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Effects of Classroom Bilingualism on Task Shifting, Verbal Memory, and Word Learning in Children

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Abstract

We examined the effects of classroom bilingual experience in children on an array of cognitive skills. Monolingual English-speaking children were compared with children who spoke English as the native language and who had been exposed to Spanish in the context of dual-immersion schooling for an average of two years. The groups were compared on a measure of non-linguistic task-shifting; measures of verbal short-term and working memory; and measures of word-learning. The two groups of children did not differ on measures of non-linguistic task-shifting and verbal short-term memory. However, the classroom-exposure bilingual group outperformed the monolingual group on the measure of verbal working memory and a measure of word-learning. Together, these findings indicate that while exposure to a second language in a classroom setting may not be sufficient to engender changes in cognitive control, it can facilitate verbal memory and verbal learning.

Keywords

bilingualism; dual-immersion; cognitive control; verbal learning

The effects of lifelong bilingualism on cognitive functioning in children have been examined thoroughly in previous research. In general, lifelong bilingualism has been shown to positively shape the development of the executive functions – higher-order cognitive processes responsible for goal-directed behavior (e.g., Bialystok, 1999; Bialystok, Craik, Klein, & Viswanathan, 2004; Colzato, et al., 2008; Costa, Hernandez, & Sebastian-Galles, 2008). In particular, prior studies have documented bilingual advantages on tasks that index the ability to inhibit irrelevant information (e.g., Bialystok et al., 2004; Costa et al., 2008), and the ability to shift between activities (e.g., Bialystok, 2010; Bialystok & Shapero, 2005; Zelazo, Frye, & Rapus, 1996). Despite generally lower levels of lexical skills in bilinguals compared to monolinguals (e.g., Bialystok & Feng, 2009; Costa, 2005; Ivanova & Costa, 2008; Michael & Gollan, 2005) and despite inconsistent findings with regards to the effects of bilingualism on verbal memory (e.g., Fernandes, et al., 2007; Kaushanskaya, Blumenfeld, & Marian, 2012; Kroll et al., 2002; Papagno & Vallar, 1995), bilingual advantages have also been documented on word-learning tasks (e.g., Kaushanskaya & Marian, 2009a; b; Kaushanskaya & Reetz, 2012). Therefore, bilingualism may have a positive influence

on a broad array of cognitive skills. However, in the vast majority of prior studies examining the effects of bilingualism on cognitive performance, only bilinguals with lifelong naturalistic exposure to both languages have been considered. Therefore, it remains unclear whether robust bilingual experience is necessary in order to observe changes to the cognitive system, or whether the effects of bilingualism on cognitive development are continuous, such that acquisition of a second language can also yield improvements in cognitive functioning. Further, it is unknown whether bilingualism influences performance on different cognitive tasks to different degrees.

In the present study, we examined the effects of classroom bilingualism on cognitive performance in children. We contrasted monolingual, native-English-speaking children with children who were native speakers of English attending dual-immersion programs and acquiring Spanish as the second language through the public school system. We focused on the skills previously shown to be positively impacted by bilingualism – i.e., executive control and word-learning, and on skills that have yielded somewhat inconsistent data with regards to bilingualism in prior research – i.e., working memory. By testing second-language learners (henceforth referred to as *classroom bilingual children*) rather than lifelong bilinguals, we aimed to examine whether a limited amount of bilingual experience in constrained contexts was sufficient to engender an effect on cognitive functioning in children, and whether different cognitive skills would be differentially impacted by the same amount of bilingual experience.

Effects of Bilingualism on Cognitive Control

The positive effects of bilingualism on executive functions have been amply demonstrated by a large number of previous studies (e.g., Bialystok, 1999; Bialystok, 2010; Bialystok, Craik, Klein, & Viswanathan, 2004; Bialystok & Shapero, 2005; Colzato, et al., 2008; Costa, Hernandez, & Sebastian-Galles, 2008; Zelazo, Frye, & Rapus, 1996). Although debates continue about the exact aspects of bilingual experience that engender such effects, and about the precise components of executive function that are sensitive to the effects of bilingualism, the robustness of the available evidence is convincing. In general, studies that demonstrate positive effects of bilingualism on executive function employ non-linguistic attention-demanding tasks that engage one's ability to inhibit irrelevant information (e.g., Carlson & Meltzoff, 2008; Martin-Rhee & Bialystok, 2008). Thus, bilinguals have been shown to outperform monolinguals on traditional measures of inhibitory control such as the Simon task (e.g., Bialystok, Martin, & Viswanathan, 2005), and the flanker task (e.g., Costa et al., 2008). Bilinguals have also been shown to outperform monolinguals on task-shifting paradigms like the Dimensional Change Card Sort (DCCS) task (e.g., Bialystok, 1999; Bialystok & Martin, 2004), which incorporate the need to inhibit a conflicting pre-potent dimension (e.g., Carlson & Moses, 2001).

Prior research is somewhat inconsistent with regards to whether the effects of bilingualism on cognitive control are graded. On the one hand, there is evidence to suggest that the length of bilingual experience is linearly related to cognitive control performance (e.g., Luk, De Sa, & Bialystok, 2011). Luk et al. (2011) found that the age at which young adults became bilingual was predictive of their performance on the flanker task, suggesting that longer

most importantly, the working memory system and word-learning skills. In this way, the present study could begin to answer the question of whether the same length of bilingual exposure affects different cognitive skills in similar or distinct ways.

Effects of Bilingualism on Working Memory

While the literature on the effects of bilingualism on various executive functions is abundant (e.g., Bialystok, 1999; Bialystok, 2010; Bialystok, Craik, Klein, & Viswanathan, 2004; Bialystok & Shapero, 2005; Colzato, et al., 2008; Costa, Hernandez, & Sebastian-Galles, 2008; Zelazo, Frye, & Rapus, 1996), surprisingly little is known about the effects of bilingualism on working memory. This dearth in the state of knowledge is especially startling considering that *all* theoretical approaches to working memory incorporate a controlled-attention component (e.g., Baddeley, 2000, 2003; Baddeley & Hitch, 1974; Cowan, 1999; Engle et al., 1999; Majerus, Heiligenstein, Gautherot, Poncelet, & Van der Linden, 2009; Unsworth & Engle, 2006) and considering that the factor-based approaches to executive functions consistently include updating of working memory as a crucial aspect of executive functions (Garon, Bryson, & Smith, 2008; Miyake et al., 2000). The picture is further complicated by the fact that the fairly limited number of available studies on bilingual working memory performance has focused on verbal and non-verbal working memory, with conflicting results for both domains.

In the non-linguistic domain, both positive and neutral effects of bilingualism on working memory have been noted. Earlier work has considered working memory only tangentially, by manipulating working-memory demands of the main cognitive-control tasks, and revealed bilingual advantages on such tasks (e.g., Bialystok et al., 2004). Later studies have also suggested a positive effect of bilingualism on complex executive-function tasks that incorporate a working-memory component, like the dual-task paradigms (e.g., Bialystok, 2011). Some studies that have explicitly measured working-memory function revealed that bilingualism facilitates non-linguistic working-memory performance in adults (Hernandez, Costa, & Humphreys, 2012; Luo et al., 2012), and in children (e.g., Morales, Calvo, & Bialystok, 2013). However, in their study of cognitive control in low-income minority children, de Abreu et al. (2012) did not find bilingual advantages on the visual-spatial working memory task. Similarly, Bonifacci et al. (2011) failed to observe bilingual advantages on the non-verbal working memory task in children.

The findings regarding the effects of bilingualism on working memory are even less consistent when examined in the linguistic domain. A large number of studies documented bilingual *disadvantages* on verbal memory tasks (e.g., Cheung, 1996; Gathercole & Baddeley, 1990; Harrington & Sawyer, 1992; Luo et al., 2012; Masoura & Gathercole, 1999; Michas & Henry, 1994; Service, 1992; Thorn & Gathercole, 1999). For instance, Luo et al. (2012), while finding bilingual advantages on the spatial working memory task, observed lower verbal working-memory performance (measured using the word-span task) in bilinguals when compared to the monolinguals. Conversely, Bonifacci et al. (2011) documented a lack of differences between bilinguals and monolinguals on the verbal working memory task involving memory for digits. Finally, it appears that under some circumstances, bilinguals can outperform monolinguals on verbal working memory tasks

(e.g., Kaushanskaya, 2012; Kroll et al., 2002; Yoo & Kaushanskaya, 2012). When bilinguals and monolinguals are tested in the language that is native to both groups, and in which they have equal proficiency, bilinguals can outperform monolinguals on verbal memory measures like the non-word repetition task (e.g., Kaushanskaya, 2012) or the reading span task (e.g., Kroll, et al. 2002). Even more interestingly, bilinguals tested in their second language can outperform monolinguals on verbal working memory tasks, especially when the tasks become more difficult (Yoo & Kaushanskaya, 2012).

The examination of the effects of bilingualism on verbal memory performance is complicated by the fact that verbal memory performance is an outcome of complex interaction dynamics between linguistic skills and attention-based mechanisms (e.g., Engle, Kane, & Tuholski, 1999). Thus, less successful verbal memory performance in the second language can be attributed to the general fact of poorer second- than native-language knowledge (e.g., Cheung, 1996; Gathercole & Baddeley, 1990; Masoura & Gathercole, 1999; Michas & Henry, 1994; Service, 1992; Thorn & Gathercole, 1999). Similarly, inferior bilingual performance on verbal memory tasks compared to monolinguals can be attributed to bilinguals' lower linguistic skills (e.g., Messer, Leseman, Boom, & Mayo, 2010; Windsor et al., 2010). However, as the verbal memory task becomes more difficult, the reliance on attention-based executive-control processes increases (e.g., Cantor, Engle, & Hamilton, 1991; Cowan, 1988; 1999; 2001; Engle, Tuholski, Laughlin, & Conway, 1999; Kail & Hall, 2001; Kane et al., 2004; Unsworth & Engle, 2006). For example, working-memory tasks that require the participant to both recall the information and to engage in cognitive processing rely on the central attentional mechanisms more than short-term memory tasks that require the participant to only recall the information (e.g., Baddeley, 2000, 2003; Baddeley & Hitch, 1974). Therefore, it is possible that improved executive control associated with bilingualism can compensate for the lower linguistic skills usually observed in bilinguals in modulating verbal memory performance. This in turn may yield comparable levels of verbal memory performance in bilinguals and monolinguals, or even superior performance in bilinguals if the task becomes so difficult that participants are functioning above the level of their short-term memory capacity.

The difficulty with interpreting the literature on bilingual verbal memory performance is then associated not only with the fluctuating levels of language proficiencies, both within studies (for instance, between bilinguals' two languages or between bilinguals and monolinguals) and across studies, but also with the possibility that different verbal memory tasks tax language-specific knowledge vs. executive attention to different degrees (e.g., Kaushanskaya & Yoo, 2012). In the present study, we examined the effects of classroom bilingual exposure on children's performance on two classic verbal memory tasks – the word-span task and the listening-span task. The word-span task is a traditional measure of short-term memory that requires participants to recall lists of words. It is therefore largely dependent on the extent of language-specific linguistic knowledge (e.g., Gathercole, 1995; Engle, Nations, & Cantor, 1990; Harrington & Sawyer, 1992; Poirier & Saint-Aubin, 1995). The listening-span task is a traditional measure of working memory that requires participants to make T/F judgments on sets of sentences, while at the same time maintaining the last word of each sentence in memory. This task is therefore dependent on both the participant's linguistic knowledge and the participant's ability to engage the central

attentional processes (e.g., Daneman & Carpenter, 1980; Engle et al., 1999; Just & Carpenter, 1992; Turner & Engle, 1989). The advantage to testing classroom bilingual children on verbal memory tasks is that it is possible to match these children precisely to the monolingual controls on language-knowledge measures since their exposure to the second language has been relatively brief and highly contextualized. Thus, all other things being equal, classroom bilinguals should perform similarly to monolinguals on the short-term memory measure. Conversely, if limited classroom exposure to the L2 can positively affect children's attentional control, the classroom bilingual children may outperform the monolingual children on the working memory measure.

Effects of Bilingualism on Word Learning

Early stages of word learning appear to be influenced by whether children are exposed to a single language or to multiple languages at birth. At least two aspects of early word-learning have been shown to be affected by bilingualism – the mutual-exclusivity bias (children's tendency to assume that an object only has a single name) and the shape bias (children's tendency to extend a label to objects that share shape). In acquiring the correspondences between labels and concepts, monolingual children and adults are more likely to map a new word to an object for which they do not yet have a name (e.g., Au & Glusman, 1990; Landau, et al., 1988; Markman & Wachtel, 1988). However, previous studies have shown that through exposure to two labels for a single object, bilingual children do not rely on the mutual-exclusivity principle as much as monolingual children (e.g., Byers-Heinlein & Werker, 2009; Davidson, et al., 1997). Furthermore, monolingual children tend to generalize the name of an object to other objects that share its shape (e.g., Yoshida & Smith, 2003). However, Brojde, Ahmed, and Colunga (2012) found that when confronted with conflicting cues to word meanings, bilingual children tended to pay attention to pragmatic cues (i.e., the direction of the experimenter's eye gaze) while monolingual children tended to pay attention to perceptual cues (e.g., the shapes of the objects). Thus, bilingualism appears to influence the principles that constrain early processes of word-learning. Moreover, bilingualism appears to enhance the *efficiency* of the word-learning process in adulthood.

Experienced language learners (adults speaking three or more languages) have been shown to outperform inexperienced language learners (monolinguals) on paired-associate learning (PAL) tasks (e.g., Papagno & Vallar, 1995; Van Hell & Mahn, 1997). Advantages for PAL-type learning in adult speakers have also been demonstrated in speakers of only two languages (Kaushanskaya, 2012; Kaushanskaya & Marian, 2009a, b; Kaushanskaya & Rehtzgel, 2012). Positive effects of knowing multiple languages on PAL tasks have been replicated in simultaneous bilingual adults who learned both of their languages through natural immersion early in life (e.g., Kaushanskaya & Marian, 2009a; b), and in sequential bilingual adults who acquired their second language through classroom exposure later in life (e.g., Kaushanskaya & Rehtzgel, 2012). Further, the extent of L2 experience has been shown to be positively associated with performance on a word-learning task in adults (Kaushanskaya, Yoo, & Van Hecke, 2013), suggesting graded effects of bilingualism on word-learning. However, the mechanisms that underlie the positive effects of bilingualism on word-learning remain unclear, in large part due to the fact that in nearly all previous studies of word-learning in bilinguals, participants acquired novel words through linking

them with native-language translations, i.e. to concepts that were familiar (Kaushanskaya & Marian, 2009a; Papagno & Vallar, 1995; Van Hell & Mahn, 1997).

It is possible that the bilingual advantages observed on word-learning tasks are rooted, at least in part, in bilinguals' better ability to map novel labels to known concepts. This in turn may arise out of early influences of bilingualism on how the mutual-exclusivity constraints are instantiated (e.g., Byers-Heinlein & Werker, 2009; Davidson, et al., 1997). It is also of note that acquisition of a second language often requires the learner to engage in activities of precisely this nature – i.e., an L2 learner will frequently map a word in their L2 to a concept they already know in their L1. Therefore, in order to delineate the mechanisms that underlie the effects of bilingualism on novel word-learning, it is important to examine whether bilingual advantages for word-learning persist for tasks where novel words must be mapped onto unfamiliar concepts. Further, it is unclear whether a limited extent of classroom exposure to a second language can engender changes in word-learning performance. Therefore, in the present study we compared classroom bilingual children to monolingual children on two word-learning tasks. The first task required children to map novel words onto familiar referents (pictures of animals). It is on tasks such as these that prior studies with adults have obtained bilingual advantages (e.g., Kaushanskaya & Marian, 2009a; Papagno & Vallar, 1995; Van Hell & Mahn, 1997). The second task required children to map novel words onto unfamiliar referents (pictures of aliens). This task enabled us to examine whether the effects of bilingualism on word-learning (if observed) would be limited only to tasks that resemble second-language acquisition (i.e., the familiar-referent task) or whether they would generalize to other word-learning tasks.

The Current Study

In the current study, we examined the effects of classroom bilingualism on task shifting, verbal memory, and word-learning performance in children. The skill domains chosen as the focus in the present study have all been shown to be sensitive to the effects of bilingualism in prior research. Yet, the available evidence for the effects of bilingualism on each of these skill domains remains underspecified with regards to the precise nature of bilingual experiences that can yield a benefit in performance. Further, prior studies on the effects of bilingualism on cognitive functions (linguistic or non-linguistic) have often encountered difficulties with equalizing the demographic data across the monolingual and the bilingual groups. Thus, it is sometimes the case that studies compare bilinguals and monolinguals from different SES backgrounds (see Morton & Harper, 2007). It is also very frequently the case that bilinguals and monolinguals differ with regards to their performance on language measures (e.g., Bialystok, 2006). In general, the approach taken in prior studies has been to statistically factor out these group differences in the analyses comparing bilinguals and monolinguals (e.g., Bialystok, Craik, & Luk, 2008; Bialystok & Feng, 2009; Carlson & Meltzoff, 2008). Testing children who are in the process of acquiring their second language in the classroom avoids the methodological pitfalls associated with unwanted differences between bilinguals and monolinguals in demographic characteristics and in language skills. The classroom bilingual children tested in the present study were precisely matched to their monolingual counterparts on SES and on language measures. Therefore, we predicted that if

classroom exposure to a second language can engender effects on cognitive abilities, then the classroom bilinguals should outperform the monolinguals on the measures of interest.

Method

Participants

Thirty-eight children enrolled in Kindergarten through Grade 2, and between the ages of 5 and 7 participated. Of these, 19 children (7 males) were native speakers of English who were enrolled in dual-immersion classrooms in the Madison Metropolitan School District elementary schools. These dual-immersion classrooms consist of children who are native speakers of English and of children who are native speakers of Spanish. The Madison Dual Language Immersion program is structured similarly to the majority of dual-language classrooms in the United States, in that it follows the 90/10 Spanish/English model. In this approach, 90% of classroom time is conducted in Spanish, and 10% is conducted in English during children's first year in school. With each grade, English instruction increases by 10% until 4th grade, at which point classroom time is evenly split between English and Spanish. This particular approach is especially suited to the questions pursued here because it ensures robust classroom exposure to Spanish for the children who speak English as their native language. The classroom bilingual children have had an average of 1.96 years of dual-immersion classroom experience, with a range of 0.25 years to 4.17 years¹.

The other 19 children (7 males) were monolingual speakers of English who have had no exposure to a language other than English, either at home or in school. These monolingual children were selected to match the classroom-bilingual children in gender, class cohort, chronological age (within the range of ± 6 months), and maternal years of education (which served as a proxy for the child's SES, within the range of ± 1 year). The resulting two groups of children were therefore matched in gender, age, and SES. None of the children had language, cognitive, hearing, or vision impairments, per parents' reports. See Table 1 for the demographic information for the two groups and for the statistical comparisons demonstrating equivalence across them on these background measures.

Standardized testing—Each child was administered a battery of language and cognitive tests. Receptive English vocabulary skills were measured using the Peabody Picture Vocabulary Test III (*PPVT-III*; Dunn & Dunn, 1997), and expressive English vocabulary skills were measured using the Picture Vocabulary subtest of the *Woodcock-Johnson III Tests of Achievement*, Form A (Woodcock, McGrew, & Mather, 2001). The Visual Matrices subtest of the Kaufman Brief Intelligence Test, Second Edition (KBIT-2; Kaufman & Kaufman, 1990) was administered as a measure of children's nonverbal intelligence. The precise values associated with participants' linguistic and cognitive performance can be

¹The lower bound of dual-immersion experience in the children in this was 3 months of exposure – a shorter duration of exposure than has been explored in prior studies. This lower bound was driven by a single child, with all other 18 children in this group having experienced at least 6 months of classroom bilingualism. This child was included in the sample because her Spanish vocabulary skills were within the range of values for the sample as a whole (with receptive Spanish vocabulary Standard Score of 99, and with expressive Spanish receptive vocabulary Standard Score of 35). With this child omitted, the average length of classroom bilingualism was 2.05 years ($SD = 1.01$) with the range of 0.6 to 4.17 years. We re-ran all analyses with this child and her monolingual counterpart omitted, and found an identical pattern of results reported for the sample as a whole. We therefore left this child in the reported analyses to maintain the sample size.

found in Table 1. Independent-samples t-tests were used to compare the two groups of children on these linguistic and cognitive measures. The groups did not differ with regards to performance on the English language measures, or a measure of non-verbal IQ (all p values $> .1$).

The classroom-bilingual children were administered measures of Spanish vocabulary knowledge. Receptive Spanish vocabulary skills were measured using the *Test de Vocabulario en Imágenes Peabody* (TVIP, Dunn, Padilla, Lugo, & Dunn, 1986), and expressive Spanish vocabulary skills were measured using the “Vocabulario Sobre Dibujos” subtest of the Bateria III Woodcock-Muñoz Prueba de Aprovechamiento (Muñoz-Sandoval, Woodcock, McGrew, & Mather, 2005). Both of these tests have a mean standard score of 100, with a Standard Deviation of 15. The children’s performance on these two measures suggested that as a group, these classroom bilinguals demonstrated within-normal receptive Spanish skills (M Standard Score = 96.11, SD = 17.43), but low expressive Spanish skills (M Standard Score = 60.72, SD = 14.07). However, it is important to note that the norms for both Spanish vocabulary measures are based on monolingual Spanish-speaking age-matched peers, whereas the children in the present study only had an average of two years of Spanish classroom experience.

Procedure

Task shifting—A version of the Dimensional Change Cart Sorting (DCCS) Task was used to measure children’s non-linguistic task-shifting ability. This version of the task was based on the DCCS task designed and used extensively by Zelazo et al. (Frye, Zelazo, & Palfai, 1995; Zelazo, Frye, & Rapus, 1996; Zelazo, Müller, Frye, & Marcovitch, 2003) to measure task-shifting abilities in children, as well as on the “color-shape game” task used by Bialystok and Martin (2004) to contrast task-shifting skills in monolingual and bilingual children. The stimuli consisted of geometric colored shapes. All stimuli were presented on a 15-inch white screen with a resolution of 1920×1200. Each display contained a sorting cue – either a shape cue (a series of grey circles and squares at the top of the screen) or a color cue (a series of amorphous patches of red and blue at the top of the screen). Each display also contained the target stimulus – a red circle or a blue square – in the center of the screen. Lastly, each display contained two response bins – a grey bucket located in the bottom left corner with a red square in the middle and a grey bucket located in the bottom right corner with a blue circle in the middle. For any given trial, the selection of bucket depended on whether the child was sorting by shape (e.g., red circle goes in right-hand bucket with blue circle) or by color (e.g., red circle goes in left-hand bucket with red square).

Children were first trained to sort by color. The practice phase consisted of 4 trials with feedback, with the passing criterion set to 3 or more correct responses. If the child made more than 1 error in the practice phase, the practice phase was repeated. In the pre-switch phase, children sorted by the same dimension on which they had just been trained (i.e., the color game). This phase consisted of 10 trials. After completing the pre-switch phase, children were introduced to a new game (the post-switch phase), and were told to begin sorting the target stimuli by shape. Children completed the 10-trial post-switch phase with no practice trials. Finally, children were told that they were going to play both games at once

(the mixed phase), and that they would need to pay attention to the symbols at the top of the screen in order to know which game to play. The mixed phase consisted of 40 trials, with an equal number of non-switch trials (20) and switch trials (20), and an equal number of shape and color trials (20 each). The sequence of trials in the mixed phase was pseudorandomized using Research Randomizer (Urbaniak & Plous, 2011).

Each trial consisted of a fixation cross (presented for 200 ms), followed by an Interstimulus Interval of 500 ms, followed by the presentation of the sorting cue at the top of the screen (1000 ms), followed by the presentation of the target stimulus in the middle of screen. The cue remained on the screen throughout the presentation of the target stimulus. The response bins (red square and blue circle) were presented on each trial positioned above the “w” and the “p” keys on the computer keyboard. The keys had overlays of a red square and a blue circle on them, with a black cover over the rest of the keyboard to avoid distraction during the task. The children were instructed to position their fingers on the two response keys, and to respond to the target stimulus as quickly and accurately as possible. The trial terminated after the child’s response or after 4000 ms, whichever came first.

Verbal memory—Two tasks were designed to measure children’s verbal memory performance. A classic word-span task was used to measure children’s short-term memory, and a classic listening-span task was used to measure children’s working memory. The female speaker chosen to record the stimuli for the word-span and the listening-span tasks was a native speaker of English, with no working knowledge of any other language. All the stimuli were recorded in a sound-proof booth at a 20kHz sampling rate and were normalized to 70dB amplitude using Praat (Boersma & Weenink, 2011).

On the *word-span* task, both syllable-length of the words and the length of the lists were manipulated. Twenty one-syllable nouns, 20 two-syllable nouns, and 20 three-syllable nouns were grouped in lists of 2, 4, 6, and 8 nouns each. All nouns were selected to be early-acquired (before age 4). Across each syllable set and across each list set, nouns were matched on lexical frequency (based on the Brysbaert & New database, 2009), and concreteness (MRC Psycholinguistic Database). The nouns were also matched in phonotactic probability (calculated according to Vitevitch & Luce, 2004), and in phonological neighborhood size (calculated according to Marian, Bartolotti, Chabal, & Shook, 2012) across lists. Children heard the lists of words and were asked to recall as many words in the list as possible. All children started with 1-syllable words in lists of 2, 4, 6, and 8 words each, followed by 2-syllable words, and 3-syllable words. Within each list, the duration from the beginning of one word to the beginning of the next word was set to 750 milliseconds. The order of words within each list was randomized for each child. Children’s productions were recorded and coded off-line.

The *listening-span* task used in the present study was designed by Gaulin and Campbell (1994) to measure verbal working memory in school-age children. The stimuli consisted of 42 short sentences, grouped into 2 sets of 1, 2, 3, 4, 5, and 6 sentences each. Each sentence was either a true or a false statement, and contained three words (subject-verb-object; subject-verb-modifier; subject-auxiliary-main verb). All sentences used simple vocabulary and unambiguous content. These sentences have been normed with children ages 5 to 12,

and the sentences were controlled for length and difficulty level across sets. The children in the present study heard sentences over computer speakers. They were asked to respond to each sentence by either saying “yes” or “no” as quickly as possible without making mistakes. At the end of each set, the children were cued to remember the last word of each sentence. The children completed two 2-sentence practice sets with feedback to ensure that they understood the task. Within each set, the duration from the beginning of one sentence to the beginning of the next sentence was set to 2000 milliseconds. The order of sentences within each list was randomized for each child. Children’s productions were recorded and coded off-line.

Word Learning—Two word-learning tasks were designed to examine children’s ability to map novel words onto familiar referents (+R task) and to map novel words onto unfamiliar referents (–R task). The novel words were selected from a set of nonword stimuli developed by Gupta et al. (2004). The nonwords in the Gupta et al. (2004) database are controlled for phonological properties, and come in sets that are equated for consonant-onset characteristics and neighborhood density. We chose 8 pairs of bi-syllabic English pseudowords that followed a CVCVC syllable structure to create two lists, List A and List B. The two lists of pseudowords were matched on length, stress patterns, and phonotactic probability. The Related-Samples Wilcoxon Signed Rank Tests confirmed that the two lists of nonwords did not differ in phoneme frequency ($p = .67$), biphone frequency ($p = .48$), or in acoustic length in milliseconds ($p = .26$).

Eight pictures of familiar animals were chosen from the International Picture Naming Database (Székely et al., 2004) for the familiar-referent (+R) task. Eight pictures of unfamiliar aliens were chosen from the Gupta et al. (2004) database for the unfamiliar-referent (–R) task. The alien stimuli developed by Gupta et al. (2004) were designed to represent a meaningful category with each individual exemplar having no preexisting individual name. The original database included 144 alien stimuli that were constructed to vary along three dimensions: head shape, appendage type, and number of arms. The 8 alien pictures we selected were chosen to be maximally distinct from each other (i.e., any two pictures did not share more than one attribute). All visual stimuli were black-and-white pictures that were matched in size, shading and thickness of lines. The 16 pictures were normed on visual complexity based on a procedure established by Snodgrass and Vanderwart (1980) that has been used in a number of previous studies (e.g., Alario & Ferrand, 1999; Forsythe, Mulhern, & Sawey, 2008; Himmanen, Gentles, & Sailor, 2003). The 8 animal pictures and the 8 alien pictures did not differ in their visual complexity ratings, $p = .29$.

Children learned 8 novel words paired with familiar referents (animals), and 8 novel words paired with unfamiliar referents (aliens) in two different learning sessions scheduled at least one week apart. The order of presentation (animals vs. aliens first) was counterbalanced across participants; similarly, novel-word lists were counterbalanced across participants (i.e., half of the participants learned list A in association with animals and list B in association with aliens, and half of the participants did the reverse). The presentation of trials within the learning blocks was randomized for each child. For all learning trials, children heard the novel word twice, and saw the corresponding picture in the middle of the computer screen.

The picture remained on the screen for 6 seconds. Children were directed to remember which words went with which pictures. Immediately after the learning phase, the children were tested on their memory for the novel words using a forced-choice recognition task. On each trial, children were presented with an array of four pictures (animals or aliens), and were instructed to pick the picture that corresponded to the heard novel word. The position of the correct picture on the display varied randomly across trials. Children were instructed to match the correct picture to the novel word as quickly as possible. The presentation of trials within the testing blocks was randomized for each child.

Coding and Analyses

Task shifting—Accuracy and RT data were collected as response measures for the pre-switch, post-switch, and mixed conditions on the DCCS task. Only RTs for the correct responses were included. RTs more or less than 2.5 standard deviations from each child's overall mean for each phase (pre-switch, post-switch, mixed) were not included. The responses in the mixed condition were further divided into switch responses (responses on trials that followed a sorting rule different from the previous trial) and non-switch responses (response on trials that followed the same sorting rule as the one from the previous trial). A series of Anovas and independent-samples t-tests was conducted to examine between-group differences on the DCCS task.

Verbal memory tasks—For the *word-span* task, all productions were transcribed word-for-word by a native speaker of English. Regardless of order, each production was scored as correct if the produced word was in the target list. The proportion correct score was derived for each list set. Semantically similar/associated words (e.g., 'hand' instead of 'arm') or duplicated words were scored as incorrect. Morphological variants (e.g., 'flowers' instead of 'flower') were scored as correct. Proportion correct scores were analyzed using a $2 \times 4 \times 3$ Mixed Anova, with group (monolingual vs. bilingual) as the between-subjects independent variable; and list length (2, 4, 6, and 8) and syllable-length (1, 2, or 3-syllables) as within-subjects independent variables. For the *listening-span* task, all True/False responses were coded as correct or incorrect, with proportion correct scores indexing the accuracy of the secondary processing task. The primary recall task was coded so that each production was scored as correct if the produced word was in the target list. The proportion correct score was derived separately for each list set, with data averaged across sets of the same length. These recall data were analyzed using a 2×6 Mixed Anova with group (monolingual vs. bilingual) as the between-subjects independent variable and list length (1 through 6) as the within-subjects independent variable.

Word-Learning task—The accuracy on the forced-choice recognition task was indexed by the proportion of correctly identified pictures out of the total of 8 trials. Recognition-accuracy data were analyzed using 2×2 Mixed Anovas, with group (monolingual vs. bilingual) as the between-subjects independent variable and referent familiarity (+R vs. -R) as a within-subjects independent variable.

Results

Task-Shifting Analyses

DCCS data (accuracy and RT) for each condition are presented in Table 2. First, pre- and post-switch data were analyzed using 2×2 Anovas, with condition (pre- vs. post-switch) as the within-subjects variable and group (monolingual vs. bilingual) as the between-subjects variable. The Anova for accuracy revealed no main effects or interactions, with similar accuracies on the pre-switch ($M = .90$, $SE = .04$) and the post-switch trials ($M = .89$, $SE = .04$), $F < 1$, and similar accuracies attained by monolinguals ($M = .88$, $SE = .03$) and bilinguals ($M = .91$, $SE = .03$), $F < 1$. The interaction between condition and group was not significant, $F < 1$. The Anova for RTs revealed a main effect of condition, $F(1, 37) = 39.52$, $p < .001$, $\eta_p^2 = .60$, with shorter RTs in the pre-switch phase ($M = 919$ msec, $SE = 56$ msec) than in the post-switch phase ($M = 1407$, $SE = 68$). Neither the main effect of group nor the interaction between condition and group ($F_s < 1$) were significant.

Second, mixed-phase data were analyzed using Anovas with condition (non-switch vs. switch) as the within-subjects variable and group (monolingual vs. bilingual) as the between-subjects variable. The Anova for accuracy revealed a main effect of condition, $F(1, 37) = 24.21$, $p < .001$, $\eta_p^2 = .47$, with higher accuracy on the non-switch trials ($M = .74$, $SE = .03$) than on the switch trials ($M = .60$, $SE = .03$). The main effect of group and the interaction between condition and group were not statistically significant ($F_s < 1$). Similarly, the Anova for RTs revealed a main effect of condition, $F(1, 37) = 11.16$, $p < .01$, $\eta_p^2 = .29$, with shorter RTs on the non-switch trials ($M = 1784$, $SE = 102$) than on the switch trials ($M = 1970$, $SE = 105$). The main effect of group and the interaction between condition and group were not significant ($F_s < 1$). These analyses indicate that the two groups of children performed identically on each of the DCCS conditions of interest.

Verbal Memory Analyses

Word-span data for monolinguals and bilinguals are presented in Table 3. The Mixed Anova yielded a main effect of syllable-length, $F(2, 210) = 11.89$, $p < .001$, $\eta_p^2 = .25$, and a main effect of list length, $F(3, 210) = 301.61$, $p < .001$, $\eta_p^2 = .90$. The effect of group was not statistically-significant, $F(1, 37) = 1.35$, $p = .25$, $\eta_p^2 = .04$, although bilinguals ($M = .63$, $SE = .02$) tended to have higher recall than monolinguals ($M = .59$, $SE = .02$). No interactions were observed. The main effect of syllable-length was driven by superior recall of 1-syllable words ($M = .63$, $SE = .03$) and 2-syllable words ($M = .64$, $SE = .01$) over 3-syllable words ($M = .56$, $SE = .02$), both p values $< .01$ (corrected for multiple comparisons using the Bonferroni method). The main effect of list-length was driven by a step-wise decrease in recall with increase in length, with 2-word lists ($M = .97$, $SE = .01$) recalled more accurately than 4-word lists ($M = .76$, $SE = .03$), 6-word lists ($M = .39$, $SE = .02$), and 8-word lists ($M = .31$, $SE = .02$); 4-word lists recalled more accurately than 6-word and 8-word lists; and 6-word lists recalled more accurately than 8-word lists (all p values $< .01$).

The T/F data from the *listening-span* task, analyzed via a Mixed Anova yielded a main effect of list length, $F(5, 170) = 9.19$, $p < .001$, $\eta_p^2 = .21$. Neither the main effect of group ($F < 1$), nor the interaction between list-length and group ($F(5, 170) = 1.10$, $p = .36$, $\eta_p^2 = .$

03) were significant. The list-length effect was driven by higher accuracy on 1- ($M = .99$, $SE = .01$) and 2- ($M = .97$, $SE = .02$) sentence sets than 3- ($M = .82$, $SE = .04$), 4- ($M = .80$, $SE = .04$), 5- ($M = .85$, $SE = .03$), and 6-sentence ($M = .89$, $SE = .03$) sets (all p values $< .01$).

The recall data from the *listening-span* task are presented in Table 4. The Mixed Anova yielded a main effect of list length, $F(5, 165) = 73.10$, $p < .001$, $\eta_p^2 = .69$, and a main effect of group, $F(1, 37) = 4.52$, $p = .04$, $\eta_p^2 = .10$. The interaction between group and list-length was not significant, $F < 1$. The main effect of group was a reflection of higher recall in the bilingual group ($M = .53$, $SE = .04$) than in the monolingual group ($M = .41$, $SE = .04$). The main effect of list length was driven by higher recall for lists that consisted of 1 sentence ($M = .87$, $SE = .06$) than for lists that consisted of 2 ($M = .68$, $SE = .06$), 3 ($M = .47$, $SE = .04$), 4 ($M = .30$, $SE = .03$), 5 ($M = .26$, $SE = .02$), and 6 ($M = .24$, $SE = .02$) sentences (all p values $< .01$). The difference between 2-sentence lists and other list-lengths as well as the difference between 3-sentence lists and other list-lengths were also significant (all p values $< .01$). These analyses indicate that classroom bilingual children outperformed monolingual children on the verbal working memory task, but not on the verbal short-term memory task.

Word-Learning Analyses

The Anova for recognition accuracy yielded a main effect of group, $F(1, 37) = 4.37$, $p = .04$, $\eta_p^2 = .10$, and a significant two-way interaction between group and referent, $F(1, 37) = 4.87$, $p = .04$, $\eta_p^2 = .09$. The main effect of referent was not statistically-significant, $F < 1$. The main effect of group was driven by higher retention of the novel words in the bilingual group ($M = .47$, $SE = .04$) than in the monolingual group ($M = .35$, $SE = .04$). However, follow-up independent-samples t-tests conducted for each referent condition separately in order to localize the interaction effect revealed that bilingual children outperformed monolingual children only in the familiar-referent condition, $t(37) = 2.08$, $p = .03$. In the unfamiliar referent condition, bilingual children and monolingual children were statistically indistinguishable, $t(37) = 0.25$, $p = .81$. These data are plotted in Figure 1.

Discussion

In the present study, we examined whether classroom bilingual exposure can affect children's cognitive function by comparing monolingual children to children who have had an average of two years of classroom Spanish exposure. We focused on the cognitive skills that have been shown to be sensitive to bilingualism in previous studies: Task-shifting, verbal memory, and word learning. We found that classroom bilingual children and monolingual children performed similarly on the measures of task shifting and verbal short-term memory. We therefore conclude that classroom bilingual exposure (at least of the duration examined here) does not affect task-shifting and verbal short-term memory skills. In contrast, we found that classroom bilingual children outperformed monolingual children on measures of verbal working memory and word-learning. We therefore conclude that classroom bilingual exposure can facilitate verbal working memory and verbal learning.

Effects of Classroom Bilingualism on Task-Shifting

The finding that the limited amount of second-language experience under scrutiny in the present study was not sufficient to yield higher levels of task-shifting performance in bilingual children is consistent with prior studies that examined executive function in dual-immersion children (Carlson & Meltzoff, 2008; Poarch & van Hell, 2012). Carlson and Meltzoff (2008) found that children who attended dual-immersion classrooms for 6 months did not differ from their monolingual peers on the DCCS task, while Poarch and van Hell (2012) observed similar levels of performance on the Simon task between children who were acquiring a second language in school for an average of 1.3 years and monolingual children. Conversely, Bialystok, Peets, & Moreno, 2012 found that children with 5 years of dual-immersion classroom experience outperformed monolingual children on some (but not all) metalinguistic tasks that required cognitive control. Furthermore, Bialystok and Barac (2012) documented a significant relationship between the length of time children had spent in an immersion program and their performance on cognitive control tasks. It is important to note that the two studies that have documented relationships between classroom bilingualism and cognitive control have focused on longer durations of second-language immersion (with an approximate average of 5 years) than the studies that have failed to observe such a relationship (ranging from 6 months to 1.3 years). This includes our study, where the average length of classroom exposure was 2 years. Therefore, although the small number of studies that has considered the effects of classroom bilingualism on executive functioning precludes broad generalizations, the Carlson and Meltzoff (2008) data and the Poarch and van Hell (2012) data together with the present dataset indicate that 6 months to 2 years of classroom bilingual exposure do not engender changes to non-linguistic executive functioning.

A large body of literature has reported positive effects of bilingualism on executive functions, especially when executive functions are indexed by non-linguistic tasks that involve inhibitory control (e.g., Bialystok, 1999; Bialystok, 2010; Bialystok, Craik, Klein, & Viswanathan, 2004; Bialystok & Martin, 2004; Bialystok, Martin, & Viswanathan, 2005; Bialystok & Shapero, 2005; Carlson & Moses, 2001; Colzato, et al., 2008; Costa, Hernandez, & Sebastian-Galles, 2008; Zelazo, Frye, & Rapus, 1996). In general, the positive effects of bilingualism on inhibitory control are associated with lifelong bilingual exposure (e.g., Bialystok, Craik, Green, & Gollan, 2009). Mechanistically, it is the need to inhibit one language when producing and/or comprehending linguistic input in the other language that is hypothesized to cause bilinguals' inhibitory control system to become more efficient (Blumenfeld & Marian, 2011; Bialystok, 2011). The argument is that the cognitive control mechanisms that underlie the need to control access to the two languages are the same domain-general cognitive control mechanisms that underlie successful performance on tasks such as the Simon, the Flanker, and the DCCS.

It is important to point out that the mechanism whereby bilingualism enhances domain-general cognitive control remains theoretical. Nevertheless, our findings regarding the limited effect that classroom bilingualism may have on executive functioning are consistent with such a mechanism. Because language use in classroom bilinguals is highly contextualized (the children are exposed to one of their languages in the home and to the

other one of their languages in school), classroom bilinguals may not experience high levels of non-target language activation when in the target-language setting. Further, after only a few years of instruction in Spanish, classroom bilinguals may experience limited co-activation of Spanish when processing information in English – the language they use more frequently. Measures of Spanish vocabulary knowledge administered to the classroom bilingual children in the present study suggest that while these children have acquired significant receptive vocabulary skills in their second language, their expressive Spanish vocabulary skills continued to trail behind the normative data for Spanish-speaking age-matched peers. It is likely that children whose expressive vocabulary skills in their native language significantly outstrip their vocabulary skills in the second language do not experience much cross-linguistic interference when speaking their two languages. Therefore, the classroom bilingual children may not need to rely on inhibitory control mechanisms when accessing their two languages, and thus classroom bilingual experience would not facilitate performance on non-linguistic executive function tasks.

Effects of Classroom Bilingualism on Working Memory

Given that classroom bilingualism did not facilitate task-shifting performance in the present study, the finding that it did facilitate verbal working memory performance is all the more remarkable. In prior work, the effects of bilingualism on verbal short-term and verbal working memory performance have been inconsistent, with some studies demonstrating lack of differences between bilinguals and monolinguals (e.g., Bonifacci et al., 2011), other studies demonstrating superior bilingual performance (e.g., Kaushanskaya, 2012; Kroll et al., 2002; Yoo & Kaushanskaya, 2012), and yet other studies yielding superior monolingual performance on verbal memory tasks (e.g., Cheung, 1996; Gathercole & Baddeley, 1990; Harrington & Sawyer, 1992; Luo et al., 2012; Masoura & Gathercole, 1999; Michas & Henry, 1994; Service, 1992; Thorn & Gathercole, 1999). Inferior performance in bilinguals compared to monolinguals on verbal memory measures has been attributed to bilinguals' lower levels of language-specific knowledge (e.g., Messer, Leseman, Boom, & Mayo, 2010; Windsor et al., 2010). Thus, if extant language abilities between bilinguals and monolinguals are equalized, differences between bilinguals and monolinguals on verbal memory tasks should also disappear. This interpretation is consistent with the lack of differences between classroom bilinguals and monolinguals we observed in the present study on the short-term memory task. However, how do we explain superior performance of the classroom bilingual children on the verbal working memory task?

In juxtaposing short-term and working memory tasks, working memory models envision the difference in terms of the involvement of attentional, executive mechanisms (e.g., Baddeley, 1986; 2000; 2003; Baddeley & Hitch, 1974). Although accounts of working memory differ in how they conceptualize the structure of the system, they all agree that controlled attention is an indelible component of working-memory functioning (e.g., Baddeley, 2000, 2003; Baddeley & Hitch, 1974; Cowan, 1999; Engle et al., 1999; Majerus, Heiligenstein, Gautherot, Poncelet, & Van der Linden, 2009; Unsworth & Engle, 2006). In general, the involvement of executive-attention mechanisms increases as the memory task becomes more difficult (e.g., Cantor, Engle, & Hamilton, 1991; Cowan, 1988; 1999; 2001; Engle, Tuholski, Laughlin, & Conway, 1999; Kail & Hall, 2001; Kane et al., 2004; Unsworth & Engle,

2006). Prior studies of bilingual influences on verbal memory have shown that bilinguals can outperform monolinguals on verbal memory tasks (Kaushanskaya, 2012; Yoo & Kaushanskaya, 2012) and that the chances of finding bilingual advantages on verbal memory tasks are higher for the more difficult levels of the task (Yoo & Kaushanskaya, 2012).

It has been proposed that bilingual advantages on verbal memory tasks are rooted in the facilitation effects associated with bilingualism on the executive-attention system. Given that factor-based approaches to executive functions consistently include updating of working memory as a crucial aspect of executive functions (Garon, Bryson, & Smith, 2008; Miyake et al., 2000), and considering the fact that there are very robust relationships between working-memory and controlled-attention measures (e.g., McCabe et al., 2010), this hypothesis is logical. In the present study, we therefore reasoned that classroom bilingualism may facilitate verbal working memory (but not verbal short-term memory), and in that sense, our findings are consistent with our hypothesis. However, the bilingual advantage on the verbal working memory task observed in the present study was not mirrored by a bilingual advantage on the cognitive control task, since the classroom bilinguals performed identically to the monolinguals on the DCSS task. We propose therefore that intensive exposure to the second language in a classroom setting has impacted executive attention mechanisms, but only when these are activated by the working memory system in the service of processing verbal information.

In order to empirically test this hypothesis, it would have been fruitful to administer parallel measures of verbal and non-verbal working memory to the children. If our interpretation is correct, we would have expected better performance in the classroom bilingual children on the verbal but not the non-verbal working memory task. Unfortunately, our design did not include a non-verbal working memory measure. Therefore, we used the existing data to examine the possibility that domain-general attentional control (as measured by the task-shifting measure) was at the basis of the influence exerted by classroom bilingualism on the verbal working memory performance. In order to do so, we ran correlation analyses between the verbal working memory measure (collapsing across the levels of difficulty on the listening span task) and the switching costs on the DCCS task (calculated as the difference in accuracy scores between switch and non-switch trials in the mixed phase). We found that in the monolingual group, the performance on the two tasks did not correlate significantly ($p > .2$). However, in the bilingual group, there was a significant correlation between the two tasks ($r = -.66, p < .01$), such that higher listening span was associated with lower switching costs. Correlation analyses are necessarily a-directional; however, one logical explanation for this relationship would be that better ability to deploy inhibitory control leads to better ability to maintain linguistic information in memory when performing a cognitively demanding verbal memory task.

We propose that a constrained effect of classroom bilingualism on verbal working memory observed here is likely engendered by the very specific environment that the classroom bilingual children occupy, and the challenges their cognitive system is called upon to solve. In the context of intense second-language exposure in the classroom setting, the children's working memory system must process and retain massive amounts of novel linguistic

information. In the process, the working memory system must rely on domain-general attention control mechanisms, and over time, the system becomes markedly more efficient at doing so. This then leads to superior performance on the verbal working memory tasks in the classroom bilingual children. However, the advantages do not generalize to the performance on the non-linguistic attention control tasks themselves and only appear when the task resembles second-language acquisition – i.e., when the system is called upon to retain verbal information in the context of a cognitively demanding situation. The correlation analyses also suggest the possibility that the working memory system is the gateway by which classroom bilingualism may begin to influence the cognitive system. That is, it may be that continuous stimulation of the link between verbal working memory and non-linguistic attention control mechanisms may facilitate general executive control mechanisms themselves over time. This in turn may lead to general executive-control advantages, although the findings of the present study indicate that an average of 2 years of classroom bilingualism is not sufficient for such generalization to take place.

It is crucial to reiterate that such a mechanism is only a conjecture, and that the results of this work cannot be used as evidence for either domain-general or domain-specific views on the attention systems that may underlie working memory performance (e.g., Barnard, 1985; Daneman & Tardif, 1987; Navon & Gopher, 1979; Schneider & Detweiler, 1987; Shah & Miyake, 1996; Wickens, 1984). In order to contribute to this debate, measures of verbal and non-verbal working and short-term memory, together with measures of non-linguistic inhibitory control would need to be administered to the same groups of monolingual and bilingual children, ideally within the context of a longitudinal design. It would also be important to incorporate a measure of processing efficiency into the design because there is strong evidence to suggest that working memory performance is constrained by domain-general processing efficiency factors (e.g., Fry & Hale, 2000). Domain-general processing efficiency therefore is a theoretically-appealing locus by which bilingualism may influence working-memory performance, especially considering the recent suggestions in the literature that bilingualism exerts its influence on the cognitive system not through the specific inhibitory-control mechanisms, but through the more broad cognitive changes to the on-line monitoring and attention-deployment processes (e.g., Bialystok, Craik, & Luk, 2012; Hernández, Costa, & Humphries, 2012; Poarch & Van Hell, 2012). Therefore, measures of cognitive efficiency that are reaction-time based would be invaluable in cementing the argument that the roots of the bilingual effects on the working memory system are the enhancements to the domain-general attention-control mechanisms.

Effects of Classroom Bilingualism on Word Learning

The classroom bilinguals in the present study outperformed monolinguals on one of the two word-learning tasks. This finding is consistent with a growing literature regarding the positive effects of bilingualism on novel word learning (e.g., Kaushanskaya, 2012; Kaushanskaya & Marian, 2009a, b; Kaushanskaya & Rechtzigel, 2012; Kaushanskaya, Yoo, & Van Hecke, in press; Papagno & Vallar, 1995; Van Hell & Mahn, 1997). The present study, however, is the first to demonstrate positive effects of bilingualism on *children's* word learning, and it crystallizes constraints on bilingual advantages for word learning, at least for classroom bilingualism. That is, the present study suggests that word-learning

advantages in classroom bilinguals are only obtainable for word-learning tasks that resemble L2 acquisition. In the present study, bilingual children outperformed monolingual children only on the word-learning task where they had to map the novel words onto familiar referents, i.e., pictures of animals. When the word-learning task involved mapping novel words onto unfamiliar referents, i.e., pictures of aliens, bilinguals and monolinguals performed identically. This then suggests that the effects of bilingualism on word-learning are specific to the process of lexical acquisition, rather than a result of a more broad effect of bilingualism on verbal memory. That is, were word-learning advantages a result of the superior verbal memory system in bilinguals, we would expect bilinguals to outperform monolinguals on both word-learning tasks, independent of whether the novel words were acquired in association with familiar or unfamiliar referents. Instead, we found a bilingual advantage only on the familiar-referent task. We therefore conclude that the effects of classroom bilingualism on word learning are likely localized to the specific experience of second language acquisition, whereby children had to acquire novel words in Spanish for concepts they had already acquired in English.

The findings of the present study point to a mechanism that underlies the positive effects of bilingualism on word learning. The literature on early word learning in young children indicates that the mutual-exclusivity bias commonly observed in monolingual children is reduced in bilingual children (e.g., Byers-Heinlein & Werker, 2009; Davidson, et al., 1997). The explanation for these differences between bilinguals and monolinguals is that bilingual children, by virtue of being exposed to words in two languages for the same object, are less reluctant to assume that novel words can map onto known entities. It is important to point out that these studies of mutual-exclusivity biases do not measure *retention* of the novel words; instead, they measure children's assumptions about what the novel words mean. In the present study, we show that these word-mapping biases (or lack thereof, in the case of bilingual children) may have repercussions for explicit word-learning tasks where retention of the novel words is the goal. We conclude that classroom bilingual children, through being exposed to Spanish words for concepts they know in English, have more practice with the task where they must map novel words onto familiar referents. It is also possible that the ability to navigate conflicting cues when acquiring novel words also contributed to bilingual advantages in this study. Brojde, Ahmed, and Colunga (2012) showed that bilingual and monolingual children attend to different word-learning cues especially in situations where cues are in conflict. In our study, children learned novel words in association with pictures of animals in the familiar referent condition, and it is likely that the known labels for these highly familiar animals were activated during learning. Children would then have to resolve a conflict between known labels and novel labels in the familiar referent condition, but not in the unfamiliar referent condition. It is possible that bilingual children, by virtue of having an enhanced ability to resolve conflict during word-learning, are especially apt to outperform monolingual children on tasks where novel labels must be learned in association with familiar objects. We conclude therefore that classroom bilingualism appears to have a very specific impact on word-learning performance, and this impact is limited to word-learning scenarios that involve conflicting information, and that the children have practiced daily in their dual-immersion classroom.

Conclusion

Methodologically, there are many advantages to testing classroom bilinguals when attempting to delineate the effects of bilingualism on cognitive functioning in children. First, it enables the researchers to ensure comparable demographic profiles in the monolingual and the bilingual groups – a task wrought with difficulty when testing simultaneous bilingual children. In the present study, our two groups of children came from the same SES backgrounds. Second, it allows the researchers to equate levels of linguistic knowledge in the monolingual and the bilingual group. The problem of unequal language proficiencies has been especially prevalent in previous studies of bilingual effects on cognition, since bilinguals are known to have reduced language-specific skills in comparison with monolinguals (e.g., Bialystok, 2006). By testing classroom bilingual children, we were able to control for linguistic between-group differences, and contrasted two groups of children that differed only in that one group had experienced an average of 2 years of classroom Spanish exposure. It is important to point out, however, that despite the lack of difference in SES and English language skills between monolinguals and classroom bilinguals in the present study, other differences between the two groups may have contributed to the patterns of findings. The foremost of these is the possibility that classroom bilingual children may have differed from the monolingual children *prior* to being placed in the dual-immersion classroom. However, three considerations make this unlikely. First, qualitative and quantitative data collected through parent interview revealed highly similar profiles of the primary caregivers who placed their children in dual-immersion classrooms and those who placed their children in English-only classrooms. For example, identical, minimal levels of exposure to Spanish in the home were reported by both sets of parents and similar professional and educational backgrounds were revealed in the two sets of families. Second, published studies that examined the reasons behind parents' choices of a dual-immersion program for their children have consistently revealed that the primary reasons cited by the parents are the desire for the children to become bilingual, and future benefits for educational and career opportunities envisioned as the result of dual-immersion programs (e.g., Gerena, 2011; Parkes, 2008; Whiting & Feinauer, 2011), rather than any particular talent for language learning that they observe in their children. Third, in the present study, we observed differences between the two groups of children on very specific measures rather than across the board. If classroom bilingual children were preselected based on their intelligence, they should have had higher non-verbal IQ than the monolingual children. Furthermore, we ensured comparable levels of English language knowledge in the two groups; if the classroom bilingual children were preselected based on their language abilities, they should have had higher English language skills than the monolingual children. Therefore, we believe that the possible self-selection variables likely played a minimal role in driving the patterns of findings in the present study. However, it is possible that parents of children with higher verbal abilities are more likely to place them in dual-immersion classrooms than parents of children with lower verbal abilities, and without random assignment of children to dual-immersion vs. English-only classrooms, this confound is unavoidable.

Theoretically, testing the effects of classroom bilingualism enabled us to examine whether the same amount of highly contextualized and fairly short-term L2 exposure influenced

children's performance on a number of different cognitive tasks that have all been shown to be sensitive to bilingualism in previous work. The findings are revealing with regards to *how* bilingualism can influence cognitive function. Our data indicate that the specifics of bilingual experience constrain the nature of cognitive advantages observed as a result of bilingualism. It may very well be (in fact, it is quite likely) that the cognitive domain most affected by *simultaneous* bilingualism is the domain-general controlled-attention system most frequently examined by studies of bilingual influences on cognitive function. Simultaneous bilinguals use their two languages in the same environments (e.g., both languages may be used in the home), and are likely to have high proficiencies in their two languages. These conditions generate intense cross-linguistic activation, and as a result there arises the need to control access to the non-target language when selecting the target language. This control is accomplished by means of relying on the domain-general inhibitory-control system. In this way, simultaneous bilingualism may yield a more efficient inhibitory-control system. *Classroom* bilinguals, on the other hand, use their two languages in two distinct environments (e.g., only English is used in the home), and after only a few years of Spanish exposure, the co-activation of Spanish while processing in English (and vice versa) may not be as likely as in simultaneous bilinguals with more even levels of proficiency in their two languages. Therefore, in classroom bilinguals, the domain-general inhibitory-control mechanisms by which access to the two linguistic systems is controlled may not be taxed to the same degree as in simultaneous bilinguals. The finding that classroom bilingualism facilitated verbal working memory but not verbal short-term memory or non-linguistic task-shifting suggests that in this population of bilinguals, the entry-point by which bilingualism may influence cognitive functioning is the controlled attention system that underlies encoding and retrieval of verbal information.

Similar reasoning applies to the word-learning data. Previous work on bilingual word-learning suggests that both simultaneous and sequential bilingualism can yield benefits to word-learning skills (e.g., Kaushanskaya & Marian, 2009a; b; Kaushanskaya & Rechtzigel, 2012). What has remained unclear was how generalizable these word-learning advantages are with regards to the various word-learning scenarios. In the present study, we found that classroom bilingualism only facilitated word-learning when the word-learning task was conceptually similar to L2 acquisition. That is, once again we demonstrate a constrained effect of bilingual exposure on cognitive functioning, in that classroom bilingualism only facilitated performance on the task that has been practiced by the classroom bilinguals. It remains to be seen whether these constrained effects of bilingualism on word learning would generalize to a wider spectrum of word-learning tasks with time.

In conclusion, the present study documented neutral effects of classroom bilingualism on non-linguistic task-shifting and verbal short-term memory, and positive effects of classroom bilingualism on verbal working memory and word-learning. It is notable that the same length of classroom experience has distinct influences on these four sets of cognitive skills. This indicates that while bilingualism may influence a number of cognitive functions, different cognitive functions may be differentially susceptible to the same amount of bilingual experience. The finding that verbal working memory and word-learning were the

two cognitive skills facilitated by classroom bilingualism suggests constrained and highly specific mechanisms by which bilingual experience can affect cognition.

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References

- Alario FX, Ferrand L. A set of 440 pictures standardized for French: Norms for name agreement, image agreement, familiarity, visual complexity, image variability, and age of acquisition. *Behavior Research Methods, Instruments, & Computers*. 1999; 31:531–552.
- Au TK, Glusman M. The principle of mutual exclusivity in word learning: To honor or not to honor? *Child Development*. 1990; 61:1474–1490. [PubMed: 2245739]
- Baddeley AD. The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences*. 2000; 4:417–423.10.1016/S1364-6613(00)01538-2 [PubMed: 11058819]
- Baddeley AD. Working memory: Looking back and looking forward. *Nature Reviews Neuroscience*. 2003; 4:829–839.10.1038/nrn1201
- Baddeley, AD.; Hitch, GJ. Working memory. In: Bower, G., editor. *The Psychology of Learning and Motivation*. New York: Academic Press; 1974. p. 47-90.
- Barnard, P. Interacting cognitive subsystems: A psycholinguistic approach to short-term memory. In: Ellis, AW., editor. *Progress in the Psychology of Language*. Vol. 2. London: Erlbaum; 1985. p. 197-258.
- Best JR, Miller PH, Jones LL. Executive function after age 5: Changes and correlates. *Developmental Review*. 2009; 29:180–200. [PubMed: 20161467]
- Bialystok E. Cognitive complexity and attentional control in the bilingual mind. *Child Development*. 1999; 70:636–644.10.1111/1467-8624.00046
- Bialystok E. Effects of bilingualism and computer video game experience on the Simon Task. *Canadian Journal of Experimental Psychology*. 2006; 60:68–79. [PubMed: 16615719]
- Bialystok E. Global-local and trial-making tasks by monolingual and bilingual children: beyond inhibition. *Developmental Psychology*. 2010; 46(1):93–105. [PubMed: 20053009]
- Bialystok E. Coordination of executive functions in monolingual and bilingual children. *Journal of Experimental Child Psychology*. 2011; 110:461–468. [PubMed: 21683958]
- Bialystok E, Barac R. Emerging bilingualism: Dissociating advantages for metalinguistic awareness and executive control. *Cognition*. 2012; 122:67–73. [PubMed: 21906732]
- Bialystok E, Craik FIM, Green DW, Gollan T. Bilingual minds. *Psychological Science in the Public Interest*. 2009; 10:89–129.
- Bialystok E, Craik FIM, Klein R, Viswanathan M. Bilingualism, aging, and cognitive control: Evidence from the Simon task. *Psychology and Aging*. 2004; 19:290–303.10.1037/0882-7974.19.2.290 [PubMed: 15222822]
- Bialystok E, Craik FIM, Luk G. Lexical access in bilinguals: Effects of vocabulary size and executive control. *Journal of Neurolinguistics*. 2008; 21:522–538.
- Bialystok E, Feng X. Language proficiency and executive control in proactive interference: Evidence from monolingual and bilingual children and adults. *Brain & Language*. 2009; 109:93–100.10.1016/j.bandl.2008.09.001 [PubMed: 18834625]
- Bialystok E, Majumder S. The relationship between bilingualism and the development of cognitive processes in problem solving. *Applied Psycholinguistics*. 1998; 19:69–85.

- Bialystok E, Martin MM. Attention and inhibition in bilingual children: Evidence from the dimensional change card sort task. *Developmental Science*. 2004; 7:325–339. [PubMed: 15595373]
- Bialystok E, Martin MM, Viswanathan M. Bilingualism across the lifespan, the rise and fall of inhibitory control. *International Journal of Bilingualism*. 2005; 9:103–119.
- Bialystok E, Peets KF, Moreno S. Producing bilinguals through immersion education: Development of metalinguistic awareness. *Applied Psycholinguistics*. 2012 in press.
- Bialystok E, Shapero D. Ambiguous benefits: The effect of bilingualism on reversing ambiguous figures. *Developmental Science*. 2005; 8(6):595–604.10.1111/j.1467-7687.2005.00451.x [PubMed: 16246250]
- Bialystok E, Viswanathan M. Components of executive control with advantages for bilingual children in two cultures. *Cognition*. 2009; 112:494–500. [PubMed: 19615674]
- Blumenfeld H, Marian V. Bilingualism influences inhibitory control in auditory comprehension. *Cognition*. 2011; 118(2):245–257.10.1016/j.cognition.2010.10.012 [PubMed: 21159332]
- Boersma, P.; Weenink, D. Praat: doing phonetics by computer [Computer program]. Version 5.2.42. 2011. Retrieved August, 2011 from <http://www.praat.org/>
- Bonifacci P, Giombini L, Bellocchi S, Conteno S. Speed of processing, anticipation, inhibition and working memory in bilinguals. *Developmental Science*. 2011; 14:256–269. [PubMed: 22213899]
- Brojde CL, Ahmed S, Colunga E. Bilingual and monolingual children attend to different cues when learning new words. *Frontiers in Psychology*. 2012; 3:1–11. [PubMed: 22279440]
- Burgess N, Hitch GJ. Memory for serial order: A network model of the phonological loop and its timing. *Psychological Review*. 1999; 106:551–541.
- Busch RM, Booth JA, McBride A, Vanderploeg RD, Curtiss G, Duchnick JJ. Role of executive functioning in verbal and visual memory. *Neuropsychology*. 2005; 19:171–180. [PubMed: 15769201]
- Byers-Heinlein K, Werker JF. Monolingual, bilingual, trilingual: Infants' language experience influences the development of a word learning heuristic. *Developmental Science*. 2009; 12:815–823.10.1111/j.1467-7687.2009.00902 [PubMed: 19702772]
- Cantor J, Engle RW, Hamilton G. Short-term memory, working memory, and verbal abilities: How do they relate? *Intelligence*. 1991; 15:229–246.10.1016/0160-2896(91)90032-9
- Carlson SM, Meltzoff NA. Bilingual experience and executive functioning in young children. *Developmental Science*. 2008; 11:282–298. [PubMed: 18333982]
- Cheung H. Nonword span as a unique predictor of second-language vocabulary learning. *Developmental Psychology*. 1996; 32(5):867–873.10.1037/0012-1649.32.5.867
- Colzato LS, Bajo MT, van den Wildenberg W, Paolieri D, Nieuwenhuis S, La Heij W, Hommel B. How does bilingualism improve executive control? A comparison of active and reactive inhibition mechanisms. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 2008; 34:302–312.
- Costa, A. Lexical access in bilingual production. In: Kroll, JF.; de Groot, AMB., editors. *Handbook of Bilingualism: Psycholinguistic Approaches*. New York: Oxford University Press; 2005. p. 308–325.
- Costa A, Hernandez M, Sebastián-Gallés N. Bilingualism aids conflict resolution: Evidence from the ANT task. *Cognition*. 2008; 106:59–86.10.1016/j.cognition.2006.12.013 [PubMed: 17275801]
- Cowan N. Evolving conceptions of memory storage, selective attention, and their mutual constraints within the human information processing system. *Psychological Bulletin*. 1988; 104:163–191.10.1037/0033-2909.104.2.163 [PubMed: 3054993]
- Cowan, N. An embedded-processes model of working memory. In: Miyake, A.; Shah, P., editors. *Models of working memory: Mechanisms of active maintenance and executive control*. Cambridge, UK: Cambridge University Press; 1999. p. 62–101.
- Cowan N. The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences*. 2001; 24:87–114.10.1017/S0140525X01003922 [PubMed: 11515286]
- Daneman M, Carpenter PA. Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*. 1980; 19:450–466.10.1016/S0022-5371(80)90312-6

- Daneman, M.; Tardif, T. Working memory and reading skills reexamined. In: Coltheart, M., editor. *Attention and Performance XIII: The Psychology of Reading*. Hillsdale, NJ: Erlbaum; 1987. p. 491-508.
- Davidson D, Jergovic D, Imami Z, Theodos V. Monolingual and bilingual children's use of the mutual exclusivity constraint. *Journal of Child Language*. 1997; 24:3-24. [PubMed: 9154006]
- de Abreu PMJE, Cruz-Santos A, Tourinho CJ, Martin R, et al. Bilingualism enriches the poor: Enhanced cognitive control in low-income minority children. *Psychological Science*. 2012; 23:1364-1371. [PubMed: 23044796]
- De Jong PF, Seveke MJ, Van Veen M. Phonological sensitivity and the acquisition of new words in children. *Journal of Experimental Child Psychology*. 2000; 76:275-301. [PubMed: 10882476]
- Diamond A, Carlson SM, Beck DM. Preschool children's performance in task switching on the Dimensional Change Card Sort task: Separating the dimensions aides the ability to switch. *Developmental Neuropsychology*. 2005; 28:689-729. [PubMed: 16144433]
- Downing PE. Interactions between visual working memory and selective attention. *Psychological Science*. 2000; 11:467-473. [PubMed: 11202491]
- Dunn, LM.; Dunn, LM. *Peabody Picture Vocabulary Test*. 3. Circle Pines, MN: American Guidance Service; 1997.
- Dunn, LM.; Padilla, ER.; Lugo, DE.; Dunn, LM. *Test de Vocabulario en Imágenes Peabody*. Circle Pines, MN: American Guidance Service; 1986.
- Ellis NC, Beaton A. Factors affecting the learning of foreign language vocabulary: Imagery keyword mediators and phonological short-term memory. *The Quarterly Journal of Experimental Psychology*. 1993; 46A:533-558. [PubMed: 8378553]
- Engle, RW.; Kane, MJ.; Tuholski, SW. Individual differences in working memory capacity and what they tell us about controlled attention, general fluid intelligence, and function of the prefrontal cortex. In: Miyake, A.; Shah, P., editors. *Models of Working Memory*. New York: Cambridge University Press; 1999. p. 28-61.
- Engle RW, Nations JK, Cantor J. Is "working memory capacity" just another name for word knowledge? *Journal of Educational Psychology*. 1990; 82:799-804.10.1037/0022-0663.82.4.799
- Engle RW, Tuholski SW, Laughlin JE, Conway ARA. Working memory, short-term memory and general fluid intelligence: A latent variable approach. *Journal of Experimental Psychology: General*. 1999; 128:309-331.10.1037/0096-3445.128.3.309 [PubMed: 10513398]
- Fernandes MA, Craik F, Bialystok E, Kreuger S. Effects of bilingualism, aging, and semantic relatedness on memory under divided attention. *Canadian Journal of Experimental Psychology*. 2007; 61:128-141. [PubMed: 17665753]
- Forsythe A, Mulhern G, Sawey M. Confounds in pictorial sets: The role of complexity and familiarity in basic-level picture processing. *Behavior Research Methods*. 2008; 40:116-129. [PubMed: 18411534]
- Fry AF, Hale S. Relationships among processing speed, working memory, and fluid intelligence in children. *Biological Psychology*. 2000; 54:1-34. [PubMed: 11035218]
- Frye D, Zelazo PD, Palfai T. Theory of mind and rule-based reasoning. *Cognitive Development*. 1995; 10:483-527.
- Garon N, Bryson SE, Smith IM. Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin*. 2008; 134:31-60. [PubMed: 18193994]
- Gathercole SE. Is nonword repetition a test of phonological memory or long-term knowledge? It all depends on the nonwords. *Memory & Cognition*. 1995; 23:83-94. [PubMed: 7885268]
- Gathercole SE, Baddeley AD. The role of phonological memory in vocabulary acquisition: A study of young children learning new names. *British Journal of Psychology*. 1990; 81:439-454.
- Gathercole SE, Willis C, Emslie H, Baddeley AD. The influences of number of syllables and wordlikeness on children's repetition of nonwords. *Applied Psycholinguistics*. 1991; 12:349-367.
- Gaulin CA, Campbell TF. Procedure for assessing verbal working memory in normal school age-children: Some preliminary data. *Perceptual and Motor Skills*. 1994; 79:55-64. [PubMed: 7991333]
- Gerena L. Parental voice and involvement in cultural context: Understanding rationales, values, and motivational construct sin a dual immersion setting. *Urban Education*. 2011; 46:342-370.

- Gupta P, MacWhinney B. Vocabulary acquisition and verbal short-term memory: Computational and neural bases. *Brain & Language*. 1997; 59:267–333. [PubMed: 9299067]
- Gupta P, Lipinski J, Abbs B, Lin PH, et al. Space aliens and nonwords: Stimuli for investigating the learning of novel word-meaning pairs. *Behavior Research Methods, Instruments, & Computers*. 2004; 36:599–603.
- Harrington M, Sawyer M. L2 working memory capacity and L2 reading skill. *Studies in Second Language Acquisition*. 1992; 14:25–38.10.1017/S0272263100010457
- Hernandez M, Costa A, Humphreys GW. Escaping capture: Bilingualism modulates distraction from working memory. *Cognition*. 2012; 122:37–50. [PubMed: 21890125]
- Hester R, Garavan H. Working memory and executive function: The influence of content and load on the control of attention. *Memory & Cognition*. 2005; 33:221–233. [PubMed: 16028577]
- Himmanen SA, Gentles K, Sailor K. Rated familiarity, visual complexity, and image agreement and their relation to naming difficulty for items from the Boston Naming Test. *Journal of Clinical and Experimental Neuropsychology*. 2003; 25:1178–1185. [PubMed: 14566589]
- Ivanova I, Costa A. Does bilingualism hamper lexical access in speech production? *Acta Psychologica*. 2008; 127:277–288. [PubMed: 17662226]
- Just MA, Carpenter PA. A capacity theory of comprehension: Individual differences in working memory. *Psychological Review*. 1992; 98:122–149.10.1037/0033-295X.99.1.122 [PubMed: 1546114]
- Kail R, Hall LK. Distinguishing short-term memory from working memory. *Memory & Cognition*. 2001; 29:1–9.10.3758/BF03195735 [PubMed: 11277452]
- Kane MJ, Bleckley MK, Conway ARA, Engle RW. A controlled-attention view of working-memory capacity. *Journal of Experimental Psychology: General*. 2001; 130:169–183.10.1037/0096-3445.130.2.169 [PubMed: 11409097]
- Kaufman, AS.; Kaufman, NL. Kaufman Brief Intelligence Test. Circle Pines, MN: American Guidance Service; 1990.
- Kaushanskaya M. Cognitive mechanisms of word learning in bilingual and monolingual adults: The role of phonological memory. *Bilingualism: Language & Cognition*. 2012; 15:470–489.
- Kaushanskaya M, Blumenfeld H, Marian V. The relationship between vocabulary and short-term memory measures in monolingual and bilingual speakers. *International Journal of Bilingualism*. 2011; 15(4):408–425. [PubMed: 22518091]
- Kaushanskaya M, Marian V. The bilingual advantage in novel word learning. *Psychonomic Bulletin & Review*. 2009a; 16(4):705–710. [PubMed: 19648456]
- Kaushanskaya M, Marian V. Bilingualism reduces native-language interference in novel word learning. *Journal of Experimental Psychology: Learning, Memory, & Cognition*. 2009b; 35:829–835.
- Kaushanskaya M, Rechtzigel K. Concreteness effects in bilingual and monolingual word learning. *Psychonomic Bulletin & Review*. 2012; 19:935–941. [PubMed: 22638985]
- Kaushanskaya M, Yoo J. Phonological short-term and working memory in bilinguals' native and second language. *Applied Psycholinguistics*. 2012 in press.
- Kaushanskaya M, Yoo J, Van Hecke S. Word learning in adults with second language experience: Effects of phonological and referent familiarity. *Journal of Speech, Language, and Hearing Research*, in press. 2013
- Kroll JF, Michael E, Tokowicz N, Dufour R. The development of lexical fluency in a second language. *Second Language Research*. 2002; 18:137–171.
- Kroll JF, Potter MC. Recognizing words, pictures and concepts: A comparison of lexical, object and reality decision. *Journal of Verbal Learning and Verbal Behavior*. 1984; 23:39–66.
- Kyllonen, PC. Is working memory capacity Spearman's g ? In: Dennis, I.; Tapsfield, P., editors. *Human Abilities: Their nature and measurement*. Mahwah, NJ: Lawrence Erlbaum; 1996. p. 49-76.
- Landau B, Smith LB, Jones S. The importance of shape in early lexical learning. *Cognitive Development*. 1988; 3:299–321.

- Loonstra A, Tarlow A, Sellers A. COWAT metanorms across age, education, and gender. *Applied Neuropsychology*. 2001; 8:161–166. [PubMed: 11686651]
- Luk G, Anderson JAE, Craik FIM, Grady C, et al. Distinct neural correlates for two types of inhibition in bilinguals: Response inhibition versus interference suppression. *Brain and Cognition*. 2010; 74:347–357. [PubMed: 20965635]
- Luk G, De Sa E, Bialystok E. Is there a relation between onset age of bilingualism and enhancement of cognitive control? *Bilingualism: Language and Cognition*. 2011; 14:588–595.
- Luo L, Luk G, Bialystok E. Effect of language proficiency and executive control on verbal fluency performance in bilinguals. *Cognition*. 2010; 114(1):29–41. [PubMed: 19793584]
- Luo L, Craik FIM, Moreno S, Bialystok E. Bilingualism interacts with domain in a working memory task: Evidence from aging. *Psychology and Aging*. 2012 in press.
- Marian V, Bartolotti J, Chabal S, Shook A. CLEARPOND: Cross-Linguistic Easy-Access Resource for Phonological and Orthographic Neighborhood Densities. *PLoS ONE*. 2012; 7(8):e43230.10.1371/journal.pone.0043230 [PubMed: 22916227]
- Markman EM, Wachtel GF. Children's use of mutual exclusivity to constraint the meaning of words. *Cognitive Psychology*. 1988; 20:121–157. [PubMed: 3365937]
- Martin-Rhee MM, Bialystok E. The development of two types of inhibitory control in monolingual and bilingual children. *Bilingualism: Language and Cognition*. 2008; 11:81–93.
- Majerus S, Heiligenstein L, Gautherot N, Poncelet M, Van der Linden M. The impact of auditory selective attention on verbal short-term memory and vocabulary development. *Journal of Experimental Child Psychology*. 2009; 103:66–86.10.1016/j.jecp.2008.07.004 [PubMed: 18778836]
- Masoura EV, Gathercole SE. Phonological short-term memory and foreign language learning. *International Journal of Psychology*. 1999; 34(5/6):383–388.
- McCabe D, Roediger HL, McDaniel A, Balota DA, et al. The relationship between working memory capacity and executive functioning: Evidence for a common executive attention construct. *Neuropsychology*. 2010; 24:222–243. [PubMed: 20230116]
- Messer M, Leseman P, Boom J, Mayo A. Phonotactic probability effect in nonword recall and its relationship with vocabulary in monolingual and bilingual preschoolers. *Journal of Experimental Child Psychology*. 2010; 105(4):306–323.10.1016/j.jecp.2009.12.006 [PubMed: 20116805]
- Miyake A, Emerson MJ, Friedman NP. Assessment of executive functions in clinical settings: Problems and recommendations. *Seminars in Speech and Language*. 2000; 21:169–183. [PubMed: 10879548]
- Miyake A, Friedman NP, Rettinger DA, Shah P, Hegarty M. How are visuospatial working memory, executive functioning, and spatial abilities related? A latent variable analysis. *Journal of Experimental Psychology: General*. 2001; 130:621–640. [PubMed: 11757872]
- Michas IC, Henry LA. The link between phonological memory and vocabulary acquisition. *British Journal of Developmental Psychology*. 1994; 12:147–163.10.1111/j.2044-835X.1994.tb00625.x
- Michael, E.; Gollan, T. Being and becoming bilingual. In: Kroll, JF.; De Groot, AMB., editors. *Handbook of Bilingualism*. New York: Oxford University Press; 2005. p. 389-407.
- Morales J, Calvo A, Bialystok E. Working memory development in monolingual and bilingual children. *Journal of Experimental Child Psychology*. 2013; 114:187–202. [PubMed: 23059128]
- Moreno S, Bialystok E, Wodniecka Z, Alain C. Conflict resolution in sentence processing by bilinguals. *Journal of Neurolinguistics*. 2010; 23:564–579. [PubMed: 21057658]
- Morton JB, Harper SN. What did Simon say? Revisiting the bilingual advantage. *Developmental Science*. 2007; 10:719–726. [PubMed: 17973787]
- Muñoz-Sandoval, AF.; Woodcock, RW.; McGrew, KS.; Mather, N. *Batería III Woodcock-Muñoz Pruebas de aprovechamiento*. Rolling Meadows, IL: Riverside; 2005.
- Navon D, Gopher D. On the economy of the human processing system. *Psychological Review*. 1979; 86:214–225.
- Nelson DL, McKinney VM, Gee NR, Janczura GA. Interpreting the influence of implicitly activated memories on recall and recognition. *Psychological Review*. 1998; 105:299–324. [PubMed: 9577240]

- Nelson DL, Schreiber TA, McEvoy CL. Processing implicit and explicit representations. *Psychological Review*. 1992; 95:322–348. [PubMed: 1594728]
- Oberauer K, Lange E, Engle RW. Working memory capacity and resistance to interference. *Journal of Memory and Language*. 2004; 51:80–96.
- Papagno C, Vallar G. Verbal short-term memory and vocabulary learning in polyglots. *Quarterly Journal of Experimental Psychology*. 1995; 48A:98–107. [PubMed: 7754088]
- Papagno C, Vallar G. Phonological short-term memory and the learning of novel words: The effects of phonological similarity and item length. *Quarterly Journal of Experimental Psychology*. 1992; 44A:44–67.
- Papagno C, Valentine T, Baddeley A. Phonological short-term memory and foreign-language vocabulary learning. *Journal of Memory and Language*. 1991; 30:331–347.
- Parkes J. Who chooses dual language education for their children and why. *International Journal of Bilingual Education and Bilingualism*. 2008; 11:635–660.
- Poarch GJ, van Hell JG. Executive functions and inhibitory control in multilingual children: Evidence from second-language learners, bilinguals, and trilinguals. *Journal of Experimental Child Psychology*. 2012; 113:535–551. [PubMed: 22892367]
- Poirier M, Saint-Aubin J. Memory for related and unrelated words: Further evidence on the influence of semantic factors in immediate serial recall. *The Quarterly Journal of Experimental Psychology*. 1995; 48A:384–404. [PubMed: 7610273]
- Prado EL, Ullman MT. Can imageability help us draw the line between storage and composition? *Journal of Experimental Psychology: Learning, Memory and Cognition*. 2009; 110:849–866.
- Rosen VM, Engle RW. Working memory capacity and suppression. *Journal of Memory and Language*. 1998; 39:418–436.
- Rudkin S, Pearson DG, Logie RH. Executive processes in visual and spatial working memory tasks. *Quarterly Journal of Experimental Psychology*. 2007; 60:79–100.
- Schneider, W.; Detweiler, M. A connectionist/control architecture for working memory. In: Bower, GH., editor. *The Psychology of Learning and Motivation*. Vol. 21. Orlando, FL: Academic Press; 1987. p. 53–119.
- Service E. Phonology, working memory, and foreign-language learning. *The Quarterly Journal of Experimental Psychology*. 1992; 45A(3):21–50. [PubMed: 1636010]
- Service E, Craik FIM. Differences between young and older adults in learning a foreign vocabulary. *Journal of Memory and Language*. 1993; 32:608–623.
- Shah P, Miyake A. The separability of working memory resources for spatial thinking and language processing: An individual differences approach. *Journal of Experimental Psychology: General*. 1996; 125:4–27. 10.1037/0096-3445.125.1.4 [PubMed: 8851737]
- Snodgrass JG, Vanderwart M. A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory*. 1980; 6:174–215. [PubMed: 7373248]
- Székely A, Jacobsen T, D'Amico S, Devescovi A, et al. A new on-line resource for psycholinguistic studies. *Journal of Memory and Language*. 2004; 51:247–250. [PubMed: 23002322]
- Thorn ASC, Gathercole SE. Language-specific knowledge and short-term memory in bilingual and non-bilingual children. *Quarterly Journal of Experimental Psychology*. 1999; 52A:303–324. 10.1080/027249899391089 [PubMed: 10371873]
- Tuner ML, Engle RW. Is working memory capacity task dependent? *Journal of Memory and Language*. 1989; 28:127–154. 10.1016/0749-596X(89)90040-5
- Unsworth N, Engle RW. Simple and complex memory spans and their relation to fluid abilities: Evidence from list-length effects. *Journal of Memory and Language*. 2006; 54:68–80. 10.1016/j.jml.2005.06.003
- Urbaniak, GC.; Plous, S. Research Randomizer (Version 3.0) [Computer software]. 2011. Retrieved from <http://www.randomizer.org/>
- Van Hell JG, Mahn AC. Keyword mnemonics versus rote rehearsal: Learning concrete and abstract foreign words by experienced and inexperienced learners. *Language Learning*. 1997; 47:507–546.

- Wickens, CD. Processing resources in attention. In: Parasuraman, R.; Davies, DR., editors. *Varieties of Attention*. New York: Academic Press; 1984. p. 63-102.
- Windsor J, Kohnert K, Lobitz KF, Pham GT. Cross-language nonword repetition by bilingual and monolingual children. *American Journal of Speech-Language Pathology*. 2010; 19:298–310.10.1044/1058-0360(2010/09-0064) [PubMed: 20601622]
- Whiting EF, Feinauer E. Reasons for enrollment at a Spanish-English two-way immersion charter school among highly motivated parents from a diverse community. *International Journal of Bilingual Education and Bilingualism*. 2011; 14:621–651.
- Whitney P, Arnett P, Driver A, Budd D. Measuring central executive functioning: What's in a reading span? *Brain & Cognition*. 2001; 45:1–14. [PubMed: 11161358]
- Woodcock, RW.; McGrew, KS.; Mather, N. Woodcock-Johnson III. Itasca, IL: Riverside Publishing; 2001.
- Yoo J, Kaushanskaya M. Phonological memory in bilinguals and monolinguals. *Memory & Cognition*. 2012; 40:1314–1330. [PubMed: 22907206]
- Yoshida H, Smith LB. Shifting ontological boundaries: how Japanese- and English-speaking children generalize names for animals and artifacts. *Developmental Science*. 2003; 6:1–17.
- Zelazo PD, Frye D, Rapus T. An age-related dissociation between knowing rules and using them. *Cognitive Development*. 1996; 11:37–63.10.1016/S0885-2014(96)90027-
- Zelazo PD, Jacques S. Children's rule use: Representation, reflection and cognitive control. *Annals of Child Development*. 1996; 12:119–176.
- Zelazo PD, Müller U, Frye D, Marcovitch S. The development of executive function in early childhood. *Monographs of the Society for Research in Child Development*. 2003; 68:3.

Figure 1. Recognition accuracy data on the word-learning task for monolinguals and classroom bilinguals. The error bars represent Standard Deviations. The asterisk represents a significant difference between the two groups at $p < .05$.

Table 1**Background Information for Monolingual and Classroom Bilingual Children**

	Monolingual Children	Bilingual Children	<i>t-test</i>
N	19	19	
Age (years)	6.3 (0.7)	6.7 (0.7)	$t(37) = 1.73$
Maternal Years of Education	19.5 (3.3)	18.3 (3.3)	$t(37) = 1.1$
KBIT-2	104.2 (15.5)	106.6 (11.7)	$t(37) = 0.53$
PPVT-III	121.3 (15.4)	115.8 (12.0)	$t(37) = 1.24$
Picture Vocabulary	107.5 (12.1)	103.6 (101.6)	$t(37) = 1.07$
Age of English Acquisition (months)	19.2 (6.6)	16.0 (6.4)	$t(37) = 1.09$
Daily Exposure to English (percentage)	99.6% (10.2)	64.5% (6.4)	$t(37) = 15.75^*$

Note: The data in Table 1 represent Means and Standard Deviations. The means for standardized measures represent Standard Scores. Age of English acquisition was reported by the parents as age in months when the child began producing two-word utterances in English. Daily exposure to English was reported by the parents as percentage of time the child is exposed to English during the course of an average week. Of the 19 children in the monolingual group, 16 were reported to be exposed to English 100% of the time, one child was reported to be exposed to English 98% of the time, and two children were reported to be exposed to English 97% of the time. The three children with less than 100% of exposure to English were reported to be exposed to friends who spoke a language other than English and/or casually exposed to Spanish through television and announcements in school. These exposure levels were reported to be minimal, and none of the children in this group had any knowledge of Spanish. The exposure to Spanish in the bilingual group fluctuated because the children were in grades K through 2; therefore, their exposure to Spanish varied from 90% of instruction to 70% of instruction based on their grade level. Independent-samples *t*-tests were conducted with group as the independent variable, and significant differences between the two groups at $p < .05$ are marked by an asterisk*.

Table 2

DCCS Task Data for Monolingual and Classroom Bilingual Children

	Monolingual Children	Bilingual Children
Accuracy Data		
Pre-Switch Accuracy	.87 (.29)	.94 (.07)
Post-Switch Accuracy	.90 (.09)	.89 (.08)
Mixed Phase Non-Switch Accuracy	.72 (.18)	.76 (.12)
Mixed Phase Switch Accuracy	.59 (.11)	.62 (.17)
RT Data		
Pre-Switch RT	996 (396)	843 (191)
Post-Switch RT	1411 (369)	1392 (327)
Mixed Phase Non-Switch RT	1746 (658)	1823 (445)
Mixed Phase Switch RT	1930 (605)	2010 (519)

Note: The data in Table 2 represent Means and Standard Deviations. Accuracy data are in proportion correct, and RT data are in milliseconds.

Table 3

Word-Span Data for Monolingual and Classroom Bilingual Children

	Monolingual Children	Bilingual Children
Monosyllabic Words		
Two-Word Lists	.92 (.19)	.94 (.24)
Four-Word Lists	.80 (.34)	.89 (.26)
Six-Word Lists	.41 (.19)	.39 (.31)
Eight-Word Lists	.35 (.16)	.35 (.14)
Disyllabic Words		
Two-Word Lists	1.00 (.00)	1.00 (.00)
Four-Word Lists	.75 (.26)	.83 (.23)
Six-Word Lists	.42 (.19)	.48 (.16)
Eight-Word Lists	.30 (.12)	.33 (.11)
Trisyllabic Words		
Two-Word Lists	.97 (.11)	1.00 (.00)
Four-Word Lists	.62 (.28)	.65 (.26)
Six-Word Lists	.31 (.13)	.34 (.11)
Eight-Word Lists	.24 (.13)	.30 (.12)

Note: The data in Table 3 represent Mean Accuracies (proportion correct) and Standard Deviations.

Table 4

Listening-Span Recall Data for Monolingual and Classroom Bilingual Children

	Monolingual Children	Bilingual Children
1-Sentence Sets	.81 (.39)	.89 (.32)
2-Sentence Sets	.61 (.37)	.78 (.28)
3-Sentence Sets	.41 (.27)	.54 (.25)
4-Sentence Sets	.26 (.18)	.34 (.18)
5-Sentence Sets	.23 (.15)	.28 (.12)
6-Sentence Sets	.21 (.15)	.27 (.11)

Note: The data in Table 4 represent Mean Accuracies (proportion correct) and Standard Deviations.