2012-01-01

Implicit and Explicit Memory Performance in Bilinguals: Implications for Transfer-Appropriate Processing and Vocabulary Learning

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IMPLICIT AND EXPLICIT MEMORY PERFORMANCE IN BILINGUALS: IMPLICATIONS FOR TRANSFER-APPROPRIATE PROCESSING AND VOCABULARY LEARNING

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Dedication

To my loving husband, Beto, for caring about my research as much as I do, for listening to my thesis ten thousand times, and for pushing me forward in every sense. To my mother, you are my inspiration and my strength! To my beautiful son Lucca for giving my life a whole new meaning. Last but certainly not least, to my advisor, mentor, and friend, Wendy, for your endless academic, professional, and personal support!

IMPLICIT AND EXPLICIT MEMORY PERFORMANCE IN BILINGUALS:

IMPLICATIONS FOR TRANSFER-APPROPRIATE PROCESSING AND

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by

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THESIS

Presented to the Faculty of the Graduate School of

The University of Texas at El Paso

in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF ARTS

Department of Psychology

THE UNIVERSITY OF TEXAS AT EL PASO

May 2012

Acknowledgements

I would like to thank Iris Perea for her hard work during data collection and data processing.

Abstract

Two experiments examined whether translation and sentence context improved memory performance in explicit and implicit memory. For explicit memory, an effect of translation was found such that translation led to better item recognition than read aloud encoding. Sentence context did not benefit recognition memory performance. For implicit memory, neither translation nor sentence context led to priming in a word-stem completion paradigm. The results are discussed in terms of the transfer-appropriate processing framework.

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Chapter 1: Introduction

The fact that a bilingual continuously activates both languages during processing raises the question of whether how information is encoded depends on whether it is encountered in a language-specific manner (e.g., reading) as opposed to a cross-linguistic manner (e.g., translating). Little is known about which of these types of encoding leads to the retention of more information. Similarly, information is often encountered in a meaningful context. However, the effects of context have not been extensively studied with respect to episodic retrieval of words in bilinguals.

Particularly for words, it is important to consider that information can be accessed in different ways. One way in which words can be accessed is through conscious explicit retrieval, another way in which words can be accessed is through subconscious implicit retrieval. When examining how bilinguals retrieve words, it is important to consider these two types of mental access to stored information. Similarly, words have different representations in the mind; one of the ways words vary in terms of how they are represented in the mind is word frequency. Typically, words that are higher in frequency have increased mental representations than low frequency words. Higher frequency words are used more often and have multiple representations and low frequency words are very distinct in the mind (Diana & Reder, 2006). Additionally, when words are produced or spoken aloud, additional processes come online that make words more easily accessible later on (Gardiner, Gregg, & Hampton, 1988). The ways in which access to words varies is important to consider when investigating how these processes work in synchrony to impact performance.

The effects of encoding task on retrieval method are important to our understanding of the processes that are recruited during different study episodes. Access to words in memory for instance can be accomplished in a number of ways, however by testing different retrieval methods, one can determine whether the encoding episode led to the recruitment of the mental

processes that are advantageous for retrieval. A useful framework that tests the degree to which study and test episodes match in terms of processing demands is the transfer-appropriate processing (TAP) framework. The TAP framework suggests that the more study and test episodes match in terms of processing requirements, the more transfer of information will be observed from study to test (Morris, Bransford & Franks, 1977). This framework is particularly useful for testing bilingual phenomena because one can hypothesize about the processes a bilingual recruits during encoding and directly test those predictions by creating a test that taps directly into those processes. The experiments here will make use of the TAP framework to make predictions about which types of encoding episodes will lead to better memory performance.

This study investigates whether bilingual translation recruits additional processes that lead to improved retrieval and whether sentence context buffers or amplifies those effects. Further, this study will test aspects of explicit and implicit memory to address whether these effects are stable across conscious and unconscious recollection. The following sections will provide a broad overview of explicit and implicit memory as well as the tasks that will be employed in this study. Established word-frequency and generation effects found in the literature for explicit and implicit tasks will be discussed. Furthermore, an overview of the transfer-appropriate processing framework will be provided as it pertains to this study. The present study will be discussed in terms of memory performance considering established transfer-appropriate processing and bilingual effects in the literature.

1.1   Explicit and Implicit Memory

Explicit memory involves conscious recollection of previously learned information. In contrast, implicit memory has been conceptualized as the unintentional influence of prior learning on cognitive performance. Engaging in elaborative processing, or processing with greater processing demands improves performance on explicit memory tasks, for example recalling specific information from encoding to test (Craik & Tulving, 1975). However,

elaborative processing does not improve recall performance on implicit memory tasks and is therefore viewed as being distinct from explicit memory (Roediger, Weldon, Stadler, & Riegler, 1992). However, meta-analyses show implicit memory does benefit to a certain extent from conceptual processing at encoding (Brown & Mitchell, 1994).

A test routinely used to measure explicit memory performance is recognition memory. In a typical recognition memory test participants are asked to discriminate between items previously studied (old items) and items not previously studied (new items). Recognition memory involves an assessment of familiarity between an item presented at test, and items presented at study (Mecklinger, 2000). This type of test is particularly sensitive to processing at encoding; participants who elaborate more on a specific item have an increased chance of recognizing that item at test (Mecklinger, 2000). This effect is particularly strong for encoding of words; participants who elaborate on stimuli (e.g., semantically related items), recognize the same items more accurately at test (Craik & Tulving, 1975; Rose, Myerson, Roediger, & Hale, 2010). Furthermore, recognition memory is sensitive to sentence context. Words encoded in particular adjective pairings, surrounded by particular semantic information, or embedded in semantically-biased contexts are recognized more accurately at test when they are surrounded by that same information at test (Light & Carter-Sobell, 1970).

A test routinely used to measure implicit memory performance is word-stem completion. In a word-stem completion paradigm participants are provided the first letters of a studied item (e.g., *app-* for apple) and asked to come up with the first word that comes to mind based on the stem. There is evidence that word-stem completion taps specifically into implicit memory, for example, amnesic patients, who typically have spared implicit memory, show normal performance on word-stem and word-fragment completion tasks (Cermak, Talbot, Chandler & Wolbarst, 1985; Graf & Schacter, 1985).

Word-stem completion was previously thought to benefit only from perceptual processing at encoding (McDermott, 1997). Nonetheless, a meta-analysis of semantic (conceptual) and non-semantic (perceptual) encoding reveals that semantic encoding leads to

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significantly greater priming at test regardless of whether the test is thought to represent perceptual or conceptual priming (Brown & Mitchell, 1994). Word-fragment completion is thought to rely upon lexical-level or perceptual information as well as conceptual information (Smith, 1991).

Studies examining the effects of sentence context on word-stem and word-fragment completion have found more priming for words embedded in sentence contexts where there are no distinctive features surrounding the target word and participants are given implicit retrieval instructions (Burt, Connors, & Taylor, 2003). However, distinctiveness (e.g., different font color for target items) is advantageous for explicit retrieval instructions, that is, when participants are explicitly told to remember the study phase when providing completions for word stems (Burt, Connors, & Taylor, 2003). Nonetheless, priming is stronger for words in isolation than for words in sentence context (Bassili, Smith & MacLeod, 1989; MacLeod, 1989; Smith, 1991). The findings for word-stem and word-fragment completion suggest that sentence context might be advantageous for stem completion despite more priming being observed for words in isolation.

The studies here will directly test different types of encoding tasks and the degree to which they benefit explicit performance (recognition memory) and implicit performance (word-stem completion). In order to fully understand how the different encoding conditions impact performance, specific word characteristics such as word-frequency must be considered. The following section will consider the effects of word frequency on memory performance.

1.2   Effects of Word Frequency on Memory Performance

Word frequency refers to the relative frequency with which a word is produced in the language. Word frequency has an effect on both explicit and implicit (direct and indirect) tests of memory (MacLeod & Kampe, 1996). For recognition memory, a direct, explicit test of memory, low frequency words are recognized more accurately than high frequency words (Diana & Reder, 2006; MacLeod & Kampe, 1996). It is hypothesized that the distinctiveness of the low frequency word makes it more accessible for a studied/not studied recognition decision at test

(Diana & Reder, 2006; Francis & Strobach, 2010). On indirect, implicit tests of memory, performance depends on the type of test; data from lexical decision paradigms, for example, show a reaction time advantage for high frequency words; however, lexical-decision priming is greater for low-frequency words (Ducheck & Neely, 1989; Forster & Davis, 1984). Likewise, data from word-fragment and word-stem completion paradigms show a priming advantage for low frequency words (MacLeod, 1989; MacLeod & Kampe, 1996).

The present study hypothesizes that low frequency words will be recognized more accurately and display increased priming in recognition memory and word-stem completion respectively. Moreover, the effects of encoding, specifically translation and context, are hypothesized to make target words distinctive enough to improve memory performance. In addition to word frequency, producing items aloud has been shown to improve performance over reading items silently. The present study will make use of such a production effect. The following section details the advantages of overt production over silent reading.

1.3   Generation Effects and Memory Performance

Generating words at study produces better explicit memory performance at test than reading words; this effect is known as a *generation effect*. The generation effect is explained by the fact that stronger memory traces are formed for words that are generated as opposed to words read silently (Gardiner, Gregg, & Hampton, 1988). Further, both high and low frequency words benefit from being generated at study. In word-fragment completion, generation effects are also observed, with greater priming in words that are generated than in words that are merely read (Gardiner, 1988). Generation effects are also found using bilingual materials, translated words lead to better recall, higher recognition accuracy, and more word fragments completed when compared to words that are read aloud (Basden, Bonilla-Meeks, & Basden, 1994; Durgunoglu & Roediger, 1987). All items in the present study will be either read aloud or translated aloud since generating items improves performance for both implicit and explicit memory and for both high and low frequency words.

In order to bridge together the different word-level effects the present studies will be conducted within the scope of the TAP framework. Using the TAP framework will allow the combination of different variables in order to generate hypotheses regarding what processing demands are recruited at encoding, and whether those processes are useful for recognition and word-stem completion. The following section is a broad overview of the TAP framework and the present studies.

1.4   Transfer-Appropriate Processing

According to the transfer-appropriate processing framework, the degree of overlap between cognitive processes recruited at encoding and test will determine the speed and accuracy with which a test task is performed (Morris, Bransford & Franks, 1977). The transfer-appropriate processing framework has been widely used to study dissociations in memory processes (e.g., Jacoby & Dallas, 1981), in verbal learning (e.g., Leboe, Whittlesea, & Milliken, 2005), in the isolation of component processes (e.g., Francis, Corral, Jones, & Saenz, 2008), and in the determination of educational interventions (e.g., Barnett, Di Vesta, & Rogozinski, 1981).

Particular interest has been paid to the dissociative effects between explicit and implicit memory performance when comparing test tasks. Deep encoding (e.g., elaboration) leads to better explicit memory performance (e.g., recognition memory) whereas shallow encoding (e.g., counting word letters) leads to better implicit memory performance (e.g., word fragment completion) creating a performance dissociation between implicit and explicit memory (Jacoby & Dallas, 1981; but see Brown & Mitchell, 1994). According to the TAP framework these dissociations in performance occur because the processes recruited at encoding match those at retrieval, thus creating these dissociations (Roediger, 1990). Furthermore, the transfer-appropriate processing framework has been used to study verbal learning; successful learning of words depends on how well the study and test episodes match. For example, if words studied are orthographically similar, or a certain font color, they must be presented in the same manner at test in order to observe maximum verbal learning (Leboe et al., 2005). However, it has been

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found that both explicit and implicit memory systems benefit significantly from elaboration at encoding (Brown & Mitchell, 1994).

The TAP framework provides a useful testing mechanism to examine bilingual phenomena as well as educational interventions. For example, the application of this framework reveals that bilingual picture naming has two component processes: object identification and word production (Francis et. al., 2008). Educational interventions have also been studied under the transfer-appropriate processing framework; for instance, researchers have investigated the degree to which note-taking processes match test-taking processes and found that free note-taking yielded more remembering of critical information (Barnett, Di Vesta, & Rogozinski, 1981).

The transfer-appropriate framework provides a unique opportunity to analyze, decompose, dissociate, and examine diverse aspects of learning. In the proposed study, the TAP framework will provide a testing paradigm for various types of encoding as well as to examine the degree to which translation and sentence contexts produce transfer of information from encoding to test in explicit and implicit memory.

1.5 The Present Study

1.5.1 Bilingualism and Translation

Research regarding bilingual translation has focused on how a bilingual's languages interact when translating words. Translation is faster and more accurate when translating from the non-dominant language (L2) to the dominant language (L1) (Kroll & Stewart, 1994). The benefit in speed and accuracy in translation from L2 to L1 is observed because there are strong lexical links connecting L2-L1 words; whereas strong conceptual links connect L1 words and their concepts (Sholl, Sankaranarayanan, & Kroll, 1995). Nonetheless, recent research has shown that translation from L2-L1 becomes concept mediated in early bilinguals who have extensive experience with both languages (Francis, Augustini & Saenz, 2003). Additionally, although L1-L2 translation is concept mediated and L2-L1 translation is lexically mediated in less fluent

bilinguals, fluent bilinguals are flexible in utilizing these processes depending on the processes recruited at task (Hatzidaki and Pothos, 2006). Concept mediation, accessing conceptual representations of words during processing, is important to the present studies because translation is hypothesized to lead to better performance in explicit and implicit memory due to the fact that bilinguals have to access conceptual information during translation and conceptual access will lead to improved performance. Another way in which conceptual information can be brought online is by presenting it in a sentence context, the following section will detail important sentence context findings relevant to the present studies.

1.5.2   Bilingualism and Sentence Context

Experiments that incorporate sentence context provide useful information about how readers access and understand language. Two major hypotheses regarding monolingual sentence processing aim to explain the processes that take place during sentence comprehension. One hypothesis assumes sentence context, or the information contained in a sentence, does not play a significant role in accessing word-level features and properties of individual words (Swinney, 1979). The second hypothesis assumes that the sentence context directly interacts with how individual words are processed (Stanovich & West, 1983). The experiments here do not directly test whether sentence processing involves access to word-level features or sentence meaning. Instead, assuming that sentence processing requires some level of individual word processing, the experiments here predict that sentences provide additional processing resources that are unavailable in single-word presentation formats.

The general consensus in the bilingual literature is that language lexical access is language non-selective. One of the major sources of evidence of language non-selectivity is the cognate facilitation effect, where cognates (words that share form and meaning across languages) are recognized faster and more accurately than non-cognate controls (e.g., Dijkstra, Grainger & van Heuven, 1999; Lemhöfer & Dijkstra, 2004, Van Hell & de Groot, 1998). Given that a bilingual's two languages are co-activated during processing, the current study seeks to examine

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how the intentional activation of a second language through translation changes the recruitment of resources necessary for word recognition and word-stem completion.

However, only recently has the nature of bilingual language activation been studied in sentence context. Specifically, high constraint sentences attenuate, but do not eliminate, cross-language activation (e.g., Duyck, Assche, Drieghe, & Hartsuiker, 2007; Schwartz & Kroll, 2006; Van Hell, 2005). Thus, sentence context reduces the degree to which bilinguals experience cross-linguistic competition. Given that sentence context reduces some of the cross-linguistic activation that occurs during bilingual processing, the current study seeks to examine whether this reduction in activation leads to better performance in word recognition and word-stem completion.

Knowledge of a second language affects bilingual access to words. Specifically, both languages are activated during processing. Sentence context alleviates some of the cross-linguistic competition that arises when processing words. The present studies make use of sentence context as a conceptual processing mechanism that allows for the processing of target words with cross-language interference reduction. Memory performance is impacted both from isolated word and sentence context encoding. The following section will provide an overview of relevant bilingual memory findings.

1.5.3 Bilingualism and Memory

The present study is an investigation into the degree to which cross-linguistic or language-specific information increases transfer of information in two memory tasks. The following effects in bilingual memory highlight important findings that directly relate to the present study. In recognition memory, bilinguals are able to adapt to task demands, for example from semantic to language-specific demands, in order to more accurately recognize words (Kintsch, 1970). Moreover, with respect to word frequency, bilinguals recognize low frequency words more accurately than high frequency words (Francis & Strobach, 2010). A similar effect is observed if those words are presented in a bilingual's non-dominant language, which suggests

that L2 words behave as low frequency L1 words (Francis & Strobach, 2010). The bilingual results thus replicate the frequency effect found in the literature with monolingual participants and further show that this effect is found across languages. Cross-linguistic encoding by translation and reading a word in two-languages has been compared single-language encoding by reading words in a single language, translated items and items read in two languages produce better recognition performance than items read in a single language (Durgunoglu & Roediger, 1987).

In word-stem completion, studied items produce priming across languages when words are studied in sentence context (Smith, 1991), suggesting that if a word is studied in a sentence in the L1, priming occurs for the L2 word as well. These findings are not observed for words in isolation. It is theorized that the lexical properties of words are separate for a bilingual's languages and thus words studied in isolation do not show significant priming (Smith, 1991). However, words encountered in sentence context provide a semantic representation which is then subject to cross-language priming (Smith, 1991). Word translation encoding has been compared to reading words as an encoding mechanism and it was found that for word-fragment completion, translation did not lead to significantly more priming (Durgunoglu & Roediger, 1987). However, some studies show that mental or written translation leads to more priming in word-fragment completion as compared to words that are read (Basden, Bonilla-Meeks & Basden, 1994). The findings both for recognition memory and for word-stem completion demonstrate that languages are not independent. The present study examines whether translation recruits additional processing resources that would be beneficial in explicit and implicit performance. From both a theoretical and applied perspective, investigating whether translation aids processing is important to our understanding of the bilingual mind.

The present study examines the extent to which cross-language processing of materials modulates the degree of transfer in explicit and implicit memory performance. Specifically, I investigated the relationship between translation and read-aloud production on performance on implicit and explicit tasks. Additionally, I investigated whether sentence context increases

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transfer of information from encoding to test. For this purpose, participants were presented with two experimental conditions, translation of words and sentences and reading words and sentences aloud.

Chapter 2: Experiment 1

Participants were tested on explicit memory performance using a recognition memory task. Participants were asked to study target words either in isolation or in sentence context. Additionally, half of the words presented in each condition were read aloud and half were translated. It was hypothesized that words encoded by translation would be recognized more accurately and faster than words encoded by reading aloud. Further, a main effect of sentence context was expected such that words embedded in sentence contexts at encoding would be recognized more accurately and faster than words encoded in isolation. Finally, we predicted that low frequency words would be recognized more accurately and faster overall.

2.1   Method

2.1.1   Participants

Thirty-two Spanish-English bilingual participants were recruited from the participant pool of the Department of Psychology at the University of Texas at El Paso in exchange for course credit. Participants' average age was 19.9 years, ranging from 17-35 years. Participants reported learning Spanish prior to English. Participants' language data is summarized in Table 1.

2.1.2   Materials

Language Background Questionnaire

Participants completed a language questionnaire to assess their usage of English and Spanish. Summary data is provided in Table 1.

Woodcock-Muñoz Language Survey Revised (WMLS-R NU)

The Woodcock-Muñoz Language Survey-Revised (Woodcock, Muñoz-Sandoval, Ruef, & Alvarado, 2005) standardized language assessment package includes both a long and short version that determines a participant's fluency in both languages. Test 1 (picture naming) was administered to determine whether English or Spanish was the dominant language for each

participant. Scores were obtained for age equivalency in each language and are presented in Table 1.

Table 1: Self-Reported and Standardized Language Proficiency Scores

Language Background Data

	Experiment 1			Experiment 2		
	English	Spanish		English	Spanish	
Age of Acquisition	2-17[1]	0-7		3-12	0-7	
	English	Spanish	Mix	English	Spanish	Mix
% Use of Language	48.21	46.87	12.87	54.37	32.43	12.56

Woodcock-Muñoz Language Survey-Revised Picture Naming Age Equivalency (WMLS-R)

	Experiment 1		Experiment 2	
	English	Spanish	English	Spanish
AE English	12.43	12.42	13.08	11.68

Word Stimuli

A set of 192 nouns was extracted from the Kucera and Francis (1967) database. In order to be part of the stimuli, words were at least 4 letters in length, non-identical cognates, and had clear, non-ambiguous Spanish translations. Words could not be identical cognates due to the fact that participants were asked to access concepts and lexical properties of words in both languages; identical cognates might show facilitated translation. Words with a frequency of 80+ words per million (wpm) were classified as high frequency words, and words with a frequency of less than 10 wpm were classified as low frequency words. Frequency of the Spanish translation

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[1] Age of acquisition presented in range, all but 1 participant in experiment 1 reported Spanish to be their native language. For experiment 2, all but 3 participants reported Spanish to be their native language.

equivalent was assessed using the frequency norms in Alameda & Cuetos (1995); words had to meet the same frequency criteria as in English. Simple sentences ranging from 5-9 words in length were created for each word. Target words appeared in the subject position 36.4% of the time, in the direct object position, 51.5% of the time, and in the indirect object position 11.9% of the time. The target word was always the main focus of the sentence as seen in the examples below, the target word is underlined for illustration; words were not made salient during the experiment. The letter in parenthesis indicates whether the target word was a high or low frequency word.

> (H) The _company_ fired the employees.
>
> (H) The _king_ ruled for forty years.
>
> (L) The _mermaid_ sings beautifully.
>
> (L) The girl's team won the _trophy._

Words were randomly assigned to 8 lists of 24, with 12 high-frequency and 12 low-frequency words in each list. Half of the lists were assigned to be foil items at test. The other half of the lists were assigned to word reading, sentence reading, word translation, and sentence translation conditions. Assignment of lists to conditions and target/foil status was counterbalanced. Participants were randomly assigned to the resulting forms, such that every word appeared in every condition equally often across participants.

2.1.3 Design

The independent variables form a 2 (encoding task) X 2 (encoding context) X 2 (word frequency) within-subjects design. The encoding task was either reading aloud or translation aloud, and the encoding context was either isolated or sentence context. Half of the words were high frequency and half low frequency. The dependent variables are hit rates, false alarm rates, discrimination scores, and response times.

2.1.4 Procedure

Participants were greeted upon entering the lab and given a consent form explaining the nature of the research. Upon completion of the consent form, participants were given a language background questionnaire, which they completed in pen/paper format. Participants were then escorted to an experiment room, given instructions, and asked to complete the experimental task. Participants saw counterbalanced blocks of words presented either in sentence context or in isolation. Additionally, participants were counterbalanced with respect to the order of the encoding tasks: isolated word translation, isolated word read-aloud, sentence translation, and sentence read-aloud. Participants saw 24 trials per block, with 4 blocks (translate word, read word, translate sentence, read sentence) total. The order of the 4 encoding tasks was counterbalanced using Latin square. Participants were tested using a yes/no recognition test. Participants were asked to decide if the item on the screen was an item they studied either in isolation or sentence context regardless of whether it was read aloud or translated. After completing the experimental task, participants performed test 1 of the Woodcock-Muñoz Language Survey Revised. Finally participants were fully debriefed.

2.1.5 Apparatus

Experiment 1 was displayed on an iMac desktop computer with a 17" screen and presented using PsyScope X experiment design software.

2.2 Results

Hit Rates and False Alarm Rates. A 2 (encoding task) X 2 (encoding context) X 2 (word frequency) within-subjects analysis of variance was performed on hit rates (see Figure 1). A main effect of encoding condition was observed $F(1, 31) = 162.05$, $MSE = .014$, $p < .001$, such that translated words were recognized more accurately than words read aloud. A main effect of context was observed $F(1, 31) = 106.831$, $MSE = .017$, $p < .001$, such that words in isolation were recognized more accurately than words in sentence context. A main effect of frequency was observed $F(1, 31) = 44.63$, $MSE = .027$, $p < .001$) such that low frequency words were

recognized more accurately than high frequency words. An interaction between context and frequency was observed $F(1, 31) = 16.58$, $MSE = .010$, $p < .001$), such that there was a greater disadvantage for high frequency words in the sentence context conditions than in the isolated word conditions. A paired-samples t-test was performed on false alarms (see figure 2) $t(31) = 4.992$, $p < .001$, such that low frequency words had a lower false alarm rate than high frequency words. No other interactions were observed, all ps $> .05$.
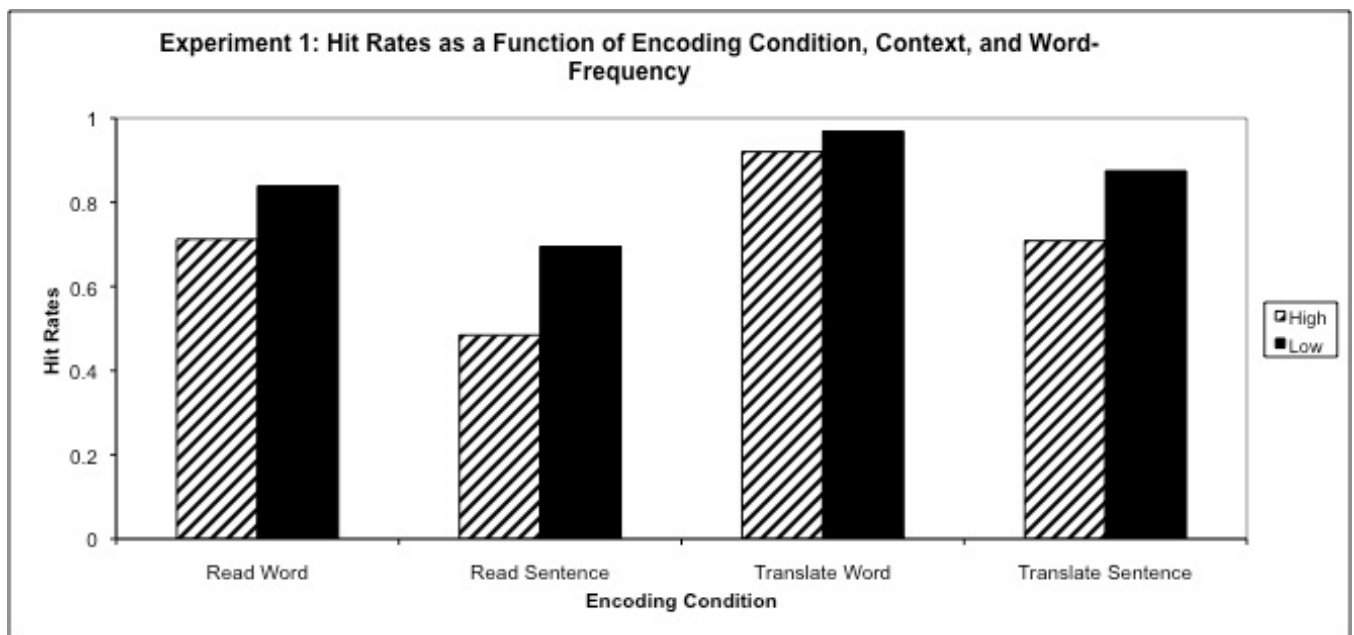

Figure 1: Experiment 1 Hit Rates as a Function of Encoding Condition, Context, and Word-Frequency
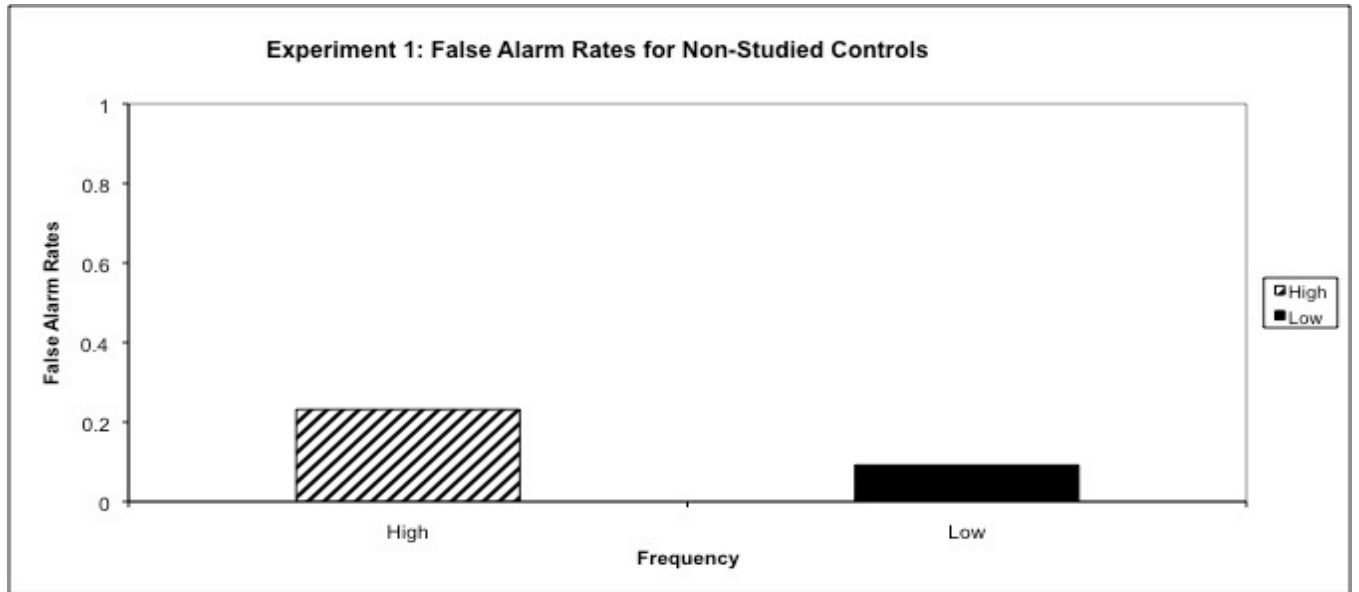
Experiment 1: False Alarm Rates for Non-Studied Controls

Figure 2: Experiment 1 False Alarm Rates for Non-Studied Controls

Discrimination. The detection statistic d' was calculated for each participant. A 2 (encoding task) X 2 (encoding context) X 2 (word frequency) within-subjects analysis of variance was performed on discrimination scores (see Figure 3). A main effect of encoding condition was observed $F(1, 31) = 150.99$, $MSE = .283$, $p < .001$) such that translated words had higher discrimination scores than words read aloud. A main effect of context was observed $F(1, 31) = 134.83$, $MSE = .293$, $p < .001$, such that words in isolation had higher discrimination scores than words in sentence context. A main effect of frequency was observed $F(1, 31) = 50.45$, $MSE = 1.81$, $p < .001$) such that low frequency words had higher discrimination scores than high frequency words. A marginal interaction between context and frequency was observed $F(1, 31) = 4.11$, $MSE = .194$, $p < .051$), such that lower discrimination scores were observed for high frequency words in the sentence context conditions. No other interactions were observed, all $ps > .05$.
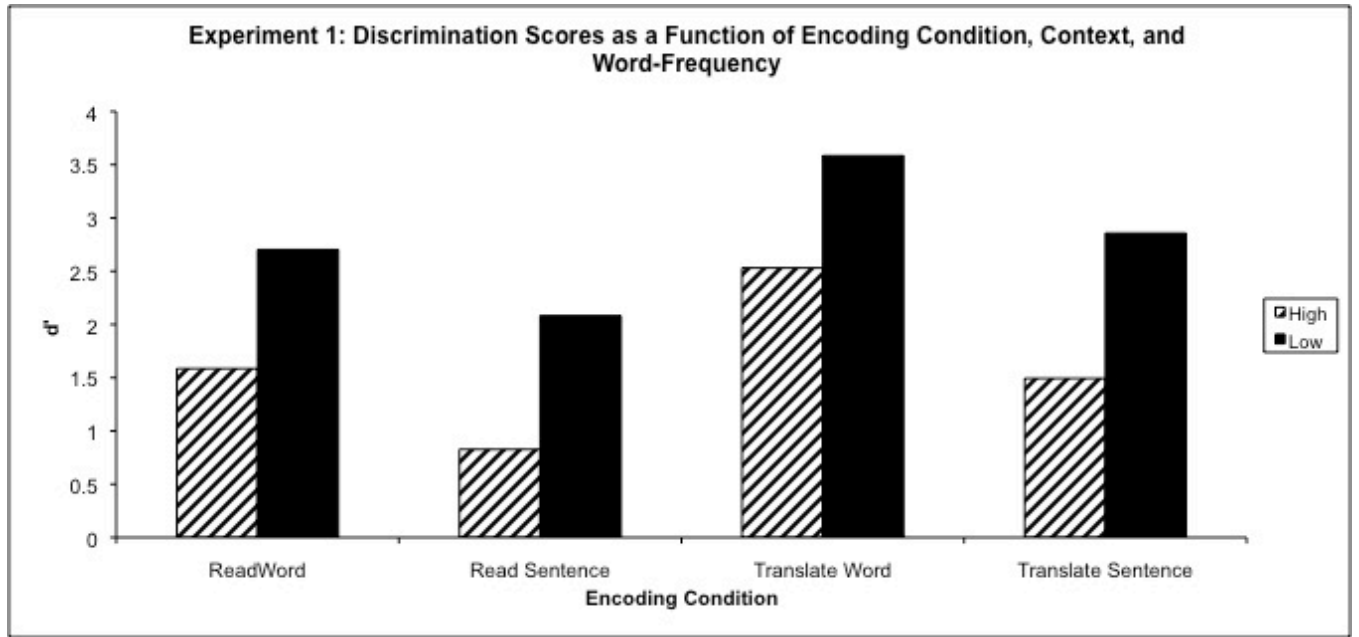
Figure 3: Experiment 1 Discrimination Scores as a Function of Encoding Condition, Context, and Word-Frequency

Response Times. Finally, a 2 (encoding task) X 2 (encoding context) X 2 (word frequency) within-subjects analysis of variance was performed on reaction times (see Figure 4). Reaction times are based on correct responses. Reaction times greater than 4000 ms were considered outliers and excluded, this procedure led to the exclusion of 4.2% of the correct reaction times. A main effect of encoding condition was observed $F(1, 31) = 14.83$, $MSE = 39070.85$, $p = .001$) such that translated words had higher reaction times than words read aloud. A main effect of context was observed $F(1, 31) = 134.83$, $MSE = 76401.33$, $p < .001$, such that words in isolation had higher reaction times than words in sentence context. A main effect of frequency was observed $F(1, 31) = 50.45$, $MSE = 52012.02$, $p < .001$) such that high frequency words had higher reaction times than low frequency words. An interaction between encoding and frequency was observed $F(1, 31) = 5.42$, $MSE = 39793.27$, $p = .027$), such that the low frequency advantage in RT was stronger in the read aloud conditions than in the translated conditions. An interaction between context and frequency was observed $F(1, 31)= 4.50$, $MSE = 32547.38$, $p=.042$), such that the low-frequency advantage in RT was greater for words that were encoded

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in isolation than for words encoded in a sentence context. No other interactions were observed, all $ps > .05$.
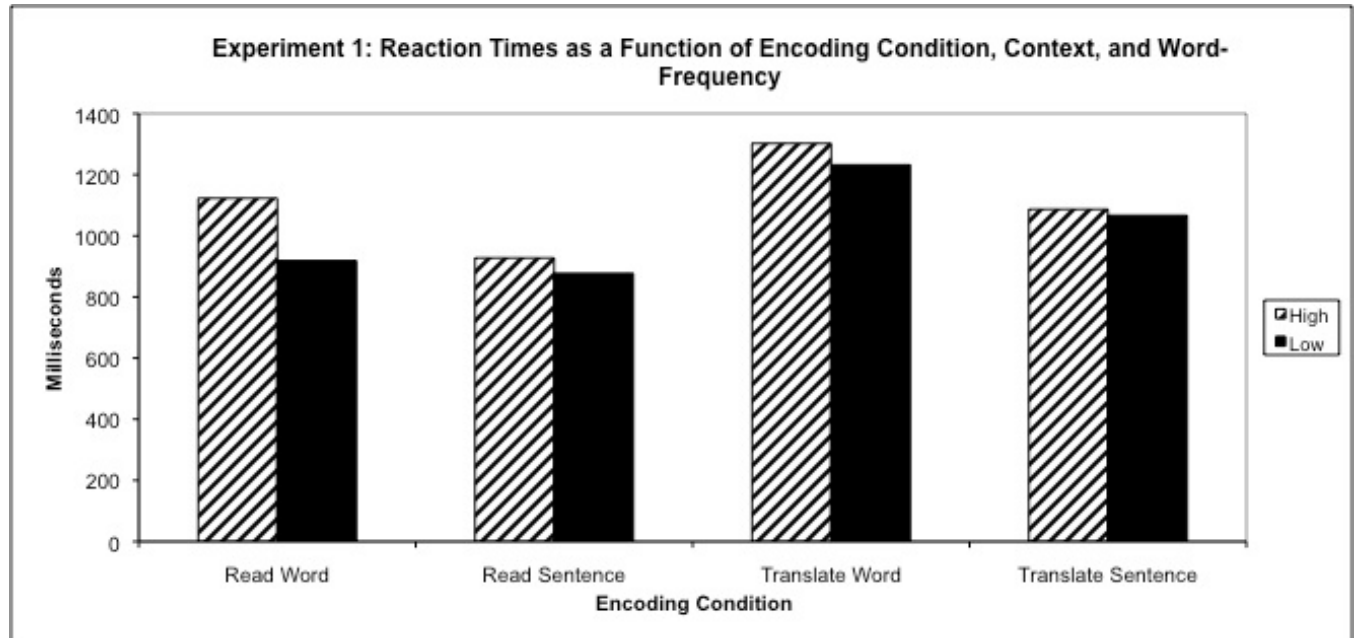

Figure 4: Experiment 1 Reaction Times as a Function of Encoding Condition, Context, and Word-Frequency

2.3   Discussion

The results of Experiment 1 support the hypothesis that translation of words at encoding leads to more accurate recognition of those words at test. The fact that translation of words led to better recognition performance suggests that translation, an encoding mechanism available only to bilinguals, recruits additional processes that bilinguals can later use when recognizing words. Higher discrimination scores were observed for translated items suggesting that participants' were better able to discriminate between studied and non-studied items if they were translated. The correct recognition of items in translation conditions exhibited a speed-accuracy trade-off. That is, while participants were better able to tell apart studied from non-studied items, they were slower at doing so when the item had been translated. One explanation for the reaction time finding in the translation conditions is that the reduced speed is the result of transfer-appropriate

processing. Since translation requires more processing time at encoding, this processing time cost was also observed at retrieval.

The hypothesis that processing a sentence context at encoding would lead items to be recognized better at test was not supported. Specifically, words were more accurately recognized when they were presented in isolation rather than sentence context. The fact that sentence context did not aid bilinguals in recognizing studied items suggests that in order to recognize words, such words need to be in distinctive contexts and sentences seem to reduce the distinctiveness of individual words.

As expected, a low frequency effect, such that low frequency words were recognized faster and more accurately than high frequency words, was observed which aligns with well-established frequency effects in the literature (e.g., Diana & Reder, 2006; MacLeod & Kampe, 1996). The false alarm data further provide support for the frequency effect with low frequency words having lower false alarm rates. Reaction time data shows that not only were low frequency words recognized more accurately, they were also recognized faster.

Experiment 1 aligns with the TAP framework in that translation recruits some of the same processing demands as recognition memory. Specifically, items are perceived both lexically and semantically, both in read-aloud and translate conditions. However, more of those processes (lexical activation and semantic representation) have to be activated in order to translate words, this leads to better recognition performance for translated items. However, when items are embedded in sentence contexts, each individual item is not lexically distinctive enough, such that attention is directed toward the global sentence meaning rather than individual words.

Chapter 3: Experiment 2

In Experiment 2, participants were tested on implicit memory performance using a word-stem completion repetition-priming task. Participants were asked to encode target words either in isolation or in sentence context. Additionally, half of the words presented in each condition were read aloud and half were translated. It is hypothesized that words encoded by translation will display more priming than words encoded by reading. Further, a main effect of sentence context is expected such that words embedded in sentence contexts will display more priming than words in isolation Finally, low frequency words will display more priming overall.

3.1   Method

3.1.1   Participants

Thirty-two Spanish-English bilingual participants were recruited from the participant pool of the Department of Psychology at the University of Texas at El Paso in exchange for course credit. Participant's background data is summarized in Table 1. Participants' average age was 21.03 years, ranging from 18-32 years. Participants reported learning Spanish prior to English. Participants' language data is summarized in Table 1.

3.1.2   Materials

The materials in Experiment 2 were the same as in Experiment 1. Note that the items not presented at study were used as control items.

3.1.3   Design

The independent variables form a 2 (encoding task) X 2 (encoding context) X 2 word frequency) within-subjects design. The encoding task was either reading aloud or translation aloud, and the encoding context was either isolated or sentence. Half of the words were high frequency and half low frequency. The dependent variable was the proportion of fragments completed with the target word.

3.1.4 Procedure and Apparatus

The procedure was the same as in Experiment 1 except for the test task in the computerized experiment. In Experiment 2, participants were tested by word-stem completion. Implicit retrieval instructions were given to participants. Participants were told that the next section of the experiment (rather than the test task) tested their working memory capacity and they were asked to look at the stem on the screen and complete it with the first word that came to mind. Participants subsequently performed the Woodcock-Muñoz Language Survey-Revised as in Experiment 1 and were fully debriefed. The apparatus was the same as in Experiment 1.

3.2 Results

Priming scores were obtained by subtracting the proportion of control items completed with the expected response from the proportion of studied items completed with the expected response. Planned single-sample t-tests were performed on each of the study conditions to see whether priming was statistically significant. Priming for high frequency words $t(31) = 3.23, p < .05$ and low frequency words $t(31) = 8.90, p < .001$ in read aloud conditions studied in isolation was significant. Priming for high frequency words studied in the read aloud sentence context condition was not significant. Priming for low frequency words studied in the read aloud sentence context condition was significant $t(31) = 4.23, p < .001$. Priming for high frequency words $t(31) = 4.58, p < .001$ and low frequency words $t(31) = 6.75, p < .001$ in isolated word translation conditions was significant. Priming for high frequency words in the translate sentence condition was not significant. Priming for low frequency words in the translate sentence condition was significant $t(31) = 6.92, p < .001$.

A 2 (encoding task) X 2 (encoding context) X 2 (word frequency) within-subjects analysis of variance was performed on priming of target items (see Figure 5). No main effect of encoding task was observed. A main effect of context was observed $F(1, 31) = 55.06, MSE = .016, p < .001$, such that words in isolation displayed more priming than words in sentence context. A main effect of frequency was observed $F(1, 31) = 7.90, MSE = .115, p = .008)$ such

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that low frequency words displayed more priming than high frequency words. No interactions were observed, all ps > .05. A planned paired-samples t-test was performed on the proportion of completed control stems which revealed that high frequency word stems had a higher probability of being completed with the expected response than low frequency word stems $t(31) = 4.512$, $p <$ .001.
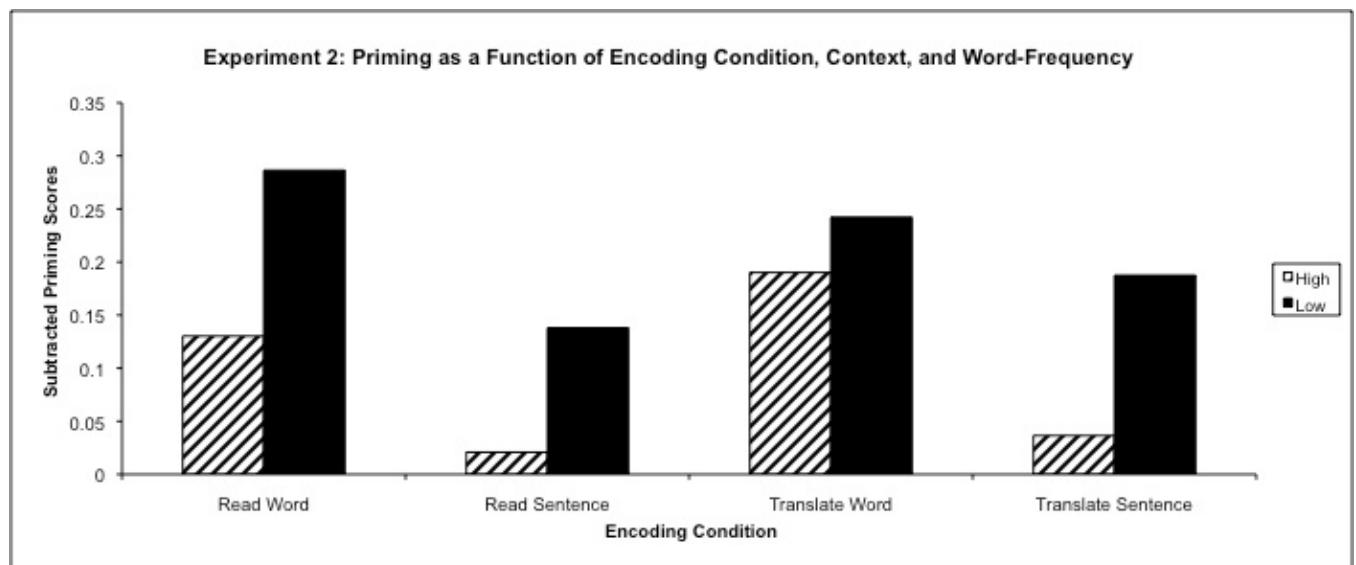

Figure 5: Experiment 2 Priming as a Function of Encoding Condition, Context, and Word-Frequency

3.3   Discussion

The prediction that translation would lead to more priming over read aloud encoding in an implicit memory task was not supported. Further the prediction that sentence context would lead to more priming over isolated word encoding in an implicit task was not supported. The frequency effect was replicated, as predicted. Words in isolation were significantly primed regardless of their frequency. However, only low frequency words were primed when they were read in sentence context. Likewise, words translated in isolation were significantly primed regardless of frequency. However, only low frequency words translated in a sentence context were significantly primed. The fact that increased priming was not observed for translation over

read aloud encoding indicates that translation does not recruit the necessary processes to facilitate implicit priming over what is expected by reading words. Finally, sentence context only primes low frequency words, but does not lead to increased priming over words studied in isolation.

A possible explanation for these findings is that word-stem completion relies more heavily on perceptual processing (Weldon, 1993) and translation and context rely more heavily on conceptual processing. This explanation, at least for translation, would be consistent with findings by Durgunoglu and Roediger (1987), which suggest that conceptual processing of items does not prove advantageous for word-stem and word-fragment completion. The processing demands recruited at encoding would thus not match those at retrieval and the TAP principles would be violated. Nonetheless, there is evidence that elaboration at encoding, which thus would lead to more conceptual processing, improves implicit performance (Brown & Mitchell, 1994). The results could thus be due to the fact that translation and context do not tap into the type of elaboration that is beneficial for implicit priming in word-stem completion. An alternative explanation is that word-stem completion relies heavily on perceptual information and an implicit task that relies on conceptual information may provide a different pattern of results.

Chapter 4: General Discussion

The findings in the current study have implications for our understanding of the mechanisms involved in bilingual memory. First, for explicit performance in recognition memory, translating words brings online processes that are later recruited allowing for better recognition of studied words. Not surprisingly this effect is more robust for low frequency words, suggesting that distinctive words, or words that are not encountered frequently are more easily recognized. The effects in explicit performance were also seen in reaction time. Translation of items led to slower recognition of words at test, suggesting perhaps that the processes required to translate require more time to come on line, and this time cost is observed at test as well. Depending on the reason for recognizing an item, this latency effect could prove advantageous or detrimental. Sentence context did not aid in recognition performance suggesting that perhaps sentence processing is a global process that does not focus on specific items but instead on sentence meaning.

From the TAP perspective, the findings suggest that single-word retrieval demands similar processing requirements at encoding and retrieval for recognition memory. The advantage at test for these items indicates that the same processes were recruited. The novel contribution of this study is that translation amplifies the effects of single-word processing. That is, participants access meaning and concepts through translation, recruiting additional processes that allow for more accurate recognition of studied items. Context seems to have different processing demands than those needed to perform a recognition decision. Context thus does not lead to increased transfer of information from study to test. An additional novel finding in the present studies is the method by which items are accessed during translation and sentence processing. Results from Experiment 1 support the idea that, although both translation and processing words in a sentence context rely on conceptual information, translation has different processing demands from processing a sentence context.

Additionally, the items here were presented in sentence context but tested in isolation. A different pattern of results might be expected if the items were tested in sentence contexts or if the isolated word features were made more salient during encoding (e.g. bold font for target items). However, the main focus of this study was not to make words salient but rather to test whether, under normal reading circumstances, encountering a word in sentence context would elicit the necessary processing that would be useful for recognizing words over encountering words in isolation.

Second, for implicit performance, neither translation nor sentence context recruited additional processes that were advantageous for word stem completion. Other implicit retrieval methods that rely on conceptual processing might show an advantage for translation and sentence processing. Similarly, both translation and sentence context rely upon conceptual information, and word-stem completion relies primarily on non-conceptual processes. The results here could be due to the fact that word-stem completion does not benefit from conceptual processing. Likewise, distinctiveness plays a role in the effect of priming. In the current study this was found with low frequency words displaying more priming than high frequency words.

From the TAP perspective, the findings for implicit memory performance suggest that neither translation nor sentence processing provide an advantage in perceptual processing that would lead to a larger proportion of stems being completed. On the contrary, the results suggest that isolated words, those requiring the least conceptual processing, match the test episode to a greater degree and thus display more priming.

Both Experiment 1 and Experiment 2 tested memory performance in four conditions. Experiment 1, testing recognition performance, showed that translation enhances recognition performance by increasing conceptual processing. Furthermore, Experiment 1 showed that recognition memory benefits from isolated word encoding. Finally, low frequency words are recognized more accurately than high frequency words, a replication of previous findings. Experiment 2 tested implicit memory performance via word stem completion and showed that for implicit priming isolated words that do not require additional conceptual processing have a

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greater priming effect. Likewise, low frequency words display greater implicit priming, a replication of previous findings.

Further directions should explore whether translation benefits other explicit memory tasks. Further, within recognition memory, the reaction time effects warrant further study. In for implicit memory, future studies could investigate other implicit tasks with respect to the effects of translation. Additionally, for sentence processing, future studies should investigate which mechanisms in sentence processing, if any, lead to information transfer.

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