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Are there advantages for additive bilinguals in working memory tasks?☆,☆☆

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ABSTRACT

The purpose of this study was to examine the development of English and Spanish working memory (WM) components within four subgroups of bilingual children. For children who maintained their classification status across testing waves, the results found no WM advantages for additive bilinguals when compared to dominant bilinguals in their respective language. However, an advantage in the executive component of WM was found for those children who transitioned from Spanish dominant to additive bilinguals and an advantage in the phonological loop component of WM was found for those children who transitioned from English dominant to additive bilinguals. The results suggested that for bilinguals who acquire vocabulary proficiency in both languages at a later time point manifest a WM advantage relative to subgroups that maintain stable vocabulary knowledge.

Learning about cognitive processing advantages in bilingual children, especially as it impacts academics, is essential. Several studies suggest that bilingual children experience some cognitive advantages over children proficient in one language only (Carlson & Meltzoff, 2008; Martin-Rhee & Bialystok, 2008). However, few studies have focused on variations in cognition among bilingual children. Cummins (1979) was among the first to suggest that variations in cognitive proficiency within bilinguals may exist. Cummins further delineated three types of bilingualism: semi-lingualism, dominant bilingualism, and additive bilingualism. Semi-lingual refers to children with low levels of competencies in both languages, whereas dominant bilinguals have a native-like competence in one of the languages. In contrast, additive bilingual children have high levels of competencies in both languages; here, positive cognitive effects are observed (Cummins, 1979, 1981).

A number of studies have shown that proficiency in L1 and L2 (i.e., bilingualism) positively influences executive functioning, flexibility, and intentional control (e.g., Bialystok, 2011). These studies suggest that navigating between two languages, having frequent opportunities to inhibit one language when using the other, and holding linguistic information in mind while manipulating another is related to the development of executive processes (e.g., Bialystok, 2011). Because executive processes are related to working memory (WM; Engle, 2002; Friedman et al., 2007), one would expect variations in bilingual proficiency to play an important role in WM performance. However, the relationship between bilingualism and WM performance is unclear. For example, Bialystok's (2009) synthesis of the literature suggested that there is little evidence that bilingualism is related to "the development and functioning of memory in general, and working memory in particular" (p. 6).

On the surface these findings seem counterintuitive because the monitoring between language systems is associated with cognitive control, which is a major mechanism related to WM (e.g., Engle, 2002). One explanation for this outcome has been attributed to reduced verbal abilities of bilingual children (Bialystok, 2009). That is, the weak relationship between WM and bilingualism emerges because bilinguals' lexical knowledge is distributed across all their languages, and therefore they do not have the full range of language proficiency when compared to their monolingual peers (Namazi & Thordardottir, 2010). For example, Bialystok and Feng (2009) suggested that bilinguals consistently outperform monolinguals on nonverbal measures of attention and control; however, this bilingual advantage does not extend to tasks of language processing (e.g., verbal short-term memory). This is because bilinguals have control over a smaller vocabulary in each language than monolinguals, which may contribute to their lower level of performance on verbal tasks relative to low- or non-verbal tasks.

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This study tests the hypothesis that language proficiency in bilinguals is related to WM performance. However, instead of comparing bilingual to monolingual children, as is commonly done in literature, we compared WM proficiency among four groups of bilingual children: emerging, English dominant, Spanish dominant, and additive. We reason that if language proficiency is related to bilingual children's WM performance, then variations in language proficiency (in this case vocabulary) will be related to WM performance. To test this hypothesis, a multicomponent model of WM outlined by Baddeley and Logie (1999) was used. The model includes at least three distinct components of WM: phonological storage (short-term memory, STM), visual–spatial sketchpad, and executive processing. Thus, our research addresses the question: is the degree of bilingualism related to performance on component measures of WM?

1. Method

1.1. Participants

The data reported here are from a subsample of the first three waves of a four-year cross-sectional, longitudinal study. Children in Grades 1 to 3 from southwest U.S. were included in this study. The total sample of 193 children included 86 boys (45%) and 107 girls (55%). All children were Hispanic and exposed to both English and Spanish languages. Parent interviews indicated that in 84% of households, the children's primary spoken home language was Spanish; 9% spoke both English and Spanish, whereas the remainder of the children primarily spoke English at home (7%). All children participating in the study were designated as English language learners (ELL) based on the school-administrated language development test, and 95% percent of the sample participated in a federally-funded free lunch program. The mean age of the children was 94.64 months ($SD = 7.36$). Seven percent of the children were in Grade 1, 46% in Grade 2, and 47% in Grade 3. In Wave 1, 35% of the children were classified as emerging bilingual ($n = 67$), 27% were English dominant bilingual ($n = 52$), 19% were Spanish dominant bilingual ($n = 37$), and the remaining 19% of the children were classified as additive bilingual ($n = 37$). Children from Wave 1 were tested in the Spring of 2010 and again one and two years later (Waves 2 and 3, respectively).

1.2. Measures

The study included group and individually administrated battery of tests in both English and Spanish. The series of tests were counterbalanced, and no Spanish and English versions of the same test were presented simultaneously (except for visual–spatial measures that required nonverbal responses).

1.3. Measures used for classification

1.3.1. Peabody Picture Vocabulary Test (PPVT)

The Peabody Picture Vocabulary Test was administered to assess English receptive vocabulary knowledge (Dunn & Dunn, 1981). The children were presented with four pictures. After hearing a spoken word, the children were required to select the picture that matched the meaning of the word. Word presentation gradually increased in difficulty in this non-timed test. The technical manual states a parallel form reliability of .91 and an internal validity of .97.

1.3.2. Test de Vocabulario en Imagenes Peabody (TVIP)

The Test de Vocabulario en Imagenes Peabody is a standardized assessment that contains universally appropriate translated items from the PPVT (Dunn, Lugo, Padilla, & Dunn, 1986) to assess Spanish receptive vocabulary. This measure is similar to the PPVT in presentation and administration, except that words were read aloud in Spanish. The manual reports a split-half reliability of .91 to .94.

1.3.3. Raven Colored Progressive Matrices

The Raven Colored Progressive Matrices (Raven, 1976) was used as an indicator of fluid intelligence. Children were shown a design matrix with a puzzle piece missing and then were asked to select the piece (out of six choices) that best completed the pattern that progressively increased in difficulty. Cronbach's coefficient alpha was .88.

1.3.4. Classification

As outlined by Cummins (1979), four subgroups based on English and Spanish language competency were created. The performance on PPVT and TVIP was used to divide the sample in terms of language competency at and above a cutoff score of 85 (1 standard deviation below the mean). Children were classified as *emerging bilingual* if they scored below 85 on both the PPVT and TVIP, *English dominant bilingual* if they scored at and above the cutoff in English language and below the cutoff in Spanish, *Spanish dominant bilingual* if they scored at and above the cutoff in Spanish language and below the cutoff in English, and *additive bilingual* if they scored 85 or above on both the PPVT and TVIP. Additionally, because the focus of this study was on children's bilingual and WM processes and not intellectual delays, all children were required to score above a standard score of 85 on the measure of basic fluid intelligence to be included in our analyses. The descriptive statistics of the PPVT, TVIP, and Raven for each bilingual group are shown in Table 1.

An ANOVA comparing the groups yielded a significant effect on English vocabulary, $F(3,189) = 95.30$, $p < .001$, and Spanish vocabulary, $F(3,189) = 108.54$, $p < .001$, but not on fluid intelligence scores, $F(3,189) = 1.46$, $p = .23$, or chronological age, $F(3, 189) = 2.32$, $p = 0.08$. A Tukey test yielded significant ($ps < .05$) differences between groups for English vocabulary (additive bilingual = English dominant > Spanish dominant = emergent) and Spanish vocabulary (additive bilingual = Spanish dominant > English dominant > emergent).

Because the classification of children into one of the four subgroups could change across the three year period, a chi-square analysis was computed comparing the classification of children in Wave 1 to Wave 3. There was a significant difference in group status classified at Wave 1 and Wave 3, $\chi^2(9, N = 193) = 83.49$, $p < .001$. As shown in Table 1, classification stability was maintained for 66.83% of emerging bilinguals, 45.24% of English dominant, 55% of Spanish dominant, and 42.86% of additive bilinguals. No significant

Table 1
Descriptive statistics for classification measures of bilingual groups.

Bilingual group	Wave 1		Wave 3		Status change			
	M	SD	M	SD	1	2	3	4
1. Emergent					30	28	6	3
English vocabulary	76.36	6.53	82.28	10.95				
Spanish vocabulary	70.61	8.80	68.04	12.81				
Fluid intelligence[a]	58.41	21.00	59.46	22.99				
2. English-dominant					5	38	1	8
English vocabulary	92.08	6.33	92.63	7.68				
Spanish vocabulary	70.46	10.33	69.12	16.03				
Fluid intelligence[a]	65.52	18.44	76.78	21.28				
3. Spanish dominant					9	4	11	13
English vocabulary	79.32	4.56	83.35	9.69				
Spanish vocabulary	98.51	12.16	89.62	15.46				
Fluid intelligence[a]	59.41	21.65	63.94	22.43				
4. Additive					3	14	2	18
English vocabulary	93.00	6.92	95.13	11.57				
Spanish vocabulary	96.27	9.53	87.54	15.22				
Fluid intelligence[a]	69.95	23.08	75.48	19.87				

Note. 1 = emerging bilingual group ($n = 67$); 2 = English dominant bilingual group ($n = 52$); 3 = Spanish dominant bilingual group ($n = 37$); 4 = additive bilingual group ($n = 37$).

[a] Fluid intelligence = percentile score.