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Executive Function of Spanish-Speaking Language-Minority Preschoolers: Structure and Relations with Early Literacy Skills and Behavioral Outcomes

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Abstract

Young children's executive function (EF) is increasingly recognized as an important construct associated with development in cognitive and socio-emotional domains. To date, however, few studies have examined EF in populations of language-minority children. In this study, 241 Spanish-speaking language-minority preschoolers who ranged in age from 38 - 69 months ($M = 54.23$, $SD = 6.17$) completed three tasks designed to measure inhibitory control (IC) and four tasks designed to measure working memory (WM). Children completed assessments of their vocabulary skills, early literacy skills, and behavioral self-regulation in both English and Spanish, and their classroom teachers completed three behavior-rating measures. Children were classified as more proficient in English or Spanish based on their scores on the vocabulary measures, and all IC and WM measures were administered in the children's more proficient language. Results of confirmatory factor analyses supported a two-factor model of EF for both groups of children as well as strong measurement and structural invariance across groups. Children's EF was substantially related to the language, early literacy, and behavioral self-regulation measures, as well as teacher ratings of inattention and hyperactivity/impulsivity. For children with more proficient English, EF was associated with skills in both English and Spanish; however, for children with more proficient Spanish, EF was associated primarily with skills in Spanish. These results provide evidence of strong correspondence for EF measured in Spanish-speaking language-

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minority preschoolers and monolingual preschoolers, and they identify a potential key factor that can enhance understanding of development in this population of children.

Keywords

executive function; preschool; language minority; bilingual

Over the past decade, there has been an increasing focus on young children's self-regulation as an important developmental construct that is associated with other important developmental outcomes, including academic achievement and socio-emotional functioning. One area of self-regulation that has received a significant amount of attention is executive function (EF). EF represents a set of inter-related domain-general cognitive skills that are linked with development of the prefrontal cortex and its role in activating and inhibiting activity in other brain regions (Garon, Bryson, & Smith, 2008). Although there are several models of EF (e.g., Barkley, 2001; Duncan & Owen, 2000), one of the most commonly studied models was developed by Miyake, Friedman, Emerson, Witzki, and Howerter (2000) based on factor-analytic work with adults. This model includes three correlated but distinct dimensions: inhibitory control (IC), updating/working memory (WM), and shifting. IC represents the capacity to withhold a predisposed response, often in favor of a non-predisposed response. WM represents the capacity to hold information in memory and either manipulate that information or update it based on ongoing sensory input. Shifting represents the capacity to alternate between sets of stimulus-response rules.

Children's EF is related to academic and behavioral outcomes both during early childhood (e.g., N. P. Allan, Hume, D. M. Allan, Farrington, & Lonigan, 2014; Schoemaker, Mulder, Dekovi, & Matthys, 2013; Thorell, Bohlin, & Rydell, 2004) and during middle childhood (e.g., Arrington, Kulesz, Francis, Fletcher, & Barnes, 2014; Brocki, Eninger, Thorell, & Bohlin, 2010). Higher levels of EF are associated with higher scores on measures of language, literacy, and math, and with lower levels of problematic behaviors. Given these linkages, knowledge of the nature and development of EF may lead to better methods of understanding factors influencing early development, which, in turn, may result in better early identification of children at-risk for academic or socio-emotional difficulties. Although there is a growing literature concerning EFs in monolingual children, little research to date has examined the nature and developmental correlates of EFs with children whose home language is different than the societal language. Many children whose home language is not the societal language experience substantial difficulties related to academic achievement (Hemphill, Vanneman, & Rahman, 2011). Consequently, the goals of this study were to examine the nature of EF with a group of preschool children whose home language was Spanish and to determine the relations between EFs and these children's academic skills and classroom behaviors.

Executive Function in Young Children

Although studies that include children as young as eight years of age (Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003) have replicated the three-factor model of EF, other studies indicate that a two-factor model (i.e., WM and IC/Shifting) adequately describes children's

EF (Lee, Bull, & Ho, 2013; van der Sluis, de Jong, & van der Leij, 2007). Lee et al. reported that a three-factor model in which shifting and IC were separate factors was supported only for their oldest group of children, who were 13 years of age. Results of some studies support a simpler, one-factor model of EF with preschool-age children (e.g., Wiebe, Espy, & Charak, 2008; Wiebe et al., 2011; Willoughby, Blair, Wirth, & Greenberg, 2010). In contrast, other studies of preschool children indicate that EF is best represented by distinct WM and IC factors (e.g., Lerner & Lonigan, 2014; Schoemaker et al., 2012). Overall, the developmental structure of EF seems to be characterized by a pattern of increasing complexity as a function of development. Studies of children between 36 and 48 months of age tend to report a single EF factor (e.g., Wiebe et al., 2008, 2011; Willoughby et al., 2010), whereas studies of children between 49 and 60 months of age tend to report two factors (e.g., Lerner & Lonigan, 2014; Schoemaker et al., 2012) and studies of adolescents report three factors (e.g., Lee et al.).

Language-Minority Children

Children in the U.S. whose families speak a language other than English at home (i.e., language-minority children) comprise about 9% of public school students (nces.ed.gov). These families represent a substantial and rapidly growing proportion of households in the U.S. For instance, according to the 2010 U.S. Census Bureau report, 60 million households use a primary language other than English, and Spanish was the primary language in approximately 37 million of these households (U.S. Census Bureau, 2011). Compared to the 2000 Census, these estimates represent a 29% increase overall and a 34% increase in the number of households in which Spanish is the primary language. Similar to the school-age population, language minority children represent a substantial number of children served in early childhood education settings. For example, 30% of children enrolled in Head Start or Early Head Start in 2012 were from homes in which a language other than English was spoken (Administration for Children and Families, 2012).

Despite the cultural, linguistic, and economic diversity present within this population, Spanish-speaking language minority children experience a greater risk of negative outcomes in both academic and behavioral domains than do their monolingual English-speaking peers. For instance, children who are English language learners (ELLs; i.e., language-minority children who have limited English proficiency) are less likely than their monolingual peers to meet national standards in reading and math, in both 4th grade and 8th grade (National Assessment of Educational Progress, 2013). Children who are ELLs also are more likely than their monolingual peers to experience internalizing (e.g., anxious or depressed; Twenge & Nolen-Hoeksema, 2002) and externalizing (e.g., inattentive, noncompliant, or aggressive; Dawson & Williams, 2008) symptoms. Consequently, it is important to understand how factors like EF, which influence academic and behavioral outcomes, develop among language minority children.

Executive Function among Language-Minority Children

Compared to the literature on the development and developmental significance of EF with younger monolingual children, there are few studies in which the development and

developmental influences of EF among younger language minority children have been examined. In a series of reports on two samples of Spanish-speaking children first assessed when they were in first grade, Swanson and colleagues (e.g., Swanson, 2015; Swanson, Sáez, Gerber, & Leafstedt, 2004) reported that WM was associated concurrently and longitudinally with children's language and reading skills in both Spanish and English, with some evidence of language specificity (i.e., Spanish WM predicted Spanish outcomes and English WM predicted English outcomes), depending on the sample and analysis.

Several studies in which the relations between IC and academic outcomes were examined in preschool and kindergarten samples included a substantial number of children identified as Spanish speakers (McClelland et al., 2007; Ponitz, McClelland, Matthews, & Morrison, 2009). Although these studies demonstrated that children with higher levels of IC measured at the start of preschool or kindergarten had higher scores on measures of literacy-related and math skills both concurrently and longitudinally, children's language status was included only as a main effect in the analysis. Consequently, the similarity or differences in relations of EF for Spanish-speaking versus monolingual English-speaking children could not be determined. Moreover, these studies used a single measure to index children's EF.

Some evidence suggests that the task of managing multiple languages accelerates the development of EF in bilingual children. Bialystok and Martin (2004) theorized that bilingual individuals have to inhibit one language when the other is used because both languages are activated simultaneously during speech production. In this way, language use recruits inhibitory processes in bilingual but not monolingual speakers, resulting in more opportunities for bilingual individuals to use and develop EF. Much of the evidence of a bilingual advantage in EF comes from studies of adults or studies of children from higher SES families (e.g., Barac & Bialystok, 2012; Esposito, Baker-Ward, & Mueller, 2013). Studies with younger children and children from less-advantaged backgrounds have produced results that are both consistent (e.g., Yang, Yang, & Lust, 2011) and inconsistent (e.g., Wanless et al., 2011) with a bilingual advantage.

Current Study

In this study, the measurement and developmental significance of EF was examined in a relatively large group of Spanish-speaking preschool children. Multiple tasks hypothesized to represent IC and WM were administered to children. Tasks hypothesized to represent shifting were not included because of the limited evidence that shifting is a component of EF that is distinct in young children (e.g., Lee et al., 2013). These tasks were administered to the children in either Spanish or English, depending on the child's more proficient language. All children completed measures of language, early literacy, and behavioral self-regulation that were administered in both Spanish and English, and teachers completed ratings of children's behavior.

There were three interrelated goals of this study. The first goal was to examine the structure of EF among Spanish-speaking preschool children. It was hypothesized that the structure of EF would be best characterized as a two-factor model with distinct but correlated WM and IC factors. The second goal was to determine if language of task administration influenced

the measurement and structure of EF. It was expected that the same factor structure would emerge when EF was measured in English or Spanish. The third goal was to determine the relations between IC and WM and measures of early-literacy skills and behavioral outcomes as well as whether these relations were moderated by the language of EF task administration. Based on prior findings from samples of monolingual English-speaking children and preliminary evidence from samples including language minority children, it was expected that higher levels of EF would be associated with stronger early-literacy skills in both languages and more positive behavioral outcomes (i.e., lower scores on teacher-reports of problem behaviors), and that these relations would not be moderated by language of administration of EF tasks. Confirmatory factor analysis was used to identify the dimensionality of EF and to determine whether language of administration for the EF tasks affected this structure. Structural equation models were used to examine relations between dimensions of EF and children's skills in language, early literacy, behavioral self-regulation, and teacher-ratings of child behaviors.

Method

Participants

The 241 children who participated in this study were recruited from a total of eight private, public, and Head Start preschool centers in either central Florida ($n = 143$) or southern New Mexico ($n = 98$). All of the children's teachers and teacher's aides ($N = 36$) were female, and 81% were Latina. Most teachers reported that they were born in the U.S. (56%), and 61% of teachers reported speaking Spanish regularly outside of the classroom (only 25% reported speaking primarily Spanish in the classroom). Teachers reported a median of 6 to 10 years of experience teaching preschool, and most teachers reported that they also had taught in grades other than preschool. The majority of teachers reported that they had attained a BA degree or higher (83%). All children recruited for the study were Spanish speakers based on teacher report and interactions with the children. The children ranged in age from 38 - 69 months ($M = 54.23$, $SD = 6.17$). Slightly more than half of the children were girls (53.5%), and the majority of the children were Latino/White (51.5%), with the remainder Black (.8%), Asian (.4%), Hawaiian/Pacific Islander (.4%), multi-racial (7.1%), or not reported (39.8%). Parents reported that 85% of the children were born in the U.S (4% not reported).

Based on the 84% of the sample for which parents returned questionnaires that asked about language use and family demographics, all children were from homes in which Spanish was spoken at least some of the time, and 82% were from homes in which only Spanish was spoken. All mothers ($n = 203$) and 95% of the fathers ($n = 181$) for whom data were reported spoke Spanish as one of their languages or as their only language, and 79% of mothers and 85% of fathers for whom data were reported were born outside of the U.S. The median reported level of maternal education was high-school graduation or equivalent, with 21% of mothers reporting some college experience and an additional 17% of mothers reporting completion of college or higher. The median reported level of paternal education was high-school graduation or equivalent, with 22% of fathers reported to have some college experience and an additional 6% of fathers reported to have completed college or

higher. Based on the 64% of the sample who responded to the question, median annual household income was \$20,000 or less, with only 7% of respondents reporting annual family income of more than \$40,000.

Measures

Executive function tasks: Inhibitory control—Children completed three tasks designed to measure IC. The Knock-Tap task is part of the Developmental Neuropsychological Assessment (Korkman, Kirk, & Kemp, 1998). During practice trials, children learned to imitate the examiner's hand gestures--either knocking on the table with the knuckles or tapping on the table with an open palm. Children were then instructed to do the opposite of the examiner's gesture (i.e., knock when examiner taps). Responses on a total of 12 trials were scored from 0-2 (0 for imitating the examiner/no response, 1 for self-correction [i.e., performing an incorrect gesture, then responding correctly without examiner feedback within two seconds], and 2 for a correct response) for a maximum score of 24. Internal consistency in this sample was high ($\alpha = .96$).

On the Picture-Imitation task (Lerner & Lonigan, 2014), children first learned to imitate the action depicted in black-and-white-line drawings of animals or same-gender children shown touching their heads or toes; then, children were instructed to continue to imitate the animal pictures but to do nothing when the picture was of a child. During the task, children were shown 12 cards, one at a time, half of which represent critical trials (child image) that were randomly ordered with the non-critical trials. Each trial was scored from 0-2 (0 for imitating the picture of the child, 1 for self-correction [e.g., beginning to imitate the picture of the child but stopping before completing the response], and 2 for a correct response) for a maximum score of 24. Internal consistency in this sample was good ($\alpha = .86$).

On the Day-Night-Stroop task (Gerstadt, Hong, & Diamond, 1994), children were shown cards with cartoon drawings depicting either the sun or the moon. After establishing that the child knew that the sun is seen during the day and the moon is seen during the night, the child was required to point to the sun card when the examiner said "night" and to point to the moon card when the examiner said "day" (a pointing response, rather than a verbal response, similar to the Carlson & Moses, 2001, Grass-Snow task, was used in this study). Each child completed 12 trials that were scored 0 to 2 (0 = pointing to incorrect card/no response, 1 = self-correct [e.g., any movement of the hand toward the incorrect card, followed by pointing to the correct card without examiner feedback within two seconds], 2 = pointing to the correct card) for a maximum score of 24. Internal consistency in this sample was high ($\alpha = .95$).

Executive function tasks: Working memory—Children completed four tasks designed to measure WM. The Size-Ordering task was modeled after the Children's Size Ordering Task (McInerney, Hrabok, & Kerns, 2005) using simpler vocabulary. Children were presented orally with lists of common objects (e.g., car, house, bird) and asked to repeat them in order from the smallest to the largest object (e.g., bird, car, house). Word lists ranged in length from two to eight words, and there were three trials of each list length (i.e., 21 trials). Scores were the number of trials in which the child repeated back all of the words

in the correct order (i.e., maximum score = 21). Internal consistency in this sample was good ($\alpha = .81$).

The Word-Span-Reversed task required children to listen to a series of simple, one-syllable words and then repeat the words back in the reverse order from how they were presented. Word lists ranged in length from two to eight words, with three trials at each word-list length (i.e., 21 trials). Scores were the number of trials in which the child repeated back all of the words in the correct order (i.e., maximum score = 21). Internal consistency in this sample was high ($\alpha = .92$).

On the Listening-Span task (Gathercole & Pickering, 2000), children were required to listen to increasingly longer lists of simple questions (e.g., “Do dogs bark?” “Can cats fly?”) and respond “yes” or “no” to each question. After all questions in a trial were presented, children were asked to recall the last word of each question (e.g., “bark,” “fly”). Trials included between two and four questions, with three trials at each level for a total of 12 trials. Scores were the number of trials in which the child repeated back all of the last words in the questions (i.e., maximum score = 12). Internal consistency in this sample was high ($\alpha = .92$).

On the Animal-Span task, which was patterned after Bull and Scerif’s (1980) Counting Span task but required labeling of pictures as the distractor component of the task instead of counting dots, children had to recall increasingly long lists of names of animals that were pictured on cards presented one at a time. Before beginning the task, the examiner made sure that the child knew the names of the animals depicted on each of the cards. On each trial, the examiner placed a card in front of the child, and the child had to name the animal depicted. That card was then turned face down and another card was placed in front of the child, and the child had to name the animal depicted. After all cards for a trial had been presented, the child was asked to recall all of the animals previously shown in that trial (i.e., before the final card). There were 12 trials that required children to remember between one and three animals from the previously presented cards, with four trials at each level. The score on the task was the number of trials in which the child recalled all of the animals presented before the last card (i.e., maximum score = 12). Internal consistency in this sample was adequate ($\alpha = .78$).

English-language measure of language and early literacy skills—All children completed the *Test of Preschool Early Literacy* (TOPEL; Lonigan, Wagner, Torgesen, & Rashotte, 2007), which is a nationally normed and standardized measure of preschool children’s early literacy skills. The TOPEL has three subtests that were designed to measure the core components of early literacy skills. For each of the 35-items on the Definitional Vocabulary subtest, children are shown a picture and must both name the picture and answer a question concerning function or relevant context for the item. The Phonological Awareness subtest includes 12 elision items that require the child to remove a part of a word to make a new word, and 15 blending items that require the child to combine word sounds to form a word. Both multiple-choice- and free-response-format items are used, and items require manipulation of sound units ranging from words to phonemes. The Print Knowledge subtest includes 36 items that include content related to print concepts, letter-name recognition, letter-sound recognition, and letter-name and letter-sound production. All items

on each subtest are scored as correct or incorrect. According to the test manual, the TOPEL has high internal consistency reliability ($\alpha = .96$), test-retest reliability ($r = .91$), and inter-scorer agreement ($r = .98$), and each subtest is reported to have good criterion validity as demonstrated by high correlations ($r_s .59$) between the subtests and other measures of similar constructs. Internal consistency reliabilities for the three subtests in this sample were high (i.e., Definitional Vocabulary: $\alpha = .98$, Phonological Awareness: $\alpha = .93$, Print Knowledge: $\alpha = .96$).

Spanish-language measure of language and early literacy skills—All children completed the *Spanish Preschool Early Literacy Assessment* (SPELA; Lonigan, 2013), which is a newly developed measure of Spanish-speaking children's early literacy skills. The SPELA, which includes four subtests, was designed to provide similar domain coverage to the TOPEL and to work with Spanish-speaking children from multiple Spanish-language dialects. For each item on the 32-item Definitional Vocabulary subtest, children are shown a picture and must both name the picture and answer a question concerning function or relevant context for the item. Both the Blending and Elision subtests have 21 items that include both multiple-choice and free-response format items that require manipulation of sound units ranging from words to phonemes. The Print Knowledge subtest includes 38 items that assess print concepts, letter-name recognition, letter-sound recognition, and letter-name and letter-sound production. All items on each subtest are scored as correct or incorrect. In development work, all four subtests had good internal consistency (α s = .93, .87, .94, & .93, for Definitional Vocabulary, Elision, Blending, & Print Knowledge subtests, respectively) and evidence of concurrent validity as demonstrated by correlations with similar constructs ranging from .23 to .54. Internal consistency reliabilities for the four subtests in this sample were high (i.e., Definitional Vocabulary: $\alpha = .98$, Blending: $\alpha = .94$, Elision: $\alpha = .98$, Print Knowledge: $\alpha = .88$).

Measure of children's behavioral self-regulation—Children's behavioral self-regulation was assessed using the Head-Toes-Knees-Shoulders task (HTKS; McClelland et al., 2007; Ponitz et al., 2009). According to McClelland and Cameron (2011), the HTKS measures multiple aspects of self-regulation, including attention, working memory, and inhibitory control as well as gross-motor skills. On the HTKS, children must do the opposite of a command spoken by the examiner (e.g., if told "touch your head," the child must touch his/her toes). After practice trials to explain the task to the child, 10 initial trials are completed with two commands (i.e., "touch your head," "touch your toes") alternating in a fixed order. In a second set of 10 trials, two new commands are added (i.e., "touch your knees," "touch your shoulders" [correct responses are touching shoulders for "knees" command and touching knees for "shoulder" command]) and interspersed with the original two commands. Each trial was scored from 0-2: Incorrect responses = 0; Self-corrects (i.e., child initially reaches for the command location [e.g., head for "touch your head"] but ends up with correct response) = 1; and Correct responses = 2. The maximum possible score on the task is 40.

McClelland and Cameron (2011) reported that the HTKS has good inter-rater reliability, inter-scorer agreement, and test-retest reliability of .93 over a three-month period. Scores on

the HTKS correlate with teachers' ratings of classroom behavior (Ponitz et al., 2009) and other direct measures of self-regulation (e.g., N. P. Allan & Lonigan, 2011). For this study, children completed the HTKS in both English and Spanish (order determined randomly for each child), conducted on separate days. Internal consistency was high for the English- ($\alpha = .94$) and Spanish-language versions ($\alpha = .95$).

Teacher-report measures of children's behavior—Children's preschool teachers completed three teacher-report measures of the children's behavior. The Strengths and Weaknesses of ADHD-Symptoms and Normal-Behaviors Rating Scale (SWAN; Swanson et al., 2001) includes 27 items that correspond to the diagnostic criteria for ADHD and Oppositional Defiant Disorder as described in the Diagnostic Statistical Manual Text Revision 4th Edition (American Psychiatric Association, 2000). On the SWAN, children are rated based on comparison to same-age peers, and scores ranged from -3 to 3 for each item. Each item is framed in the positive direction, such that higher scores reflect lower levels of behavior problems. The SWAN yields three subscales that relate to behaviors associated with inattention, hyperactivity/impulsivity, and oppositionality. The SWAN has good internal consistency (i.e., α s $>.94$) and test-retest reliability (r s between $.71$ and $.76$) for each subscale (Lakes, Swanson, & Riggs, 2012). In this sample, the SWAN also had good internal consistency (i.e., α s = $.93$, $.85$, & $.91$, for the Attention, Hyperactive/Impulsive, and Oppositional subscales respectively).

Teachers completed a short-form version of the Conners' Teacher-Ratings Scale (CTRS-15; Purpura & Lonigan, 2009). On the CTRS-15, items related to inattention, hyperactivity/impulsivity, and oppositional defiant behaviors are rated on a four-point scale (i.e., 0 = "never/not at all," 3 = "very often/frequently") and make up three five-item subscales that are highly correlated with the subscales from the full measure (i.e., r s $>.91$) as well as to other measures of symptoms of ADHD. In this sample, the CTRS-15 had good internal consistency (i.e., α s = $.88$, $.90$, & $.86$, for the Inattention, Hyperactivity/Impulsivity, and Oppositional Defiant subscales respectively).

Finally, teachers completed the Social Competence and Behavior Evaluation measure (SCBE; LaFreniere & Dumas, 1996), a 30-item rating scale of young children's prosocial behavior and problem behaviors. The SCBE yields three 10-item subscales (i.e., Social Competence, Anger/Aggression, Anxiety). Items are rated on a six-point scale (1 = "never," 6 = "always"). The SCBE subscales have good internal consistency (α s = $.80$ -. $.92$), test-retest validity (r s = $.78$ -. $.86$), and validity (e.g., r s = $.92$ -. $.97$; LaFreniere & Dumas). In this sample, the SCBE had good internal consistency (i.e., α s = $.87$, $.91$, & $.85$ for the Social Competence, Anger/Aggression, and Anxiety subscales, respectively).

Procedure

Parents or guardians of all children included in the study provided written informed consent/permission for their children to participate. All assessments were conducted by trained bilingual research staff members in a quiet area of the children's preschools. Tasks were administered across multiple days during 20- to 30-minute assessment sessions. During these sessions, children were given breaks if requested or if they became fatigued or

distracted during the assessments. All assessments, including the EF tasks and self-regulation measure included practice trials. During practice trials, corrective feedback was given, but no feedback was given during the non-practice trials of the tasks. Children first completed the assessments of language and early literacy skills (i.e., TOPEL and SPELA measures) and the assessment of self-regulation (i.e., HTKS task). The order of administration of tasks administered in Spanish and English varied across children. Children's classroom teachers were asked to complete the three rating forms for each consented child in the time period in which the language/literacy assessments were being conducted. Teachers completed these ratings within an average of 0.94 months ($SD = 2.32$) of the standardized assessments. Children's parents were asked to complete several questionnaires concerning their language use in the home and family background. Both English and Spanish versions of these questionnaires were made available to parents.

Following completion of the language measures, children's more proficient language was determined based on their scores on the Definitional Vocabulary subtests of the SPELA and TOPEL. A child was judged to be more proficient in English if her or his standard scores on the TOPEL Definitional Vocabulary subtest was 75 or higher and her or his raw score on the TOPEL Definitional Vocabulary subtest was higher than her or his raw score on the SPELA Definitional Vocabulary subtest. A child was judged to be more proficient in Spanish if her or his standard score on the TOPEL Definitional Vocabulary subtest was less than 75 and her or his raw score on the SPELA Definitional Vocabulary subtest was higher than her or his raw score on the TOPEL Definitional Vocabulary subtest. In cases in which a child's more proficient language was unclear using these rules (about 9% of children), examiners interacted with the child both in Spanish and in English to determine the child's preferred conversational language, and this language was used as the child's more proficient language. Of the 241 children, 87 were determined to be more proficient in English and 154 were judged to be more proficient in Spanish. All EF measures were administered to children in the language in which they were judged to be more proficient.

Missing data—All children in the sample had complete data for the EF tasks, the Definitional Vocabulary subtest of the TOPEL, and all four subtests of the SPELA. A small percentage of children were missing data on the Phonological Awareness ($n = 4$) and Print Knowledge ($n = 3$) subtests of the TOPEL, and one child each was missing either the Spanish or English administration of the HTKS. There was more missing data for the teacher-report measures (9, 10, & 38 children were missing data on the SWAN, CTRS-15, and SCBE, respectively) because these children's teachers did not complete/return the measure. In predictive analyses using measures with missing data, full-information-maximum-likelihood estimation was used to account for the missing data.

Results

Descriptive Statistics

As a group, children in this study scored in the low-average (print knowledge) to below-average (definitional vocabulary, phonological awareness) range on the standardized measure of early literacy skills in English. Descriptive statistics for the language and literacy

measures, the behavioral self-regulation measures, and the teacher ratings of children's behavior are shown in Table 1 separately for children who completed the EF measures in English and children who completed the EF measures in Spanish. As seen in the table, there were no differences in age between children who completed EF tasks in English or Spanish, but children who completed the EF tasks in English scored significantly higher on all English early literacy subtests, the Spanish print knowledge subtest, as well as the English administration of the HTKS. Children who completed the EF tasks in Spanish scored higher on the Spanish vocabulary subtest. Teachers rated children who completed the EF tasks in English as more attentive and as displaying fewer behaviors associated with hyperactive or impulsive behavior than they rated children who completed the EF tasks in Spanish.

Descriptive statistics and correlations for the EF tasks are shown in Table 2. With the exception of scores on the Knock-Tap task and Size-Ordering tasks, there were no statistically significant differences in average scores for children who completed the EF tasks in English or children who completed the EF tasks in Spanish. On Knock-Tap, children who completed the task in English ($M = 18.39$, $SD = 7.81$) scored higher than did children who completed the task in Spanish ($M = 15.42$, $SD = 9.39$), $F(1, 239) = 6.25$, $p < .02$. On Size-Ordering, children who completed the task in English ($M = 5.45$, $SD = 5.02$) scored higher than did children who completed the task in Spanish ($M = 4.13$, $SD = 4.81$), $F(1, 239) = 4.05$, $p < .05$.

Correlations between EF tasks for children who completed the tasks in Spanish (below diagonal) and for children who completed the tasks in English (above diagonal) also are shown in Table 2. Average correlation between the tasks (after r -to- z transformations) was moderate for both the Spanish- (average $r = .30$) and the English-completion (average $r = .26$) groups. Average correlations between the IC tasks were .43 and .51 for Spanish- and English-completion groups, respectively, and average correlations between the WM tasks were .31 and .19 for Spanish- and English-completion groups, respectively. Average correlations of the IC tasks with the WM tasks were .26 and .23 for Spanish- and English-completion groups, respectively.

Dimensionality of Executive Functions

To determine the dimensionality of EF, confirmatory factor analyses (CFA) were conducted in Mplus 7.11 (Muthén & Muthén, 2012). The Satorra-Bentler chi-square (S-B χ^2 ; Satorra & Bentler, 1999) was used to correct standard errors for non-normal distributions. The S-B χ^2 and several other fit indices were used to assess overall model fit. A nonsignificant S-B χ^2 indicates that the overall test of model fit was acceptable. A comparative fit index (CFI) and a Tucker-Lewis index (TLI) greater than or equal to .90 and a root mean square error of approximation (RMSEA) below .08 also indicate acceptable model fit (e.g., Hu & Bentler, 1999). All analyses were conducted with and without a sandwich estimator to adjust standard errors to account for the clustering of children in preschools; however, because there were few preschools relative to the number of model parameters and because all substantive results were the same across both types of analyses, analyses without the sandwich estimator are reported.

CFAs were conducted separately for the children who completed the EF tasks in Spanish and children who completed the EF tasks in English. A two-factor (IC + WM) model fit the data adequately for both children who completed EF tasks in Spanish ($S-B\chi^2 = 17.45$, $p = .18$, CFI = .98, TLI = .96, RMSEA = .05 [95% CI: .00 - .09]) and children who completed EF tasks in English ($S-B\chi^2 = 19.85$, $p = .10$, CFI = .94, TLI = .90, RMSEA = .08 [95% CI: .00 - .14]). For both children who completed the EF tasks in Spanish, χ^2 -difference (1, $N = 154$) = 4.21, $p < .05$, and children who completed the EF tasks in English, χ^2 -difference (1, $N = 87$) = 18.41, $p < .001$, the two-factor model provided a better fit to the data than did a one-factor model. Factor loadings and factor correlations for the two-factor model for children who completed the EF tasks in Spanish and children who completed the EF tasks in English are shown in Table 3. All EF tasks loaded significantly on their respective factors in the separate samples. The correlation between IC and WM was .70 and .69 for children who completed EF tasks in English and children who completed EF tasks in Spanish, respectively.

Measurement and Structural Invariance Across Language of Assessment

Measurement invariance and structural invariance was examined for the two-factor model in the samples of children who completed the EF tasks in English or in Spanish. Results of these multi-group analyses are shown in Table 4. Equality constraints across the groups were imposed sequentially such that tests of any set of constraints included all prior constraints. Neither fixing the factor loadings to equality nor fixing the factor intercepts to equality resulted in a significant reduction in model fit compared to the fully unconstrained model. Therefore, strong measurement (scalar) invariance was achieved. Constraining the correlation between IC and WM to equality across groups did not result in a significant reduction in model fit compared to the fully unconstrained model. Therefore, full structural invariance was achieved. Finally, constraining the residuals to equality across groups did result in a significant reduction in model fit compared to the fully unconstrained model; however, the release of the constraint on the residual for the Knock-Tap task resulted in a model that fit as well as the fully unconstrained model. Consequently, partial strict measurement invariance was achieved.

Association of Executive Functions with Academic Skills and Behavioral Regulation

The relations between the EF factors and measures of academic skills were examined separately for children who completed the EF tasks in English and children who completed the EF tasks in Spanish using the model with scalar and structural invariance (i.e., cross-group constraints on factor loadings, factor intercepts, and the factor correlation). Zero-order and partial (controlling for age) correlations of the WM and IC factors with language, early literacy, and self-regulation measures that were assessed in both English and Spanish are shown in Table 5. For children who completed the EF measures in English, most zero-order correlations with both English and Spanish measures of language, early literacy, and behavioral self-regulation skills were positive and significant. Children with higher levels of IC and WM scored higher on the academic measures in both English and Spanish, and they had higher levels of behavioral self-regulation as measured by the HTKS in both English and Spanish. Comparisons of zero-order correlations using Steiger's (1980) T2 statistic with Bonferroni correction across IC and WM factors indicated that scores on the TOPEL

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Definitional Vocabulary subtest were more highly correlated with IC than with WM, and scores on the SPELA Blending subtest were more highly correlated with WM than with IC. When age was controlled in these models, the size of most correlations was reduced. The more strongly associated EF factor continued to be significantly associated with vocabulary and phonological awareness scores in both English and Spanish, but neither IC nor WM was associated with print knowledge once age was taken into account. IC continued to be strongly related to HTKS scores in English, but the correlations between EF factors and HTKS scores in Spanish were reduced to marginal significance.

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For children who completed the EF measures in Spanish, zero-order correlations with measures of language, early literacy, and behavioral self-regulation skills measured in Spanish were positive and significant, but the zero-order correlations with these skills measured in English were lower and most often not statistically significant. Comparisons of zero-order correlations across IC and WM factors, using Steiger's (1980) T2 statistic with Bonferroni correction, indicated that there were significant differences in the correlations for scores on the TOPEL Definitional Vocabulary and Phonological Awareness subtests across IC and WM factors, and scores on the Elision subtest of the SPELA were more highly correlated with WM than with IC. When age was controlled in these models, the size of the correlations was reduced; however, both IC and WM continued to be significantly associated with Spanish vocabulary, blending, and elision scores. As with children who completed the EF measures in English, neither IC nor WM was associated with print knowledge once age was taken into account, and the associations of IC and WM with HTKS scores in Spanish were reduced to marginal significance.

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Comparisons of zero-order correlations for IC and WM across groups of children who completed the EF tasks in English and children who completed the EF tasks in Spanish, using Steiger's (1980) T2 statistic with Bonferroni correction, revealed that scores on the Definitional Vocabulary subtest of the TOPEL and scores on the HTKS administered in English were more highly correlated with both IC and WM for the English-completion group than they were for the Spanish-completion group. Scores on the Phonological Awareness and Print Knowledge subtests of the TOPEL were more highly correlated with WM for children who completed EF tasks in English than they were for children who completed EF tasks in Spanish.

Association of Executive Functions with Children's Classroom Behaviors

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The relations between the EF factors and teachers' ratings of behavior also were examined separately for children who completed the EF tasks in English and children who completed the EF tasks in Spanish using the model with scalar and structural invariance. Zero-order and partial (controlling for age) correlations of the WM and IC factors with teacher reports on the SWAN, the CTRS-15, and the SCBE are shown in Table 6. For children who completed the EF tasks in English, zero-order correlations of IC and WM with Attention measured by both the SWAN and the CTRS-15 were significant. Children with higher levels of IC and WM were reported by teachers to have fewer problems of attention. Hyperactive/impulsive behavior was significantly correlated with IC when measured by both the SWAN and the CTRS-15. Hyperactive/impulsive behavior was significantly correlated with WM

only for the CTRS-15 measure. Children with higher levels of IC and WM were reported by their teachers to exhibit lower levels of hyperactive/impulsive behavior. Teachers' reports of children's social competence, anger/aggression, and anxiety on the SCBE were unrelated to IC and WM. The only difference in strength of correlations across IC and WM factors, using Steiger's (1980) T2 statistic with Bonferroni correction, was that inattention as measured by the CTRS-15 was more strongly related to WM than it was to IC. Controlling for age in these models rendered most correlations nonsignificant or marginally significant, with the exception of the association between WM and inattention as measured by the CTRS-15, and the association between IC and hyperactivity/impulsivity as measured by the CTRS-15.

For children who completed the EF tasks in Spanish, zero-order correlations with the teacher-report measures were generally lower and less often statistically significant than they were for children who completed the EF tasks in English. Inattention reported on the CTRS-15 was correlated with both IC and WM, but inattention reported on the SWAN was only correlated with IC. Hyperactive/impulsive behavior reported on both the SWAN and the CTRS-15 was correlated with IC, and teacher-reported social competence on the SCBE was associated with IC. Children with higher IC scores were rated by their teachers as more socially competent. The only difference in strength of zero-order correlations across IC and WM was that social competence as measured by the SCBE was more strongly associated with IC than it was with WM. Controlling for age in these models rendered most correlations nonsignificant or marginally significant.

Comparisons of zero-order correlations for IC and WM factors with teacher reports across groups of children who completed the EF tasks in English and children who completed the EF tasks in Spanish, using Steiger's (1980) T2 statistic with Bonferroni correction, revealed that attention as measured by the SWAN was more strongly related to WM and that both inattention and hyperactive/impulsive behaviors as measured by the CTRS-15 were more strongly related to both IC and WM for children who completed the EF tasks in English than they were for children who completed the EF tasks in Spanish.

Discussion

The goals of this study were to examine the structure of EF for Spanish-speaking language-minority preschool children and to examine the relations between these children's EF and their scores on measures of academic and behavioral functioning. The results indicated that EF was best characterized as a multi-dimensional construct consisting of correlated IC and WM components. Identical structures of EF were obtained from children who completed EF tasks in English and children who completed EF tasks in Spanish. Children's EF was significantly correlated with their language and early-literacy scores, their behavioral self-regulation, and with several dimensions of teacher-rated behaviors; however, the strength of these associations differed for children who completed EF tasks in English and children who completed EF tasks in Spanish. These results indicate that the nature of EF is the same for language minority children as it is for monolingual children. Similarly, EF for Spanish-speaking language-minority children is an important predictor of academic and behavioral outcomes as it is for monolingual children.

Structure of Executive Function in Spanish-Speaking Language Minority Preschoolers

Consistent with the results of two recent studies (Lerner & Lonigan, 2014; Schoemaker et al., 2012), results of this study supported a multi-dimensional structure of EF among Spanish-speaking language-minority preschoolers. Both for children who completed the EF measures in English and for children who completed the EF measures in Spanish, the seven measures of EF were best characterized as representing correlated but distinct IC and WM factors. As noted previously, earlier studies did not find evidence of distinct EF factors in preschool-age children (e.g., Wiebe et al., 2008, 2011; Willoughby et al., 2010). Possible reasons for different findings across studies include the age of the children studied, the type and number of tasks selected to index the underlying constructs, as well as the analytic method used. At present, accumulating evidence suggests that two distinct components of EF, IC and WM, can be measured, at least in older preschool children, when tasks are selected that align with the constructs they are intended to represent and sufficient tasks are used to identify a distinct factor. Regardless, the results of this study provide strong evidence that the nature of EF is similar for both monolingual preschoolers and Spanish-speaking language-minority preschoolers.

In this study, children completed the measures of EF in their more proficient language. Tests of measurement and structural equivalence indicated that assessment of EF was invariant to language of administration. That is, analyses indicated that the EF tasks demonstrated strong measurement invariance, and with the exception of one cross-group constraint of residual variance, strict measurement invariance was achieved. The significant implication of these results is that well-translated versions of common measures of EF, administered in the child's more proficient language, provide assessment of the same underlying EF constructs for Spanish-speaking language-minority preschoolers regardless of the language of administration.

Relations of Executive Function with Academic and Behavioral Self-Regulation Skills

Similar to results of studies with monolingual English-speaking preschoolers (e.g., N. P. Allan & Lonigan, 2011; Blair & Razza, 2007; Fuhs, Farran, & Nesbitt, 2015), components of EF for Spanish-speaking language-minority preschoolers were significantly and positively correlated with measures of language and early-literacy skills. For children who completed EF tasks in English, both IC and WM were correlated with language and early literacy measured in both English and Spanish. In contrast, for children who completed EF tasks in Spanish, although both IC and WM were correlated with language and early literacy measured in Spanish, IC and WM were non-significantly or weakly correlated with language and early literacy measured in English, most likely because of the limited variability of these skills measured in English for these children. In general, the size of these relations was higher than the average correlation between measures of IC and academic outcomes reported for preschool and kindergarten children (N. P. Allan et al., 2014); however, this was likely due to the measurement advantages of latent variables (i.e., absence of error) over observed variables rather than a true stronger relation between EF and academic outcomes for Spanish-speaking language-minority children.

Similar to findings for the relations between EF and academic skills, whether IC and WM were significantly correlated with children's behavioral self-regulation as measured by the HTKS task depended on the language in which the task was administered and the language in which children completed the EF tasks. For children who completed EF tasks in English, both IC and WM were correlated with HTKS scores from both English and Spanish administrations; however, for children who completed EF tasks in Spanish, IC and WM were correlated with HTKS scores from the Spanish administration only. As with the measures of academic skills, this result may have been partially due to more limited variability on the HTKS administered in English for the more Spanish-proficient children but probably also reflected these children's abilities to easily process the commands associated with the task.

Relations of Executive Function with Teacher-Rated Behaviors

Like in studies of monolingual preschoolers (e.g., Schoemaker et al., 2013), children's EF was associated with teacher-rated behaviors. In this sample, children with lower levels of EF were reported to have more problems of attention and higher levels of hyperactive/impulsive behaviors. EF was not associated with general problems with oppositional behaviors, problems of anger and aggression, or with anxious behaviors. For children with more proficient Spanish, higher EF was associated with higher levels of teacher-reported social competence. Overall, relations between EF and teacher ratings of behavior were stronger for children who completed the EF tasks in English than they were for children who completed the EF tasks in Spanish. One possible explanation for these differences is that children with more proficient Spanish may have come from families who adhered more strictly to Latino values that underscore the family's role in producing respectful, moral, and well-behaved children (Halgunseth, Ispa, & Rudy, 2006). The increased emphasis on discipline in the home may lead these children to behave better in the classroom than would be expected based on their actual EF skills, weakening the linkage between observed behaviors and performance on direct measures of EF.

Children's proficiency in the language spoken in the classroom also may impact the degree to which teachers' ratings of behavior accurately reflect underlying self-regulatory skills. That is, although a child's difficulty paying attention in the classroom may be attributable to language comprehension problems rather than EF deficits, a teacher may rate the child as having difficulty paying attention. Conversely, although a child may have true EF deficits, a teacher may provide conservative ratings of problem behaviors because of concerns that the child fails to function well because she or he simply does not understand classroom expectations. In this way, the complicated relation between language proficiency and classroom behaviors may weaken the observed relation between teacher-reported behaviors and actual EF capacities. More information regarding family, teacher, and classroom characteristics will be needed to explore these possible explanations.

Differences in Relations of IC and WM with Academic and Behavioral Outcomes

There was not a strong pattern of differential associations of IC and WM with the academic-related or behavioral self-regulation outcomes. With the exception of definitional vocabulary measured in English and findings for phonological awareness measures specific to one or

the other groups of children who completed the EF tasks in English or Spanish, the strength of the relations of IC and WM were similar across the academic-related and behavioral self-regulation measures. These results suggest that it may be the common variance in IC and WM constructs that is primarily responsible for the relations between these constructs and children's early literacy skills and behavioral self-regulation. This possibility is consistent with results reported by Miyake and Friedman (2012) from studies of college students in which variance common to EF tasks subsumed the variance associated with IC tasks in bi-factor models and a longitudinal study in which an early measure of self-restraint was associated with a common EF factor but not a specific WM factor in a sample of adolescents. Miyake and Friedman hypothesized that the common component of EF represents the ability to maintain task goals and goal-related information, and to utilize this focus to direct lower-level processes.

There were significant differences in the correlations of IC and WM with English definitional vocabulary for both groups of children. For children with more proficient English, the correlations of both IC and WM with vocabulary were positive and statistically significant, but IC was more strongly correlated with English vocabulary scores than was WM. For children with more proficient Spanish, the correlations of both IC and WM with English vocabulary were not statistically significant, and the statistical difference between correlations likely reflected the fact that the correlations were in opposite directions. Notably, this pattern of significantly different correlations was not replicated for the Spanish-language measure of vocabulary; however, there was a trend for Spanish vocabulary to be more highly correlated with IC than with WM for children with more proficient Spanish. Because on each measure, answers given in the other language were scored as incorrect, it is possible that children with higher levels of IC specifically were better able to inhibit their less-proficient language to provide the answer in the language of the test, suggesting a specific role of IC for language-minority children.

Teachers' ratings of children's attention were more strongly related to WM than to IC. This statistically significant difference was obtained on different measures for the different language of administration groups (i.e., CTRS-15 for English, SWAN for Spanish), although the general pattern across measures and language of administration groups was consistent. It may be that teachers attribute the cause of children's failure to follow through on tasks to children not paying attention to instructions or tasks, but that the actual underlying reason for children's difficulties are associated with working memory.

Age-Related Influences on Relations of EF with Academic and Behavioral Outcomes

Controlling for age in analyses examining relations of EF factors with academic and behavioral outcomes reduced the size of most correlations; however, there were still many robust associations between EF factors and the academic, behavioral self-regulation, and teacher-rated outcomes, indicating that the association between EF and these outcomes was not primarily a function of age. Controlling for age appeared to have a larger effect on the relations between EF and teacher-rated behaviors than on the relations between EF and children's academic skills. Once age was taken into account, the significant associations between children's IC and WM with scores on the SWAN were rendered non-significant;

however, although relations between IC and WM with scores on the Inattention and Hyperactivity/Impulsivity subscales of the CTRS-15 were reduced, several of these associations continued to be statistically or marginally significant, particularly for children who completed the EF measures in English. Reasons for the apparent differential effects of age on EF's relations with scores on the SWAN versus the CTRS-15 are not clear; however, it could be the result of differences in the format of questions across measures. Questions on the SWAN are worded in a positive direction (e.g., "Gives close attention to detail and avoids careless mistakes") whereas all questions on the CTRS-15 are worded consistent with problematic behaviors (e.g., "Inattentive, easily distracted"). These differences across measures and the patterns of results across measures may indicate that age-related increases in self-regulation as measured by EF tasks are more similar to age-related increases in teacher reports of positive regulation than to teacher reports of unregulated behavior.

Bilingual Advantage on Executive Function Tasks

Although not specifically designed to address the question of a bilingual advantage for EF, the differences between groups of children in this study provide some relevant information. Children with more proficient English and children with more proficient Spanish differed in the degree to which they exhibited bilingualism. Children who completed the EF measures in English appeared to have better language skills overall than did children who completed the EF measures in Spanish. Consequently, although both groups of children were Spanish-speakers and were exposed to the societal language to varying degrees, children with more proficient English were more bilingual than were children with more proficient Spanish. Comparisons of the two groups' scores on the seven EF tasks revealed just two statistically significant differences; however, if adjusted for multiple comparisons, these differences would not be statistically significant, indicating that there was no bilingual advantage for the children with more proficient English compared to the children with more proficient Spanish in this sample.

Consistent with the limited evidence of a bilingual advantage on EF tasks in this study, previous studies that have compared monolingual and bilingual children's performance on WM tasks have reported that the groups perform similarly (e.g., Namazi & Thordardottir, 2010). Moreover, it is possible that a bilingual advantage is present on only some types of IC tasks. A bilingual advantage has been reported for interference suppression tasks, which require the ignoring or suppressing salient perceptual information in a bivalent task, but not for response inhibition tasks, which require the suppression of a dominant response (Esposito et al., 2013; Martin-Rhee & Bialystok, 2008). All IC tasks in this study were response inhibition tasks in which accuracy was the metric of performance. Finally, it is possible that the absence of support of a bilingual advantage reflects population differences between this and other studies. The advantage is often reported for relatively proficient and balanced bilinguals (Adesope, Laving, Thompson, & Ungerleider, 2010). Even the children with more proficient English in this sample scored in the low-average range, as a group, on the English vocabulary measure.

Limitations and Future Directions

Despite the strengths of this study, including a relatively large sample, carefully selected measures, and assessment of children's outcomes in both English and Spanish, there were a number of limitations. First, all of the data for the study were concurrent; therefore, knowledge of the relative stability of EF as well as its longitudinal predictive value in this population must await further study. Second, all of our measures of children's behavior came from a single source, using a common method, and representing behavior in a single context. Because it is common to find low levels of agreement among different informants and assessment methods when measuring children's behaviors (e.g., Phillips & Lonigan, 2010; Sims & Lonigan, 2012), future studies should assess behavior across multiple sources, methods, and settings to determine if EF is a stable predictor across these variations. Third, we did not collect measures of general cognitive ability in this study. Although the relation between EF and other outcomes may be specific to EF, it may also reflect a common association between these outcomes, EF, and general cognitive abilities. Identifying the specificity of EF's associations with other outcomes would be a useful goal of future studies. Fourth, an objective determination of language proficiency could not be made based on Spanish and English definitional vocabulary scores for 9% of the sample. Although these children were those most likely to have relatively equal proficiency in Spanish and English, the judgement of a child's more proficient language was based on the child's apparent conversational preference and was subjective. Finally, all of our measures of IC were response inhibition measures. Future work should explore responses to other IC measures (e.g., interference suppression), which will allow a stronger test of whether a bilingual advantage exists for Spanish-speaking language-minority preschoolers.

Summary and Conclusions

The results of this study provide clear evidence of similarities for EF measured in Spanish-speaking language-minority preschoolers and monolingual preschoolers. For both populations, EF is best described as two correlated factors, IC and WM. Moreover, when administered in children's more proficient language, tasks commonly used to measure IC and WM function virtually identically regardless of language of administration. Similar to accumulating results with monolingual preschoolers, the EF of Spanish-speaking language-minority preschoolers is strongly related to their language, early literacy, and behavioral self-regulation skills as well as teachers' ratings of their behavior. The robust associations of EF with these important developmental outcomes may represent a key developmental factor that can further understanding of processes that enhance or inhibit positive outcomes for this frequently vulnerable population of children.

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Highlights

- Measured executive function (EF) of Spanish-speaking language minority preschoolers.
- Confirmatory factor analyses demonstrated that EF is a multidimensional construct.
- Identified distinct but correlated Inhibitory Control and Working Memory factors.
- Obtained measurement and structural invariance across language of administration.
- Found strong relations of IC and WM with measures of early literacy and behavior.

Table 1

Descriptive statistics for language, early literacy, and self-regulation measures in English and Spanish, and teacher-behavior ratings for children who were administered executive function tasks in English or Spanish, based on children's more proficient language

Measure	Language of Administration for EF Tasks				Effect Size ^I
	English		Spanish		
	Mean	(SD)	Mean	(SD)	
Chronological Age (months)	54.32	(6.40)	54.18	(5.91)	.02
TOPEL Definitional Vocabulary SS	91.64	(14.00)	58.03	(7.48)	3.26***
TOPEL Phonological Awareness SS	89.40	(18.43)	68.74	(12.34)	1.39***
TOPEL Print Knowledge SS	96.99	(15.88)	81.93	(8.63)	1.28***
SPELA Definitional Vocabulary	25.08	(19.56)	36.27	(16.62)	−.63***
SPELA Blending	12.72	(6.49)	13.36	(6.43)	−.10
SPELA Elision	7.32	(4.50)	7.15	(4.14)	.04
SPELA Print Knowledge	12.41	(7.44)	8.81	(4.76)	.61***
HTKS English Administration	8.21	(11.17)	4.39	(8.07)	.41**
HTKS Spanish Administration	7.95	(11.63)	7.15	(10.80)	.07
SWAN Attention	0.38	(1.09)	−0.07	(0.92)	.46***
SWAN Hyperactivity/Impulsivity	0.27	(1.19)	0.00	(0.86)	.27*
SWAN Oppositional Defiant	0.26	(1.17)	0.17	(0.91)	.08
CTRS-15 Inattention	0.51	(0.58)	0.61	(0.71)	−.14
CTRS Hyperactivity/Impulsivity	0.45	(0.61)	0.45	(0.63)	−.01
CTRS-15 Oppositional Defiant	0.37	(0.54)	0.39	(0.59)	−.02
SCBE Social Competence	3.73	(0.84)	3.62	(0.83)	.13
SCBE Anger/Aggression	1.77	(0.87)	1.71	(0.72)	.07
SCBE Anxiety	1.87	(0.63)	1.95	(0.70)	.13

^I Note. Hedges g effect size for group comparison (i.e., children who completed executive function tasks in English vs Spanish).

EF = executive functions; TOPEL = Test of Preschool Early Literacy; SPELA = Spanish Preschool Early Literacy Assessment; HTKS = Head-Toes-Knees-Shoulders task; SWAN = Strengths and Weakness of ADHD Symptoms and Normal Behavior Scale; CTRS-15 = Connors Teacher Rating Scale, short form; SCBE = Social Competence and Behavior Evaluation; SS = standard score.

* $p < .05$,

** $p < .01$,

*** $p < .001$.

Table 2

Overall descriptive statistics and correlations between executive function tasks for children who completed tasks in Spanish (below diagonal) and in English (above diagonal)

	KT	PI	DNS	SO	WSR	AS	LS
Knock-Tap		.50***	.59***	.22*	.36***	.33**	.30**
Picture Imitation	.47***		.42***	.23*	.15	.20 ⁺	.17
Day-Night Stroop	.44***	.39***		.14	.35***	.11	.14
Size Ordering	.14	.29***	.19*		.11	.10	.27**
Word-Span Reversed	.24**	.26***	.26***	.36***		.03	.34***
Animal Span	.29***	.38***	.31***	.25**	.31***		.27**
Listening Span	.23**	.24***	.25***	.14	.43***	.35***	
Mean	16.49	17.54	13.19	4.61	1.01	4.10	2.46
SD	8.95	6.13	7.67	4.92	1.85	2.45	3.30
Minimum	0	0	0	0	0	0	0
Maximum	24	24	20	23	10	12	12
Skew	-.88	-.69	-.74	1.28	1.97	.23	1.36
Kurtosis	-.87	-.08	-1.07	.95	3.84	.21	.72

Note. $N = 241$; children completing tasks in Spanish ($n = 154$); children completing tasks in English ($n = 87$).

KT = Knock-Tap task; PI = Picture Imitation task; DNS = Day-Night-Stroop task; SO = Size-ordering task; WSR = Word-Span-Reversed task; AS = Animal-Span task; LS = Listening-Span task.

*
 $p < .05$,

**
 $p < .01$,

 $p < .001$.

Table 3

Factor loadings from two-factor model of executive function for children administered tasks in English, Spanish, and combined sample

Task	Sample			
	English Administration		Spanish Administration	
	IC	WM	IC	WM
Knock-Tap	.90		.63	
Picture Imitation	.57		.74	
Day-Night Stroop	.67		.67	
Size Ordering		.35**		.44
Word-Span Reversed		.50		.63
Animal Span		.38*		.60
Listening Span		.57		.56
IC-WM <i>r</i>		.70		.69

Note. IC = Inhibitory Control; WM = Working Memory. All parameters were significant at $p < .001$ unless otherwise noted.

*
 $p < .05$,

**
 $p < .01$.

Table 4
Model fit statistics and comparisons across language of assessment for executive function tasks

Model Description	Model χ^2	df	CFI	TLI	RMSEA [95% CI]	AIC	BIC	Corrected χ^2 Difference ^f
1. No Constraints	37.21	26	.96	.94	.06 [.00 - .10]	9470.15	9623.30	---
2. Constrained Factor Loadings	46.49	33	.95	.94	.06 [.00 - .10]	9466.28	9595.06	9.36 <i>ns</i>
3. Constrained Factor Loadings & Intercepts	58.02	40	.94	.93	.06 [.02-.09]	9463.82	9568.24	20.76 <i>ns</i>
4. Constrained Factor Loadings, Intercepts, & Covariance	58.50	41	.94	.94	.06 [.02-.09]	9462.03	9562.97	21.29 <i>ns</i>
5. Constrained Factor Loadings, Covariance, Intercepts, & Residuals	79.96	48	.89	.90	.07 [.04-.10]	9473.04	9549.61	41.74***
6. Free Knock-Tap task Residual	67.67	47	.93	.95	.06 [.00 - .09]	9462.92	9542.97	30.42 <i>ns</i>

^f *Note.* All comparisons are to Model 1 (unconstrained model).

CFI = Comparative fit index; TLI = Tucker-Lewis index; RMSEA = Root mean square error of approximation; CI = confidence interval; AIC = Akaike information criterion; BIC = Bayesian information criterion.

ns $p > .05$,

*** $p < .01$.

Table 5

Correlations (and partial correlations controlling for age) between executive function factors and English-language and Spanish-language outcome measures (raw scores) for children administered executive function tasks in English or Spanish

Measure		Language of Administration for EF Tasks			
		English		Spanish	
		IC	WM	IC	WM
TOPEL Definitional Vocabulary	<i>r</i> (<i>pr</i>)	.57*** (.28**)	.33 (-.01)	.04 (-.02)	-.13 (-.17 ⁺)
TOPEL Phonological Awareness	<i>r</i> (<i>pr</i>)	.50*** (.31**)	.50** (.32*)	.30*** (.16 ⁺)	.12 (.00)
TOPEL Print Knowledge	<i>r</i> (<i>pr</i>)	.34** (.10)	.36* (.13)	.17* (.11)	.02 (-.03)
SPELA Definitional Vocabulary	<i>r</i> (<i>pr</i>)	.34*** (.10)	.22 (-.02)	.58*** (.43***)	.65*** (.53***)
SPELA Blending	<i>r</i> (<i>pr</i>)	.31** (.07)	.52*** (.32**)	.56*** (.41***)	.55*** (.40***)
SPELA Elision	<i>r</i> (<i>pr</i>)	.51*** (.29**)	.37* (.17)	.34*** (.19*)	.53*** (.41***)
SPELA Print Knowledge	<i>r</i> (<i>pr</i>)	.34*** (.11)	.31* (.11)	.24** (.11)	.26** (.14)
HTKS-English Administration	<i>r</i> (<i>pr</i>)	.49*** (.29***)	.42** (.24)	.15 (.13)	.07 (.05)
HTKS-Spanish Administration	<i>r</i> (<i>pr</i>)	.38*** (.16 ⁺)	.48** (.28 ⁺)	.27** (.16 ⁺)	.28** (.17 ⁺)

Note. EF = executive functions; IC = Inhibitory Control; WM = Working Memory; TOPEL = Test of Preschool Early Literacy; SPELA = Spanish Preschool Early Literacy Assessment; HTKS = Head-Toes-Knees-Shoulders task.

⁺ $p < .10$;

* $p < .05$,

** $p < .01$,

*** $p < .001$.

Table 6

Correlations (and partial correlations controlling for age) between executive function factors and teachers' ratings of children's behaviors for children administered executive function tasks in English or Spanish

Measure		Language of Administration for EF Tasks			
		English		Spanish	
		IC	WM	IC	WM
SWAN Attention	<i>r</i> (<i>pr</i>)	.35*** (.14)	.42** (.20)	.20* (.11)	.10 (.02)
SWAN Hyperactivity/Impulsivity	<i>r</i> (<i>pr</i>)	.29** (.15)	.26 (.12)	.10 (.03)	.07 (.01)
SWAN Oppositional Defiant	<i>r</i> (<i>pr</i>)	.05 (.08)	.06 (.07)	.08 (.05)	-.07 (-.10)
CTRS-15 Inattention	<i>r</i> (<i>pr</i>)	-.37*** (-.17+)	-.55*** (-.36**)	-.23* (-.09)	-.27** (-.16+)
CTRS-15 Hyperactivity/Impulsivity	<i>r</i> (<i>pr</i>)	-.42*** (-.28**)	-.38** (-.25+)	-.23* (-.10)	-.13 (-.02)
CTRS-15 Oppositional Defiant	<i>r</i> (<i>pr</i>)	-.05 (-.04)	-.20 (-.19)	-.13 (-.00)	-.07 (.04)
SCBE Social Competence	<i>r</i> (<i>pr</i>)	.14 (.02)	.26 (.13)	.25** (.14+)	-.01 (-.12)
SCBE Anger/Aggression	<i>r</i> (<i>pr</i>)	-.10 (-.14)	-.20 (-.23+)	.02 (.09)	-.02 (.04)
SCBE Anxiety	<i>r</i> (<i>pr</i>)	-.16 (-.16)	-.18 (-.14)	-.07 (.01)	-.18 (-.13)

Note. EF = executive functions; IC = Inhibitory Control; WM = Working Memory; SWAN = Strengths and Weakness of ADHD Symptoms and Normal Behavior Scale; CTRS-15 = Connors Teacher Rating Scale, short form; SCBE = Social Competence and Behavior Evaluation

+ $p < .10$;

* $p < .05$,

** $p < .01$,

*** $p < .001$.