EXECUTIVE FUNCTION AND NOVEL WORD LEARNING IN MONOLINGUAL AND BILINGUAL CHILDREN

By

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Bachelor of Science in Communication Sciences and Disorders

Kansas State University

Manhattan, Kansas

2021

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 2023

EXECUTIVE FUNCTION AND NOVEL WORD LEARNING IN MONOLINGUAL AND BILINGUAL CHILDREN

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ACKNOWLEDGEMENTS

Thanks to Dr. Roha Kaipa for the opportunity to complete a thesis under her direction and to my graduate committee of Dr. Peter Richtsmeier, and Ms. Kristi Carpenter, M.S., CCC-SLP for their feedback and guidance on the study. Thanks to Dr. Holly Storkel and Dr. Sonja Pruitt Lord for their input on the novel words and experimental procedure.

Finally, thanks to the OSU Language Lab graduate assistant Grace Touchstone and the undergraduate research assistants: Cielo Muñoz, Nicole Pogue, Emma Joy Sherrer, Jayla Hurt, Lauren Weber, Madison Young, Saige Ward, and Anna Farve for their invaluable assistance in gathering the experimental data.

Name: EMMA LEE SULLIVAN

Date of Degree: MAY, 2023

Title of Study: EXECUTIVE FUNCTION AND NOVEL WORD LEARNING IN MONOLINGUAL AND BILINGUAL CHILDREN

Major Field: COMMUNICATION SCIENCES AND DISORDERS

Abstract: The proposed study aimed to compare the executive function ability of monolingual and bilingual preschoolers between 4 and 6 years. The preliminary data suggests that both groups differed across all the tasks except for the working memory subcomponent. Although both working memory tasks were visuospatial and assessed the same subcomponents, there were discrepancies in results due to the task setup. Researchers and clinicians must be cautious while selecting and setting the tasks as tasks employed could bring about performance differences.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Executive function (EF) refers to a set of skills that enable us to plan, set goals and execute various tasks. EF skills are used in day-to-day life and develop right from early childhood. Research suggests multiple benefits of strong EF skills, including enhanced language abilities, self-regulation, and problem-solving (Sun et al., 2017). In addition, EF skills are critical to cognitive and language development and academic success (Diamond, 2012). EF has three recognized components: inhibition, working memory, and cognitive flexibility. Inhibition enables an individual to disregard the nuisance sources competing for his/her attention, therefor they "inhibit" themselves from attending to other tasks that could be distracting while focusing on the task at hand. Working memory is the ability to maintain and access recently learned information. Cognitive flexibility is also known as mental flexibility or task shifting and is the ability to operate using relevant information and rules for interaction – changing appropriately as the situation requires (Eakin et al., 2004; Stemmer & Whitaker, 2008). Research suggests that these EF skills have some level of influence on bilingual children's developing language skills (Bialystok, 2015).

The impact of EF skills on word learning in children needs more exploration, particularly in the bilingual population. Though it has been documented that bilingual children may have stronger EF skills than their monolingual peers, the specific aspects of EF included in these claims need more clarity and arguably require further research (Bialystok & Martin, 2004). The current study seeks to contribute to the existing knowledge of monolingual and bilingual children's EF skills and word-learning abilities. This additional knowledge will help inform the clinical decisions of speech-language pathologists specifically related to working with the bilingual population.

Executive Function (EF)

In the current study, the researchers used Miyake, et al.'s model of EF, which has been a popular referent for cognition-based research since its publication in 2000. According to this model, EF is defined as "general-purpose control mechanisms that modulate the operation of various cognitive subprocesses and thereby regulate the dynamics of human cognition" (p. 50). The model defines EF as being constructed by the subcomponents of inhibition, working memory, and cognitive flexibility (Miyake et al., 2000). The study found that while these are closely related, no evidence indicated any two or all three to be the same function and in fact are distinct. However, even though the tasks used in the study focused on working on one component per task, there is a mild likelihood that one or both of the other two were recruited to assist in completion. Miyake et al. define the first component, inhibition, as the ability to purposefully limit a default response and select a less powerful response in its place (Miyake et al., 2000). Working memory holds information ready for use in the mind using linguistic, visual, and temporal subcomponents (Repovš & Baddeley, 2006; Baddeley, 2012). Cognitive flexibility is the third major EF component, continuously monitoring and altering the information stored in working memory with the most recent relevant information. These components aid an individual's function and overall cognitive development and influence their effect on language acquisition and development. They are critical for childhood development, relevant to academic success, and have lasting effects through adolescence and even adulthood (Eakin et al., 2004). Together, these skills allow us to engage in goal-directed behavior, control impulses, and shift attention between tasks (Stemmer & Whitaker, 2008).

EF in Monolinguals and Bilinguals

Research comparing the differences in EF skills in monolingual and bilingual children tends to vary greatly. Some studies have found advantages in individual aspects of EF skills in bilingual persons (Green, 1998; Brysbaert, 1998; Gollan & Kroll, 2001; Bialystok & Martin, 2004; Bialystok, Craik, & Luk, 2008; Bialystok & Viswanathan, 2009; Bialystok, 2011; Fan et al., 2015; Kaushanskaya et al., 2017), while others show no bilingual advantage for higher-level analysis tasks (Engel de Abrau, 2011; Hilchey & Klein, 2011; Hill & Wagovich, 2012; Paap & Greenberg, 2013; Anton et al., 2014; Bialystok, 2015; Arizmendi et al., 2018; Zaretsky, 2020).

This discrepancy could be attributed to the need for more consistency in defining the cognitive processes required for the tasks the participants completed (Bialystok & Martin, 2004). For example, throughout three studies using multiple variations on the dimensional change card sort task, monolingual children performed equally well on tasks based on analytical knowledge without misleading contexts present. However, bilingual children had an advantage when the need to choose between competing or misleading responses was present. In short, when both inhibition and selective attention were required to complete a task, bilingual children performed better than monolinguals (Bialystok & Martin, 2004).

Bialystok (2015) states that bilingualism creates a fundamental difference in cognitive development beginning as early as infancy. Research has consistently found that bilingual children can demonstrate higher levels of inhibition than monolingual children in respective control tasks such as the Dimension Change Card Sort tasking cognitive flexibility (Bialystok, 1999). The functions of performance Bialystok lists as representative of such control tasks include selective attention, inhibition of attention away from misleading information, and cognitive flexibility to shift between competing options (Bialystok & Martin, 2004). Her research has shown that bilingual children develop these control processes more effectively than monolingual children, and her studies and others support this claim (Brysbaert, 1998; Gollan & Kroll, 2001). Bialystok & Martin (2004) investigated potential cultural and linguistic differences in bilingual EF abilities, by splitting ninety 8-year-old children from similar socioeconomic backgrounds across Canada and India into three groups: English monolinguals, heterogeneous Canadian bilinguals with English as one language, and Indian bilinguals who spoke English and Tamil or Telugu. All groups completed a battery of standardized language and cognitive assessments (Peabody Picture Vocabulary Test, 3rd Edition, sequencing span task, animal span task) and then completed a composite EF task working inhibitory control, working memory, and updating. Regardless of cultural or linguistic differences, both bilingual groups were consistently significantly better at the EF task, showing an advantage in inhibitory control and updating over their monolingual peers.

Chen et al. suggest that the bilingual advantage may be found only in fluent children who demonstrate proficiency in both languages (2014). Between monolingual, language exposure-only, and true bilingual children, the bilingual children outperformed the other two groups on the Dimension Change Card Sort and Kaufman Brief Intelligence Test, 2nd Edition. However, the exposure-only and monolingual groups did not differ in either of these measures (Fan et al., 2015). Green (1998) suggests that bilingual children must suppress or inhibit the control of one of their two languages by utilizing the same EF skills to control inhibition and attention. From this perspective, bilingual individuals are essentially 'practicing' inhibition regularly, which supports the likelihood that bilingual children would have better inhibition skills than monolingual children. In a comparison of 32 monolingual and 31 bilingual children’s ability to complete simple and complex EF tasks using working memory, inhibition, and cognitive flexibility, Bialystok found that while the bilingual children held similar reaction time rates as monolingual children on both EF tasks, their accuracy increased for the complex EF task (2011). While there are studies that identify areas of a bilingual advantage in EF, there are still others that find no advantage. Anton et al. (2014) compared the performance of 180 pairs of Spanish-Basque bilingual children and monolingual Spanish-speaking children on the Attentional Network Test, which resulted in no significant difference in results between groups' inhibition abilities. Another study found that when 22 matched pairs of monolingual and bilingual children between the ages of 6 and 8 participated in working memory and language assessments (e.g., forward and backward digit span, counting recall task, Raven Colored Progressive Matrices Test, expressive vocabulary and syntax tests), the monolingual children scored higher on all measures across three years of testing (Engel de Abrau, 2011). Zaretsky (2020) found that between age-matched 30 low socioeconomic status Spanish-English bilingual children, 30 English monolingual children, and 15 children with specific language impairment, the bilingual group used only their phonological working memory when reading and spelling but did not differ in verbal working memory and early literacy outcomes.

The current research consensus leans slightly more in favor of bilingual children and adults generally possessing higher EF skills than their monolingual peers (Bialystok & Viswanathan, 2009; Bialystok, 2011; Fan et al., 2015). However, the specific components of EF have yet to be sufficiently studied in bilinguals. The purpose of this study is to contribute to the existing literature by assessing each component of EF separately (using separate tasks to measure and assess inhibition, working memory, and cognitive flexibility) as well as collectively (using tasks that require the use of multiple components of EF simultaneously to achieve a composite score) in monolingual and bilingual children.

Word Learning in Monolinguals and Bilinguals

Word learning and vocabulary development may be impacted by various factors, including phonological form memory, vocabulary size, parental interaction, and various childhood experiences (Nagy, 2007; Stokes & Klee, 2009). According to Gathercole and Baddeley (1990), short-term phonological memory is a strong factor in vocabulary development in children. A child must remember how a word sounds to add it to their repertoire of acquired words (Gathercole & Baddeley, 1990). Few studies suggest that the effects of phonological memory may be higher for children acquiring a second language (Service, 1992; Zaretsky, 2020). Also relevant to vocabulary development is semantic depth, where children build webs of meaning between words by generalizing new words to previously learned concepts and the use of context clues (Nagy et al., 1987; McGregor et al., 2012).

De Houwer et al. (2014) found that bilingual children had a greater vocabulary than monolingual children when socioeconomic status, age, and gender were controlled. If these vocabulary skills were to generalize to word learning, bilingual children might be expected to perform better during word-learning tasks. However, conflicting research exists concerning this topic. Some researchers document bilingual children scoring lower on vocabulary tests than their monolingual peers (Uchikoshi, 2006; Bialystok et al., 2010). This could be due to the unlikelihood of learning corresponding words in each language – bilingual children may score lower in vocabulary tests for each language but have a larger vocabulary bank overall. Alt et al. (2019) describes bilingualchildren as slightly less accurate in determining linguistic features of semantics and the correctness of pronunciation for new words. Still, their word-learning process appears to be very similar to monolinguals. Compared to monolinguals, the vocabulary knowledge of bilinguals in a newly acquired language is higher overall, which could be attributed to better bilingual word-learning skills (Cenoz, 2003).

The current study clarifies conflicting research concerning vocabulary and word-learning skills in monolingual and bilingual children. Additionally, it provides parents and caregivers with a better understanding of vocabulary and word-learning skills. It may impact their decisions concerning what languages are spoken in a child's home environment and how often a family uses a second language to communicate with children. We hope to contribute to existing knowledge on these topics by conducting vocabulary and word-learning ability assessments for monolingual and bilingual participants.

EF and Word learning

EF skills are necessary for daily function; much research has been devoted to its role in developing language skills, especially those of children. Kapa and Erikson (2020) found that EF and word learning have a positive relationship where EF performance accounted for more variance in their participants' word-learning outcomes than the factor of typical development versus delayed language development. Specifically, inhibition and short-term memory were positively linked to word learning outcomes. An interesting study examined the effect of EF skills on language ability in a group of monolingual preschoolers and adults. The authors found that inhibition affected word learning strongly in adults, while attentional shifting and monitoring influenced word learning in children (Kapa & Colombo, 2014). Kaushanskaya et al. (2017) posited that school-aged monolingual linguistic performance is more likely linked to "domain-general EF skills."

On the other hand, Hill and Wagovich (2020) did not find a significant relationship between EF and word learning, either as a main effect or as an effect of interaction with language ability, suggesting independent language development from working memory. One factor to consider among the studies that find a significant relationship between the two variables is their sample size. In their systematic review, Arizmendi et al. (2018) stated that the existing literature showing a significant positive relationship between EF skills and language had a small sample size. However, that effect became smaller as the sample size increased. They also note a possible publication bias favoring the bilingual advantage's existence, and overall, there was no true bilingual advantage as shown in the literature they examined. Paap and colleagues (Paap & Greenberg, 2013; Paap, 2014; Paap & Sawi, 2014; Paap, Johnson, Sawi, 2015; Paap et al., 2015; Paap et al., 2017) have also documented potential bilingual disadvantages in a series of studies in bilingual adults. They found a null advantage and one bilingual disadvantage over 19 executive processing factors. The existence of a bilingual advantage is in question when multiple sets and individual studies find results refuting it.

Clinical Relevance of EF

Even though EF skills are known to impact language ability positively, relatively few studies have examined how each of the specific components of EF outlined above may contribute (Kapa & Erikson, 2020). Determining if a specific component and/or combination of components might positively impact a child's word-learning ability also has considerable implications for the clinical field. Addressing EF skills in the clinical setting could result in positive outcomes for children and their families. Children who can control their impulses, focus attention on a task and articulate their needs are more likely to thrive in early education settings and social environments (Guernsey, 2020).

EF deficits have been documented in children with specific language impairments and those diagnosed with autism spectrum disorder (Henry et al., 2011; Akbar et al., 2013; Gooch et al., 2014). Recent research suggests that children with language deficits might benefit from targeting EF skills in therapy (Sun et al., 2017). For typically developing children and those with language deficits, further exploration of the benefits of specific EF skills regarding a schoolreadiness skill like word learning arguably represents an effective use of time and resources. This study was designed to expand the existing research on EF and word learning in bilingual children.

The current study

Past studies have varied in their definitions of EF, tasks that assessed EF skills, the number of languages used by the participants recruited, and others. While we are growing in our understanding of EF skills and word-learning skills, the ambiguity of the research shows that we still have much to learn. How does language acquisition interact with EF skills, and how does that change when more than one language is acquired? Does this acquisition of multiple languages strengthen the EF skills of their users (e.g., bilingual children)?

The current study sought to understand EF skills and word learning in monolingual and bilingual children between 4 and 7 years. The researchers sought to examine how the exposure to and use of two languages in childhood – as opposed to one – is affected by the participants' EF skills. Pursuing this line of research will contribute to the existing knowledge of EF skills and word learning in monolingual, bilingual preschoolers using age-appropriate computerized EF tasks and two-day word learning. The study will potentially contribute to evidence-based practice models of treatment utilizing EF-stimulating tasks in clinical settings.

Research Questions and Hypotheses

We specifically posed three research questions: (1) will the two-day word-learning approach facilitate retention of the novel words across the two groups, (2) will bilinguals perform better than monolinguals on the two-day word-learning paradigm, and finally, (3) will bilinguals perform better than monolinguals on the EF tasks? Based on prior literature and the studies discussed above, we hypothesized that:

1. The two-day word learning approach will facilitate the retention of the novel words across the two groups.

2. Bilinguals will perform better than monolinguals on the two-day word-learning paradigm.

3. Bilinguals will perform better on the EF tasks than monolinguals

CHAPTER II

METHODOLOGY

The study followed a quasi-experimental research design. The study and all its procedures and materials were reviewed and approved by the Institutional Review Board at Oklahoma State University (OSU) (IRB-20-482).

Participants

Forty children between the ages of 4 and 7 years were recruited for the study (M = 4.98, SD = 0.66; 18 males, 22 females). Twenty children were monolingual English speakers, and the rest were bilingual Spanish-English speakers. The monolingual English speakers were typically exposed to or used English at home, at school, and in their social experiences. The bilingual group comprised children exposed to Spanish at home and English at school and used both languages for everyday interactions. Participants were typically developing, without any history of speech, language, hearing, or cognitive deficits, and were recruited for the study. The participants were recruited by word-of-mouth and by posting flyers and hand-outs at various daycare locations, after-school programs, churches, and research labs in Oklahoma. Monolingual English speakers were recruited primarily from the Oklahoma State University Child

Development Laboratory, a daycare on the university's Stillwater campus. The bilingual children were recruited from various cities in Oklahoma. Three participants did not complete the study due to COVID-19 and quarantine restrictions.

Background Measures and Stimuli

Consent form and Background measures

Parents of all the participants completed a consent form detailing the study's purpose, potential risks, and benefits before their child's participation. In addition, the parents also completed the McArthur Scale of Subjective Social Status to gather information on the socioeconomic status (SES) of the participants. The language background of the participants was collected using the Alberta Language and Development Questionnaire (ALDeQ©) and Alberta Language Environment Questionnaire (ALEQ). ALDeQ© collected the parent's perception of their child's language development and other behaviors, including any languages learned besides their first. ALEQ assessed the context and prevalence of non-English language used by the child's family members when around and with the child.

Language and related measures

The Goldman-Fristoe Test of Articulation, 3rd Edition (GFTA), was used to assess the articulatory capabilities of all the research participants. The Sounds-in-Words section was used. The Spanish-speaking participants completed the English and Spanish versions of the GFTA Sounds-in-Words sections.

The participants completed the Peabody Picture Vocabulary Test, 4th Edition (PPVT), and the Expressive Vocabulary Test, 2nd Edition (EVT), to assess their receptive and expressive vocabularies. The PPVT required the participant to identify the target picture from a set of four pictures given the item's spoken name. In contrast, EVT required the participant to label the pictures verbally. All participants began the assessment at the 2;6 year starting point and proceeded until reaching a ceiling score. The bilingual Spanish-speaking participants completed the above-mentioned English assessments and the Test de Vocabulario en Imagenes Peabody Adaptación Hispanoamericana (TVIP). This test is based on the PPVT as a measure of receptive Spanish vocabulary. Like other assessments, the participants started at the first item as their basal scores, then proceeded through the test until they reached their ceiling. The Kaufman Brief Intelligence Test, 2nd Edition (KBIT), was used to measure verbal and nonverbal intelligence in children over four years old. Participants were asked to answer riddle-like questions, identify and predict patterns in matrices, and name target pictures. All the participants started at the same level and progressed until they reached a ceiling score.

EF Tasks

Inquisit is a computerized psychometric software application that presents stimuli on a computer screen and records the responses of the participant for various tasks. Following the EF framework mentioned above, computer-based tasks from Inquisit and the Dimensional Change Card Sort task (DCCS) were used to assess working memory, cognitive flexibility, and inhibition. All computer-based tasks used the Inquisit software to record the participants' reaction time and accuracy. All the tasks selected were child-friendly and age-appropriate.

Hearts and Flowers was a comprehensive task used to assess three aspects of EF: inhibition, working memory, and cognitive flexibility. A fixation cross was displayed in the center of the screen, and a heart icon or flower icon was displayed to its left or right. Participants were required to press buttons according to the displayed image. If a heart icon was displayed, the participants had to press a key corresponding to the same side of the screen in which the icon was shown. If a flower icon was displayed, the participants pressed a key corresponding to the opposite side that the icon was shown. The "A" key was the left-side button, and the "L" key was the right-side button. Working memory was assessed in the first stage through a block of heart-only congruent trials where the participant had to remember which key was left and which was right. In the second stage, working memory and inhibition were assessed through a block of flower-only incongruent trials where participants used the opposite-side keys. Finally, working memory, inhibition, and cognitive flexibility were tested in the third stage of mixed trials by creating a combined hearts and flowers task where participants switched between different tasks and maintained each task's required action.

The Flanker Fish task assessed inhibition in children. During this task, the participants were presented with five fish in a row and were instructed to pay attention to the one in the center of the row, which serves as the target fish. The participants were instructed to press the "E" key if the target fish faced the right and the "I" key if it faced the left side. In congruent trials, all five fish faced the same direction, and in incongruent trials, the center fish faced the opposite direction of the flanking fish.

Mr. Peanut was the final computerized task and assessed working memory. Mr. Peanut was a cartoon illustration of a peanut who decorated himself with colorful stickers on various locations of his body. After the original image was briefly displayed and then disappeared, the participants identified each sticker's correct color and location on a blank version of Mr. Peanut. The program tracked each trial's accuracy and difficulty increased each round until a ceiling was reached.

The DCCS task assessed cognitive flexibility by requiring participants to sort cards by shape, color, and border. The first round required the participant to sort cards by color, and the second round was sorted by shape. The final round required that the cards be sorted into either color or shape categories based on whether the card in play has a border around its edge. The presence or absence of the border determined the shape or color dimension.

Word Learning Paradigm

The participants were exposed to ten novel words over two consecutive days. Five words were paired with an image of an object likely to be unfamiliar to the participant to reduce confusion with known words. The other five words were paired with images of objects familiar to the participant to measure their ability to inhibit previous word knowledge and use the new pseudo label. The novel word list was comprised of ten words following English phonotactics and was adopted from a previous study within the same age group (Kapa & Erickson, 2020). The novel word stimuli list used for the study is provided in Appendix 1.

On days 1 and 2, the word learning paradigm comprised familiarization, comprehension, and retention. Day 1 began with the familiarization: The researcher presented a slideshow of the novel words to the participant. The researcher read each novel word aloud, which the participant directly repeated. After these ten novel words were presented, each word and image pairing was presented ten times again in random order across 100 slides. The researcher presented each slide with a familiarization phrase incorporating the target word into a sentence, such as "I like the _____" or "It's a ___." Each novel word was used with ten different simple sentences. The familiarization session was followed by retention assessment. The retention session had three tasks: an expression task, phonological form task, and a comprehension task. The expression task consisted of the participant verbally labeling the presented stimulus image with the correct novel word. Responses were scored as correct if there were one or fewer phoneme errors and marked incorrect if no response was provided or had more than one phoneme error. The phonological form task required the participant to look at three different novel words paired with a dot and identify which novel word/dot was the correct label for the stimulus image also presented. The participant selected the target picture from among four options during the comprehension task in response to hearing the novel word.

Procedures

Before beginning data collection, the parents or caregivers of potential participants provided their consent for their child's participation in the study. The research session took place over four days, taking approximately 30 minutes to 60 minutes per day. Word learning was completed consecutively on days 1 and 2 to maximize word learning potential. All the other tasks and measures were collected across the four days in random order. In addition to the language measures in English, bilingual participants were tested using Spanish language tests, including the TVIP and GFTA-3 in Spanish. Upon completing the study, each child received a $25 gift card.

Data and statistical analysis

Completed background forms provided information on each participant's socioeconomic status, language background, language environment(s), and family use of language. The mean standardized scores from the tests, including PPVT, GFTA, and KBIT, are provided in Table 1. Additionally, the GFTA-Spanish and PPVT Spanish scores are reported for the bilingual participants. Additional correlations were computed to determine the direction of the relation between these variables and are provided in Table 2 (monolinguals) and 3 (bilinguals).

Inquisit software provided the scores for all the computerized EF assessment tasks. The Hearts and Flowers tasks provided an overall measure of the EF abilities of the participants by measuring working memory, inhibitory control, and cognitive flexibility. The task collected the accuracy of the participants for congruent trials, incongruent trials, and mixed trials. The mixed trials provided a composite measure of participants' working memory, inhibitory control, and cognitive flexibility. The mean error rate for the Flanker fish task examined the inhibitory control abilities of the participants. Each participant's mean error rate was subtracted from 100 to determine the accuracy rate for this task. The Mr. Peanut task provided the percentage of correct trials and was considered as an accuracy score for statistical analysis. The DCCS task also determined the mean number of correct trials for each participant and was used for analysis.

The word learning scores were collected for day 1 and day 2 for the three word-learning tasks. The expressive task collected the percentage of correct phonemes on day 1 and day 2. In contrast, phonological and comprehension tasks were scored as either correct or incorrect on day 1 and day 2. Three participants were not included in the analysis due to attrition from COVID-19 and quarantine restrictions.

Three separate statistical analyses were carried out in SPSS 26.0 (IBM Corp., Armonk, NY) to answer the research questions that were posed initially. A dependent *t*-test was performed to compare the participants' word learning across two days. A 2*3*2 mixed model analysis of variance (ANOVA) was carried out to compare the word learning scores of the groups across the tasks and days. The data were analyzed as a function of the word learning scores. The within-subject variables were tasks (phonological, comprehension, expressive tasks) and days (days 1 and 2), and the between-subjects factor was the two groups (monolingual and bilingual). The third analysis compared the performance of both groups on EF tasks (Hearts & Flowers, Flanker, Mr. Peanut, and DCCS) using Mann-Whitney U tests due to data violating normality assumptions. The alpha value was set at .05.

CHAPTER III

RESULTS

The results of the dependent *t*-test revealed that participants in both groups differed significantly in their word learning scores from day 1 (M=4.22; SD=2.60) to day 2 (M=5.55; SD=2.12), supporting retention of novel words following training, $t(119) = 8.06$, $p<.001$.

`The second analysis compared the word learning scores of the groups across the tasks and days. The mixed-model analysis of variance revealed that there was a significant main effect of the task, F (2, 76) =178.49, $p < .001$, and the participants performed better on the comprehension task (M = 6.59; SD = 1.34) in comparison to phonological form task (M =*5.78*; SD = 1.65) and expression task (M =2.3; SD = 1.82); (F (2, 37) = 287.49; p<0.01). The participants also performed significantly different across the two days of learning, F (1,38) =56.15, $p < .001$. The participants performed better on the day 2 (M =4.22; SD = 2.12) when compared to day 1 (M =5.56; SD = 2.60); (F (1,38) = 56.15; p<0.01). Additionally, the groups did not significantly differ in their word learning scores, F (1, 38) =1.56, p>0.05. The monolingual (M =5.04; SD =2.52) and bilingual participants (M =4.73; SD = 2.40) had similar word learning scores. Figure 1 displays the mean word learning scores across the groups, three tasks, and days (1 and 2).

The third set of analyses compared the performance of both groups on EF tasks (Hearts & Flowers, Flanker, Mr. Peanut, and DCCS) using Mann-Whitney U tests. Table 4 provides a summary of the Mann-Whitney U tests.

CHAPTER IV

DISCUSSION

The current study examined the retention of novel words across the participants and compared the performance of both groups on word learning and EF tasks. The results of the study are discussed below in order of the hypotheses that were initially posed.

1. *The two-day word learning approach will facilitate the retention of novel words among the participants.*

The day 2 scores of the participants were significantly higher than day 1 scores, suggesting retention of the novel words over the two days of word learning. The current results are in line with the findings from previous studies like Kapa & Erikson (2020). The methodology and word learning paradigm for the current study was similar to that used by Kapa and Erickson (2020). Additionally, the novel words used in this study were taught as nouns, which are easier for young children to learn than other classes of words, such as verbs (Childers & Tomasello, 2002). The current study used these novel words in sentences during the word learning phase, but the participants were not required to generate their own sentences with novel words. Therefore, retention of these nouns would have been easier for the participants than other tasks like sentence generation.

Another reason for the significant improvement from day 1 to day 2 scores is likely due to both groups having familiarity with English phonotactics, as English was either their L1 or L2. Storkel found that familiarity of phonotactic probabilities had a significant effect on novel word learning in form identification, referent identification, and picture naming tasks given to 34 monolingual English children between ages 3 and 6. White (2021) found that South African school-aged English language learners in an English immersion program could pick up English-based novel words due to prior familiarity with English phonotactics. The novel words in this study were taken from the Novel Object and Unusual Name Database and followed English phonotactics. Participants did not have to learn new rules, only new words. Working memory would likely have been activated to take in the novel words because each was an unfamiliar phoneme sequence associated with a new meaning, which was then tested on recall and recognition the next day after learning (White, 2021).

This study used a quick two-day learning paradigm that would have promoted word retention. The children were given approximately 24 hours between initial instruction and retesting. Multiple factors are at play regarding retention, including the number of exemplars, timing, repetition, and memory consolidation (Shea et al., 2000; Twomey, et al., 2014: Vlachs & Sandhofer, 2012; Ranson & Horst, 2014). If the paradigm used here had instead utilized multiple exemplars within a narrow category, a more significant difference between the two groups may have developed (Twomey et al., 2014). When given supports such as repetition or saliency, children's memory retention was least decreased over the course of testing at multiple points up to 1 month from initial instruction (Vlachs & Sandhofer, 2012).

2. *Bilinguals will perform better than monolinguals on the two-day word-learning paradigm.*

The bilingual group did not perform better than monolinguals on the two-day word-learning paradigm. The results indicate neither a bilingual advantage nor disadvantage but that the two groups learned the novel words at a similar rate. Both groups performed better on the comprehension task than the phonological form task and expression, which follows typical language development. Children incorporate novel words into their receptive vocabulary before expressing them.

According to a longitudinal study by Shniedman et al. (2013), more child-directed utterances by a primary caregiver or multiple family members showed a greater effect in building vocabulary between PPVT scores tested at a year's interval. Similarly, the word learning procedure used in this study called for direct instruction of the word addressed to the child first in naming, then in 10 example sentences. Both bilinguals and monolinguals received the same instruction method for the novel words, which could explain the non-significant differences in their respective group word learning scores as they had similar vocabulary building and retention.

3. *Bilinguals will perform better on the EF tasks than monolinguals.*

The bilingual group performed significantly better than the monolingual group on all EF tasks except on the working memory measure of the Hearts and Flowers task. The greater success of the bilingual group on the EF tasks is supported yet also disputed by previous studies (Bialystok & Martin, 2004; Bialystok, 2011; Hilchey & Klein, 2011; Paap & Greenberg, 2013; Bialystok, Craik, & Luk, 2008; Kapa & Colombo, 2014; Fan et al., 2015; Arizmendi et al., 2018; Kapa & Erikson, 2020).

The Hearts & Flowers task provided a composite EF score by assessing the three components (inhibition, working memory, and cognitive flexibility) within the same task. The bilingual participants had better accuracy on all the components except the working memory subcomponent. The greater accuracy experienced by the bilinguals in a composite EF task has been documented in prior research (Bialystok, 2011; Fan et al., 2015). It could be due to greater requirements in EF activation in daily navigating between multiple languages. Bilinguals having increased accuracy scores is especially noted in visual, key press-based tasks similar in design to

Hearts & Flowers (Bialystok, 2011). Visual input is easier to respond to than audio input, which requires activating and interacting with one's lexicon and increases the potential likelihood of error.

The Flanker fish task showed an inhibition advantage in the bilingual participants compared to their monolingual counterparts. The results of the study support other studies' findings within research on bilingual executive function, where the bilingual participants showed an inhibitory ability greater than their monolingual counterparts when it comes to incongruent trials requiring conflict resolution (Bialystok et al., 2004; Hilchey & Klein, 2011). It is yet to be determined if this inhibition is part of domain-general abilities cited by some, such as Gangopadhyay, Weismer, & Kaushanskaya (2019), Hilchey & Klein (2011) or if it is specific to language abilities as others, such as Paap & Greenberg (2013) claim. Bialystok (2015) suggests that it may not be the use of inhibition itself but the lack of the use of two or more languages that causes those who are bilingual to activate greater levels of executive processing to achieve better results than monolinguals.

With the Mr. Peanut task, the participants were directed to indicate previously displayed locations of colored dots. Activating working memory requires both holding and manipulating information simultaneously, which was assessed by increasing the difficulty by changing the colors, locations, and numbers of dots in each task trial. Previous research shows bilinguals have higher accuracy in increasingly complex conditions of working memory tasks (Morales, Calo, & Bialystok, 2012). This same study also showed that 5-year-old bilingual children were performing at the same level of accuracy as 7-year-old monolingual children on the simple condition and that working memory effects were enhanced when recruiting other components. This would affect the selections made by the participants on Mr. Peanut, where children were constantly updating their memory of each trial by recruiting cognitive flexibility. Mr. Peanut is a visuospatial working memory task, which aligns with our method of using nonverbal EF tasks. Barbosa et al. also found that bilinguals outperform monolinguals on visuospatial and verbal working memory tasks (Barbosa, Jiang, & Nicoladis, 2019).

However, the current study found a discrepancy in the performance of the participants across the two working memory tasks. The working memory subcomponent of the Hearts and Flowers task found that the participants did not differ in accuracy. In contrast, the Mr. Peanut task that assessed working memory found significant differences across the groups, and bilinguals performed better than monolinguals. Although both assessed the same subcomponent of EF and were visuospatial tasks, the results did not correspond. The Mr. Peanut task adjusted the difficulty level based on the participant's responses—however, the Hearts and Flowers task did not have an increasing level of difficulty built into the software. This may have resulted in a difference in performance across the groups and participants.

Bilinguals have shown greater ability than monolingual peers in inhibiting formerly relevant information to access and apply new information. These participants maintain multiple lexicons and syntactic systems and must switch back and forth between the two language systems to determine which rules apply to the current task. This back-and-forth transfer between languages allows the practice of non-linguistic-based tasks such as the DCCS, which also require simultaneous maintenance of different rule sets. Bilingual children have consistently shown significantly greater cognitive flexibility on tasks like DCCS (Bialystok, 1999; Bialystok & Martin, 2004). Bilinguals likely have a better representational ability, reimagining the target with a different perspective than the original rules dictated (Bialystok & Martin, 2004). Another factor could be more mapping connections between words and concepts in a common conceptual store (Kroll & de Groot, 1997). A greater level of ability in cognitive flexibility remains even as bilinguals age, showing that it is not solely related to youth but the upkeep of managing the demands of different rules (Bialystok, Craik, & Luk, 2008).

CHAPTER V

CONCLUSION

The current study focused on exploring the aspects of executive function and novel word learning in bilingual children compared to monolingual peers. With the research being divided on how a bilingual advantage may or may not exist, further investigation of the relationship between EF and word learning continues to bear merit. Despite better performance across all EF tasks, the bilingual group did not appear to be recruiting EF skills to recall and express the newly learned novel words at a greater success rate. The participants' word learning scores were similar across groups and, combined with the knowledge that bilinguals seem to have a slight EF advantage, indicates that the bilingual and monolingual groups are learning novel words at similar rates. The observed bilingual advantage from this study may be real and in line with other studies' findings cited previously but may not manifest as an advantage specifically in regard to word learning.

Limitations

The limitations of the current study are noted below. The sample size of 40 was less for the current study considering the number of variables examined. The geographical location limited the diversity in the sample. Participant attrition (n = 3) was another limitation and was primarily due to COVID-19 and quarantine. There was a discrepancy in the working memory tasks employed in the study, which essentially affected the performance of the participants. Mr. Peanut and hearts and flowers task assessed the working memory. Compared to the Hearts & Flowers task, Mr. Peanut had an inherent difficulty adaptation function which increased the difficulty level based on the participant's performance. The authors acknowledge that the participants scored lower on the KBIT than the average scores seen in typical research.

Future Directions

Due to the continued uncertainty of the nature of EF and language abilities, of which word learning is only one part, more research would be beneficial in order to determine the cognitive aspects of monolingual and bilingual word learning and provide best practice intervention methods to children, caretakers, and educators. The age-old chicken-and-egg conundrum exists in determining the direction of relationship between language and EF. If language were to develop cognition as seems to be the case, then we would need to explore the implications of language ability and how that predicts cognitive ability, both with and without regards to language, furthering a similar line of research to Kaushanskaya et al. (2017). In the case where there is no relationship between language and greater executive function for bilinguals, it would be beneficial to investigate the way or ways that the bilingual EF advantage does manifest.

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APPENDICES

English nonwords used for the study

1. bæbɪn
2. bɪm
3. gɪp
4. kub
5. nokɛn
6. kɪdɪt
7. mæbɛp
8. pɛb
9. tæm
10. wæb

TABLES

Table 1: Demographic, Standardized test raw scores and their standard deviation (in parenthesis).

Variable	**Monolinguals**	**Bilinguals**
Age (years)	5.07 (0.68)	4.90 (0.64)
Maternal Education	18.90 (1.89)	13.55 (2.11)
PPVT-4	113.65 (17.97)	101.35 (8.29)
PPVT Spanish	--------------	101.85 (9.09)
GFTA-3 Sounds in words	8.10 (6.80)	9. 95(4.42)
GFTA Spanish	--------------	6.80 (4.11)
EVT Scores	97.65 (7.50)	93.90 (4.72)
KBIT	88.65 (2.81)	87.95 (2.31)

Table 2: Correlation across demographics, standardized tests, executive function tasks and word learning for monolinguals. The Bonferroni correction of alpha was set at 0.003.

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Age	1	.066	.335	.103	.461	.057	-.392	.334	.283	.250	.165	.263	.254	.042
2	Maternal Education	.066	1	.094	.095	.260	.348	.380	.098	.438	.116	.133	.072	.091	.205
3	PPVT (English)	.335	.094	1	.574**	.160	.291	.184	.427	.580**	.585**	.133	.568**	.578**	.128
4.	EVT	.103	.095	.574**	1	.054	.086	.180	.051	.200	.258	.219	.240	.317	.286
5	KBIT	.461	.260	.160	.054	1	.051	.142	.263	.606**	.204	.692**	.082	.602**	.309
6	Comprehension scores	.057	.348	.291	.086	.051	1	.274	.562**	.599**	.093	.003	.379	.571**	.146
7	Phonological form scores	-.392	.380	.184	.180	.142	.274	1	.190	.055	.095	.573**	.348	.116	.099
8	Expression scores	.334	.098	.427	.051	.263	.562**	.190	1	.279	.008	.199	.547**	.278	.088
9	Heart and Flowers-Working memory	.283	.438	.580**	.200	.606**	.599**	.055	.279	1	.227	.068	.162	.566**	.042
10	Heart and Flowers-Working memory and Inhibitory Control	.250	.116	.585**	.258	.204	.093	.095	.008	.277	1	.128	.099	.038	.127
11	Heart and Flowers-Working memory, Inhibitory Control, and Cognitive Flexibility	.165	.133	.133	.219	.692**	.003	.573**	.199	.068	.128	1	.588**	.592**	.536**
12	Flanker	.263	.072	.568**	.240	.082	.379	.348	.547**	.162	.099	.588**	1	.595**	.369
13	Mr. Peanut	.254	.091	.578**	.317	.602**	.571**	.116	.278	.566**	.038	.592**	.595**	1	.391
14	DCCS	.042	.205	.128	.286	.309	.146	.099	.088	.042	.127	.536**	.369	.391	1

Table 3: Correlation across demographics, standardized tests, executive function tasks and word learning for bilinguals. The Bonferroni correction of alpha was set at 0.003.

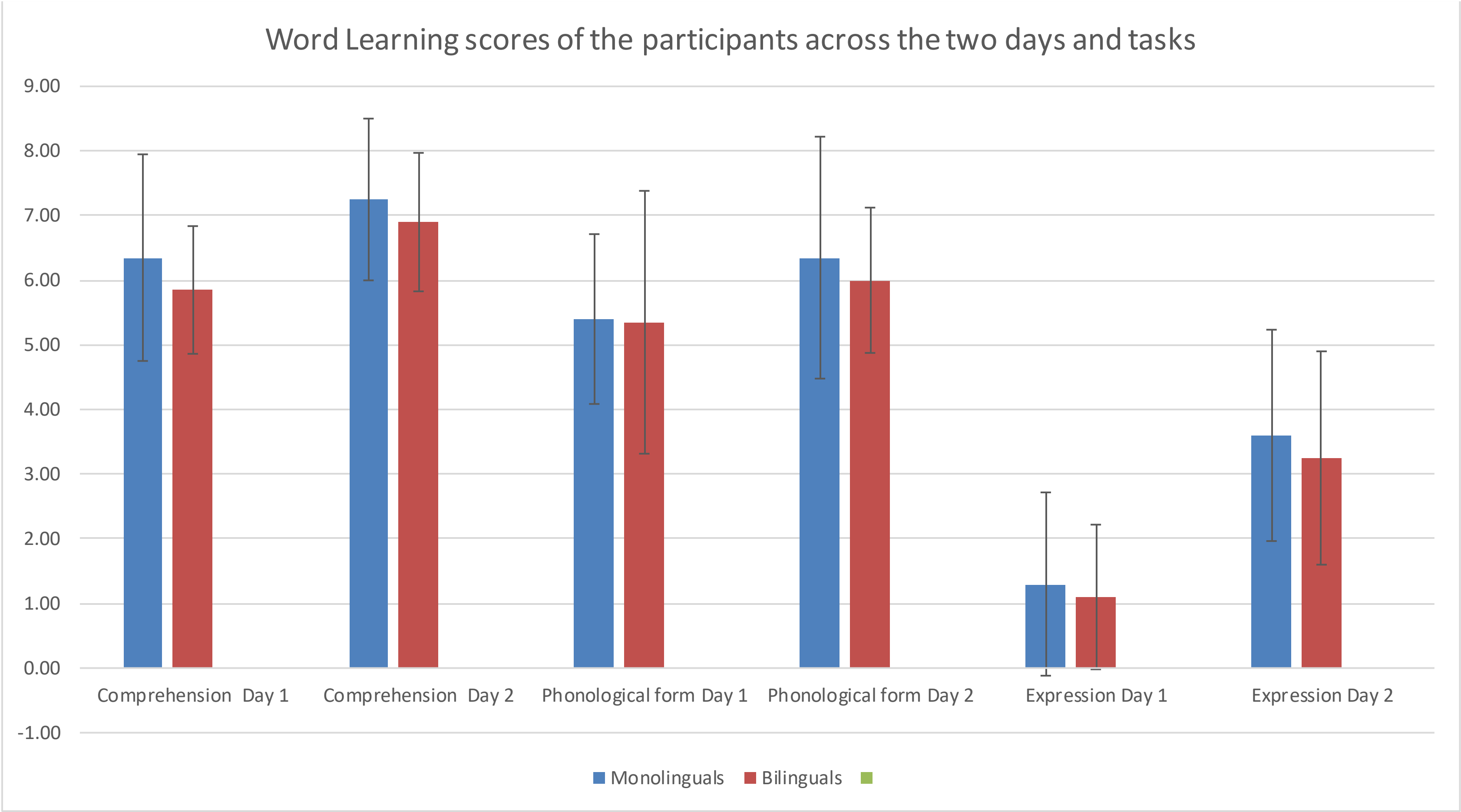
	Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1	Age	1	.182	.083	.233	.663**	.308	.394	.336	.021	.055	.263	.366	.142	.050
2	Maternal Education	.182	1	.161	.042	.087	.400	.130	.131	.166	.232	.353	.232	.031	.058
3	PPVT (Spanish)	.083	.161	1	.663**	.228	.624**	.373	.385	.591**	.587**	.393	.572**	.626**	.353
4.	EVT	.233	.042	.663**	1	.134	.598**	.203	.301	.378	.086	.245	.376	.163	.098
5	KBIT	.663**	.087	.228	.134	1	.570**	.284	.071	.562**	.088	.638**	.123	.570**	.328
6	Comprehension scores	.308	.400	.624**	.598**	.570**	1	.234	.586**	.538**	.585**	.630**	.328	.640**	.321
7	Phonological form scores	.394	.130	.373	.203	.284	.234	1	.036	.074	.116	.500**	.130	.279	.222
8	Expression scores	.336	.131	.385	.301	.071	.586**	.036	1	.021	.335	.276	.561**	.102	.193
9	Heart and Flowers- Working memory	.021	.166	.591**	.378	.562**	.538**	.074	.021	1	.204	.159	.276	.589**	.248
10	Heart and Flowers- Working memory and Inhibitory Control	.055	.232	.587**	.086	.088	.585**	.116	.335	.204	1	.612**	.564**	.142	.563**
11	Heart and Flowers- Working memory, Inhibitory Control, and Cognitive Flexibility	.263	.353	.393	.245	.638**	.630**	.500**	.276	.159	.612**	1	.570**	.566**	.606**
12	Flanker	.366	.232	.572**	.376	.123	.328	.130	.561**	.276	.564**	.570**	1	.591**	.361
13	Mr. Peanut	.142	.031	.626**	.163	.570**	.640**	.279	.102	.589**	.142	.566**	.591**	1	.163
14	DCCS	.050	.058	.353	.098	.328	.321	.222	.193	.248	.563**	.606**	.361	.163	1

Table 4: Summary of Mann-Whitney U tests of the EF tasks. Significant *p* values are noted by *.

Task	**EF aspect**	***U***	***p* value**	**Results**
Hearts & Flowers	EF composite task Working memory, Inhibitory control and Cognitive flexibility (Mixed trials)	99	.006*	Bilinguals (Mdn=80) performed significantly better than monolinguals (Mdn=73) on the EF composite task (mixed trials), U=99, p=0.006.
	Working memory and Inhibitory control (Incongruent trials)	120	.030*	Bilinguals (Mdn=78) performed significantly better than monolinguals (Mdn=65) on the incongruent trials, U=120, p=0.030.
	Working memory (Congruent trials)	156	.230	Both the groups didn't significantly differ from one another.
Flanker	Inhibitory control (Incongruent trials)	97	.005*	Bilinguals (Mdn=53.35) performed significantly better than monolinguals (Mdn=23.67) on inhibitory control, U=97, p=0.005.
Mr. Peanut	Working memory	117	.013*	Bilinguals (Mdn=55.56) performed significantly better than monolinguals (Mdn=44.44) working memory, U=117, p=0.13.
DCCS	Cognitive flexibility	68	.001*	Bilinguals (Mdn=100) performed significantly better than monolinguals (Mdn=66.67) on cognitive flexibility, U=68, p=0.001.

FIGURES

Figure 1: Mean word learning scores of the participants across the days and tasks.



VITA

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Master of Science

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