy, 2003). They were asked to report the words and grammatical structures they had heard their children use.

Measures

Phonological Memory. Nonword repetition tasks were used to measure phonological short term memory. The stimuli are presented in table 1. They consisted of twelve English-like and 12 Spanish-like nonwords. These nonwords were constructed from real words taken from the *MacArthur-Bates Communicative Development Inventory* (Fenson, et al., 1993) for children 16 to 30 months and its Spanish version, *Inventario del Desarrollo de las Habilidades Comunicativas* (Jackson-Maldonado, et al., 2003). There were four 1-syllable, four 2-syllable, and four 3-syllable nonwords in each language.

The monosyllabic nonwords were constructed by interchanging the onsets and rhymes of the monosyllabic real words. The bisyllabic nonwords were formed by combining the onset of the first syllable of one real word with the rhyme and second syllable of another real word. The trisyllabic nonwords were a combination of the first,

second and third syllables respectively of three different real words for English and the combination of the onset and nucleus of one real word with the second and third syllables of another real word for Spanish.

The accuracy of nonword repetition was measured by calculating the percentage of consonants that were repeated correctly (PCC). The coding of English nonwords was made by an expert phonetician and a graduate student trained in phonetic transcription. Both of them are native English speakers. The coding of Spanish nonwords was made by the expert phonetician, a fluent Spanish speaker, and two graduate students trained in phonetic transcriptions who are native speakers of Spanish. In cases of disagreement, a consensus among the graduate students and the phonetician was obtained.

Language Development. Vocabulary and grammar were assessed using the *MacArthur-Bates Communicative Development Inventory*, CDI (Fenson, et al., 1993), and the Spanish version, the *Inventario del Desarrollo de las Habilidades Comunicativas-II*, IDCH (Jackson-Maldonado, et al., 2003). The vocabulary size was calculated from part I of the CDI and IDCH, Words Children Use. This part contains 680 words of different lexical categories including nouns, verbs, adjectives, prepositions, pronouns, and articles. Parents are asked to check the words they have heard their children say.

The measure of grammatical development corresponded to the section Complexity from part II, Sentences and Grammar, of the CDI and IDCH. In this section, parents are presented with 37 pairs of sentences. Each pair contains one sentence that is more complex than the other. Parents are asked to select which sentence is more

representative of the sentences their children use. The number of times they choose the more complex sentence is calculated.

Language Input. The percentage of language exposure to English and Spanish was estimated by the primary caregivers using the Home Language Environment Questionnaire (HLEQ). The HLEQ is 145-item interview protocol designed for this study that was originally based on an instrument developed by Marchman and colleagues (2004). One indication of the validity of this instrument is the significant correlation between the ratio of the Spanish to English exposure reported in the interview and the ratio of the Spanish to English exposure recorded in diary logs that parents kept.

Results

Descriptive Statistics

The means, and standard deviations for the measures of English language input, nonword repetition (NWR) in English and Spanish at 22 months, and vocabulary size and grammatical complexity in English and Spanish at the age of 25 months are presented in Table 2.

Relations among Language Exposure, Phonological Memory, Vocabulary and Grammar

Table 3 shows the simple correlations among percent of input in English, nonword repetition accuracy, vocabulary scores, and grammatical complexity scores in English and Spanish. English and Spanish nonword repetition were significantly associated. English nonword repetition accuracy was significantly correlated with vocabulary size and grammatical complexity in English, and Spanish nonword repetition accuracy was significantly correlated with vocabulary size and grammatical complexity in both English and Spanish. In addition, the correlations between vocabulary size and

grammatical complexity were positive and significant within languages. Across languages the correlations between these variables were negative, and only the correlation between English vocabulary size and Spanish grammatical complexity was significant but weak. Thus, the relations between phonological memory and both vocabulary and grammar was language-specific in English but not in Spanish, and vocabulary size strongly predicted grammatical complexity within but not across languages. Finally, within and across languages, percent of input in English was correlated with vocabulary size and grammatical complexity but uncorrelated with nonword repetition accuracy.

The Relation of Phonological Memory to Vocabulary and Grammar after Partialing Out English Language Input

Percent of input that was in English was shown to be positively related to vocabulary size and grammatical complexity in English and negatively related to vocabulary size and grammatical complexity in Spanish. In order to control for the potential confounding effects of this variable on the relations among phonological memory, vocabulary and grammar correlations of vocabulary size and grammatical complexity with phonological memory were repeated with the percent of English language input partialled out. The partial correlation between English NWR and Spanish NWR was significant ($r(41) = .82, p < .001$). In addition, Table 4 shows that all the within and between language relations between phonological memory and both vocabulary size and grammatical complexity were significant after controlling for language input. When the effect of amount of English exposure is controlled, the nonword repetition tasks predicted vocabulary size and grammatical complexity both

within and across languages. Finally, Table 4 also shows that when variance attributable to English exposure is controlled, vocabulary size and grammatical complexity remain highly and significantly correlated within but not across languages.

Test of the Specificity of the Relations between Phonological Memory and Vocabulary, and Phonological Memory and Grammar

Z-tests were performed to see whether the partial correlations between nonword repetition accuracy and both vocabulary size and grammatical complexity were significantly higher in the same than across languages. None of the tests were significant indicating that the within language relations are not significantly higher than the relations between languages.

Discussion

In this study, the relations between phonological memory and both vocabulary size and grammatical complexity were examined in a sample of Spanish-English simultaneous bilinguals asking whether phonological memory is a language-specific or language-general skill. The findings were that phonological skills assessed in English and Spanish were strongly correlated with each other and that phonological memory skill in each language predicted vocabulary and grammar both within and across languages. These findings suggest that at this age and in these two languages phonological memory is a language-general capacity.

Other studies have found significant relations between phonological memory and both vocabulary and grammar in young monolinguals, and in children acquiring a second language at school (e.g., Adams & Gathercole, 1996; French & O'Brien, 2007; Gathercole & Adams, 1993; Gathercole & Baddeley, 1989; Gathercole et al, 1997; Gathercole, et al

1992; Hoff, Core, & Bridges, 2008; Masoura & Gathercole, 1999). However, no study had tested these relations in simultaneous bilinguals as young as 25 months. The significant correlations found in the present study show that very early in development, phonological memory is contributing to the acquisition of both vocabulary and grammar in simultaneous bilinguals. It is possible that the role of phonological memory is to serve as a temporary storage for novel words (as proposed by Gathercole, 2006), or novel sentences (as proposed by Speidel, 1993) from which the phonological specification of the sounds, and/ or the structure of the language is abstracted.

The present study also found the relations between nonword repetition and both vocabulary size and grammatical complexity were not significantly higher within than between languages. These findings indicate that the mechanism underlying nonword repetition, phonological memory, possesses a general and universal component that contributes to the acquisition of vocabulary and grammar in both languages. This general component may be a manifestation of overlapping phonological representations of English and Spanish speech sounds. The question is why this sample of bilinguals might have not developed, as it was predicted, independent phonological representations? A possible explanation lies in the quantity and the quality of the language input received. Although on average the children were being exposed to approximately the same amount of language input in both English and Spanish, there was great variability in the ratio of Spanish to English input each child was receiving. In addition, some of the children were receiving the language input either in English or Spanish from nonnative speakers. As a consequence of insufficient and/or poor language input, the phonological representations may not be well-specified in either Spanish, or English, or both. Alternatively, the

general contribution of phonological memory to vocabulary and grammatical development may have to do with general abilities to process novel information and/or with the capacity of the phonological store.

Although there was not strong evidence for specificity in the relations of phonological memory to both vocabulary development and grammatical development, there was evidence for the influence of language-specific factors in the relation of vocabulary to grammatical complexity. This result agrees with previous findings that on young Spanish-English bilinguals vocabulary development is strongly related to grammar abilities within but not across languages (Conboy & Thal, 2006). Moreover, the strong within-language relation between vocabulary development and grammatical development suggests that there is an unknown language-specific variable, cognitive, linguistic, or environmental in nature that is driving either the simultaneous development of vocabulary and grammar, or driving first the development of vocabulary, and later the development of grammar through vocabulary in each language.

In conclusion, the present study provides evidence that that at the early stages of language development phonological memory is a general capacity that plays an important role in early language development in simultaneous bilinguals. Future research will answer the question of whether these results apply to simultaneous balanced bilinguals as well. In other words, whether phonological memory contributes in a general way to the development of the languages in simultaneous bilinguals receiving the same amount of input in each language. This study also corroborated the presence of language-specific factors affecting language development. The nature of these factors remains to be investigated

Table 1

Real Word and Nonword Stimuli

Language	Real word	Nonword
Spanish	pan, luz, tren, sol, vaca, gato, mesa, leche, muñeca, gallina, caballo, pelota.	lan, trus, sen, pol, vato meca,lesa, gache, gañeca, mullina, peballo, calota.
English	dog, juice, cat, book, balloon, cookie, puppy, chicken, banana, telephone, lollipop, pajamas.	kog, buice, jat, dook, challoon, pookie,kuppy, bicken, bajapop, tellina, lolemas, panaphone.

Table 2

Descriptive Statistics: English Input, Nonword Repetition Accuracy, Vocabulary Size, and Grammatical Complexity in English and Spanish (n=41).

Variable	Mean	Standard Deviation
Percent of input in English	49.88	29.12
English nonword repetition accuracy at 22 months ¹	35.04	25.93
Spanish nonword repetition accuracy at 22 months ¹	26.97	22.20
English vocabulary at 25 months ²	240.80	159.78
Spanish vocabulary at 25 months ²	142.41	112.07
English grammatical complexity at 25 months ²	7.19	9.35
Spanish grammatical complexity at 25 months ²	3.02	6.32

¹ Percent consonants correctly repeated (PCC).

² Raw scores.

Table 3

Correlations among English Language Input, Nonword Repetition (NWR), Vocabulary Size, and Grammatical Complexity Within and Across Languages (n=41).

Variable	1	2	3	4	5	6	7
1. English NWR at 22 months	—	.79***	.54***	.23	.49**	.18	.26
2. Spanish NWR at 22 months		—	.29*	.37**	.28*	.26*	-.02
3. English vocabulary at 25 months			—	-.19	.84***	-.28*	.72***
4. Spanish vocabulary at 25 months				—	-.17	.61***	-.57***
5. English grammar at 25 months					—	-.15	.58***
6. Spanish grammar at 25 months						—	-.45**
7. Percent of input in English							—

* $p < .05$, ** $p < .01$ *** $p < .001$, one-tailed.

Table 4

Correlations among Nonword Repetition (NWR), Vocabulary Size, and Grammatical Complexity Within and Across Languages after Controlling for English Language Input (n=41).

Variable	1	2	3	4	5	6
1. English NWR at 22 months	—	.82***	.52***	.47**	.43**	.34*
2. Spanish NWR at 22 months		—	.45**	.43**	.36**	.28*
3. English vocabulary at 25 months			—	.38**	.75***	.06
4. Spanish vocabulary at 25 months				—	.24	.48**
5. English grammar at 25 months					—	.15
6. Spanish grammar at 25 months						—

* $p < .05$, ** $p < .01$, *** $p < .001$, one-tailed.

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