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Nonword Repetition Performance Patterns In English - Spanish Bilingual Adults And English And Spanish Monolingual Adults

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NONWORD REPETITION PERFORMANCE IN ENGLISH-SPANISH BILINGUAL ADULTS AND ENGLISH AND SPANISH MONOLINGUAL ADULTS

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Abstract

Nonword repetition (NWR) is known to be a less biased measure for assessing language abilities of culturally and linguistically diverse (CLD) children (Dollaghan & Campbell, 1998). NWR is used to examine phonological short-term memory mechanisms (also called working memory), because the tasks require the capability to discriminate, store, remember and reproduce phonological sequences (Baddeley, 1989; Braddeley 1974). The purpose of this study was to collect normative data on the NWR performance of bilingual and monolingual adults. This may contribute to the interpretation of performance in bilingual children by providing the standard of adult-like performance. This study examined the performance patterns of thirty-eight Spanish/English bilingual adult, twenty-two English speaking adults, and twenty Spanish speaking adult participants on English and Spanish NWR task (using percent of phonemes correct [PPC] as a measurement). A language questionnaire was used to evaluate language usage (Input/Output) for both bilinguals and monolingual adults.

Results suggested that bilingual adults with comparable experiences in English and Spanish performed more accurately on Spanish NWR than English NWR. Monolingual English adults' performance was notably better in their native tongue. The monolingual Spanish adults' performance was statistically significantly lower in both English and Spanish NWR, and were the least accurate of all the groups. These findings suggest that English and Spanish bilingual adults and monolingual adults performance is supported by long-term language memory and that adults are more likely tapping into their long term phonological memory to facilitate recall of nonwords. The results also indicate that if adults (with Spanish exposure) perform well or poorly in one language their performance will be analogous in the other language regardless of their language dominance.

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Chapter 1: Background

Hispanics are the largest minority in the U.S. today emphasizing the need for nonbiased assessment tools to evaluate the English and Spanish bilingual population especially for children. One such potentially non biased tool is the nonword repetition task which has proven a less biased measure because repeating nonwords is not as reliant on language knowledge when compared to conventional language measures (Dollaghan, & Campbell, 1998; Ellis, et al., 2000; Girbau, & Schwartz, 2007). Nonwords, or nonsense words, were originally developed by Hermann Ebbinghaus, a German philosopher and were used for measuring memory and learning. Nonwords have been deemed extremely useful to assess memory and learning because nonwords are meaningless, which indicate that they do not fit into the listeners pre-established network of existing associations (Ebbinghus, 1885). Hence, nonword recall tasks allow us to evaluate verbal working memory.

1.1 Working Memory

Verbal working memory (VWM) is an important system that aids in maintaining temporary information during processing operations (Gathercole & Pickering, 2000). Research that supports the link between performance in nonword repetition tasks and word learning has emerged. Data from those studies propose that word learning may be supported by the rehearsal and phonological representation and storage processes underlying verbal working memory (Gathercole & Baddeley, 1989; 1990; 1993). Processing this type of information is a complex task. However, numerous models have been offered to describe VWM in monolinguals.

1.2 Phonological Loop

The phonological loop is a component of working memory that helps support spoken and written material. The Baddeley & Hitch, (1974) model consists of two slave systems (i.e. the visual-spatial and phonological loop components) and they are controlled by a central executive mechanism (attentional control). As described by Baddeley and Hitch (1974), the central executive mechanism utilizes the slave components through attention and inhibition, and is responsible for monitoring and coordinating the operation of the slave systems. The visuo-spatial sketchpad (inner eye) stores and processes information in a visual or spatial form. The phonological loop facilitates the storage of verbal material, and consists of the phonological store (inner ear), and articulatory control process (inner voice). The phonological store holds auditory information in speech-based form (i.e. spoken words) for 1-2 seconds, and the articulatory control process (i.e. speech production) is used to rehearse verbal information from the phonological store. Baddeley (2000) added an additional component called the episodic buffer which acts as a 'backup' store that communicates with long term memory and the components of working memory. To store long-term language information, crystallized memory is used in this model (Braddeley, 2003).

1.2.1 The function of the phonological loop and nonword repetition. The phonological loop was hypothesized as the auxiliary component responsible for maintaining active phonological representations in memory for short periods of time (Baddeley and Hitch, 1974). To undertake this process, it employed two subcomponents of its own. The subcomponents are a temporary storage system and an articulatory subvocal rehearsal system. The phonological loop uses both the temporary storage; capable of holding memory traces for about 2 seconds, and the articulatory subvocal rehearsal system; to facilitate nonword recall. As the string of sounds are held for a brief period of time, long-term knowledge is activated when the strings of sound segments resemble lexical representation. The temporary storage system could hold episodic memory traces over approximately two seconds, during which they decayed, unless they were refreshed by the subvocal rehearsal system (Baddeley, 2002). The rehearsal mechanism, being episodic, is affected by the length of the items being rehearsed. Specifically, longer items (e.g., multisyllabic words) resulted in slower rehearsal times, which allowed increased forgetting (Gathercole & Baddeley, 1989, 1990; Gathercole, Willis, Baddeley, & Emslie, 1994). If multisyllabic words resulted in slower rehearsal times, we must also consider other factors (i.e. phonotactic knowledge, word-likeness, stress patterns, language experience and socioeconomic status) that could potentially contribute to the accuracy in which adults repeat nonwords.

1.3 Factors affecting NWR

The majority of studies have used nonword repetition tasks as a measure of phonological working memory (e.g., Gathercole & Baddeley, 1989). However, it is important to discuss other factors that could possibly influence nonword repetition tasks as a means to understanding the adult's performance patterns. Other concepts such as phonotactic knowledge, word-likeness, stress patterns, language experience and socioeconomic status have been evaluated to understand and describe adult phonological working memory performance.

1.3.1 Phonotactic Knowledge. Phonotactic constraints can be described as a set of possible sound patterns in a given language. In each language there are restriction on the distribution of sounds, e.g. in certain structural positions or next to certain other sounds. For example, Brown and Hildum (1956) illustrated that adult English speakers perceive nonwords beginning with phonotactically legal onset clusters (e.g. /pr/) more accurately than nonwords beginning with illegal onset clusters (e.g. /zdr/). In the NWR tasks, nonwords that consist of more frequent sound patterns are perceived more quickly than nonwords consisting of less frequent sound patterns (Coleman and Pierrehumbert, 1997; Treiman et al., 2000). Thus, non-words with high-frequency syllables are perceived more quickly than non-words with low frequency syllables (Vitevitch et al., 1997).

Spanish and English have different phonotactic rules that may affect NWR performance. Spanish uses five vowels and twenty consonants, while English uses thirteen vowels and twenty-four consonants (Hammond 2001). Therefore, the rules on how the number of syllables, consonant clusters, stress patterns and phonemes are arranged will differ in each language. In English there are more contrasting sound combinations compared to Spanish, which increases phonotactic complexity by adding syllable final consonants and consonant sequences. Navarro, (1968) and Shriberg and Kent, (1982) illustrate how Spanish consists of more multi-syllabic words than English, therefore longer syllable and consonant vowel sequences are more frequent in Spanish than and in English. Some studies have found a strong effect of nonword length (indexed by number of syllables) and resulted in more repetition errors than shorter nonwords (Gathercole & Baddeley, 1989, 1990b; Gathercole et al., 1994). However, there has been one exception to this otherwise robust finding by Gathercole and Baddeley (1989), in which a group of four-year-old and five-year-old children exhibited lower performance on one-syllable nonwords than on two-syllable nonwords. They hypothesized that the fundamental phonological make-up of the monosyllabic nonwords was a factor in the finding. Gathercole and Baddeley recommended that more efficient analyses of the stimulus (monosyllabic words) was required prior to deciding what factors impacted these results.

1.3.2 Word-likeness. Keeping in mind the mechanisms that facilitate phonological process, the word-likeness of nonwords should be considered. High-probability constituent nonwords contain elements that reflect the phonotactic constraints of a particular language and may sound more "word-like" (i.e. sladding, or glistering) (Gathercole and Baddeley, 1989). Low-probability constituents also contain some elements of the language phonotactic constrains, but sound less "word-like" (Frisch et al., 2000), for example (voup, or naib) Dollaghan and Campbell (1998). In some adult studies, nonwords with higher probability components produced better recall performance, suggesting that participants were able to use their knowledge of frequently arising lexical patterns to increase recognition (Frisch et al., 2000).

Gathercole (1995) showed that the beneficial effects of word-likeness, and repetition of nonwords were accessible to all children as they matured (got older) and their experiences with print became more frequent. These findings suggested that language experience plays a role in the accuracy in recall capabilities of nonwords. Garthercole (1995) also illustrated how repetition of less word-like items was more closely related to measures of short-term memory. These results suggested that speakers exploit similarities to items or patterns in long term memory when holding novel material in memory, but are less able to use information in long term memory when the novel material is less familiar, as it would occur in second language learning.

1.3.3 Stress patterns. Another factor that plays a role to the perception of word-likeness is stress pattern. Dollaghan et al. (1995) created a set of nonwords which included syllables corresponding to real words and manipulated stress assignment in those stimuli. In half of the nonwords, the syllable carrying primary stress was the real word, and the other half had a nonsense syllable stressed. Results showed how nonwords with stressed syllables corresponding to real words were repeated more accurately than nonwords with stress on syllables that were not identical to real words.

1.3.4 Language experience. Bilingual children display varying experiences in each language. Sequential bilinguals acquire Spanish as their L1 and English as their L2 with academic instruction (Girbau & Schwartz 2008). Simultaneous bilinguals acquire English-Spanish concurrently; however semantic knowledge in both languages may vary. Varying exposure and input in English and Spanish may result in different levels of proficiency in each language. Language domains may remain underdeveloped in bilingual children (Girbau & Schwartz 2008). Equal proficiency in English and Spanish is dependent on children's experiences in each language, instruction received, and communication interactions in each language (Girbau & Schwartz, 2008). Research has revealed that NWR performance may be influenced by previous language experiences (Masoura and Gathercole, 1999; Summers et al., 2010). Masoura and Gathercole (1999) found that Greek/English speaking children performed better on two-syllable to five-syllable Greek nonwords, which resembled their L1. Higher NWR performances in their L1 may have been attributed to the nonwords resembling their native language; in which they were more experienced. Summers et al. (2010) demonstrated that bilingual children with more experiences in Spanish were better at nonwords that resembled multisyllabic words in that language. As vocabulary levels increases in children, they use their stored phonological information about words to gradually 'build up' to attain adult-like phonetic precision in their productions, as measured by their recall of nonwords (Edwards, Beckman, & Munson, 2004).

1.3.5 Socioeconomic status (SES) and cultural effects on verbal working memory. Socioeconomic status is determined by on a combination of variables, typically including occupation, education, income, wealth, and place of residence. Culture aspects include an individual's race, ethnic background, lifestyle, physical/mental ability, religious beliefs/practices, and heritage (Hoff & Tian, 2004**)** There is evidence that measures of verbal short term memory that tap into the phonological loop appear to be culturally unbiased. Studies with typically developing children from ethic majority and minority backgrounds have been found to differ in standardized measure of vocabulary, but not on nonword repetition tasks (Campbell, Dollaghan, Needleman, & Janosky,1997; Ellis Weimer et al., 2000). Engel de Abreu et al. (2013) explored the impact of test language and cultural status on vocabulary and working memory performance in multilingual language-minority children. This study revealed language status had an impact on the repetition of high-wordlike but not on low-wordlike L2 nonwords. Despite this findings on NWR and cultural status, NWR tasks which is a working memory task, could potentially be influenced by SES. However, this topic has not been explored much. Therefore, consideration of other working memory studies from human development journals and epidemiology journals were sought out.

Cognitive tasks have shown a bias against low SES (Kaplan et al. (2001). Kaplan et al. (2001) investigated whether the socioeconomic environment experienced during childhood had an impact on cognitive functioning (measured by using Trail Making, Selective Reminding Test, Verbal Fluency Test, Visual Reproduction Test, and Mini Mental State Exam) in middle age. They found that participants from more disadvantaged backgrounds exhibited the poorest performance on cognitive test. Evans and Schamberg (2009), demonstrated that childhood poverty is inversely related to working memory in young adults. Working memory was measured by the subject's ability to recall a sequence of stimuli presented on a touch pad divided into 4 quadrants. They suggested that the correlation between childhood poverty and working memory was mediated by elevated chronic stress during childhood. Chronic stress was measured by allostatic load, a biological marker of cumulative wear and tear on the body that is caused by the mobilization of multiple physiological systems in response to chronic environmental demands.

1.4 Frameworks for Nonword Repetition

Evaluating other frameworks of lexical access and describing how words are selected for language production are important concepts to help understand how nonword repetition simulates word learning. The hypothesis is that similar mechanisms might be utilized during the selection of language units to produce a nonword. Therefore, describing the mechanisms involved in the processing of nonwords prompts a discussion of three theoretically interrelated frameworks devoted to the study of lexical access. The serial activation model (Gupta, 2005), computational model (Gupta, 1996) and (Gupta & MacWhinney, 1997), and probabilistic phonological models (Edwards, Beckman, & Munson, 2004; Munson, 2006) will be discussed to help understand the underling mechanisms that are utilized during adult processing of nonwords.

1.4.1 Serial activation model. Gupta (2005) indicated that in order to recall a word or a nonword, it is important to immediately retrieve "the serial order of a novel phonological sequence". In nonword repetition tasks, the novel phonological sequence occurs at the sublexical level (as a phoneme or a syllable). Therefore, phonological serial ordering must be capable of representing lexical and sublexical units.

Gupta (2003) illustrates how short term recall of sublexical sequences varied with the serial position of the to-be-recalled sequences within the nonwords. In a series of adult nonword repetition studies, primacy and recency effects were encountered. Primacy effects refer to the advantage in recall of syllables in the first few positions within a nonword (in other words, the first sounds heard), while recency effects refer to advantages in recall for the last few syllables (the last sounds heard) in a nonword. Primacy and recency effects take place in nonword repetition as a result of short-term connections between a sequence memory component and the lexical and sublexical phonological levels of representation in long-term memory. Gupta has suggested that nonword repetition ability relies on long-term phonological storage.

1.4.2 Computational model. Gupta (1996) and Gupta and MacWhinney (1997) proposed a computational model to explain how word learning and nonword repetition may possibly be based on phonological storage and canonical serial ordering. In addition, they suggest that there are multiple processes supporting access to a nonword and/or a real word. In their model of word learning, word form repetition, and immediate serial recall of words and nonword lists, there are several layers of activation. They propose that as a familiar or unfamiliar word form is encountered, the chunk layer (chunk layer holds groupings of one or more syllables) in the model will activate. To repeat the nonword, the phonological store avalanche node (containing a list of chunk layers – within word elements) activates the appropriate chunk layer node, which in turn, gradiently activates the appropriate phoneme layer. The activation of the phoneme layer supports articulation of the word form. This model also provides an explanations for the role of sequence memory: "The greater the number of syllables in a nonword, the greater will be the decay of weights between the phonological store and the chunk layer and phoneme layer nodes" (Gupta & MacWhinney, 1997, p. 297). Overall, this framework suggest that the long-term linguistic knowledge is instantiated by the strength of the networks between the units in the various layers.

1.4.3 Probabilistic phonological models. Probabilistic phonological model analyze the influence of frequency distributions on the cognitive representation of phonological forms. This model proposes that the frequency of the sound structure of a language establishes 'linguistic experience' and can become a facilitator in the acquisition of perceptive and productive phonological and phonetic competence (Pierrehumbert, 2001). Munson and colleagues (Edwards, Beckman, & Munson, 2004; Munson, 2006) findings from the study of probabilistic phonological knowledge in adults, suggest that linguistic experience was a variable in nonword repetition performance. In child studies by Munson and colleagues, sixteen monolingual English-speaking children with typical and atypical speech and language demonstrated more accurate repetitions of nonwords with high probability phonetic segments, compared with nonwords that contained low probability segments (Munson, Edwards, & Beckman, 2005; Munson, Kurtz, & Windsor, 2005). Thus, nonword tasks will be supported long-term memory, prior experience with the particular word, and by prior experience with other words with similar phonetic constituents, especially when the specific phonetic pattern is regular and frequent in the language (Gathercole, Frankish, Pickering, & Peaker, 1999).

1.5 The present study

In order to understand the variations in NWR performance patterns of bilingual children, NWR performance data from bilingual adults is needed. Nonword repetition performance of adult bilinguals and monolinguals with various "balanced" to "dominant" linguistic experience and proficiency profiles (Kohnert, & Bates, 2002) might aid in the interpretation of the performance of bilingual children, complementing the existing body of research. This project sought to answer the following questions:

- What are the patterns of NWR performance across syllable lengths in adults with varying language experience in Spanish and English?
- Are there significant differences between English/Spanish bilingual, English monolingual and Spanish monolingual adults' performance on NWR tasks?

Chapter 2: Method

2.1 Participants

A total of 80 adults participated in this study; 38 Spanish/English bilingual adults (mean age 29), 22 English monolingual adults (mean age 29), and 20 Spanish monolingual adults (mean age 45), were recruited for this study. The participants were 21 (26%) males and 59 (74%) females. The bilingual and monolingual English adults were recruited from a university and community college setting, and monolingual Spanish adults were recruited from a nonprofit organization. Participants from all three groups reported no history of hearing impairment, neurological, or language problems. All participants received an incentive of a gift-card ($35.00 for the bilingual adults and $25 for the English and Spanish monolingual adults) once they completed the tasks.

Due to the geographical nature of the city of El Paso, Texas and the proximity to the Juarez, Chihuahua, Mexico border there are many bilingual speakers who speak Spanish and English and attend the local community college and university. English monolingual participants were also recruited from the university and community college setting as there are many out-of-state students who only speak English. According to the United States Census Bureau (2010), the population in El Paso, Texas was estimated to be 827,718 for 2013, with 81% Hispanic or Latinos. The median yearly household income is $39,699 and it is estimated that 24% of the population live below the poverty level.

Finding monolingual Spanish adults proved to be a difficult task, because all university students have instruction in English. Therefore, the monolingual Spanish group was recruited from a nonprofit organization in San Elizario, Texas. The nonprofit organization provides a variety of educational and health services to help low-income families in the community. They help addresses social injustices and poverty in the colonias by serving over 3,000 colonia women, children and their families through a comprehensive program that focuses on economic self-sufficiency, homeownership opportunities, domestic violence victim services, health awareness, basic education, asset building and community development. According to the United States Census Bureau (2010), the population in San Elizario, Texas was estimated to be 13,603 for 2010, with 98.7% Hispanic or Latinos. The median yearly household income is $25,551 and it is estimated that 48.3% of the population live below the poverty level.

2.2 Measures

The study included two measures: a language questionnaire, and NWR tasks that were conducted in both English and Spanish. The bilingual participants were tested in two sessions, the first session was forty-five minutes, and the second session was twenty minutes. The order of language testing was counterbalanced, half of the participants began testing in English then Spanish, and the other half began in Spanish then English. Monolingual participants' testing was completed in one thirty minute session. The sessions were conducted, audio-recorded, transcribed, and scored by undergraduate and graduate research assistants.

2.3 Questionnaire

The language questionnaire was adapted from the Bilingual English Spanish Assessment (BESA; Peña, Gutíerrez-Clellen, Iglesias, Goldstein, & Bedore, 2014) and was administered at the beginning of the first session to determine the participants' current language usage (the percent of English and Spanish Input/Output). Input and output was established by asking questions about current usage (daily activities they engaged in during the week and on weekends, who their speaking partners were, and what languages they were hearing and speaking on an hourly basis each day). The bilingual group had 59% English and 41% Spanish Input/Output, the monolingual English group had 98% English and 2% Spanish Input/Output, and the monolingual Spanish group had 1% English and 99% Spanish Input/Output. The participants were also asked how many years of education they completed (see Table 1).

Table 1
Current Language Usage and Years of Education

	Monolingual English		Bilingual Eng/Span		Monolingual Spanish	
	Mean	SD	Mean	SD	Mean	SD
Eng In/Out	98.00	0.02	59.00	19.01	01.00	.009
Span In/Out	2.00	0.02	41.00	19.01	99.00	.009
Age	24	5.18	29	6.42	45	10.58
Years of Education	16.2	2.91	16.9	2.34	7.6	3.17

2.4 Nonword repetition

The English nonword repetition tasks were adapted from Dollaghan & Campbell (1998) and the Spanish NWR tasks were adapted from Calderon (2003). They included sixteen nonwords in each language, with one to four syllables in length for English, and two to five syllables in Spanish. Both English and Spanish nonword lists reflected the phonotactic constraints of each language and included only tense vowels. Dollaghan and Campbell (1998) created the nonwords excluding late developing sounds, consonant clusters, and individual syllables that corresponded to real words. The English nonwords had no weak syllables (by contrast with the typical English metrical stress pattern in which strong and weak syllables alternate) to control for familiarity effects, and helped reduce the possibility that the correct vowel in any syllable could be guessed. In Calderon (2003), they used fewer late developing sounds (e.g., /s/ and /r/), and stress patterns in the nonwords reflected the Spanish language, the last syllable was stressed.

2.5 Procedures

Administration of the language questionnaire and nonword repetition tasks for the bilingual and monolingual English groups took place at the University of Texas at El Paso, Speech and Hearing Clinic and Bilingual Research Language Lab in quiet rooms with some ambient noise. The monolingual Spanish group's administration took place at nonprofit organization's facility. The facility was a small house in a rural community outside the El Paso area and the rooms were only divided by a partition wall without a ceiling, which were not ideal for maintaining a quite environment.

The tasks were administered by bilingual speech-language pathology research assistants. Instructions for the language questionnaire and the nonword tasks were provided to the participants in the target language, English or Spanish, (bilinguals were addressed in the language they were being tested in that particular day, since this group was tested twice). For the NWR tasks, the examiner said, "You are going to hear some words that are not 'real' words, they are made-up." Then the examiner would verbally give the participant a made-up nonword that was not used in the actual stimulus test list, for example the examiner would say "for example /gami/, or /tukiyua/" and waited for the participant to repeat the nonword, to assure that the participant understood the task. "I can only play each word once, so please pay close attention and listen carefully to each word and then repeat each word aloud, and do your best." Each nonword was presented once. The participants wore headphones to listen to each nonword and their responses were audio-recorded. Responses were scored phoneme by phoneme to calculate English percent of phonemes correct (EPPC), and Spanish percent of phonemes correct (SPPC) for each nonword. Bilingual research assistants scored 20% of the samples and acquired greater than 90% inter-rater reliability.

2.6 Analysis

Analysis of variance (ANOVA) was used to evaluate the adults' performance patterns of NWR across languages and language experiences (i.e. Input/Output). First, 2 one-way repeated measures ANOVAs were run separately for English and Spanish, and compared the group performance of NWR scores; PPC (using one, two, three, and four syllable lengths for English nonwords, and two, three, four and five syllable lengths for Spanish nonwords) as the dependent variables. In addition, when a significant *F* test results in an ANOVA test for a main effect of a factor, a post hoc test was used to help evaluate exactly which groups differ in performance. To answer the second research question, a repeated-measures ANOVA was run to examine the within subject effects for language (English and Spanish) with NWR totals; EPPC totals and SPPC totals as the dependent variables.

Chapter 3: Results

3.1 Descriptive results (Input/Output, NWR)

The first research question set out to evaluate the patterns of NWR performance across syllable lengths in adults with varying language experience in Spanish and English. Table 2 illustrates the summary of English and Spanish NWR scores by syllables length, and percentage of current language usage (Input/Output) for the three language groups. The monolingual English group scored higher on English NWR for all syllable lengths compared to the bilingual and monolingual Spanish groups. The bilingual group scored higher on Spanish NWR for all syllable lengths compared to the monolingual English and monolingual Spanish groups. These results suggest (see Figure 1) that as the number of syllables increased for English and Spanish nonwords there was a decline in performance. However, the decline was unsteady as there were some peaks in performance for EPPC2 for the monolingual English group and bilingual group, and SPPC4 for all three groups. There was a steep decline for SPPC5 for all three groups.

Table 2

Means and Standard deviations (SD) of NWR performance

	Monolingual English		Bilingual Eng/Span		Monolingual Spanish	
	Mean	SD	Mean	SD	Mean	SD
NWR English percent correct						
EPCC1	**75.75**	13.34	68.64	12.91	61.66	15.85
EPPC2	**84.54**	8.85	78.15	9.96	59.25	15.58
EPPC3	**75.81**	8.31	72.83	11.87	58.03	11.97
EPPC4	**74.74**	7.5	67.17	11.47	59.86	9.55
EPPC total	**77.71**	7.29	71.70	9.66	59.70	9.52
NWR Spanish percent correct						
SPPC2	79.43	9.90	**82.70**	8.88	72.85	12.36
SPPC3	56.24	15.75	**78.47**	12.82	73.05	10.20
SPPC4	73.28	15.01	**78.72**	12.85	77.92	9.12
SPPC5	45.36	9.73	**48.33**	12.01	41.12	16.1
SPPC total	68.94	6.26	**72.06**	8.98	60.87	10.78

Note: Numbers in bold indicate highest mean per syllable length.

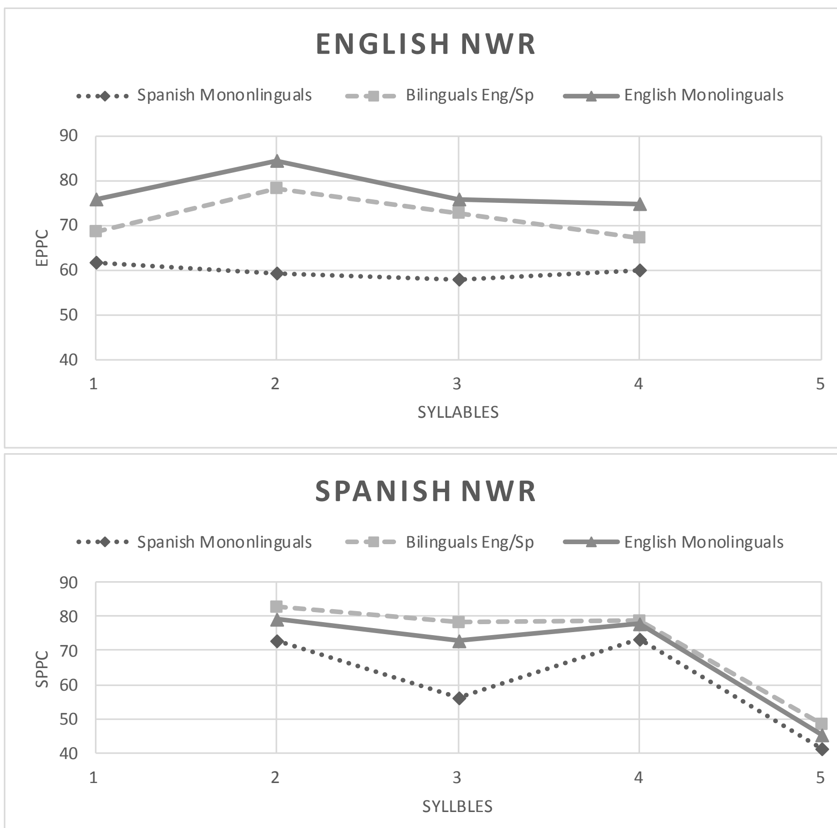

Figure 1

English/Spanish NWR across Syllables

3.2 ANOVAs for each language

A one-way repeated measures ANOVA was run separately for English and Spanish, and compared the group performance of NWR scores; PPC (using one, two, three, and four syllable lengths for English nonwords, and two, three, four and five syllable lengths for Spanish nonwords) as the dependent variables. In addition, when a statistically significant *F* test results in an ANOVA test for a main effect of a factor, a post hoc test was used to help evaluate exactly which groups differ in performance.

3.2.1 English. Table 3, illustrates the one-way ANOVA for language (Input/Output) comparing all nonword syllable lengths in English (EPPC). The analysis showed that there were statistically significant main effects across all syllable lengths in English nonwords; EPPC1 $F(2,77) = 5.426$, $p > .006$; EPPC2 $F(2,77) = 28.465$, $p > .0001$; EPPC3 $F(2,77) = 16.028$, $p > .0001$; EPPC4 $F(2,77) = 11.464$, $p > .0001$. The post hoc test (see Table 4) revealed that the monolingual Spanish group statistically significantly differed in performance for the all syllable lengths (EPPC1, EPPC2, EPPC3, and EPPC4) in English nonwords compared to the monolingual English group. The monolingual Spanish group also statistically differed from the bilingual group for syllable lengths EPPC2, EPPC3, EPPC4. The bilingual group was statically significantly different from the monolingual English group for EPPC 4.

Table 3
Oneway ANOVA for English

	d.f.	Den d.f	*F*-value	*p* – value
EPPC1	2	77	5.462	.006
EPPC2	2	77	28.465	.0001
EPPC3	2	77	16.028	.0001
EPPC4	2	77	11.464	.0001

The mean difference is significant at the .05 level.
Note: Number of d.f.= number of group -1; Den d.f. = n – number of groups

Table 4

Post Hoc Test for English ANOVA

Syllable Length	Group Comparisons	*p* - value
EPPC1	Monolingual Spanish vs. Monolingual English	.004
EPPC2	Monolingual Spanish vs. Bilingual	.000
	Monolingual Spanish vs. Monolingual English	.000
EPPC3	Monolingual Spanish vs Bilingual	.000
	Monolingual Spanish vs. Monolingual English	.000
EPPC4	Monolingual Spanish vs. Bilingual	.031
	Monolingual Spanish vs. Monolingual English	.000
	Bilingual vs. Monolingual English	.019

The mean difference is significant at the .05 level.

3.2.2 Spanish. Table 5, illustrates the one-way ANOVA for language (Input/Output) comparing all nonword syllable lengths in Spanish (SPPC). The Input/Output analysis showed that there were statistically significant main effects across syllable lengths for SPPC2 $F(2,77) = 6.207$, $p > .003$, and SPPC3 $F(2,77) = 19.429$, $p > .0001$, in Spanish nonwords. No statistically significant differences were found for SPPC4 and SPPC5. The post hoc test (see Table 6) revealed that the monolingual Spanish group statistically differed in performance for syllable length SPPC2, SPPC3 in Spanish nonwords compared to the bilingual group. The Spanish group also differed in performance for SPPC3 compared to the English monolingual group.

Table 5

Oneway ANOVA for Spanish ANOVA

	d.f.	Den d.f	*F*-	*p* - value
SPPC2	2	77	6.207	.003
SPPC3	2	77	19.429	.0001
SPPC4	2	77	1.285	.282
SPPC5	2	77	2.152	.123

The mean difference is significant at the .05 level.

Note: Number of d.f = number of group -1; Den d.f. = n – number of groups

Table 6
Post Hoc Test for Spanish ANOVA

Syllable Length	Group Comparison	*p* - value
SPPC2	Monolingual Spanish vs. Bilingual	.002
SPPC3	Monolingual Spanish vs. Bilingual	.0001
	Monolingual Spanish vs. Monolingual English	.0001
SPPC4	no significance	
SPPC5	no significance	

The mean difference is significant at the .05 level.

3.3 Repeated-measures ANOVA for language with NWR totals

The second question set out to determine if there are significant differences between English/Spanish bilingual, English monolingual and Spanish monolingual adults' performance on NWR tasks. A repeated-measures ANOVA was used to examine the within subject effects for language (English and Spanish) with NWR totals; EPPC totals and SPPC totals as the dependent variables. There was a statistically significant effect (see Table 7) for Language $F(1,77) = 5.728$, $p > .019$, and Language and Group $F(2,77) = 9.457$, $p > .000$. Figure 2, illustrates a statistically significant interaction as the monolingual Spanish group's overall performance was significantly significantly lower for Spanish and English nonwords, compared to the bilingual and monolingual English groups.

Table 7
Repeated Measure ANOVA for Language (English and Spanish) and Group (PPC Totals)

	d.f.	Den. d.f.	*F*-value	*p* - value
Language	1	77	5.728	.019
Language and Group	2	77	9.457	.019

Note: The mean difference is significant at the .05 level. Note: Number of d.f.= number of group -1; Den d.f. = n – number of groups
Language = English and Spanish
Groups = Bilingual, Monolingual English, Monolingual Spanish

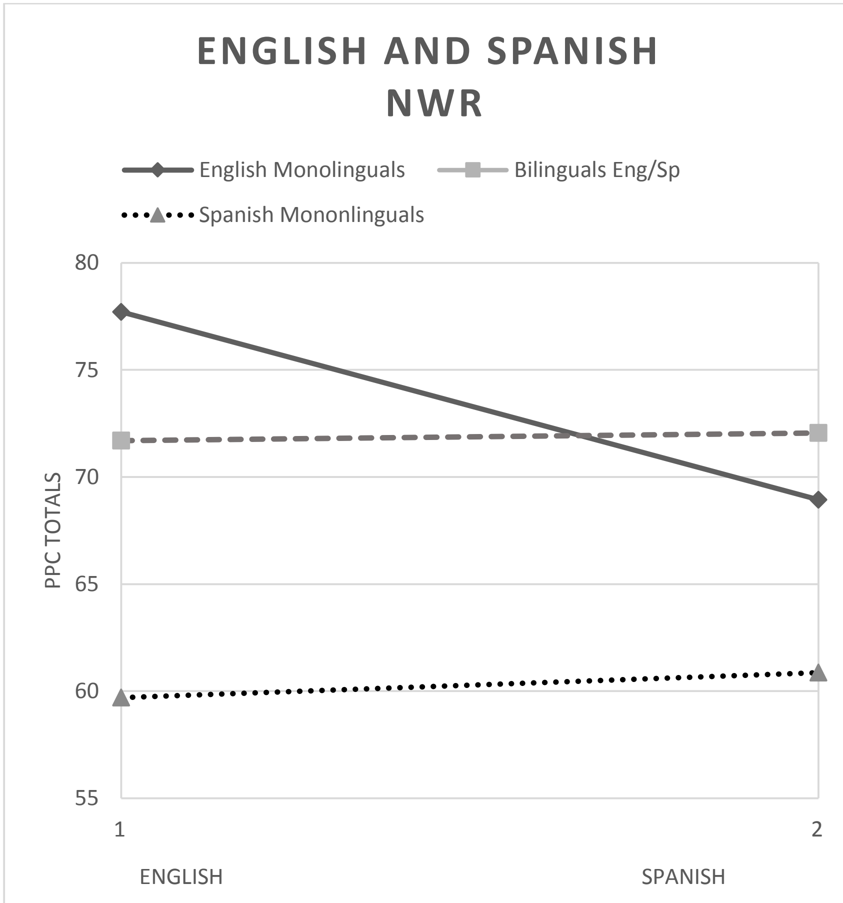

Figure 2
Language (English and Spanish) and Group (PPC Totals)

Language = English and Spanish
Groups = Bilingual, Monolingual English, Monolingual Spanish

Chapter 4: Discussion

NWR is considered to be a less biased measure of phonological short-term memory (when syllable sequences are low in word-likeness, and low in frequency). NWR is used to examine phonological short-term memory mechanisms because the tasks require the capability to discriminate, store, remember and reproduce phonological sequences (Baddeley, 1989; Braddeley 1974). This study did not attempt to evaluate which of the systems play a role in repeating the nonwords. Instead, the goal of this study was to evaluate NWR performance patterns across adults with various Spanish and English language experiences, and to establish any differences between the groups' performance on English and Spanish NWR tasks.

In this study the findings suggested that adult monolingual Spanish speakers' performance was much less accurate than the bilingual group and monolingual English group, not only for English nonwords, but also for Spanish nonwords. However, we need to consider several factors that could potentially account for the monolingual Spanish group's performance. The Spanish monolingual adult participants were not matched equally in education, SES (socioeconomic status), and testing conditions compared to the other two groups. Studies with typically developing children from ethic majority and minority backgrounds have not been shown to differ on nonword repetition tasks (Campbell, Dollaghan, Needleman, & Janosky,1997; Ellis Weimer et al., 2000). On the other hand, Evans and Schaberg (2009), have found that participants with disadvantaged backgrounds had poorest performance on working memory tasks in young adults. These conflicting studies, make it difficult to conclude which factors affected performance. The present study did not control for SES or education. Therefore it is difficult to postulate that SES or education could be factors that could have potentially influenced performance for the monolingual Spanish group. This study highlights the need for future research in evaluating SES and education in cultural and linguistically diverse populations (CLD) and performance patterns on NWR tasks.

Although the monolingual Spanish group's performance was statistically lower, an interesting pattern was observed in the two groups that had exposure to Spanish (bilingual group and monolingual Spanish group). These two groups performed evenly across English and Spanish nonword tasks (see Figure 2). This finding may imply that for the monolingual Spanish group and bilingual group, the more accurate they are at repeating nonwords in one language, they will be more accurate repeating nonwords in another language. Correspondingly, when performance is inaccurate in one language there will inaccurate in the other language regardless of language dominance. In contrast, the monolingual English group (who had no exposure to Spanish) had a marked decrease from English to Spanish nonwords (see Figure 2). This could suggest an influence with the longer nonwords, as seen in studies where they found a strong effect of nonword length (as nonwords become longer, more errors occurred) (Gathercole & Baddeley, 1989, 1990b; Gathercole et al., 1994). Spanish consists of more multi-syllabic words than English, and could account for the monolingual English group's marked decrease from English to Spanish nonwords repetition performance.

Despite the fact that the adult bilinguals in this study used English (59%) slightly more than Spanish (41%) on a daily basis (according to the language questionnaire) they scored better on the Spanish nonwords compared to the monolingual Spanish speaker. We would expect bilingual adults to also perform as well as monolingual English adults, in the English nonword recall, since they are using English on a daily basis. However, adult bilinguals challenged this and managed to recall the Spanish nonwords more accurately than Spanish adults in spite their current language usage. Bilingual adults easily retrieved the phonemic representations in

Spanish to facilitate their productions in the Spanish nonword task. This finding was consistent with Braddeley, (2003) phonological loop model, and may suggest that the bilingual group tapped into their crystalized phonological long-term memory to produce Spanish nonwords more accurately.

The study illustrates the overall differences in performance between the bilingual, monolingual Spanish, and monolingual English groups, however there were some similarities in performance for SPPC4 and SPPC5 (see Figure 1). Repetition accuracy varies with length, we know that there is decay as the syllables get longer, therefore causing adults to have less accurate repetitions as the nonwords become longer. However, the three groups did not have a steady decline as seen on Figure 1. In contrast, all three groups had a peak in performance for SPPC4, and the monolingual English and bilingual group exhibited a peak for EPPC2 (see Figure 1). This finding is similar to that of Gathercole and Baddeley's (1989) child study, in which a group of four-year-old and five-year-old children exhibited lower performance on one-syllable nonwords than on two-syllable nonwords. It is difficult to postulate which factor could be affecting this pattern. It could be possible that the two syllable words in English and four syllable words in Spanish were perceived to be more word-like than the other nonwords presented. This performance pattern would be supported by the probabilistic phonological models. This model suggests that the frequency of the sound structure (high probability phonetic segments) and 'linguistic experience' can be facilitator in perceiving and producing phonological and phonetic structures (Pierrehumbert, 2001). Consequently, long-term memory could support repetition of nonword since these adults would have prior experience with similar phonetic constituents, especially when the specific phonetic pattern is regular and frequent in the language (Gathercole, Frankish, Pickering, & Peaker, 1999).

4.1 Clinical Implications

Evaluating adult bilingual and monolingual adults' performance patterns could contribute to the interpretation of performance in bilingual children by providing the standard of adult-like performance. The results in this study indicated that the accuracy of nonword repetition will vary depending on the individual's differences in language exposure and use (Input/Output). This supports the importance of determining an individual's language exposure, by gathering a complete and accurate history of their pervious and current language usage during the assessment process.

The parallel performance patterns on NWR tasks as seen by the monolingual Spanish group and bilingual group (for Spanish and English nonwords) indicates that if the home language (in this case Spanish) is supported, then we could expect even performance across English and Spanish nonword tasks as bilingual children mature and gain more language experience. The clinical implication for choosing to support the home language (L1) (in this case, Spanish) is supported by this finding, because it shows how adult bilinguals can have analogous performance in the other language (L2) regardless of their language dominance.

Differences in performance between the two languages may be related to differences in the strength of linguistic representations as seen in the monolingual English adults. Children will also vary in their exposure and use of the languages, therefore children with greater exposure to a given language may find it easier to draw similarities with the phonological forms of real words in that language. However, as bilingual children mature (and be become more 'balanced'), we would expect them to use their long-term (crystalized) memory to facilitate retrieval of the phonemic representations to repeat nonwords, and perform evenly across English and Spanish nonword tasks. The clinical implication for this finding are that children will vary in their dominance across their development, therefore this finding emphasis the importance of re-evaluating periodically as children develop and gain more language experience as we would expect to see a shift in performance.

4.2 Limitations

Recruitment of the Spanish monolingual adult participants in this study proved to be a difficult task. In an attempt to find Spanish monolingual adult participants we fell upon a group that was not matched equally in education, and SES (socioeconomic status) compared to the other two groups. In addition, due to time constrains and transportation issues for this group, testing conditions also differed from the monolingual English and bilingual group (as they were not tested in the same type of room and noise levels). These factors were difficult to control in the study, and possibly influenced the monolingual Spanish adults' performance. Nevertheless, this situation highlights many realistic factors about the disadvantages that monolingual Spanish speakers face in this country. This minority group tends to have less education, lower income, and less opportunities. In this study, we missed an opportunity to get detailed socio-demographic information for each individual participant, which would have allowed us to evaluate their performance against other SES variables. Although this study was not aimed to address the educational and SES factors, this study emphasized the need to further evaluate and add empirical data about bilingual and monolingual Spanish speaker's language performance to better serve this population.

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Vita

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