The Effects of Word Form Rehearsal and Language Experience on Fast Mapping in Young Bilingual Adults

Lauren Janich

Speech, Language, and Hearing Sciences

Dr. Pui-Fong Kan, Primary Advisor

Dr. Pui-Fong Kan, SLHS
Dr. Bhuvana Narasimhan, LING
Dr. Kathryn Arehart, SLHS

October 25, 2011
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Figure 2: Comprehension Language-Condition Comparison
The purpose of this study was to analyze the effects of both word-form rehearsal and language experience on fast mapping production and comprehension skills. This experiment studied thirty Spanish-English bilingual young adults. The experimental portion of the study contained four main parts: (1) word-form rehearsal, (2) presentation (3) production, and (4) comprehension.

Each participant was randomly assigned to one of three word-form rehearsal conditions. Each participant began the experiment by repeating a set of sixteen novel nonwords either fifteen times each, five times each, or zero times (control group). Next, the participants were presented a visual and auditory nonword stimulus simultaneously. Next, each participant was aurally asked to verbally produce the nonword when presented with a visual stimulus. Finally, each participant was asked to identify a specific visual stimulus that corresponds with an aurally presented nonword. The participants completed these four tasks in two phonologically similar languages (English and Spanish) and one phonologically unfamiliar language (Cantonese). Results demonstrated that the more speech training a participant undergoes, the better the performance on production fast mapping tasks. Results also showed a significant language effect, with participants performing better on fast mapping tasks in the familiar languages (English and Spanish).
I would like to thank the many individuals who supported me while writing my undergraduate Honors Thesis. First, thank you to my primary advisor Pui Fong Kan for her time, expertise, and support. Thank you as well to the other members of my thesis committee, Dr. Kathryn Arehart and Dr. Bhuvana Narasimha for their guidance and help. Finally, many thanks to Marixa Andrade for her time and assistance while collecting data. I could not have done this without all of your support and encouragement.
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Introduction

Words are building blocks of language and our ability to learn new words is fundamental for language development and academic performance (e.g., Justice, Meier Walpole, 2005). Word learning, starting from early childhood, is a continuous part of our daily lives throughout adulthood. Learning a new word requires the learning of the word form, its referent and its link (e.g., Gupta & Tisdale, 2009). Infants, as young as 13 months, know how to map word form and its referent after a brief exposure to a new word (e.g., Woodward, Markman, & Fitzsimmons, 1994). Adults continue to rely on the ability to map form and meaning to learn new words (e.g., Bloom & Markson, 1998).

The purpose of this study is to examine the effects of word-form rehearsal and language experience on fast mapping skills in bilingual young adults. Fast mapping is generally defined as the initial stage of learning new words. During this stage, an individual constructs a representation for a new word on the basis of minimal exposures to it. This initial representation might contain linguistic information (e.g., the semantic, phonological, or syntactic characteristics of the new lexical item), as well as nonlinguistic information related to the situation in which it was encountered (e.g., Bloom, 2000). The success of learning a new word requires additional exposures to the new words across various contexts. This process is called word learning or slow mapping (e.g., Capone & McGregor, 2005). It is proven that word learning is an important learning mechanism for both children who are in the beginning stages of language acquisition, as well as adults who are refining and expanding their lexicon (e.g., Gathercole, 2006). Word learning builds on the concept of fast mapping. Without successful fast mapping skills, further word learning is nearly impossible (Gray, 2003). Logically, the initial stage of form-meaning mapping is the basis for the entire word learning process. Decreased ability to establish the initial
representation of a new word during this stage has been linked to decreased word learning (Gray, 2003; 2004).

In experimental settings, fast mapping involves the initial opportunities to associate a novel word form and its referent (Capone & McGregor, 2005; Gathercole, 2006). A novel word form (also called nonword) is a lexical form that follows the phonology of a language but does have any meaning. In a typical fast mapping experiment, three phases are completed. First, the research assistant presents or models the name for each target word and object (e.g., “This is the [target word]”) (Gray, 2003). Second, the research assistant initiates a comprehension probe for the target words and their object (e.g., “Hand me the [target word]”). Lastly, the research assistant initiates a production probe for each object (e.g., “What is the name of the object you are holding?”). Previous studies have shown that two main factors are linked to the success of learning new words: (1) levels of exposures and (2) language experience (e.g., Capone & McGregor, 2005; Kan & Kohnert, in press; Kan & Sadagopan, 2010). In a recent study, Kan and Sadagopan (2010) investigated the effect of lexical form rehearsal (i.e., repeating target word forms multiple times prior to fast mapping) on fast mapping performance (i.e., performance of form-meaning mapping) of monolingual English-speaking adults in three language conditions: English (a language that participants have most experience with), Spanish (a second language that is typologically similar to English), and Cantonese (a second language that is typologically dissimilar to English). The results show that there was a significant effect of lexical-form exposures on fast mapping. That is, intensive word-form rehearsal contributes to the success of establishing the initial representation of the new words. Importantly, the effect is greater in the English condition than the other two language conditions, indicating language experience plays a significant role in fast mapping.
This study is designed to examine the effects of word-form rehearsal and language experience on fast mapping (i.e., form-meaning association). In particular, I replicate the study by Kan and Sadagopan (2010) and examine whether familiarizing a novel lexical form prior to the fast mapping experiment facilitates an individual’s fast mapping performance. In addition, in order to further understand how language experience impacts word-form rehearsal, I examine fast mapping skills in Spanish-English bilinguals. The results contribute to our understanding of the dynamic relationship between existing language systems and our ability to learn new words. Clinically, this information is important because repeating after a model is a common technique that is used in intervention (e.g., Vinson, 2011), and it is vital to understand how and why these methods are successful. In what follows, I review the literature focusing on how these two factors are related to fast mapping.

**Word-form Rehearsal and Fast Mapping**

*Theoretical Perspectives: Word-form Rehearsing and Fast Mapping*

The theoretical perspectives that informed the design of this investigation included the following: (a) repeating novel word-forms (i.e., nonword repetition) and fast mapping (form-meaning mapping) are operated in a common cognitive processing system within which multiple processes are involved (e.g., Gathercole, 2006) (b) rehearsing and familiarizing the word forms allow more attentional resources to be allocated to the processing of the semantic properties of the novel word as well as the form-meaning link during the subsequent fast mapping task (Kahneman, 1973; cf., Ellis Weismer & Hesketh, 1993; 1996; 1998; Just & Carpenter, 1992). These perspectives are elaborated in the following paragraphs.

First, the skills of repeating novel word-forms and fast mapping are operated in a common cognitive processing system (e.g., Gathercole, 2006). Accordingly, there is a common
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temporary phonological storage for repeating novel word forms and fast mapping. In order to understand the role phonological storage plays in repeating and rehearsing novel word forms and fast mapping, it is vital to have a working definition of phonological storage. According to Baddeley’s (1986) model of phonological short-term store, an auditory input is received and it is immediately subject to rapid time-based decay. To fend off this natural time-based decay, a subvocal rehearsal process takes place, thus finalizing the phonological representation and keeping its form fresh in the mind. Phonological forms of novel words form a basis for the gradual process of establishing stable sound structures in word learning. Anything that hinders the initial phonological representation will slow down the word learning rate (Gathercole, 2006). There are three contributing factors that determine how well the phonological representation will initially be stored. These three factors are the processing skills, the quality and persistence of the phonological representation, and the speech motor skills (Gathercole, 2006).

First, repeating novel word forms and fast mapping are multiply determined (e.g., Gathercole, 2006). This means that the ability to repeat nonwords is not simply dependent on phonological storage, but that a plethora of other processes are necessary. Repeating nonwords and fast mapping involves auditory processing skills, phonological processing skills, and motor speech skills (for producing a novel word in a fast mapping task). Auditory processing is a key factor that affects an individual’s ability to properly repeat a nonword. Any sort of hearing loss or impairment immediately jeopardizes the detection of a new sound. Since simple detection is compromised, the ability to process longer, multisyllabic words, or words presented at a faster rate becomes nearly impossible (e.g., Gathercole, 2006; Stelmachowicz, Pittman, Hoover, & Lewis, 2004).
Second, phonological processing also influences the quality of the phonological representation when repeating a novel word. Once the auditory signal successfully reaches the brain, the phonological structure of the word needs to be identified. This means that the sound-based representation is formed by phonological awareness and sensitivity, skills that are common components of early language development in young children. An individual who lacks phonological sensitivity and awareness will probably have difficulty with nonword discrimination, thus making the link between form and meaning much more difficult (Gathercole, 2006). For example, a study conducted in 2004 by Shelley Gray determined whether phonological memory or semantic knowledge predicted word-learning success better. Gray studied 20 preschoolers with specific language impairment (SLI) and 20 age-matched peers with normal language (NL). Results from this study showed that existing lexical knowledge is key for fast mapping skills. She determined that preschools who were identified as “poor word learners” performed well on comprehension fast mapping tasks as well as retaining sufficient semantic knowledge of the referents, but performed rather poorly when asked to produce the referents. Also, Gray states that fast-mapping performance is a good indicator in identifying poor word learners. Gray concluded that both semantic knowledge and phonological memory have an effect on word-learning difficulty.

The last process vital to nonword repetition and the production of the novel word on a fast mapping task is the speech-motor output process. Speech production (e.g., repeating a word or naming a novel object) involves the retrieval of the movements from memory, the coordination of all speech production subsystems, and executing speech motor commands (e.g., Gathercole, 2006; Maas et al., 2008). The inability to properly produce familiar lexical phonological forms will affect production and accuracy (Gathercole, 2006). Repeating novel
word forms multiple times can facilitate auditory, phonological, and speech-motor processes, thus positively influencing fast mapping performance. The repetition of the novel nonword form leads to an improvement in auditory processing, making the nonword more familiar. Phonological processing improves through the repetition of the auditory stimulus as well as the word form rehearsal, because the individual becomes more familiar not only hearing the phonemes and phoneme patterns, but more familiar producing them. This comfort producing the words increases speech-motor processing, as muscle memory is established and phonemes that were once foreign become second nature.

The second theoretical basis for investigating the potential link between target word from rehearsal and the subsequent fast mapping performance is rooted within the framework of a limited-capacity model of attention (Kahneman, 1973; Just & Carpenter, 1992). According to this perspective, cognitive capacity—which is the maximum amount of activation available for storage and processing—is a key factor for learning new words (e.g., Ellis Weismer & Hesketh, 1993). When a task’s demands exceed the capacity (e.g., learning too many words at the same time), both storage and processing are negatively affected. This leads to poor performance. In other words, a less demanding task such as learning a fewer amount of words or being provided stronger semantic or phonological representation could lead to a better performance by the individual. For example, Ellis Weismer and Hesketh (1996) investigated the comprehension and production accuracy of children with specific language impairment (SLI) and their age-matched peers with normal language (NL). Their study showed that children with SLI produced fewer words that had been presented at a faster rate than their NL matched peers. The children with SLI and the normal language children performed similarly on a less demanding task (i.e. nonword comprehension). When the task became more demanding and difficult, both groups of children
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were negatively affected. In particular, children with SLI performed poorer than their peers. This is a prime example of how the task’s demands exceeded the capacity and affects word learning performance. In the same vein, Capone and McGregor (2005) found that additional semantic information in the input facilitated toddlers’ word retrieval ability. In this experiment, semantic representation was enhanced through the use of iconic, or representation gestures. This increase in semantic knowledge allows the toddler to pay more attention to learn the meaning of the nonword faster, thus allowing the toddler to create the link between the meaning and form at a quicker rate.

This literature relates to the current study in the following way. Since there is a limited capacity as to what our brain is capable of accomplishing at any given time, allocating time for the brain to simply practice and master word-form rehearsal allows the brain to transition quicker to establishing the link as well as the meaning of the novel word. Resources are allocated at a much quicker rate due to the effectiveness of word-form rehearsal and its ability to allow the recognition and speech-motor production of a nonword to become second nature. Rather than the brain actively trying to remember the phonemes and morphemes of the nonword, the brain can passively produce it while actively remembering the link to the nonword meaning (e.g. visual stimulus).

In this study, I anticipate that, since our minds are only capable of handling a certain capacity at any given time, the more information about the word form is established, the more attentional resources can be allocated to learn the semantic information of the word and to developing a link between the word form and the newly learned meaning.

Summary
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In summary, both processing and limited capacity theories suggest that word form rehearsal is likely to facilitate fast mapping. The processing perspective suggests that rehearsing the words multiple times facilitates the auditory, phonological, and speech-motor processing of the new words and, thus, boosts the subsequent fast mapping performance. Rehearsal of new word forms allows an individual to actively store these new word forms for later use. One step further, manipulating the speech motor articulators and forcing them to not only learn these new phonemes, but master them allows the brain to make these novel nonwords natural and instinctive. The limited capacity framework suggests that once the word form is established, the learner can allocate more attention to the meaning of the word, and of the link between the word form and the actual meaning. That is, word form rehearsal might make fast mapping tasks much easier as well as making the fast mapping process much more efficient. I want to focus on how the characteristics of a stimulus affects how well this nonword stimulus is fast mapped. More specifically, I want to show that mastering the phonology of a nonword prior to being exposed to the definition will make learning the meaning of a nonword much easier. This means that the link between form and meaning can develop at a quicker rate if the individual is exposed to and comprehends the phonological and prosodic patterns prior to having to learn the meaning. By implementing various levels of speech training as well as testing a control group, I can further pinpoint how different levels of exposures to new words affect our fast mapping abilities.

Language Experience and Fast Mapping

There is good reason to believe that language experience influences the success of establishing a form-meaning association. The ability to perceive the phonemes of a word is critical for our skills to rapidly form an initial representation of a novel word in a fast mapping experiment. Increasing evidence indicates that our speech perception system becomes attuned to
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the phonetic inventory of the native language (L1) during L1 acquisition (e.g., Zhang, Kuhl, Imada, Kotani, & Tohkura, 2005). For example, during the first year of life, monolingual children gradually become more sensitive to the phonetic units of the language that they are exposed to (Kuhl, Tsao, & Liu, 2003; Kuhl, Stevens, Hayashi, Deguchi, Kiritani, & Iverson, 2006). It has been argued that the loss of this ability is caused by a “neural commitment” to a specific language and its acoustic properties (Kuhl, Tsao & Liu 2003). For young adults, it is proven that processing non-native speech sounds required a significantly longer period of brain activation (e.g., Zhang et al 2005). For example, Zhang et al (2005) looked at the brain activity in American and Japanese listeners when they were asked to listen to a set of phonemes that were phonemic in English but not in Japanese. The data showed that Japanese listeners were less sensitive to the /r-l/ difference, because the two phonemes are not considered different in Japanese. On the other hand, the control /ba-wa/ stimuli showed no significant difference (Zhang 2005). This suggests that since brain activation is longer during exposure to foreign sounds, rehearsing these foreign sounds and discriminating between the phonemes can lead to a better understanding of the novel nonword form. Interestingly, when given frequent enough exposure, the ability to discriminate between the phonemes of a non-native language can be “regained” to a certain degree (e.g., Flege & Liu, 2001). In addition, typological differences between the native language (L1) and the second language may play a role in word learning. For example, the more distant a phoneme from a second language is from the closest phoneme in the first language, the more learnable the phoneme in the second language will be (e.g., Aoyama 2004). In a study, Aoyama (2004) observed that native Japanese speakers recognized a greater phonetic dissimilarity between the English /r/ than the English /l/, leading native Japanese speakers to produce and master the /r/ sound much quicker than the /l/ sound.
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In a recent study, Kan and Sadagopan (2010) examined the fast mapping skills in monolingual English-speaking young adults in three language conditions: English, Spanish, and Cantonese. The novel word stimuli were developed following the phonological rules of each language. For example, each syllable of a novel word in Cantonese involves a lexical tone (e.g., ngaat pam koi). Not surprisingly, significantly higher fast mapping scores were found in the English condition than the other language conditions. In this current study, I examine the language experience on fast mapping in bilingual adults who have experience in two languages (Spanish and English) from childhood and are proficient in both languages. I anticipate that higher fast mapping scores will be found in both the English and Spanish conditions compared to the Cantonese condition. This is due to the participants’ established familiarity with Spanish and English phonemes, making auditory processing, phonological processing, speech-motor processing, and phonological storage much more efficient.

In this study, I define bilingual as an individual who functionally and regularly uses two languages in his or her daily life (Grosjean 1992). There are six main characteristics that are potentially related to the language proficiency and learning of this diverse group of language learners. These characteristics are: (1) Language history and language relationship (2) Language stability (3) Function of languages (4) Language proficiency (5) Language modes (6) Biographical data (Grosjean 1998). Since a bilingual individual has so many dynamic components of their own language, studying their diverse language experience is incredible. While most individuals have been exposed to a single set of around 40 phonemes and the phoneme combinations for their lifespan, studying individuals who have consistently been exposed to and mastered two distinct sets of phonemes examines a different side to word learning. Although the bilingual is not expected to have two identical lexicons in each language,
a bilingual should be able to master the ‘form’ component of a nonword in two languages (Spanish and English) faster than an English only monolingual speaker. Bilinguals are also studied because it is interesting to see how a bilingual (Spanish and English) responds to a third foreign language (Cantonese) that has lower phonological or morphological relationship with either of the languages the participant is familiar with.

**Current Study**

In this research study, I am focusing on answering two main questions. The first question asks how the rehearsal of target word forms affects an individual’s ability to fast map those words. The second question asks how previous language experience affects fast mapping skills.

Throughout this experiment I had two working hypotheses. First, I hypothesized that an increased level of exposure to the words would result in higher fast mapping skills. As stated previously, familiarity with the form of a word allows an individual to allocate the attentional resources to the meaning of the word and the form-meaning link at a much quicker rate. Second, I hypothesized that higher language experience levels would result in higher fast mapping skills. More specifically, the more familiar a participant was with the phonology, morphology, and syntax of a language prior to entering the experiment, the more successful he or she would perform. This information is relevant because the concept of modeling is very common in clinical settings.

**Methods**

**Participants**

Participants (9 males and 21 females) were Spanish-English bilingual young adults. Table 1 summarizes the characteristics of the participants. All participants were between the ages of 19 and 29, with the mean age being 23.03 years (SD = 2.99). All participants learned Spanish as a
home language from birth and started to learn English some time during childhood. At the time of testing, all participants reported that they were fluent in both English and Spanish. To verify the participants’ Spanish and Language skills, I tested the participants using the Picture Vocabulary and Verbal Analogies subtests of the Woodcock-Muñoz Spanish and English Language Surveys (See the summary in Table 1) and had them filled out a language learning experience survey where he/she answered various questions related to their use of both English and Spanish across settings.

In addition, each participant passed a pure tone hearing screening to verify that he/she had no noticeable hearing loss. Each participant also confirmed that he/she did not have any concerns about his/her speech, language, hearing or learning abilities.

As shown in Table 1, the participants averaged 15.83 years of education including 14.68 years of education in English and the mean age of starting school was 4.07 years. Twenty-eight of the 30 participants had previously taken classes in a second language, with 18 having taken classes in Spanish, 4 having taken classes in English, 2 in Japanese, 2 in Chinese, 3 in French, one in Dutch, and two in an unspecified language.

In terms of their language skills, all participants stated that they functionally use both Spanish and English on a regular basis. Of the 30 participants, nine reported speaking solely Spanish at home, six reported speaking only English, 14 reported speaking both English and Spanish, and one participant reported speaking English, Spanish, and Dutch at home. In the work environment, two participants reported speaking Spanish, 15 reported speaking just English, and 13 reported speaking both Spanish and English. In a school setting, one reported speaking solely Spanish, 19 reported speaking English, eight reported speaking both English and Spanish, and two participants reported not currently attending school. 17 of the 30 participants reported that
their most comfortable language is English, while seven reported Spanish as their most
comfortable language, five reported being equally as comfortable with English and Spanish, and
one having Spanish and an unmentioned language being his/her most comfortable language. 22
participants reported they were more proficient in English, while seven said they were more
proficient in Spanish, and one said he/she was equally proficient in English and Spanish.

Group Assignment

Each participant was randomly assigned one of three word-form rehearsal conditions:
Condition one (C1; experimental group 1), the longest of the three speech training sessions,
consisted of the participant repeating each of the 16 novel word-forms 15 times (240 repetitions
total) prior to the fast mapping experiment. Condition two (C2; experimental group 2) consisted
of the participant repeating each of the 16 novel words 5 times (80 repetitions total) prior to the
fast mapping experiment. Condition three (C3) was the control group which consisted of no
speech training. In total, 10 participants were assigned condition one, 10 were assigned condition
two, and 10 were assigned condition three. These three groups were not significantly different in
participant characteristics, as proven by their participant characteristics. The ANOVA test
analyzing between group relationships of age, years of education, and years of English education
showed p-values greater than 0.05, indicating that the participants were chosen at random and
that they were randomly assigned to a word-form rehearsal condition.

General Procedures

The first session of the two-part experiment took place in The Child Language and
Learning Lab in the Speech, Language, and Hearing Sciences Building on the campus of the
University of Colorado-Boulder. The first testing period consisted of four parts: 1) A pure tone
hearing test 2) The Woodcock-Muñoz Spanish and English Language Surveys 3) The Test of
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Nonverbal Intelligence Fourth Edition (TONI-4) 4) The experimental speech training and language learning task.

Each participant first had to pass a pure tone hearing screening. Next, the Woodcock Muñoz Language Survey was administered. The experimental portion of the study consisted of two parts. The Picture Vocabulary portion of the survey asked participants to verbally identify a series of pictures. The Verbal Analogy portion asked participants to complete a series of verbally presented analogies. Each of these tests was completed in both English and Spanish. Third, the Test of Nonverbal Intelligence Fourth Edition (TONI-4) was administered. During the presentation of this test, the participant was asked to point at the shape(s) he/she believed completed the given pattern. This test helped determine the participant’s nonverbal intelligence. The experimental portion of the task started once the entire battery of tests was completed.

The Experimental Speech Training Task and Fast Mapping Task

Stimuli

Two types of stimuli were used during this experiment. The visual stimuli were presented to the participants during the presentation portion of the fast mapping task. These stimuli were different geometric shapes that varied in color and shape. The stimuli were chosen using a bank of novel objects called Mathematica. Once the novel objects were chosen, randomly chosen young adults completed a survey and were asked to identify the novel objects that appeared least familiar and the most foreign. The survey input was analyzed to narrow down the large set of novel objects to 16. See Appendix B for images of the novel objects.

The auditory stimuli were chosen using a novel word generator. Individual native speakers of each of the three languages were surveyed and asked to identify the novel words that sounded most natural to them and that were not familiar to any other word in their respective
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language. These results were analyzed and eventually 48 nonwords (16 English, 16 Spanish, and 16 Cantonese) were chosen to be used during the experiment. A complete list of the words and their phonetic transcriptions can be seen in Appendix A.

Implementation

At this point each participant was taken into a separate room in the lab where they were seated approximately two feet away from computer. The proctor then verbally presented instructions to simply repeat each of the novel words exactly as he/she hears them loudly and clearly into two microphones simultaneously. At that point each participant was presented with a black computer screen while they were aurally presented with the audio stimuli. If participants were assigned to condition three, they would skip this portion of the study and move directly to the fast mapping tasks.

Immediately following the speech training the fast mapping task began. The fast mapping portion of the study was conducted on an E-Prime Program consisting of four blocks, each with four novel nonwords. First, the participant was presented with a series of pictures along with their respective names and asked to remember as many of the pictures and their names as possible. This step was considered the presentation phase. Next, the participant was presented one of the four pictures and asked to verbally produce the name of the picture into a microphone. If the participant did not remember the name of the picture, they were asked to remain silent and wait for the next picture to appear. This step was repeated three additional times with a total of four pictures being presented. This concluded the production portion of the task. Finally, the participant was shown four pictures simultaneously and then asked to identify the picture that corresponded with the name aurally presented to them via microphone. The participant was
asked to press the numbered button that corresponded with what they believed to be the number of the correct picture on the screen. This concluded the comprehension portion of the task.

This series of three steps was repeated three more times, for a total of four blocks consisting of four words each. Altogether, the participant was presented with 16 words in each language. Once the participant completed this series of speech training and fast mapping tasks in one language (i.e. English), the participant repeated this same procedure in the two remaining languages (i.e. Cantonese and Spanish). The order in which the words and languages were presented was determined randomly prior to the participant arriving at the lab.

Scoring Criteria

On the production portion of the experiment, the participant had to verbally produce the nonword exactly as it was presented during the presentation phase of the fast mapping task. The participant had to pronounce all phonemes correctly. If the participant put the stress on the wrong syllable, the response was still counted as correct. For the comprehension portion of the experiment, the participant had to correctly press the numbered button that corresponded with the numbered object on the screen. If the participant did not press the correct button, did not respond at all, or did not respond during the allotted time, the answer was marked as incorrect.

Reliability

Ten percent of the production data were examined by another examiner. A Kappa reliability test produced a k-value of 0.92. This reliability rating is according to the recorded productions produced by the participant.

Results

Table 2 and Table 3 summarize the results of the fast mapping tasks. A repeated-measures, mixed-factorial Multivariate analysis of variance (MANOVA) was used to assess
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between- and within-subject differences of the two dependent variables: production and comprehension scores of the fast mapping tasks. The between-group factor was experimental speech rehearsal conditions (C1, C2, and C3). The within-group factor was language conditions (English, Spanish, and Cantonese).

Production

The analysis showed that there were significant speech rehearsal condition effect, $F(2, 27) = 4.99, p < 0.05$; language effect, $F(2, 54) = 26.19, p < 0.001$; and Group × Condition interaction effect, $F(4, 54) = 2.68, p < 0.05$. Post hoc comparisons indicated that the fast mapping production scores for the speech training experimental group 1 (15 repetitions for each word) were not significantly different from the speech training experimental group 2 (5 repetitions) ($p = .64$), whereas the experimental group 1 outperformed the control group ($p < 0.05, d = 5.859$). Post hoc comparisons also indicated that fast mapping production scores in English and in Spanish were not significantly different for each other ($p = 1$) whereas the scores in English and in Spanish were greater than those in Cantonese (English vs. Cantonese, $p < .001$, Spanish vs. Cantonese, $p < .001$).

Comprehension

The analysis showed that there were no significant effects of speech rehearsal condition, language, or Group × Condition interaction effects. The findings indicate that fast mapping comprehension scores were not different across speech rehearsal conditions and language.

Discussion

The purpose of this study was to examine whether there are effects of word form rehearsal and language experience effect on fast mapping. The findings of the study are consistent with the findings in Kan and Sadagopan (2010). Results determined that an individual’s production skills are positively affected by both the amount of word-form rehearsal.
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Results also concluded that there was a language effect present, as participants performed better on the Spanish and English language conditions compared to the Cantonese condition.

*Word-Form Rehearsal*

Consistent with my hypothesis, there is a strong effect of word-form rehearsal on fast mapping skills. The comparison across the three speech training conditions showed that there was a significant effect on the level of speech training on the production scores of the fast mapping task. More specifically, the results showed that condition one (C1) word-form rehearsal participants outperformed participants in condition two (C2) and condition three (C3). The higher the level of word form rehearsal, the higher the fast mapping scores. Interestingly, the effect was only for production task—a task that is typically more challenging than comprehension task in previous studies (e.g., Gray, 2004). While the data showed a strong effect of the level of word-form rehearsal on fast mapping responses during the production portion of the task, there seemed to be no significant relationship between word-form rehearsal and the comprehension task.

Gathercole (2006) argues the effect of phonological storage as well as various processes on the ability to learn new words. Relating to the current study, phonological storage remained the same for both the production and comprehension portions of the fast mapping tasks. On the other hand, the way in which auditory, phonological, and speech-motor processes are used during these two tasks vary substantially. For both production and comprehension, auditory and phonological processing were identical. This means that during the word-form rehearsal, the participants’ heard and processed the same words as well as became familiar with the phonetic makeup of the nonwords. These two processes benefit the participants’ ability to reproduce and comprehend the nonwords. The speech-motor processing on the other hand only has a positive
effect on the production portion of the fast mapping task, not the comprehension portion. It is likely that word-form rehearsal allows the participant to train their articulators and muscles to produce these foreign sounds, but it does not train their brain to match the sound of the nonword to a picture of the nonword.

The results indicate that there is no real relationship between speech training conditions and comprehension fast mapping task scores. The characteristics of the word-form rehearsal clearly explain why the word-form rehearsal and the fast mapping production scores are positively correlated. It is vital to notice that word-form rehearsal (production) would boost production performance on the fast mapping task because of how the processes involved in word-form rehearsal relate to production skills. Word-form rehearsal involved establishing the speech-motor muscle movement of the words as well as the phonetic makeup of the word. It did not involve creating the link between how the word is heard and the visual stimuli off the nonword.

Language Effect

Consistent with the second hypothesis, the data proved that previous language experience affects fast mapping skills. The results showed that there was a language effect on fast mapping tasks. The findings are consistent with the findings in Kan and Sadagopan (2010). In Kan and Sadagopan (2010), a similar study was conducted testing the effects of language effect on fast mapping skills in monolingual individuals. Their results showed a significant English language learning effect, with participants scoring much higher on fast mapping tasks in English than in Spanish and Cantonese (Kan and Sadagopan 2010). Since monolingual English speakers were previously familiar only with English phonological system, it is expected they would score higher on the English tests.
REHEARSAL, LANGUAGE EXPERIENCE, AND FAST MAPPING

For the current study, the results show that there is a significant Spanish and English language learning effect. This means that because the participants were previously familiar and had mastered the phonological systems of both English and Spanish, they performed better on fast mapping tasks that involved those two languages. Because they were completely unfamiliar with the Cantonese language and its speech sounds, they performed much poorer on those tasks in both production and comprehension.

While these bilingual participants scored considerably higher on English and Spanish tasks, the control (C3) results reveal more information about the makeup of our bilingual participants as well as a more specific language learning effect. In regards to the data from the production portion of the fast mapping tasks, these participants scored noticeably higher on the Spanish tests than on the English tests (English: Mean = 3.8, SD = .79; Spanish: Mean = 5.6, SD = .86, p < .001, d = 0.74. Since condition three involves no word-form rehearsal, these participants performed the fast mapping tasks without any prior knowledge of the nonword sounds or composition. This means that they were not able to process the nonwords in their auditory system, phonological system, or speech-motor system prior to the initial presentation phase of the fast mapping task. Since the participants performed better on the Spanish tasks than English tasks, we could assume that these participants are more comfortable with Spanish than English. Data collected earlier in the experiment about the characteristics of the participants proves why these individuals scored higher on Spanish tasks without any speech training. Participants scored higher on the Woodcock-Muñoz Spanish picture vocabulary and analogy tests than on the English equivalents (p = 0.002). This result explains why the participants would score higher on the Spanish tasks without any prior speech training.
Gathercole (2006) argues that experienced second language learner master new words in a unique way. Rather than relying on the effectiveness of word-form repetition and consistent auditory, phonological, and speech-motor processing, second language learners instead capitalize on previous knowledge (e.g. semantic, conceptual, or phonological in form) in order to learn a new word. More specifically, this means that when an experienced second language learner hears a new word in a language they are familiar with, rather than trying to form a new phonological representation in their brain, they find the closest neighboring phonological representation and use that as the base for the new word. She argues that this process and the overall process of learning new words are easier for individuals with stronger lexicons in their various languages.

Gathercole’s argument proves true in relation to the current study. There is a significant language experience effect, proving that participants performed much better on fast mapping tasks that involved languages they had prior experience with, compared to a language they had no prior experience with.

The overall results of this study prove that repetition as well as language knowledge and history combine to facilitate an individual’s ability to fast map a novel nonword. Clinically, since Spanish is becoming more widely-used, becoming more familiar with bilinguals and the way in which they learn new words might be beneficial to speech language pathologists. Since modeling and repetition are already successful and common therapy techniques, learning how to apply these techniques to an individual who has developed phonological processing, auditory processing, and speech-motor processing in more than one language is vital to the individual’s therapy process.

**Study Limitations**

As discussed earlier, the challenges associated with defining a bilingual person can lead to a very broad definition and demographic. If possible, controlling for specific variables that
REHEARSAL, LANGUAGE EXPERIENCE, AND FAST MAPPING

affect bilingual’s language use and experience (e.g, time to learn two languages, i.e. sequential, simultaneous; current language proficiency in both languages) as well as focusing on a more specific age group could potentially lead to more specific results. Also, controlling for socioeconomic status (SES) could be very interesting. SES pertains not only to income, but also an individual’s education, locale, and ethnicity, which are all contributing factors to language development and disorders. Finally, rather than using nouns as done in this study, testing individuals using novel adjectives or verbs could be extremely insightful. Since adjectives and verbs typically follow specific patterns in the English language, previous language experience might play a greater role in fast-mapping skills than it did when using just nouns.

Further Research Suggestions

This study primarily focused on the immediate production and comprehension of nonwords after a short word-form rehearsal task. It tested only an individual’s short term retrieval skills, not their long term retention abilities. It would be interesting to look at the effect of both word-form rehearsal and language experience on an individual’s fast mapping retention abilities. For example, rather than just testing the immediate retrieval skills of the individual, it would be interesting to see how well the participant could not only produce and comprehend the nonword, but how well they could distinguish a previously learned nonword from a new nonword.

Another possible research experiment might be to present the speech training in a different fashion. Rather than a computer aurally presenting the novel nonwords, participants may respond differently to words presented aurally via a human proctor.

Finally, analyzing children could provide interesting insight into the way in which a child learns new words as well as the child’s phonological, auditory, and speech-motor processes. Rather than looking at a language system that is mostly developed, studying two language
systems that are still developing could show how a child inputs, processes, and stores different stimuli from two different phonetic systems.


REHEARSAL, LANGUAGE EXPERIENCE, AND FAST MAPPING


Table 1: Participant Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Experimental Group 1</th>
<th></th>
<th>Experimental Group 2</th>
<th></th>
<th>Control Group</th>
<th></th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Age</td>
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<td>2.951</td>
<td>22.44</td>
<td>2.506</td>
<td>24.09</td>
<td>3.33</td>
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<tr>
<td>Y.E.</td>
<td>15.9</td>
<td>2.675</td>
<td>13.33</td>
<td>6.727</td>
<td>17.91</td>
<td>3.33</td>
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<tr>
<td>Y.E.E.</td>
<td>14.8</td>
<td>4.204</td>
<td>13.89</td>
<td>5.776</td>
<td>13.86</td>
<td>5.119</td>
</tr>
<tr>
<td>TONI-S</td>
<td>102.3</td>
<td>13.712</td>
<td>94.56</td>
<td>8.187</td>
<td>100.91</td>
<td>10.597</td>
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<tr>
<td>WM_E_1</td>
<td>44.8</td>
<td>5.029</td>
<td>42.11</td>
<td>3.983</td>
<td>43.09</td>
<td>4.657</td>
</tr>
<tr>
<td>WM_E_2</td>
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<td>28.56</td>
<td>3.575</td>
<td>27.09</td>
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<tr>
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<td>4.766</td>
<td>41.67</td>
<td>7.55</td>
<td>44.18</td>
<td>2.892</td>
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<tr>
<td>WM_S_2</td>
<td>33.56</td>
<td>2.833</td>
<td>28.67</td>
<td>4.387</td>
<td>29.82</td>
<td>7.872</td>
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### Table 2: Fast Mapping Production Scores and Standard Deviation

<table>
<thead>
<tr>
<th>Condition</th>
<th>English Group</th>
<th>Spanish Group</th>
<th>Cantonese Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Condition One</td>
<td>8.90</td>
<td>2.601</td>
<td>8.10</td>
</tr>
<tr>
<td>Condition Two</td>
<td>7.20</td>
<td>2.044</td>
<td>7.20</td>
</tr>
<tr>
<td>Condition Three</td>
<td>3.80</td>
<td>2.486</td>
<td>5.60</td>
</tr>
</tbody>
</table>
Table 3: Fast Mapping Comprehension Scores and Standard Errors

<table>
<thead>
<tr>
<th></th>
<th>English Group</th>
<th></th>
<th>Spanish Group</th>
<th></th>
<th>Cantonese Group</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Condition Two</td>
<td>13.50</td>
<td>3.274</td>
<td>13.00</td>
<td>2.539</td>
<td>12.10</td>
<td>3.604</td>
</tr>
<tr>
<td>Condition Three</td>
<td>10.60</td>
<td>3.806</td>
<td>11.60</td>
<td>2.547</td>
<td>10.20</td>
<td>4.709</td>
</tr>
</tbody>
</table>
REHEARSAL, LANGUAGE EXPERIENCE, AND FAST MAPPING

Figure 1: Production Language-Condition Comparison

![Production Language-Condition Comparison](chart.png)
Figure 2: Comprehension Language-Condition Comparison

Comprehension

- Condition One
- Condition Two
- Condition Three

Languages:
- English
- Spanish
- Cantonese
### Appendices

#### Appendix A: Phonetic Transcription of Nonwords

<table>
<thead>
<tr>
<th>English</th>
<th>IPA</th>
<th>Spanish</th>
<th>IPA</th>
<th>Cantonese</th>
<th>IPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 baysloop</td>
<td>/bæslup/</td>
<td>famo</td>
<td>/famo/</td>
<td>feoi tsim</td>
<td>/fœi2 tśim5/</td>
</tr>
<tr>
<td>2 cayskuz</td>
<td>/keɪskʌz/</td>
<td>gaji</td>
<td>/ɣagi/</td>
<td>gat pib</td>
<td>/ɡɛt3 pɪb 6/</td>
</tr>
<tr>
<td>3 thaperthow</td>
<td>/θæpərθʌw/</td>
<td>dajofi</td>
<td>dajofɪ</td>
<td>ngaat pam koi</td>
<td>/ɲɛt6 pem1 kʰoɪ1/</td>
</tr>
<tr>
<td>4 fuchasaib</td>
<td>/fʊʃəsæɪb/</td>
<td>sajelu</td>
<td>sajelʊ</td>
<td>koi him daau</td>
<td>/kʰoɪ1 hɪm3 deʊ2/</td>
</tr>
<tr>
<td>5 beemaz</td>
<td>/bɪmæz/</td>
<td>chani</td>
<td>/tʃəni/</td>
<td>doe ngaan</td>
<td>/doe1 ɲən1/</td>
</tr>
<tr>
<td>6 gaushoop</td>
<td>/ɡəʊʃʌp/</td>
<td>chube</td>
<td>/tʃʊbe/</td>
<td>paa taw</td>
<td>/pɛt3 wʌu3/</td>
</tr>
<tr>
<td>7 moyvaysav</td>
<td>/mɔɪvɛseɪv/</td>
<td>bifupa</td>
<td>/bɪfʊpa/</td>
<td>goi tsei moí</td>
<td>/ɡɔi3 tse1 mɔi2/</td>
</tr>
<tr>
<td>8 daspowpud</td>
<td>/dæspɔwpʌd/</td>
<td>purobi</td>
<td>/pʊrobi/</td>
<td>fou tsim kap</td>
<td>/fʊu1 tśim3 kɛp3/</td>
</tr>
<tr>
<td>9 liteev</td>
<td>/lɪtɪv/</td>
<td>muja</td>
<td>/mʊxa/</td>
<td>kok be</td>
<td>/kɔk3 be3/</td>
</tr>
<tr>
<td>10 vaypem</td>
<td>/veɪpɛm/</td>
<td>najo</td>
<td>/ɲəxo/</td>
<td>wang shyun</td>
<td>/weɲ1 tsʰyɲ1/</td>
</tr>
<tr>
<td>11 bagozaip</td>
<td>/bəɡɒzʌip/</td>
<td>mochafe</td>
<td>/mɔtʃafə/</td>
<td>bou moe faam</td>
<td>/bou1 moe1 fem3/</td>
</tr>
<tr>
<td>12 fraydofreeb</td>
<td>/fɛɪdʊʃfɹɪb/</td>
<td>pichube</td>
<td>/pɪtʃʊbe/</td>
<td>faat myu tshaap</td>
<td>/fɛt1 myʊ1 tsʰɛp1/</td>
</tr>
<tr>
<td>13 moobaive</td>
<td>/mʊbəɪv/</td>
<td>feju</td>
<td>/fɛju/</td>
<td>sip bim</td>
<td>/sɪp1 bɪm3/</td>
</tr>
<tr>
<td>14 pergob</td>
<td>/pɛrɡɔb/</td>
<td>pemi</td>
<td>/pɛmi/</td>
<td>poi tshui</td>
<td>/pɔi3 tsʰui3/</td>
</tr>
<tr>
<td>15 thazeblint</td>
<td>/θæzəblɪnt/</td>
<td>goruda</td>
<td>gorʊda</td>
<td>bou fau hak</td>
<td>/bou3 faʊ3 hɑk3/</td>
</tr>
<tr>
<td>16 sapperwike</td>
<td>/sæpərwɪk/</td>
<td>fonute</td>
<td>fonʊtə</td>
<td>mik ngei fip</td>
<td>/mɪk3 nɛi1 fɪp1/</td>
</tr>
</tbody>
</table>

**Note.**

Each syllable of the novel words in Cantonese carries a lexical tone. The number immediately after each syllable of each word is the tonal marker: 1 † High Level tone  2 † Low-Mid to High-Rising  3 † Mid Level  4 † Low-Mid to Low Falling  5 † Low to Low-Mid Rising  6 † Low-Mid Level.
Appendix B: Visual Stimuli