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L1 and L2 semantic priming effects on L2 picture naming and expressive vocabulary in children

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Priyanka Shailat[1]
Eastern New Mexico University
Karen J. Mainess[2]
Loma Linda University
Benjamin J. Becerra[3]
California State University San Bernardino

Abstract

This study aimed to investigate the influence of L1 (Spanish) and L2 (English) categorical semantic primes on L2 picture naming and examine their relationship with bilingual expressive vocabulary in bilingual school-aged children in the upper elementary grades. We compared primed L2 picture naming speed under four experimental conditions: Categorical Semantic Spanish (CSS), Categorical Semantic English (CSE), Unrelated Spanish (URS) and Unrelated English (URE), and a no prime (NP) control condition. In addition, we conducted correlational analysis to compare L1 and L2 priming as a function of bilingual expressive vocabulary. All experimental primes interfered with L2 picture naming, but L2-L2 semantic priming exhibited a unique pattern of significantly lesser interference. There was a moderate to low positive relationship between bilingual expressive vocabulary and L1-L2 picture naming speed. These findings point towards specific roles for L1 and L2 in language processing for bilingual children with possible implications for tailoring bilingual instruction. While developing L2-L2 semantic connections may distinctly impact picture naming speed in L2, fostering implicit connectivity between L1 and L2 may be relevant to enhance bilingual expressive vocabulary.

Keywords: Spanish-English bilingualism, picture naming, categorical semantic priming, expressive vocabulary, bilingual school-aged children

1. Introduction

The number of children with Spanish-English bilingual exposure is increasing in the school systems of the United States of America. The American Community Survey (2009-2013) data on the languages spoken in the home indicate that there are over 37 million individuals over the age of five who speak Spanish and/or a Spanish creole in the United States. Among

[1] Dr. Shailat is an Assistant Professor of Communicative Disorders at Eastern New Mexico University, Portales, New Mexico. Her research interests are in the areas of speech and language processing, language disorders and bilingualism.
Corresponding author: priyanka.shailat@enmu.edu

[2] Dr. Mainess is an Assistant Professor and Speech Language Pathology Graduate Program Director in the School of Allied Health Professions at Loma Linda University, California. She conducts research in areas related to the assessment and intervention of children with developmental disorders and autism. e-mail: kmainess@llu.edu

[3] Dr. Becerra is an Assistant Professor in the Department of Information & Decision Sciences at California State University, San Bernardino. He is also the co-Director for the Center for Health Equity on campus and uses data analytics, research methods, and statistics to perform research in health-related areas. e-mail: benjamin.becerra@csusb.edu

them, over 16 million individuals report that they speak English less than very well (U. S. Census Bureau, 2015). Bilingualism influences language and academic development. Schools attempt to provide English language support through several types of instruction (Barrow & Markman-Pithers, 2016; Gándara & Escamilla, 2016).

There is a plethora of research regarding bilingual language processing in adults with a dominant first language (L1) (Brown & Altarriba, 2007; Costa & Caramazza, 1999; Weber & Cutler, 2004). These research findings encourage instructional support through L1 to facilitate language development in a second language (L2). Research on bilingual processing in school-aged children, however, is lacking. Initial research findings in bilingual school-aged children are inconsistent concerning dominance of L1 to L2 facilitation (Goodrich & Lonigan, 2018a). On one hand, research suggests that words are known selectively in L1 and L2. Conversely, findings also support that L2 vocabulary increases as L1 vocabulary gradually decreases in bilingual children (Goodrich & Lonigan, 2018b; Peña et al., 2002). Also, all bilingual children do not necessarily have a dominant L1 when they enter the school system, and even if they do, the context of exposure to L1 and L2 may differ. Additionally, the relevance or use of L1 and L2 may change over time. Thus, the nature of bilingualism is evolving and a singular view of supporting English language development through L1 becomes imprecise.

Given this dynamic variability in bilingual children, it is important to identify how the two languages interact to determine how to tailor instructional support in schools with selective roles for L1 and L2. In Spanish-English bilingual children with varying degrees of exposure to Spanish, and academic performances measured in English, it becomes necessary to explore the impact of bilingualism on the language used at school. One such aspect of language, vocabulary, is a key variable which contributes to academic achievement (Storch & Whitehurst, 2002). By analyzing implicit bilingual organization and its relationship to vocabulary retrieval, we can determine the applicability of bilingualism, Spanish and English in this case, for English language use in the school setting. In this study, we investigated this through a set of semantically primed picture naming tasks and explored their relationship with conceptual vocabulary which considers responses in Spanish and/or English.

Semantic priming is an experimental method used to examine the semantic network operating at an implicit level (Floccia et al., 2020; Glaser & Dungelhoff, 1984; Jerger et al., 2002). Explicit tasks such as word association and generative naming require individuals to name semantically related words whereas priming allows an examination of automatic semantic connections not obscured by the explicit output. In a typical priming paradigm, experimenters present two words in temporal proximity. One of the words acts as a prime and the other becomes a target. If an individual has a semantic relationship between the words, the activation of one would activate the other. Semantic priming occurs when there is a change in accuracy or speed of a response to a target word preceded by a related prime in comparison with a control condition. The priming effect may be facilitative (rapid responses) or interfering (delayed responses) depending on the prime-target relationship, duration parameters, and nature of the response task. Both facilitation and

interference rely on the underlying principle of networking within the semantic system (Collins & Loftus, 1975). Researchers have used tasks such as lexical decision making, preferential looking, auditory repetition and picture naming, to elicit a response on a target word (Goodrich & Lonigan, 2018a; Liu et al., 1997; Rose et al., 2019; Singh 2013). The first two tasks are non-speech. The lexical decision task requires that individuals decide whether a given target is a word or non-word. The preferential looking task is passive in that individuals need not provide a conscious, effortful response. The latter two tasks are speech-based. Auditory repetition requires individuals to repeat an audible target word without lexical retrieval. Picture naming is a task where individuals label a given picture with a corresponding word. In this study with elementary-aged children, we chose the picture naming task as it parallels a task measuring expressive vocabulary. Picture naming also engages participants actively, requires lexical retrieval and excludes any decision-making process that may interfere with implicit semantic processing.

Semantic priming research using picture naming in monolinguals suggests that categorical related primes interfere with the speed of naming pictures (Damian & Martin, 1999; Glaser & Dungelhoff, 1984; Rose et al., 2019; Xavier Alario et al., 2000). On the contrary, other tasks such as lexical decision and preferential looking elicit facilitation by semantic primes (Goodrich & Lonigan, 2018a; Jardak & Byers-Heinlein, 2018; Singh, 2013). Comparison between categorical primes and unrelated primes show that the former reduces the speed of picture naming significantly more than the latter (Damian & Martin, 1999; Glaser & Dungelhoff, 1984). Both these primes interfere when compared with a non-linguistic prime, e.g., ##### symbol, which is not expected to exert a language-based influence on the responses (Costa & Caramazza, 1999; Roelofs et al., 2016). Based on the extent of interference caused by categorical primes and unrelated primes, researchers posit that categorically related words interact at a conceptual level, due to a relationship between semantically connected units, while unrelated words compete with target words at a lexical level, due to a relationship between lexemes (Glaser & Dungelhoff, 1984; Roelofs et al., 2016; Rose et al., 2019). There are certain conditions noted for these effects to occur. First, the response must be a speech production task such as picture naming. Second, there must be a close temporal relationship between the prime and target such that the prime is either just before the target or at the same time as the target (Glaser & Glaser, 1989; Neumann. 1986; Schriefers et al., 1990; Xavier Alario et al., 2000). If the prime occurs much before the target, the interfering effect of the prime on that target ceases due to a decay in the activation of the prime with time. It could then explicitly facilitate naming (Carr et al., 1982). This effect of interference by categorical semantic primes is a semantic relatedness paradox (Neumann. 1986). The paradox pertains with the slowing of naming when the relationship between the prime and target, i.e., semantic distance, is closer. Theoretically, while the prime facilitates target naming, the competing effect of its own activation supersedes the facilitation of the target by the prime resulting in interference. This is reverse priming (Neumann, 1986; La Heij et al., 1990). An alternate view, the response-exclusion argument, considers categorical semantic primes as non-competitors. The targets have their own activation thresholds, and the primes aid the targets reaching the threshold

sooner. Here, the interference is at the level of word planning where one must exclude the articulatory response to the prime, taking time for target actualization (Janssen et al., 2008). Evidence from evoked responses which demonstrate similar long latency amplitude responses (N400) for semantic category interference and facilitation by identity primes (primes comprising the same phonemes as the target) support the presence of priming (Roelofs et al., 2016). Monolingual children (five to seven years) and teenagers (12 to 14 years) also show interference by semantic and unrelated primes on picture naming. Their absolute reaction time values, however, indicate more time is needed to inhibit the semantically related primes and activate the target response (Jerger et al., 2002). Overall, picture naming becomes slower under the influence of a categorical semantic prime within a language.

Studies in bilingual adults dominate cross-linguistic semantic priming research using picture naming. They have shown a pattern of interference compared with unrelated primes when the primes are in the L1 and naming responses are in their L2 (Costa & Caramazza, 1999; Costa et al., 2003). This is a dominance effect. Here, the stronger first language enables faster access to the second language, due to the use of translation from L2 to L1. It occurs because of stronger connection with the conceptual system, while learning the second language (Basnight-Brown & Altarriba, 2007; Weber & Cutler, 2004). Studies have shown that the extent of interference caused by semantically related primes across languages is like its corresponding effect within a language (Costa et al., 2003; Costa & Caramazza, 1999). Unrelated cross-linguistic primes are also more interfering than non-linguistic primes (Costa et al., 2003). These effects contrast with facilitation using translation priming in bilinguals (Costa et al., 2003; Costa & Caramazza, 1999; Roelofs et al., 2011). Studies using evoked response potentials have shown that both facilitation by translation primes and interference by categorical primes produce similar electrophysiological responses, contrasting with unrelated and nonlinguistic primes (Roelofs et al., 2016). This supports a connection between languages for semantic categories and translation equivalents. In addition, bilinguals may show differing priming effects based on inherent differences in the speed of picture naming between the two languages. Gollan et al. (2005) found that Spanish-English bilinguals named pictures in English at a slower rate than in Spanish. The confounding variable was their knowledge of Spanish translation equivalents to the words in English. There was no difference in picture naming speed between the languages if the bilinguals were aware of the Spanish translation equivalents to the English targets. Costa et al. (2006) found that the competition of lexical entities between languages is more when language proficiency is lower. Therefore, cross-linguistic semantic primes in the dominant or first language interfere with the speed of picture naming, and vocabulary knowledge or language proficiency may influence priming in bilingual adults.

Fewer studies on semantic priming in bilingual children are present in existing research and none of them use picture naming as the response task. Floccia et al. (2020) found that English-French bilingual 27-month-old children did not show a language dominance effect or an advantage of translation priming over cross-language semantic priming through a preferential looking paradigm. Jardak and Byers-Heinlein (2018) also found no language

dominance effect of semantic priming through preferential looking in French-English bilingual 30-month-old children. On the other hand, Singh (2013) found preferential looking priming effects only when the primes were in the dominant languages regardless of the target language in a semantic priming study on English-Mandarin Chinese toddlers aged two and a half years. Furthermore, semantic priming research in bilingual school children is scarce. In a study on Spanish-English bilingual children under nine years of age with limited proficiency in L1, semantic priming was present from L2 to L1 on a looking-while-listening task. This reworking of the preferential looking paradigm pointed to a shared semantic system between the languages. The effect of semantic priming, including categorical, associative and synonym primes, did not show on the lexical decision task, while translation priming was bidirectional on the looking-while-listening task (Goodrich & Lonigan, 2018a). These mixed results indicate that bilingual children may not have a like-for-like miniature representation of the adult bilingual lexicon. It highlights the importance of examining bilingual language processing in various stages of development (DeAnda et al., 2016). We did not find a study in school-aged children over nine years of age and one with picture naming as the task in semantic priming. Overall, bilingual priming studies in children show no specific pattern of interaction between the two languages.

Research shows that factors associated with language knowledge influence the study of the semantic lexicon through priming (Costa et al., 2006; Gollan et al., 2005; Kotz & Elston-Güttler, 2004). Although semantic networking emerges as early as 21 months in typically developing monolingual children and cross-language networking by around 30 months in bilingual children (Arias-Trejo & Plunkett, 2009; Jardak & Byers-Heinlein, 2018), semantic priming continues to improve with growing language proficiency. In addition, children with language-based reading disabilities do not exhibit significant semantic priming (Betjemann & Keenan, 2008). So, it is crucial to consider language knowledge in a semantic priming study. For monolingual semantic priming, we could consider scores on a measure of monolingual vocabulary to compare with the speed of priming on word-level tasks. For bilingual children with various levels of exposure to the two languages, it becomes harder to establish their combined language proficiency. For instance, estimating vocabulary in the two languages separately may provide an inaccurate representation of their overall knowledge of concepts if they experience certain words in L1 and others in L2 contexts. Bilingual children as early as two years six months demonstrate a language-specific moderate to low correlation between vocabulary and online lexical comprehension (Marchman et al., 2010). To address this conundrum where language-specific vocabulary measured separately may not be equivalent to their collective vocabulary, research suggests the method of conceptual scoring where children can respond in either of the two languages (Goodrich & Lonigan, 2018b). Therefore, we used a measure of bilingual vocabulary to study its relationship with semantic priming.

Current research on semantic priming in bilingual children has focused on bilingual toddlers exposed to two languages simultaneously and school-aged bilingual children up to nine years of age (Floccia et al., 2020, Goodrich & Lonigan, 2018a; Jardak & Byers-Heinlein, 2018; Singh, 2013). While the

studies in toddlers reveal equivocal findings with reference to the impact of a dominant language on the other, school-aged children show task-specific semantic priming. In this study, we aimed to extend this line of research to Spanish-English bilingual children in the two upper elementary grades with English as the medium of instruction at school. This study explored whether the two languages in their environment, inclusive of variations in exposure, would continue to exert an influence on an English picture naming task. We examined the impact of semantically related, e.g., orange - apple, zapato (shoe) - sock, and unrelated auditory primes, e.g., duck - lamp, gato (cat) – sun, in either L1 (Spanish) or L2 (English) on the speed of picture naming in English. Given the years of experience with English in the school setting, we anticipated that semantic primes in English would influence the speed of picture naming in English. It was hypothesized that the influence of semantic primes in Spanish on picture naming in English might not be straightforward. If the children made sufficient automatic connections between the two languages based on their exposure to Spanish outside the school setting, semantic primes in Spanish may influence the speed of picture naming in English. If the children had weaker bilingual semantic relatedness, we expected to find contrary results. We chose to study semantic priming effects on picture naming in English and not Spanish with the purpose to investigate the relevance of bilingual input for performance in the language used for instruction and academic measurement. To account for the role of vocabulary knowledge in automatic semantic processing, the relationship between the priming effects and bilingual vocabulary was evaluated. The primed picture naming reaction time values of each participant were compared with their bilingual expressive vocabulary scores. We hypothesized that participants with higher vocabulary would show stronger semantic priming by both English and Spanish primes.

2. Methodology

The Loma Linda University Office of Sponsored Research Institutional Review Board and the Fontana Unified School District Research Review Board both approved the data collection and preliminary analyses for this study.

2.1. Participants

Thirty Spanish-English neurotypical bilingual 4th and 5th grade students enrolled in a local public-school district in southern California participated in the study. English was their medium of classroom instruction. The participants were selected using consecutive sampling and their identities were kept confidential by encoding the participant names using alphanumeric codes. None of the participants had an Individualized Education Plan or a 504 plan. As part of the university and school district Institutional Review Boards' processes, we obtained a written informed consent from a parent of each participant and an informed assent from each participant.

For participant recruitment, flyers and interest slips in English and Spanish were distributed to fourth and fifth grade students to share with their parents. We contacted parents of students who expressed interest in participating through the return of interest slips to present written informed consent in English or Spanish (with an interpreter). Subsequently, written assent forms

were presented to the participants. All the students who returned the flyers with interest slips were given a toy worth one dollar. The flyers indicated Spanish-English knowledge as one of the requirements for participation in the study. The researchers considered the information provided by the student, and their respective parent/s and teacher/s in determining the bilingual status of the student.

Thirty participants heard Spanish at home and English mainly during their school day. The level of exposure to Spanish varied across participants from some exposure (e.g., grandparent spoke Spanish) to full exposure (e.g., both parents spoke Spanish) at home. There was variability in the quality of Spanish exposure (e.g., some family members were fluent speakers of Spanish). All participants had English exposure at least in the school setting for a minimum of four school years, i.e., from kindergarten to third grade. The participants aged from nine to 11 years at the time of participation. The sample comprised 16 (six males, 10 females) fourth and 14 (eight males and six females) fifth graders.

2.2. Instrumentation

The DMDX (Forster & Forster, 2003) and CheckVocal (Protopapas, 2007) software were installed on a Lenovo YOGA730 13IKB laptop with a Windows 10 operating system. A compatible headset microphone with noise cancellation (Logitech-H390) was used for prime presentation and recording of responses. DMDX has provisions to experimentally control the timing of presentation of stimuli through auditory and visual modes and record the reaction time of participants' responses. The researchers used the CheckVocal software for the analysis of recorded responses in terms of accuracy and timing in milliseconds. The Expressive One-Word Picture Vocabulary Test – 4: Spanish-Bilingual Edition (EOWPVT-4, Martin, 2013) was used to obtain two measures (raw score and standard score) of expressive vocabulary through picture naming.

2.3. Material

For the priming experiment, pictures were used as targets and spoken words as primes. To ensure that targets and primes were familiar to fourth and fifth grade students, the researchers selected third grade-level items of common lexical categories such as animals, common household objects, clothing, vehicle, fruits, vegetables, food, drinks, and body parts. To verify familiarity of the chosen items for third grade students, we provided the list of 150 items to three third grade teachers to rate the items on a three-point rating scale: very familiar, familiar, and unfamiliar. Teachers rated 12 words as unfamiliar, 32 as familiar and 106 as very familiar. The 138 familiar and very familiar words were combined and 100 of them were randomly chosen as targets for the primed picture naming task. The 100 targets were divided among four experimental conditions (Categorical Semantic Spanish - CSS, Categorical Semantic English - CSE, Unrelated Spanish – URS and Unrelated English - URE) and one control condition (No Prime - NP) with 20 items in each condition, using systematic random assignment. We used color pictures of the chosen items in bmp format as targets for the picture naming task.

To choose primes in Spanish for CSS and URS conditions, the researchers used 20 translation equivalents of items that belonged to the same lexical category as their targets, e.g., oso (bear) - tiger, and 20 translation equivalents of items that did not belong to the same lexical category as their targets, e.g., manzana (apple) - bus, respectively. To choose primes in English for CSE and URE conditions, we used 20 items that belong to the same lexical category as their targets, e.g., orange – apple, and 20 items that do not belong to the same lexical category as their targets, e.g., book – deer, respectively. It was ensured that the prime and target pairs did not associate with each other (e.g., bread - butter). Thus, we arrived at the primes and targets for the four experimental conditions and targets for the no prime condition (see Appendix A). The primes were audio recorded for each of the experimental conditions (CSS, CSE, URS, URE) using Praat software (Boersma, 2001). The sound files were edited to remove periods of silence before and after the spoken word for the precise duration of primes in milliseconds: CSS (M=816, SD=129), CSE (M=748, SD=127), URS (M=848, SD=167) and URE (M=765, SD=148), and saved in wav format. We considered the use of graphemic primes comparable with the auditory primes but rejected them due to our participants' lack of exposure to written Spanish making the presentation of graphemic Spanish primes for the L1 to L2 priming conditions irrelevant. Ten prime-target pairs that were not a part of the main experiment were used for practice trials. The program for the priming experiment on DMDX was written to follow this order: fixation point, '*', for 500 milliseconds, auditory prime (duration equal to the length of each audio file for the respective prime) and target picture for 3000 milliseconds for each experimental condition. The control condition had a silence period prior to the presentation of the target pictures.

2.4. Procedure

The primed picture naming task and EOWPVT-4 were administered in a well-lit room with minimum background noise, located in the elementary school of the participants. Data collection sessions lasted between 45 and 60 minutes with breaks between the various tasks/conditions. We seated the participants such that the laptop screen was clearly visible, and they wore the headset microphone to hear binaural auditory primes. The participants familiarized with the target pictures before the practice trials. This was done to ensure that picture familiarity did not interfere with speeded naming. The participants were instructed to visually focus on the computer screen. When an asterisk (*) appeared on the screen, this was their visual cue to prepare to see the target picture and name it in English as quickly as possible. The participants were told that they may hear some sounds through the headphones, but that they should only name the visually presented picture. The prime durations were equal to their stimulus onset asynchrony, i.e., duration between the onset of the prime to the onset of the target. Since the onset of the prime preceded the onset of the target, the stimulus onset asynchrony is negative. The participants underwent practice trials until they were familiar with the task. The 20 control (NP) and 80 experimental items (CSS, CSE, URS, URE) were presented in random order. DMDX randomized the order of presentation of items within each of the conditions. Participants took short breaks between the tasks per their requirement. The participants took the bilingual expressive

vocabulary test based on the instructions in the test manual. After the completion of all the tasks, the participants received gifts worth $10 each.

2.5. Analyses

Raw and standard scores on the EOWPVT-4 were calculated for each participant and their primed picture naming responses were analyzed using the CheckVocal software to determine onset of accurately named responses in milliseconds. Erred responses (<2.4%) were excluded. Auditory playback, waveform and spectrogram information were used to determine the point of onset of correct picture naming responses in relation to the onset of the target pictures. The Statistical Package for Social Sciences (version 26) software was used to run the descriptive and inferential statistics. All statistical tests used $p<.05$ as the level of significance. Paired t-tests were used for pairwise comparisons across all the experimental and control conditions. Effect size was calculated for all paired comparisons using Cohen's d, with a t value for correlated observations (tc), $d=tc\,[2(1-r)/n]^{½}$ and $tc=MD/(SDD/n^{½})$ (MD is the difference of means, SDD is the standard deviation of differences, r is the correlation co-efficient, and n stands for sample size) (Dunlap et al., 1996). Pearson's product-moment correlation coefficients determined the relationship between picture naming reaction times and bilingual expressive vocabulary scores. Semi-partial correlations were performed, controlling the vocabulary scores for age or grade.

3. Findings

The descriptive statistics across the experimental and control conditions indicated that the mean values of reaction times of the primed conditions were slower than that of the no prime condition. Table 1. shows the mean and standard deviation values of the primed picture naming reaction times (in milliseconds) and the bilingual vocabulary scores (raw and standard scores).

Table 1
Descriptive Statistics on Reaction Time (in milliseconds) and EOWPVT-4 Scores

Task/Test	M	SD	Error (%)
No Prime (NP)	888.9	114.8	1.5
Categorical Semantic Spanish (CSS)	1013.6	121.8	2.3
Unrelated Spanish (URS)	998.7	127.9	2.3
Categorical Semantic English (CSE)	939.9	104.8	2.3
Unrelated English (URE)	978.4	89	2.1
EOWPVT-4 Raw Score (EV-RS)	97	12	-
EOWPVT-4 Standard Score (EV-SS)	113.1	11.4	-

Note. *percentage of erred picture naming responses excluded from analysis

The results of the paired t-tests conducted to examine the effects of within-language and cross-language categorical semantic and unrelated primes on picture naming along with the no prime control condition revealed that CSS, URS, CSE and URE all differed significantly in comparison with NP ($M_{CSS-NP}=124.6$, $t(29)=4.65$, $p<.001$, $d=1.05$, $r=.23$; $M_{URS-NP}=109.7$, $t(29)=4.71$, $p<.001$, $d=.9$, $r=.45$; $M_{CSE-NP}=50.9$, $t(29)=2.31$, $p<.05$, $d=.46$, $r=.4$; $M_{URE-NP}=89.4$, $t(29)=4.66$, $p<.001$, $d=.85$, $r=.49$) with slower reaction times of the primed conditions. There was, however, no significant difference between CSS

and URS indicating that although the Spanish primes elicited slower reaction times compared to NP, they did not differ on account of their categorical semantic relationship with the target in English ($M_{CSS-URS}$=14.9, t(29)=.77, p=.44, d=.12, r=.64). On the contrary, CSE and URE were significantly different and their relative mean reaction time values showed that unrelated English primes slowed English picture naming more than the categorically related English primes ($M_{URE-CSE}$=38.4, t(29)=2.25, p<.05, d=.39, r=.54). Further, pairwise comparisons were conducted across the primed conditions in the two languages. Only CSE was significantly different from CSS and URS whereas URE was not ($M_{CSS-CSE}$=73.9, t(29)=4.24, p<.001, d=.64, r=.65; $M_{URS-CSE}$=58, t(29)=3.97, p<.001, d=.48, r=.77; $M_{CSS-URE}$=35.2, t(29)=1.76, p=.08, d=.32, r=.49; $M_{URS-URE}$=20.2, t(29)=1.04, p=.3, d=.17, r=.57).

Overall, the paired comparisons revealed that all primes reduced the speed of picture naming in English compared to NP. The extent of slowing of picture naming in English by CSS, URS and URE primes were similar. They collectively differed from the reduction in speed by CSE primes. CSE primed reaction time was faster than the reaction times elicited through CSS, URS and URE priming.

Pearson's product-moment correlations between no prime reaction time (NP) and bilingual expressive vocabulary scores (EV-RS and EV-SS) showed no statistically significant correlations. Correlations between primed picture naming reaction times (CSS, URS, CSE, URE) and bilingual expressive vocabulary scores (EV-RS and EV-SS) found moderate to low positive correlations between CSS and both EV-RS and EV-SS (CSS and EV-RS: r = .373; p = .043; CSS and EV-SS: r = .435; p = .016). There were no statistically significant correlations between the other primed reaction time values and vocabulary scores. This pattern was consistent across the semi-partial correlations after controlling for age or grade. Table 2. summarizes these findings.

Table 2

Pearson's Correlation between Priming Effects and Vocabulary Scores

Condition/Vocabulary	EV-RS *r* (*p*)	EV-RS[a] *r* (*p*)	EV-RS[g] *r* (*p*)	EV-SS *r* (*p*)	EV-SS[g] *r* (*p*)
NP	-.333 (.072)	-.261 (.171)	-.263 (.168)	-.233 (.216)	-.218 (.256)
CSS	.373* (.043)	.431* (.019)	.413* (.026)	.435* (.016)	.435* (.018)
URS	-.125 (.51)	-.025 (.898)	-.002 (.991)	-.005 (.979)	.021 (.914)
CSE	-.078 (.682)	-.023 (.907)	-.013 (.947)	-.017 (.929)	-.004 (.985)
URE	.022 (.907)	.110 (.571)	.136 (.482)	.130 (.494)	.153 (.427)

Note. [a]controlled for age, [g]controlled for grade, *p<0.05

4. Discussion and Conclusions

Our first aim was to determine semantic priming effects on speeded picture naming in L2 (English) given primes in either L1 (Spanish) or L2 (English). The reaction time values for picture naming in English were examined in the

presence and absence of auditory primes comprising categorically related and unrelated words in both languages. The comparisons between CSS and NP, CSE and NP, URS and NP, and URE and NP conditions revealed that all primes regardless of language or semantic relatedness reduced the speed of picture naming in English. This interference by auditory primes on a picture-based speech production task is in consensus with monolingual and bilingual findings in relation with categorical and unrelated primes (Costa & Caramazza, 1999; Costa et al., 2003; Damian & Martin, 1999; Glaser & Dungelhoff, 1984; Jerger et al., 2002; Rose et al., 2019; Xavier Alario et al., 2000). As anticipated, the interference was in contrast with facilitation observed on non-speech tasks in sematic priming experiments confirming task-specific differences across priming paradigms (Goodrich & Lonigan, 2018a; Jardak & Byers-Heinlein, 2018; Singh, 2013). Picture naming interference may occur due to a combination of conceptual and lexical levels of interaction between a prime and target (Glaser & Dungelhoff, 1984; Roelofs et al., 2016; Rose et al., 2019). If CSE ≠ URE or CSS ≠ URS, the reason for interference would be at the conceptual level due to the semantic relationship between the primes and targets. If CSE = URE or CSS = URS, the reason for interference would be at the lexical level. We investigated these reasons through paired comparisons across the four primed picture naming reaction time values.

Comparisons between the two English priming conditions, CSE and URE, revealed that semantically related primes interfered to a lesser extent than unrelated primes. Interestingly, this finding was a reversal of the anticipated pattern where categorical semantic primes within a language interfere more than the unrelated primes as unrelated primes interfere at the lexical level and categorical semantic primes initiate delay at the conceptual level (Damian & Martin, 1999; Jerger et al., 2002; Xavier Alario et al., 2000). Nonetheless, the CSE effect was significantly different from that of the URE pointing to a conceptual influence in the form of relative facilitation by the semantic prime. Although this contrasted with an expected increase in reaction time with a reduction in semantic distance (Rose et al., 2019), it is possible that longer negative stimulus onset asynchronies (due to auditory prime durations >537 milliseconds) yielded a facilitation effect through priming at the conceptual level (Carr et al., 1982). When a prime occurs well before the target, the competition it creates with the activation of the target reduces as the activation of the prime fades. This aids faster naming of the target. Similarities in electrophysiological findings pertaining with semantic-relatedness-based facilitation and interference depending on the task support this theory (Roelofs et al., 2016). Therefore, the measured reaction time is a net interference effect of categorical semantic primes with conceptual facilitation and lexical interference. In other words, the result supports within-language (L2 to L2) semantic priming in the context of speeded picture naming in L2.

Although cross-linguistic semantic priming was evident through the interference caused by CSS and URS, there was no difference in the magnitude of interference between the two Spanish primes unlike the effects of English primes. Since the magnitude of interference by CSS and URS were similar, both Spanish primes are likely to have slowed the picture naming process due to lexical interference. This contrasted with the expected pattern of

interference rendering the categorical prime more interfering than the unrelated prime even across languages (Roelofs et al., 2016; Rose et al., 2019). This is indicative of an absence of conceptual connectivity in terms of categorical relatedness between Spanish and English languages in this population and supports the existence of separate conceptual systems in the two languages for bilingual children in this stage of development (Marchman et al., 2010). This result does not agree with cross-linguistic (L1 to L2) semantic priming for primed L2 picture naming in bilingual school-aged children.

The findings of the primed picture naming experiments revealed the presence of links between categorically related words within L2 at the conceptual level. We did not discover cross-linguistic conceptual priming, contrasting with studies demonstrating the dominance effect of L1 to L2 priming (Basnight-Brown & Altarriba, 2007; Singh 2013; Weber & Cutler, 2004). The absence of the dominance effect was in consonance with previous findings in bilingual toddlers (Floccia et al.., 2020; Jardak & Byers-Heinlein, 2018), extending these results to school-aged children between nine and 11 years. This, however, does not categorically rule out the impact of the nature of exposure to the two languages as semantic relatedness may also reflect the levels of L1 and L2 proficiency (Gollan et al., 2005; Singh, 2013). That the bilingual children in the study all received academic instruction in English, may have an impact on the result that categorical semantic primes in English influenced picture naming in English. Overall, the findings support language specific semantic relatedness.

Our second aim was to discover any relationship between primed picture naming reaction times and bilingual expressive vocabulary to understand how implicit L1 and L2 semantic connections relate with combined Spanish and English vocabulary knowledge. To establish a baseline for comparison with the primed picture naming reaction times, the relationship between the no prime picture naming speed and vocabulary was analyzed. The absence of a significant correlation between NP reaction times and vocabulary scores indicated that the speed of naming a picture was not related to expressive vocabulary knowledge. In bilingual school-aged children, the rate of picture naming in the language of academic instruction did not vary as a function of vocabulary knowledge in the two languages, in contrast with the findings of Marchman et al. (2010) who found a language-specific moderate to low correlation between vocabulary and real time lexical comprehension speed in bilingual toddlers. To the best of our knowledge, there are no studies comparing primed naming reaction times with bilingual expressive vocabulary. This finding suggests that picture naming speed and vocabulary scores measure distinct aspects of language processing.

Among the primed picture naming reaction times, only CSS exhibited a moderate to low correlation with both bilingual vocabulary scores, which remained after controlling for age or grade. Participants who obtained higher bilingual expressive vocabulary scores were more likely to have greater interference by semantically related primes in Spanish preceding picture naming in English. In other words, the stronger the implicit semantic connections between Spanish and English as seen through primed picture naming in English, the greater are their chances of having a stronger bilingual

expressive vocabulary. Although this finding does not correspond with the salient role of English through L2 to L2 priming on the primed picture naming task, it supports the role of L1 (Spanish) in bilingual expressive vocabulary development for bilingual children. The correlational finding acknowledges a subtle role of L1, which the values of primed reaction times do not make apparent. In bilingual children, even after three or more years of exposure to L2, L1 to L2 semantic connectivity relates with bilingual conceptual vocabulary.

Therefore, this study supported that Spanish-English bilingual children in the upper elementary grades continue to exhibit effects of L1 as well as L2 on their performance measured in L2, albeit differently. While both semantic primes in L1 and L2 influenced picture naming in L2, we observed that L1 did so through its relationship with conceptual vocabulary and L2 directly speeded the naming of a related word. As anticipated, English to English semantic connections were most relevant for a speech-based lexical retrieval task in English. The relevance of Spanish to English semantic connectivity was indirect that children who had more bilingual lexical competitors on the speeded naming task also had higher bilingual vocabulary scores. The findings suggest that we must consider the differential effect of English and Spanish languages in tailoring instruction for bilingual children in grades 4 and 5 as both L1 and L2 semantically related units are relevant for language use in L2. From a clinical or educational perspective, the priming results signify that to facilitate naming a picture in L2 faster it is beneficial to use a semantically related word in the same language as a prime, provided the relationship between the two words is familiar to the child. This holds good for bilingual children exposed to academic instruction primarily in L2. It is possible that priming with categorically related words may enhance word retrieval in various expressive language tasks such as labeling, sentence formulation and verbal analogies. The results of the correlational analyses imply that it is advantageous to use L1 along with L2 to broaden a bilingual's semantic system as it is related to expressive vocabulary measured with the two languages put together. Hence, creating opportunities for exposure to the first language may be relevant even when children primarily use and learn through a second language in the school setting.

To the best of our knowledge, this is the first study to investigate the importance of bilingual semantics in bilingual children older than 9 years, and the first with a primed speech production task in bilingual children, making it applicable for comparison with explicit speech-based tasks such as picture naming and word naming, in the school setting. The results of the study are generalizable to bilingual children with varied levels of L1 exposure and academic instruction in L2 as the inclusion and exclusion criteria for the participants reflect a representative sample of this population. Although it may be argued that it would have been beneficial to obtain a quantifiable measure of English and Spanish language exposure for inclusion in the analysis, we note that a lack of homogeneity within the bilingual school-aged population would make it cumbersome to assign defined groups as well as generalize the results to a dynamic bilingual population. With reference to the primed picture naming experiment, we ensured that it did not suffer from the confounds of lack of familiarity with the target items, order effect, task simplicity (picture

naming), and fatigue to participations, rendering the observed results internally valid for examining implicit bilingual semantic connections. Since the L1 or L2 semantic priming conditions were compared with corresponding unrelated primes and a no prime condition, the results confirm both presence of priming effects and delineate the level of priming within semantics, i.e., lexical or conceptual. That the study related implicit semantic connectivity with bilingual conceptual vocabulary rather than separate single language vocabulary measures, also enhances the relevance of the findings for children in language environments where bilingual exposure is situation or setting specific.

The study has a few limitations which future research could consider when examining bilingual implicit semantic development in the school-aged population. For semantic priming, we considered categorical semantic primes and did not include associative primes. We aimed to specifically discover categorical semantic relations, unlike a previous study on semantic priming in school-aged children where the experiment considered varied semantic priming relations collectively with equivocal findings (Goodrich & Lonigan, 2018a). In future, it might be worthwhile to examine implicit bilingual connections separately with associative primes to further identify which semantic relations between L1 and L2 are more important to L2 use in bilingual children. Although we did not categorize the participants' exposure to Spanish and English languages for statistical analyses with the intent of accounting for natural variations in the bilingual population, it may be beneficial to obtain a quantifiable measure of language exposure to Spanish and English. Particularly, considering two groups of bilingual children, with and without a dominant L1, would provide greater insight into how L1 and L2 roles for instruction vary with and without a dominance effect of priming. In this priming study, semantically related and unrelated, and L1 and L2 factors were considered to define the prime-target relations of the experimental conditions. Adding translation priming and repetition priming to the experimental conditions may have been useful for closer comparisons with previous semantic priming research in bilingual adults and children. Likewise, using the same priming paradigm across different response tasks as in extant research, e.g., preferential looking, auditory repetition, lexical decision, would enable a finer understanding of the development of bilingual semantics. In considering a measure of vocabulary, a bilingual expressive vocabulary test was chosen to provide an opportunity for bilingual children to demonstrate their conceptual knowledge. We could have additionally considered single language vocabulary measures in English and Spanish, for comparison with language-specific primed picture naming reaction times. The current findings, possible practical implications and ensuing limitations support the need for more research on implicit semantic processing across the stages of bilingual language development in bilingual children.

In summary, categorical semantic primes in both L1 and L2 have specific roles in the language use of bilingual children in fourth- and fifth-grades. The results support the use of within language priming through categorical semantic relations for enhancing the speed of picture naming in that language and the relevance of cross-linguistic categorical semantic relations for bilingual conceptual vocabulary. The study endorses the application of

tailored bilingual instruction for children who have academic exposure to the language at school for three years or more, and advocates for future research exploring the intricacies of implicit bilingual semantic development.

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Appendix

CSE		CSS		URE		URS		NP
Prime	**Target**	**Prime**	**Target**	**Prime**	**Target**	**Prime**	**Target**	**Target**
orange	apple	naranja	banana	car	orange	carro	grapes	strawberry
mango	blueberries	mango	papaya	bike	pineapple	bicicleta	mango	watermelon
sheep	dog	oveja	horse	guitar	cat	guitarra	pig	sheep
bear	monkey	oso	tiger	onion	zebra	rosa	giraffe	bear
giraffe	racoon	jirafa	rabbit	book	deer	libro	chicken	elephant
table	bed	lechuga	broccoli	duck	lamp	lampara	potato	carrot
tomato	onion	tomate	pumpkin	eraser	lettuce	borrador	tomato	corn
glue	pencil	pegamento	marker	corn	pen	elote	crayon	scissors
elephant	skunk	regla	eraser	juice	ruler	elefante	table	glue
ruler	book	triangulo	square	ant	circle	hormiga	rectangle	triangle
sunflower	rose	dientes	eyes	glue	sunflower	pato	airplane	teeth
leg	hand	pierna	ear	blueberries	leg	pina	shirt	pants
lamp	chair	zapato	sock	rose	hat	cebolla	shoe	belt
belt	shorts	cinturon	watch	carrot	dress	zanahoria	glasses	earrings
shoes	ring	negro	green	potato	blue	papa	orange	red
red	yellow	rojo	brown	milk	black	leche	pink	happy
angry	sad	hugo	milk	crayon	angry	cayola	water	juice
ant	butterfly	hormiga	cockroach	pencil	ant	lapiz	spider	bee
guitar	drum	guitarra	violin	cat	guitar	gato	sun	tree
chicken	duck	avion	car	earrings	bike	aretes	lips	truck