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Concreteness, frequency, and bilingual language dominance: Implications for the impact of context availability in explicit memory

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CONCRETENESS, FREQUENCY, AND BILINGUAL LANGUAGE DOMINANCE: IMPLICATIONS FOR THE IMPACT OF CONTEXT AVAILABILITY IN EXPLICIT MEMORY

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Dedication

I would like to dedicate this to all the people who have encouraged and supported me throughout my time in graduate school. To my parents for always trying to teach me the importance of education and their support throughout my time in school. To my fiancé Katheryne, she has more confidence in me than I have in myself and her support has meant very much to me. I would like to thank my mentor, Dr. Wendy Francis, working with her has shown me what the difference between a boss and a mentor is. Finally, I would like to dedicate this to the administrators, teachers and staff of the University of Texas at El Paso. Their dedication to the University's continuing mission of bringing quality and affordable education to underrepresented, underprivileged, and first-generation students, enabled me to pursue higher education from undergraduate to Ph.D.

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Abstract

One explanation for why concrete words are better recalled than abstract words is systematic differences across these word types in the availability of context information. In contrast, explanations for the concrete word advantage in recognition memory do not consider a possible role for context availability. Like concrete words, low-frequency words and L2 words also demonstrate item recognition advantages over high-frequency words and L1 words, respectively. Although the theories explaining these advantages do not explicitly discuss context availability, the mechanisms described suggest that context availability may play a role. The present study examined the extent to which context availability can explain the effects of word concreteness, word frequency, and bilingual language dominance in four explicit memory experiments. Concreteness and frequency effects across free recall and item recognition were consistent with previous research, with concrete word advantages in both tasks, a high-frequency advantage in recall, and a low-frequency advantage in recognition. In recognition, L2 words were better discriminated than L1 words. Additionally, language and frequency interacted such that the low-frequency advantage was larger in L2 words than in L1 words.

In recall, studying target words in sentence contexts harmed performance at test, and the detriment was larger for high-constraint than for low-constraint sentence frames. Alternatively, in recognition, providing a sentence context at study was not detrimental at test when manipulated within subjects. Low-constraint sentence frames led to the best performance, while there was no difference between targets studied in isolated and high-constraint contexts. However, when manipulated between subjects, the presence of sentence context at encoding decreased recognition performance at test. Providing context at study did not reduce concreteness effects in either recall or recognition, which is inconsistent with predictions of the context availability account of concreteness effects. Language dominance and sentence context did not interact in item recognition, suggesting that the effect is driven by differences in base level familiarity. However, semantic constraint increased the low-frequency advantage in recognition when context was manipulated as a within subjects variable. This finding suggests that accounts of the low-frequency advantage might benefit from consideration of the role of context availability, particularly when it is considered as a relative rather than absolute construct.

Table of Contents

Acknowledgements v

Abstract vi

Table of Contents viii

List of Tables xi

Chapter 1: Introduction 1

- 1.1 Effects of word concreteness 1
- 1.2 Effects of word frequency 7
- 1.3 Effects of bilingual language proficiency 9
- 1.4 Effects of sentence context and sentence constraint 12
- 1.5 The present study 13

Chapter 2: Experiment 1 17

- 2.1 Design 17
  - 2.1.1 Participants 17
  - 2.1.2 Design 18
  - 2.1.3 Materials 18
  - 2.1.4 Apparatus 19
  - 2.1.5 Procedure 20
- 2.2 Results 20
- 2.3 Discussion 22

Chapter 3: Experiment 2 24

- 3.1 Method 25
  - 3.1.1 Participants 25
  - 3.1.2 Design 25
  - 3.1.3 Materials 26
  - 3.1.4 Apparatus 27
  - 3.1.5 Procedure 27
- 3.2 Results 28
  - 3.2.1 Discrimination 28
  - 3.2.2 Hit rates 28

3.2.3 False alarm rates 29
3.2.4 Response times..29
3.3 Discussion 31
Chapter 4: Experiment 3 34
4.1 Method 34
4.1.1 Participants...34
4.1.2 Design 35
4.1.3 Materials 35
4.1.4 Apparatus 36
4.1.5 Procedure 37
4.2 Results..38
4.2.1 Discrimination...38
4.2.2 Hit rates...38
4.2.3 False alarm rates 38
4.2.4 Response times..39
4.3 Discussion 40
Chapter 5: Experiment 4 42
5.1 Method 43
5.1.1 Participants...43
5.1.2 Design 44
5.1.3 Materials 44
5.1.4 Apparatus 44
5.1.5 Procedure 44
5.2 Results...45
5.2.1 Discrimination..45
5.2.2 Hit rates..45
5.2.3 False alarm rates 46
5.2.4 Response times...46
5.3 Discussion 47
Chapter 6: Experiments 3 and 4..49
6.1 Results...49
6.1.1 Discrimination..49

6.1.2 Hit rates 50
6.1.3 False alarm rates 50
6.1.4 Response times..51
6.2 Discussion 52
Chapter 7: General discussion 55
7.1 Implications for the impact of context availability on concreteness effects 57
7.2 Implications for the impact of context availability on word frequency effects 60
7.3 Implications for the impact of context availability on bilingual language effects..........61
7.4 Implications for other relevant theories 63
7.5 Conclusions..65
References..68
Vita 77

List of Tables

Table 1: Review of theoretical accounts. 15
Table 2: Median frequencies of target words and mean CLOZE probabilities for stimulus sentences. 19
Table 3: Mean (SE) recall proportions in Experiment 1. 21
Table 4: Mean (SE) recognition performance in Experiment 2. 30
Table 5: Average Woodcock-Muñoz composite age equivalency scores and ESPADA self-report language proficiency information. 35
Table 6: Median word frequencies and average CLOZE probabilities for Experiments 3 and 4. 36
Table 7: Mean (SE) recognition performance for Experiment 3. 39
Table 8: Average Woodcock-Muñoz composite age equivalency scores and ESPADA self-report language proficiency information for Experiment 4. 44
Table 9: Mean (SE) recognition performance in Experiment 4. 47
Table 10: Summary of results from Experiments 1 - 4. 55

Chapter 1: Introduction

Verbal memory tasks have been a mainstay in cognitive psychology research for the past century. It has long been known that memory performance varies as a function of semantic and lexical properties of the words to be remembered. In particular, word concreteness, word frequency, and bilingual language dominance have marked effects on explicit memory tasks, including free recall and recognition. However, there has been some debate about the mechanisms underlying these effects. In the present study, the possible role of context availability in explaining the effects of word concreteness, word frequency, and bilingual language dominance in explicit memory are examined. Specifically, the present work examines whether context manipulations at encoding moderate the effects of concreteness, frequency, and bilingual language dominance on free recall and item recognition performance.

1.1 Effects of word concreteness

The concreteness of a word is the extent to which a word represents a material object as opposed to an abstract quality, state, or action (Hawkins & Allen, 1991; as cited in Walker & Hulme, 1999, p. 1258). The difference between concrete and abstract words can be illustrated by comparing words like *house* and *truth*. A concrete word such as *house* represents a tangible object whereas *truth* represents an intangible quality or state of being. In addition to being more likely to represent a tangible object, concrete words also more readily invoke a familiar mental image as compared to abstract words. Word concreteness and imageability are highly correlated and in many cases the terms have been used interchangeably (de Groot, Dannenburg, & van Hell, 1994). Nevertheless a case can be made that concreteness and imageability ratings symbolize somewhat different aspects of a word's semantic representation (Kousta, Vigliocco, Vinson, Andrews, & Campo, 2011). The current study examines effects of concreteness as defined by concreteness ratings from published sources.

The effects of word concreteness on memory and lexical processing have been examined in a vast literature of research spanning five decades and covering a variety of tasks, stimulus types, and languages (ter Doest & Semin, 2005). The general finding across this literature that concrete words have an advantage over abstract words is known as the *concreteness effect*. This finding has been reported in memory tasks such as free recall, serial recall, and cued recall (e.g., Holmes & Langford, 1976; Richardson, 2003; Romani, McAlpine, & Martin, 2008; Walker & Hulme, 1999), recognition (e.g, Glanzer & Adams, 1985; Glanzer, Adams, Iverson, & kim, 1993; Hirshman & Arndt, 1997), as well as in lexical processing tasks such as lexical decision and translation (e.g., Schwanenflugel, Harneshfeger, & Stowe, 1988; van Hell & de Groot, 1998, 2008). However, the mechanisms and processes that lead to this advantage remain a subject of debate in a variety of theoretical frameworks.

One of the most well known theoretical explanations of the concreteness effect is *dual coding theory* (for a review see Paivio, 1991). This account details two processing systems, a verbal system and an image system. Under this theory, it is assumed that concrete words are processed in both systems while abstract words are processed only in the verbal system. As a result of being processed in both systems, and thus having two possible retrieval routes, concrete words are more easily retrieved than abstract words. Subsequent research revealed shortcomings of the dual coding account including failures to replicate key findings used to support it. But perhaps the most difficult challenge to the dual coding theory came from a growing body of evidence that, although consistently observed for stimuli presented in isolation, the concreteness effect was eliminated when stimuli where studied within the context of a sentence or paragraph (Wattenmaker & Shoben, 1987).

This limitation of dual coding theory was the impetus for the development of the *context availability* framework as an explanation of the concrete advantage (see Kieras, 1978; Schwanenflugel & Shoben, 1983; Wattenmaker & Shoben, 1987). The central tenet of this framework is that comprehension is benefitted by the addition of contextual information. The term *context* is often underspecified and different researchers may have different views of what constitutes context. For example, context may potentially be thought of as episodic or environmental information, such as the time or location in which an event took place. Context may also be thought of as semantic information that serves to provide detail and specify meaning. There are a few clues from the literature that can help to define context as it relates to the context availability framework. One is that context is proposed to be available either from the materials presented to a participant or from the participant's pre-experimental experiences (Wattenmaker & Shoben, 1987). Another clue comes from the ways in which context availability is commonly manipulated experimentally. One strategy is to provide participants with sentences or paragraphs rather than simply presenting words in isolation. Another is to have a participants rate target words on a context availability scale by asking them to judge how easy it is to imagine a context in which the word would appear. These clues are more consistent with the semantic definition of context, rather than the episodic definition. Thus, throughout this paper the term context will refer to semantic information that serves to provide additional detail and specify the meaning of target words.

Under the context availability account, the concrete advantage arises due to differential availability of contextual information for concrete and abstract words presented in isolation.

Contextual information is thought to be easier to access for a concrete word like *house* than for an abstract word like *truth,* thus leading to a memory advantage for concrete words. This reasoning has been supported by findings showing that the concreteness effect is reduced or eliminated when concrete and abstract words have equal access to contextual information. One approach was to control for participant-rated context availability across word types. Matching concrete and abstract words on context availability led to the elimination of concreteness effects in lexical decision and word-translation response times (Schwanenflugel et al., 1988; van Hell & de Groot, 1998). However, in free recall, matching context availability for concrete and abstract words produced mixed results. In one experiment, controlling for context availability did not reduce the advantage for concrete words, but in a second experiment the concreteness effect was reduced when rated context availability was controlled, particularly when participants were instructed to judge the context availability of words at study (Schwanenflugel, Akin, & Luh, 1992).

Another approach for matching context availability across concrete and abstract words has been to provide participants with a sentence or paragraph for context. Concrete sentences were read faster than abstract sentences, but when sentences were presented with an accompanying context paragraph the reading times were not significantly different. Additionally, lexical decision times were faster for concrete than for abstract target words when presented in isolation, but when preceded by a context sentence, the lexical decision times were not significantly different (Schwanenflugel & Shoben, 1983). Semantic constraint appears to play a role in the impact of context on concreteness effects. Presenting target words in the context of high-constraint sentences, which are sentences that have highly predictable endings, eliminated the concreteness effect in lexical decision and significantly reduced it in translation, whereas low-constraint sentences failed to do so (van Hell & de Groot, 2008). This result is consistent with the context availability account if we consider that high-constraint sentences have enough relevant context to bias processing of a particular target.

In recall, providing a sentence context has produced mixed results. In one study, providing a sentence context did not eliminate the concrete advantage. In particular, sentences containing concrete nouns, such as *Adult elephants are protected by strong skins,* were better recalled than sentences containing abstract nouns, such as *Large companies are regulated by strict rules*. Furthermore, when the abstract sentences were recalled, participants recalled significantly fewer words from the sentence than when concrete sentences were recalled (Holmes & Langford, 1976). Two other studies of sentence recall produced results that were more consistent with the idea that context availability can impact concreteness effects. Abstract and concrete sentences were equally well recalled when items were presented in a coherent paragraph context, but when sentences were organized in a random order there was a concrete advantage (Marschark, 1985; Wattenmaker & Shoben, 1987).

A third account grew out of research on recognition memory, which exhibits a pattern of findings known as the mirror effect. The mirror effect occurs when one stimulus type produces a higher hit rate (i.e., probability of classifying a studied item as studied) and a lower false alarm rate (i.e., probability of classifying a new item as studied) relative to another stimulus type. Several studies have reported that concreteness manipulations produce mirror effects, or higher hit rates and lower false alarm rates for concrete words as compared to abstract words (e.g., Glanzer & Adams, 1985; Glanzer, Adams, Iverson, & Kim, 1993; Hockley, 1994), indicating that the concreteness effect extends to recognition memory. However, the presence of this effect is not consistently reported in the literature. A review of mirror effects for word concreteness in recognition memory found that while most experiments surveyed produced the mirror effect, it was not unanimous (Glanzer & Adams, 1985). Additionally, a more recent series of seven experiments showed that although there was a consistent advantage for concrete words in false alarm rates, the hit rates showed either no significant concreteness effect or an advantage for abstract words (Hirshman & Arndt, 1997).

The general finding that hit and false alarm rates do not always favor the same word type was interpreted as support for the *memory-based* explanation of the concrete advantage in item recognition (Hirshman & Arndt, 1997). According to this account, concrete words have qualities that make them more discriminable than abstract words, including more precise meanings, more distinctive orthography, and lower pre-experimental strength in memory. The logic behind the counter-intuitive contention that concrete words have lower pre-experimental strength in memory than abstract words is that pre-experimental exposures for non-studied concrete words will have less overlap with the study episode and therefore be less likely to elicit false alarms than non-studied abstract words. This account proposes that properties of concrete and abstract words lead to differences in discriminability rather than a shift in decision criterion, which the authors postulated would produce complementary changes in hit and false alarm rates (i.e., a mirror effect). Although the memory-based explanation considers the overlap of memory representations of pre-experimental exposures to the target with representations of exposures to the target in the study context, it does not consider the potential impact of context availability. Considering that context availability is a factor that has been shown to moderate the concreteness effect in other tasks, this may be a significant limitation of the framework.

1.2 Effects of word frequency

Another word characteristic that has an impact in lexical processing and memory is word frequency, a measure of how often a word appears in a language. For example, a word like *kiwi* occurs much less frequently than a word like *apple*. High-frequency words tend to be identified, comprehended, and produced faster and more accurately than low-frequency words (e.g., Bowers & Turner, 2003; Burke et al., 1991; Forster & Davis, 1984; Jescheniak & Levelt, 1994; Wheeldon & Monsell, 1992). Word frequency effects in explicit memory show a different pattern across tasks than concreteness effects, in that there is a reversal of the frequency effect across recall and recognition tasks. Specifically, high-frequency words are better recalled than low-frequency words, especially in frequency pure lists, but low-frequency words are better recognized than high-frequency words (e.g., Balota & Neely, 1980; Kinsbourne & George, 1974; MacLeod & Kampe, 1996; Mandler, Goodman, & Wilkes-Gibbs, 1982). One explanation for the high-frequency advantage in recall is that high-frequency words benefit from stronger inter-item associations (Hulme, Stuart, Brown, & Morin, 2003). The inter-item associations of high-frequency words are thought to arise from their higher level of pre-experimental exposure and more effective rehearsal at study; that is, high-frequency words tend to be rehearsed more times and further into the study sequence (Tan & Ward, 2000; Ward, Woodard, Stevens, & Stinson, 2003).

The low-frequency advantage in yes/no recognition tasks has been explained by the *source of activation confusion* theory (for a review of this theory see Reder et al., 2000). This account details two main properties that lead to this advantage. The *fan factor* assumes that low-frequency words are associated pre-experimentally with fewer episodic contexts than high-frequency words. This property makes the episode of studying a low-frequency word more distinguishable from its pre-experimental episodes, thus boosting hit rates. This property is similar to the concept of context variability, or the variety of episodic contexts that a word may appear in and with which it becomes associated, a factor that is highly correlated with word frequency (Criss, Aue, & Smith, 2011). The second property, the *base factor*, assumes that low-frequency words are less familiar and have lower pre-experimental strength in memory than high-frequency words because they have been encountered fewer times than high-frequency words. This lower base level of familiarity makes low-frequency words that were not studied less likely to trigger a sense of familiarity that would be falsely attributed to the study episode, thus leading to lower false alarm rates. The *memory-based explanation* is also used to explain the low-frequency recognition advantage. According to this framework, low-frequency words have properties that make them more distinctive than high-frequency words, such as lower pre-experimental memory strength and more distinctive orthography and phonology.

It is interesting to note that the source of activation confusion account and memory-based explanation for word frequency effects in recognition memory share similar mechanisms. Both accounts focus on properties that make low-frequency words more distinctive than high-frequency words, and both refer to base levels of memory strength. Additionally, neither account explicitly discusses the potential impact of context availability. The source of activation confusion account does refer to the *number* of pre-experimental episodic contexts associated with a word, with the assumption that high-frequency words are associated pre-experimentally with a greater number of episodic contexts. These associations allow activation to spread among more potential contexts in which the word could have been encountered, which in turn makes it difficult to distinguish the target as having occurred in the study context rather than a pre-experimental context.

It is also possible that the logic of context availability has implications for the manifestation of the frequency effect in item recognition. The availability of additional context information at study might focus activation from the target on the current study context by helping to further discriminate the study episode from pre-experimental episodes. This may serve to benefit high-frequency words more than low-frequency words considering that high-frequency words are thought to be associated with more pre-experimental contexts, and thus, suffer in recognition. Under this assumption, increasing context availability should reduce the low-frequency item recognition advantage over high-frequency words by boosting discriminability for the study context from the more numerous pre-experimental contexts associated with high-frequency words. Therefore, although not explicitly discussed in the models explaining the low-frequency recognition advantage, the logic of the source of activation confusion theory suggest that context availability might change the magnitude of the word-frequency effect.

1.3 Effects of bilingual language proficiency

Even when a bilingual individual is highly proficient in both of their languages they are usually more proficient in one language (L1) than the other (L2). Major theoretical frameworks explaining bilingual processing, the revised hierarchical model (Kroll & Stewart, 1994), the bilingual interactive activation model (Dijkstra & Van Heuven, 2002), and the inhibitory control model (Green, 1998), assume that L2 words have weaker associations to semantic representations than L1 words. This weaker semantic association is thought to be a result of the more limited exposure to, and usage of, L2 words. This line of thinking has been detailed in the *weaker-links hypothesis* (Gollan, Montoya, Cera, & Sandoval, 2008), which proposes that language proficiency effects and word frequency effects can be explained by a common mechanism.

One might reasonably assume that memory performance in L1 would always be superior as compared to L2. Indeed, recall performance in L1 is typically better than L2 performance (Durgunoglu & Roediger, 1987; Glanzer & Duarte, 1971; Lopez & Young, 1974; Nott & Lambert, 1968). However, considering the weaker-links hypothesis of a common mechanism for language proficiency and frequency effects (Gollan et al., 2008) together with prior findings of a low-frequency advantage in recognition memory (e.g., MacLeod & Kampe, 1996) leads to the prediction that L2 performance in recognition memory may be superior to L1 performance. Indeed, recent research has demonstrated superior recognition performance for L2 words over L1 words (Francis & Gutiérrez, 2012; Francis & Strobach, 2013). Thus the conceptualization of L2 words as being similar to low-frequency words is further supported by the reversal of the L1/L2 advantage in recall and recognition as has been well documented for high-frequency and low-frequency words (Balota & Neely, 1980; Kinsbourne & George, 1974; MacLeod & Kampe, 1996; Mandler, Goodman, & Wilkes-Gibbs, 1982).

The source of activation confusion theory has been proposed as an explanation of the L2 recognition advantage (Francis & Strobach, 2013). Like low-frequency words, L2 words were thought to have a lower level of familiarity and to be associated with fewer episodic contexts than L1 words. However, more recent findings necessitated a refinement of this explanation. In particular, tests of source recognition, which are thought to rely on recollection processes and eliminate the influences of item familiarity (Tosun, Vaid, & Geraci, 2013), exhibited no significant performance differences between L1 and L2 words (Francis, Strobach, Martínez, & Gurrola, 2016; Penalver & Francis, 2016). This finding suggests that the L2 advantage in item recognition relies primarily on the familiarity component of the source of activation confusion logic. Thus the L2 item recognition advantage may be better explained by the base factor (familiarity) of the source of activation confusion theory rather than the fan factor. This finding also implies that contextual associations are made at the language-general conceptual level rather than the language-specific word form level and therefore do not depend on language proficiency.

If contextual associations are made at the conceptual level, then specific predictions can be made about whether context availability will interact with language dominance. The first possibility arises from the logic applied to word frequency. Specifically, providing additional context information may focus activation to the study context, thereby reducing the L2 advantage by serving to help discriminate the study context from the pre-experimental contexts associated with L1 words. The second possibility arises from a key difference between low-frequency words and L2 words. Specifically, although both the word form and the associated concept are less familiar for low-frequency words than for high-frequency words, only the word form is less familiar for L2 words than for L1 words. This is because translation equivalents share common conceptual representations (e.g. Francis, 1999; Taylor & Francis, 2017). Under this assumption, manipulations of context availability would not be expected to change the effects of language dominance in recognition.

Some researchers have argued that translation equivalents with abstract meanings have a lower degree of conceptual overlap than translation equivalents with concrete meanings (de Groot, 1992; van Hell & de Groot, 1998b), but another study suggested that core concepts for concrete and abstract words have the same degree of overlap across languages (Francis & Goldmann, 2011). If abstract words in fact have less conceptual overlap, then abstract words will have greater context availability in L1 than in L2, and the L2 recognition advantage should be greater than for concrete words. In contrast, if concrete and abstract words have the same degree of overlap, then context availability will be equal across languages, and the L2 recognition advantage will be the same for concrete and abstract words.

1.4 Effects of sentence context and sentence constraint

Sentence constraint can be thought of as the degree to which a sentence biases processing towards a particular target word. High-constraint sentence frames lead to high predictability and a high probability that a reader will complete the sentence with the intended target word. For example, the sentence; *He got the leash and collar to take a walk with his* ________ is highly constraining towards the target *dog*. On the other hand the sentence; *The woman needed to go to the store to buy some more* _________ is low-constraint because there are many potential targets that could fit with that frame. Increased sentence constraint facilitates lexical processing of the target and leads to faster response latencies in word production (Griffin & Bock, 1998) and lexical decision (Fischler & Bloom, 1979). As discussed above, sentence constraint has been manipulated in examinations of the context availability explanation of the concrete advantage in lexical decision and translation, and indeed presenting words in high-constraint sentence contexts reduced processing advantages for concrete words (van Hell & de Groot, 2008).

Embedding words within a sentence context also impacts explicit memory performance. In recall, nouns presented in sentence contexts were less well recalled than nouns presented in isolation (Cofer, 1968; Wood, 1970). In a study where semantic constraint was manipulated, high-constraint sentences led to better recall of target words than low-constraint sentences (McFalls & Schwanenflugel, 2002). In recognition, studying words in sentence contexts diminished performance relative to studying words presented in isolation (Schwartz, 1975). However I could find no published studies that examined the effects of semantic constraint on later recognition of target words.

1.5 The present study

The present experiments were motivated by several factors, see Table 1 for a summary of the theoretical accounts raised throughout the introduction. First, although the context availability framework has been proposed as a general explanation of concreteness effects, only a few studies have examined how the effects of context and concreteness might interact in memory tasks. Evidence supporting the context availability account has come from studies showing that concrete and abstract sentences were recalled equally well when presented in a coherent paragraph context but concrete sentences were better recalled than abstract sentences when presented in randomized paragraph contexts (Marschark, 1985; Wattenmaker & Shoben, 1987). However, it is unknown whether studying words in sentence contexts would reduce the concreteness effect in the recall of individual target words relative to studying the target words in isolation. This possibility would be consistent with evidence that matching concrete and abstract words for participant-rated context availability showed some propensity to reduce concreteness effects in recall of words studied in isolation (Schwanenflugel, Akin, & Luh, 1992). The major goal of Experiment 1 was to extend these findings by examining the effects of concreteness and context availability in recall of individual words that were studied either in isolation, in low-constraint sentences, or in high-constraint sentences.

Second, although concreteness effects have been reported in recognition memory, the *memory-based explanation* of this effect does not consider the potential impact of context availability. Furthermore, there do not appear to be any studies of recognition memory that have examined the effects of concreteness and context availability simultaneously. A major goal of Experiments 2, 3, and 4 was to test the context availability account of the concreteness effect in a recognition task. This was accomplished in Experiment 2 by having participants study words in isolation, low-constraint sentences, and high-constraint sentences and then complete a yes/no recognition task on studied target words mixed with non-studied target words. In Experiments 3 and 4, the context factor was manipulated between subjects such that participants were randomly assigned to study words in isolation or in sentence contexts.

Third, previous studies examining the potential influence of context availability as a moderating factor have been restricted to investigations of concreteness effects. However, like concrete words, low-frequency words and L2 words exhibit advantages in recognition memory. The source of activation confusion theory, which has been proposed as an explanation of both of these effects, leaves open the possibility that context availability may play a role in both effects. However, recent findings suggest that a revision of the source-of-activation-confusion logic may be warranted when it is applied to the L2 item recognition advantage (Francis, Strobach, Martínez, & Gurrola, 2017). Specifically, if the advantage for L2 item recognition depends mainly on the base factor, and contextual associations are made at the conceptual level, then context availability would not be expected to have an impact on language effects in item recognition. Thus, additional goals of Experiments 2, 3, and 4 were to examine whether context availability might play a role in the effects of word frequency and language dominance on recognition. Additionally, the *memory-based explanation,* which has been applied to word frequency effects in recognition and could potentially be extended to explain L2 recognition advantages, includes no potential role for context availability.

Finally, although the effects of word concreteness and word frequency are well documented in both recall and recognition, in many studies, the effects of one were not considered or controlled when examining the effects of the other. This leaves open the possibility that concreteness effects could be explained by frequency differences or frequency effects could be explained by concreteness differences. Only a small number of studies have manipulated both stimulus properties within the same experiment. An early study examined both factors in free recall and found a significant concrete advantage, but there was not a significant effect of frequency or an interaction of the factors (Winnick & Kressel, 1965). A more recent study of immediate serial recall showed that concreteness effects were smaller for high-frequency words than for low-frequency words (Miller & Roodenrys, 2009). In contrast, concreteness and frequency effects in recognition memory did not interact in hit rates or false alarm rates (Hirshman & Arndt, 1997). However, considering that the memory-based and source-of-activation-confusion explanations of advantages for concrete words and low-frequency words in recognition are rather similar and that the number of studies manipulating both factors is small, the current experiments included manipulations of both concreteness and frequency.

Table 1: Review of theoretical accounts.

Theory	Effects explained	Key assumptions	Important findings
Context availability	Concrete advantage in lexical processing and recall.	Availability of context information benefits comprehension. Easier to access context information associated with a concrete word than an abstract word.	Increasing sentence constraint eliminated and reduced concreteness effects in lexical processing tasks. Matching stimuli on rated context availability reduced the concrete advantage in recall. Placing target sentences in coherent paragraph context eliminated concrete advantages in recall.
Memory based explanation	Concrete advantage in item recognition.	Concrete and low-frequency words have	General advantages for concrete and low-

	Low-frequency advantage in item recognition.	unique properties which make them more discriminable than their counterparts. Concrete words have lower strength in memory and more precise meanings. Low-frequency words have lower strength in memory and distinctive word forms.	frequency words in item recognition. Advantages in false alarm rates are not always accompanied by advantages in hit rates. Suggests differences in discriminability, and not a shift in decision criterion, are responsible.
Source of activation confusion	Low-frequency advantage in item recognition. L2 advantage in item recognition.	Low-frequency and L2 words have unique properties leading to benefits in recognition. Being associated with fewer pre-experimental episodic contexts boosts hit rates. Having a lower base level of familiarity decreases false alarm rates.	Advantages for low-frequency and L2 words over their counterparts in item recognition. Demonstrations of low-frequency mirror effect. Having higher hit rates and lower false alarm rates than high-frequency words. Lack of language effect in source memory experiments. Suggests that item recognition effect may be based on familiarity and not pre-experimental episodic contexts.

Chapter 2: Experiment 1

Experiment 1 examined the effects of word concreteness, word frequency, and sentence constraint in a free recall task. Previous work has shown that controlling for participant rated context availability can reduce the concreteness effect in recall tasks, and providing participants with sentences to serve as context can reduce the concreteness effect in lexical processing. Thus, the major goal of Experiment 1 was to determine whether studying words in sentence contexts would reduce the concreteness effect in free recall of individual target words. A prior study reported that the concreteness effect was moderated by sentence constraint in lexical decision and translation (van Hell & de Groot, 2008). Due to their detail and specificity, it may be reasonable to assume that high-constraint sentences provide greater context availability than low-constraint sentences. So although the context availability account does not make specific predictions about sentence constraint, it does suppose that increasing context availability benefits comprehension, leading to the prediction that high-constraint sentence frames should produce a greater impact than low-constraint sentences that in turn should produce a greater impact than words in isolation. Therefore, using the context availability logic, it was hypothesized that concreteness and frequency effects would be graded such that they would be strongest for words in isolation and weakest for words presented in high-constraint sentences.

2.1 Design

2.1.1 Participants

Participants were 72 students from the University of Texas at El Paso. Participants were recruited from psychology courses and earned their choice of either course credit or $10. The sample consisted of 45 women and 27 men with a median age of 20. English language proficiency was assessed using the Picture Vocabulary Test from the Woodcock-Muñoz

Language Survey Revised (Woodcock, Muñoz-Sandoval, Ruef, & Alvarado, 2005). Participants had an average age-equivalency score of 15 years and 2 months, indicating that they were sufficiently proficient in English. Two additional participants were excluded and replaced due to their desire to end the study session before completing the experiment.

2.1.2 Design

The experimental conditions formed a 2 (concreteness) X 2 (frequency) X 3 (study context) within-subjects design. The concreteness factor divided stimuli into concrete and abstract words and the frequency factor divided stimuli into high- and low-frequency words. The context factor included words presented in isolation, words presented in low-constraint sentence frames, and words presented in high-constraint sentence frames. Target words presented in the low-constraint and high-constraint sentence conditions were always presented as the last word of the sentence and in capital letters so as to be salient. The dependent variable was recall proportion, which represents how many targets were recalled out of the total possible number of words that could have been recalled. Increased recall proportion is generally interpreted as improved memory performance.

2.1.3 Materials

Stimuli were selected from three published sources (Altarriba, Bauer, & Benvenuto, 1999; Miller & Roodenrys, 2009; Tokowicz & Kroll, 2007) in which normed abstract and concrete words were provided. Word frequency information for the stimuli was obtained using CELEX (Baayen et al., 1995). For items to be included as low-frequency words the reported occurrence per million had to be no greater than 40. To be included as a high-frequency word the item needed to have a reported occurrence per million of at least 70. Median word frequencies for each stimulus category are provided in Table 1.

High- and low-constraint sentence frames were developed and pilot tested using a CLOZE procedure (see Griffin & Bock, 1998). The 32 pilot participants were drawn from the same population as the experimental sample but did not participate in the main experiments. Pilot participants were provided sentence frames in which the final word had been omitted, and they were asked to write in the word that they thought would end the sentence. For high-constraint sentences, the 36 sentences of each word type with the highest proportion of expected responses were selected, along with the matched low-constraint sentences. Table 1 shows the mean CLOZE probabilities for high-constraint and low-constraint sentences.

The final stimulus set included 144 target words (36 words for each stimulus category) that were randomly distributed across 12 lists (3 lists for each stimulus category) of 12 targets each. Assignment of lists to study context conditions was counterbalanced across participants using a Latin square.

Table 2: Median frequencies of target words and mean CLOZE probabilities for stimulus sentences.

	Concrete High-Frequency	Concrete Low-Frequency	Abstract High-Frequency	Abstract Low-Frequency
CLOZE High Constraint	.90	.82	.86	.75
CLOZE Low Constraint	.04	.02	.03	.05
Word Frequency	155.81	20.78	158.22	25.30

2.1.4 Apparatus

Stimuli were presented on a Macintosh computer, and the experiment was programmed using PsyScope X software (Cohen, MacWhinney, Flatt, & Provost, 1993). Participant recall responses were recorded using a Sony IC voice recorder.

2.1.5 Procedure

Participants were tested individually in sessions lasting approximately 45 minutes. Participants were first provided an informed consent form to review and sign. Next, the researcher administered the English language Picture Vocabulary assessment to the participant. After this assessment was finished, participants completed a brief language and demographic background questionnaire while the experimenter scored the assessment. Once the assessment and questionnaire were completed the main experiment began. For the main experiment, participants were seated in front of the computer in a small experiment room. The experimenter explained that the participant's responses were going to be recorded for the purposes of later transcription.

Participants then completed 12 study-test cycles in which they were first presented a sequence of 12 words or sentences one at a time and then asked to immediately recall as many target words as they could remember. Participants were instructed to read each target word or sentence out loud and to commit the target words to memory. The study-test cycles were blocked by context and stimulus category such that there were four cycles for each context condition (one for each stimulus category). The orders of the context conditions and stimulus types were counterbalanced across participants. Upon completion of the final test trial, the experimenter debriefed the participant and answered any questions they might have had.

2.2 Results

Recall proportions (see Table 2) were calculated in each condition for each participant. These values were submitted to a 2 (concreteness) x 2 (frequency) x 3 (study context) repeated-measures ANOVA. A significant effect of frequency indicated that more high-frequency words were recalled than low-frequency words, $F(1, 71) = 11.21$, $MSE = .195$, $p = .001$. A significant concreteness effect indicated that more concrete words were recalled than abstract words, $F(1, 71) = 120.83$, $MSE = 1.35$, $p < .001$. There was a significant interaction of frequency and concreteness, $F(1, 71) = 12.57$, $MSE = .121$, $p = .001$, indicating that the concreteness effect was larger for high-frequency words than for low-frequency words.

There was a significant main effect of study context, $F(2, 71) = 35.68$, $MSE = .532$, $p < .001$. Planned comparisons showed that targets presented in isolation were recalled more than targets in low-constraint sentences, $F(1, 71) = 29.53$, $MSE = .852$, $p < .001$, and high-constraint sentences, $F(1, 71) = 57.11$, $MSE = 2.07$, $p < .001$. Targets in low-constraint sentences were also recalled more than targets in high-constraint sentences, $F(1, 71) = 10.98$, $MSE = .267$, $p = .001$. The interaction of frequency, concreteness, and context was also significant, $F(2, 142) = 4.07$, $MSE = .047$, $p = .019$. Planned comparisons showed that in isolated conditions the effects of frequency and concreteness did not interact, $F(1, 71) = 2.01$, $MSE = .048$, $p = .161$, but in high-constraint conditions they did interact such that the concrete advantage was larger for high-frequency words than for low-frequency words, $F(1, 71) = 7.80$, $MSE = .190$, $p = .007$. No other interactions reached significance, $ps > .05$.

Table 3: Mean (SE) recall proportions in Experiment 1.

Concreteness Frequency Study Context	Recall proportion
Concrete	
Low frequency	
Isolated	.485 (.02)
Low constraint	.418 (.02)
High constraint	.390 (.02)
High frequency	
Isolated	.529 (.02)
Low constraint	.482 (.02)
High constraint	.443 (.02)
Abstract	
Low frequency	

Isolated	.398 (.02)
Low constraint	.362 (.02)
High constraint	.366 (.02)
High Frequency	
Isolated	.447 (.02)
Low constraint	.378 (.02)
High constraint	.321 (.02)

2.3 Discussion

As expected, recall proportions were higher for concrete words than for abstract words, thereby demonstrating the typical concreteness effect. High-frequency words produced higher recall proportions than low-frequency words, thus replicating the typical high-frequency recall advantage. Concreteness and frequency interacted such that the concrete advantage was larger for high-frequency words. This interaction is characterized by the opposite pattern as was reported in a prior study that examined serial recall (Miller & Roodenrys, 2009).

The effects of context were somewhat surprising. Isolated words were recalled more than words presented in the context of sentences, and words from low-constraint sentences were recalled more than words from high-constraint sentences. The finding that embedding words in a sentence context lowered recall rates is consistent with findings from prior research (Cofer, 1968; Wood, 1970). A proposed explanation was that the sentence contexts might have disrupted the formation of associations among target words (Cofer, 1968). Inter-item processing, or formation of new associations among items at study is important for recall (e.g., Hunt & McDaniel, 1993).

The finding that high-constraint sentence contexts led to *lower* recall of target words than low-constraint sentence contexts stands in contrast to the results of a previous study in which high-constraint sentence contexts produced *better* recall of target words than low-constraint sentence contexts (McFalls & Schwanenflugel, 2002). Two important differences between the prior study and Experiment 1 may explain the different patterns of results observed. First, there was a marked difference in the level of constraint that defined the low-constraint conditions. The prior study reported the mean CLOZE percentage for low-constraint sentences as 38%, which is much higher than the rate of approximately 4% in Experiment 1 (see Table 1). Thus it may be more appropriate to think of the present low-constraint condition as very low-constraint and the prior study low-constraint condition as medium constraint. Two previous studies examining sentence constraint provide support for this distinction. In one prior study that grouped stimuli as high, medium, and low constraint, the medium-constraint conditions had reported cloze probabilities of .40 and .42, and in low-constraint conditions, sentences were constructed so as to be equally well completed by any target word (Griffin & Bock, 1998). A second study reported including sentence frames with cloze probabilities ranging from .99 to .09 with the average probability being .53 (Fischler & Bloom, 1979).

The second difference is that the McFalls and Schwanenflugel (2002) study had a design wherein all items were studied in one block and recalled in a second block, whereas the present study divided items into 12 study-test blocks and did not mix constraint levels within blocks. Therefore, although Experiment 1 utilized a larger stimulus set, each study-test block was based on about half as many trials as in the previous study. The difference in definitions of low constraint across the studies was likely the more critical factor. And because there was no overlap in the ranges of cloze probabilities for the "low-constraint" item sets used in the two studies, the results are not necessarily contradictory. In any case, the present results can be explained in a simple manner. A high-constraint sentence produces a context that interrupts inter-item processing to an even greater degree than a low-constraint sentence, thereby negatively affecting recall performance.

The effects of concreteness and context did not interact as would be expected under the context availability account. The context availability framework would have predicted an elimination, or significant reduction, of the concrete advantage when targets where studied in a sentence context. Similarly, there was no interaction of word frequency and context, indicating that context availability is not an explanatory factor in the high-frequency advantage in free recall. However, there was a significant 3-way interaction of frequency, concreteness, and context. A decomposition of this interaction revealed that for low-frequency words (but not high-frequency words) there was a marginal (p = .069) interaction of concreteness and context such that the concreteness effect was larger for isolated words than for words presented in high-constraint sentences. This marginally significant interaction was the only aspect of the results that was consistent with the context availability account. However even this finding is limited by the fact that the pattern existed only for low-frequency words, a pattern that would not be predicted under the context availability framework.

The current findings do not speak directly to the assumptions of the memory based explanation nor the source of activation confusion theory considering that they are meant to specifically explain effects of item recognition.

Chapter 3: Experiment 2

Experiment 2 examined the same factors as Experiment 1 using the same stimulus set but with item recognition as the test task. The major goal of Experiment 2 was to examine whether the impact of context availability on the manifestation of the concreteness effect, as reported in prior studies, would extend to item recognition. As in Experiment 1, it was predicted that context availability effects would be graded such that concreteness effects would be strongest for target words studied in isolation and weakest for target words studied in high-constraint sentences. A secondary goal of Experiment 2 was to examine the potential impact of context availability on the manifestation of the frequency effect in recognition. Although the source of activation confusion theory and memory based explanation do not address the potential role of context availability, a logical case for its impact can be made based on key assumptions of the two accounts. Specifically, it was hypothesized that increasing context availability would benefit high-frequency words more than low-frequency words by serving to improve discriminability of the current study context from pre-experimental episodic contexts, thereby reducing the low-frequency advantage.

3.1 Method

3.1.1 Participants

Participants were 96 students from the University of Texas at El Paso. Participants were recruited from psychology courses and earned their choice of either course credit or $10. The sample consisted of 56 women and 40 men with a median age of 24. English language proficiency was assessed using the Picture Vocabulary test from the Woodcock-Muñoz Language Survey Revised (Woodcock, Muñoz-Sandoval, Ruef, & Alvarado, 2005). Participants had an average age-equivalency score of 17 years and 9 months, indicating that they were sufficiently proficient in English. Ten additional volunteers were disqualified before completing the memory experiment based on low English proficiency scores, and two additional volunteers who completed the protocol were excluded for failure to follow test instructions (i.e., using only one of the two response buttons).

3.1.2 Design

The experimental conditions formed a 2 (concreteness) X 2 (frequency) X 4 (study context) within-subjects design. The concreteness factor divided stimuli into concrete and abstract words and the frequency factor divided stimuli into high- and low-frequency words. The context factor included words presented in isolation, words presented in low-constraint sentence frames, words presented in high-constraint sentence frames, and words not presented at study. Target words presented in the low-constraint and high-constraint sentence conditions were always presented at the end of the sentence and in capital letters to make them salient. The experiment included multiple dependent variables. Hit rates provide a measure of how well participants correctly recognize targets that they had seen at encoding such that higher hit rates indicate a larger proportion of correctly recognized targets. False-alarm rates measure false recognition of foil words such that increased false-alarm rates indicate a larger proportion of falsely recognized foils. d' is a measure of overall discriminability including both targets and foils. Increased d' scores indicate better overall recognition performance. Finally, response times provide a measure of how quickly participants produce a response. Faster response time is often interpreted as facilitated processing, often through a reduced level of cognitive effort required to complete the task.

3.1.3 Materials

Experiment 2 utilized the same stimulus set as Experiment 1. The main difference was that the recognition task required withholding items at study to serve as foils at test. Thus the 144 target words were randomly assigned to 16 lists of 9 targets each. These lists were rotated through conditions across participants using a Latin square. Experiment 2 also utilized the same demographic and language background questionnaire as in Experiment 1.

3.1.4 Apparatus

Stimuli were presented on a Macintosh computer, and the experiment was programmed using PsyScope X software (Cohen, MacWhinney, Flatt, & Provost, 1993). Responses were recorded using an ioLab Systems button box.

3.1.5 Procedure

Participants were tested individually in sessions lasting approximately 45 minutes. Participants were first provided an informed consent form to review and sign. Next, the researcher administered the English language Picture Vocabulary assessment to the participant. After this assessment was finished the participants completed the language and demographic background questionnaires while the experimenter scored the assessment. Once the assessment and questionnaire were completed the main experiment began. Participants were seated in front of the computer and button box in a small experiment room. At study, participants completed 3 blocks of 36 trials. The trials in each block were presented in the same context condition (isolated, high constraint, or low constraint) and contained concrete, abstract, high-frequency, and low-frequency target words. Orders of blocks and target word types within blocks were counterbalanced across participants. Participants were asked to read each stimulus word or sentence out loud and try to commit the target words to memory.

Immediately after the study trials were completed, instructions were given for the test trials. At test participants were administered a yes/no recognition task. The test trials consisted of two blocks of 72 trials and contained all stimuli, including words from the not-presented control condition. Participants were instructed to press one of two buttons on the button box to indicate whether they recognized each word from the study trials or not. Upon completion of the test trials, the experimenter debriefed the participant and answered any questions they might have had.

3.2 Results

3.2.1 Discrimination

The detection parameter *d'* was calculated (see Table 3) in each condition for each participant using the equal variance model. These values were then analyzed using a 2 (concreteness) x 2 (frequency) x 3 (study context) repeated-measures ANOVA. A significant effect of frequency indicated that low-frequency words were more accurately recognized than high-frequency words, $F(1, 95) = 22.82$, $MSE = 19.59$, $p < .001$. A significant effect of concreteness revealed that concrete were better discriminated than abstract words, $F(1, 95) = 4.01$, $MSE = 3.41$, $p = .048$. There was also a main effect of context, $F(2, 94) = 5.12$, $MSE = 2.14$, $p = .007$. Planned comparisons showed that targets in low constraint sentences were better recognized than targets in isolation, $F(1, 95) = 8.22$, $MSE = 7.58$, $p = .005$, and targets in high constraint sentences, $F(1, 95) = 8.58$, $MSE = 5.02$, $p = .004$. Although the full interaction of frequency and context did not reach significance, F(2, 190) = 2.86, MSE = .860, p = .06, planned comparisons revealed that the low-frequency advantage was larger for words studied in high-constraint sentences than for words studied in isolation, $F(1, 95) = 4.53$, $MSE = 3.44$, $p = .036$. No other interactions reached significance, $ps > .05$.

3.2.2 Hit rates

Hit rates (see Table 3) were submitted to a 2 (concreteness) x 2 (frequency) x 3 (study context) repeated-measures ANOVA. Low-frequency words had higher hit rates than high-frequency words, $F(1, 95) = 11.65$, $MSE = .452$, $p = .001$. A main effect of concreteness revealed that abstract words had higher hit rates than concrete words, $F(1, 95) = 5.71$, $MSE = .180$, $p =$

.019. There was also a main effect of context, $F(2, 94) = 5.08$, $MSE = .219$, $p = .007$. Planned comparisons showed that words in low constraint sentences had higher hit rates than words in isolation, $F(1, 95) = 8.58$, $MSE = .820$, $p = .004$, and words in high constraint sentences, $F(1, 95) = 7.46$, $MSE = .438$, $p = .008$. There was also a significant interaction of frequency and context, $F(1, 95) = 3.33$, $MSE = .107$, $p = .038$, such that for high-frequency words, targets presented in isolation had higher hit rates than targets in high constraint sentences, but low-frequency words showed the opposite pattern. No other interactions reached significance, $ps > .05$.

3.2.3 False alarm rates

False alarm rates (see Table 3) were submitted to a 2 (concreteness) x 2 (frequency) repeated measures ANOVA. Because context was manipulated via study condition, and false alarm rates are based on items not presented at study, there was no context factor. Low-frequency words produced lower false alarm rates than high-frequency words, $F(1, 95) = 7.73$, $MSE = .133$, $p = .007$, and concrete words produced lower false alarm rates than abstract words, $F(1, 95) = 14.25$, $MSE = .239$, $p < .001$. The interaction of frequency and concreteness was not significant, $p = .457$.

3.2.4 Response times

Response times (see Table 3) were recorded in each condition for each participant but only correct responses were included for analysis. Response times for hits were submitted to a 2 (concreteness) x 2 (frequency) x 3 (study context) repeated-measures ANOVA. The data from one participant was excluded from the analysis due to having no correct responses, and therefore no valid response times, in one condition. There was a significant effect of frequency, $F(1, 94) = 10.42$, $MSE = 5264638$, $p = .002$, such that responses to low-frequency words were faster than responses to high-frequency words. There was also a significant interaction of concreteness and context, $F(2, 188) = 3.80$, $MSE = 909540$, $p = .024$. Planned comparisons showed that when target words had been presented in isolation, hit responses were faster for abstract words, but when target words had been presented in low-constraint sentences, hit responses were faster for concrete words, $F(1, 94) = 6.39$, $MSE = 3228661$, $p = .013$. A comparison of responses times for hits to target words studied in low-constraint and high-constraint sentences, $F(1, 94) = 5.16$, $MSE = 2110080$, $p = .025$, indicated that the pattern of faster responses to concrete words than to abstract words was stronger in the low-constraint condition than in the high-constraint condition. No other main effects or interactions reached significance, *ps* > .05.

Response times for correct rejections (see Table 3) were submitted to a 2 (concreteness) x 2 (frequency) repeated measures ANOVA. There was a significant effect of frequency, $F(1, 95) = 16.95$, $MSE = 9815807$, $p < .001$, such that correct rejections responses were faster for low-frequency words than for high-frequency words. No other main effects or interactions reached significance, *ps* > .05.

Table 4: Mean (SE) recognition performance in Experiment 2.

Concreteness Frequency Study Context	Hit rate	FA rate	d'	Response time
Concrete				
Low frequency				
Isolated	.623 (.02)	--	1.48 (.09)	1330 (75)
Low constraint	.691 (.02)	--	1.69 (.09)	1254 (56)
High constraint	.683 (.02)	--	1.64 (.08)	1405 (72)
Not presented	--	.166 (.01)		1559 (79)
High frequency				
Isolated	.626 (.02)	--	1.30 (.09)	1536 (102)
Low constraint	.681 (.02)	--	1.46 (.08)	1338 (43)
High constraint	.601 (.02)	--	1.21 (.07)	1523 (88)
Not presented	--	.218 (.02)		1905 (103)
Abstract				
Low frequency				
Isolated	.674 (.02)	--	1.40 (.09)	1304 (64)
Low constraint	.721 (.02)	--	1.56 (.09)	1361 (87)
High constraint	.705 (.02)	--	1.47 (.08)	1523 (88)

Not presented	--	.230 (.02)		1665 (84)
High Frequency				
Isolated	.652 (.02)	--	1.24 (.09)	1475 (78)
Low constraint	.666 (.02)	--	1.27 (.09)	1514 (53)
High constraint	.636 (.02)	--	1.90 (.08)	1497 (65)
Not presented	--	.253 (.02)		1959 (120)

3.3 Discussion

Detection (d’) scores were higher for concrete words, producing the expected concreteness effect. Hit rates were higher for abstract words than for concrete words, but false alarm rates were lower for concrete words than for abstract words as expected. Thus, the abstract advantage in hit rates was outweighed by the stronger concrete advantage in false alarm rates. It should be noted that the literature on mirror effects for concrete words in recognition is mixed. Although concrete words have been shown to have higher hit rates and lower false alarm rates than abstract words at times (Glanzer & Adams, 1985; Hockley, 1994), there have also been numerous experiments in which the mirror effect was not observed (Glanzer & Adams, 1985; Hirshman & Arndt, 1997). Notably, Hirshman and Arndt (1997) did not report a significant concrete advantage in hit rates in any of their 7 experiments and some experiments showed an abstract advantage in hit rates. Thus the current results match what would be expected under the *memory based explanation*.

Low-frequency words had significantly higher discrimination scores than high-frequency words, with both higher hit rates and lower false alarm rates. These findings replicate the low-frequency recognition advantage and the word-frequency mirror effect typically seen in previous research. These results match what would be predicted by both the *source of activation confusion* theory (Reder et al., 2000) and the *memory based explanation* (Hirshman & Arndt, 1997).

Words embedded in low-constraint sentences had higher discrimination scores and higher hit rates than words embedded in high constraint sentences as well as words presented in isolation. This pattern of performance across context conditions was somewhat unexpected. Little work examining the effects of context or semantic constraint on recognition has been reported. One prior study found that recognition accuracy was significantly decreased for words presented in sentence contexts (Schwartz, 1975), but the level of constraint in the sentences was not clear.

Context did not interact with concreteness in the accuracy data. Under the context availability account, studying target words in a sentence context was expected to reduce or eliminate the concreteness effect, particularly for the high-constraint condition. Context did interact with frequency, showing a larger frequency effect for targets presented in high-constraint sentences than for targets presented in isolation. Although this effect was in the opposite direction from what was predicted, this finding suggests that although context availability is not considered in the memory-based explanation or the source of activation confusion theory, it may play a role in the low-frequency recognition advantage.

Although specific a priori predictions about response times were not made, the data were available and an analysis was deemed appropriate. The results revealed that correct responses, both hits and correct rejections, were faster for low-frequency words than for high-frequency words. This finding is consistent with the low-frequency advantage reported in the accuracy data. The response time analysis also revealed a significant interaction of concreteness and context in hit responses. When presented in isolation, concrete words produced faster response times for hits than abstract words. In low- and high-constraint sentences, abstract words produced faster response times for hits with the advantage being larger for targets presented in low-constraint sentences than targets presented in high-constraint sentences. Thus although the context availability account would predict an interaction of context and concreteness, the pattern of the current findings is in the opposite direction as what would be predicted under the framework. Specifically, the current results demonstrated that the concrete advantage was larger in sentence context, particularly for targets presented in low-constraint sentences.

Chapter 4: Experiment 3

The purpose of Experiment 3 was to examine the effects of word concreteness, word frequency, and bilingual language dominance in item recognition of target words studied in isolation. There were two primary goals of Experiment 3, one was to continue the examination of word frequency and concreteness effects in recognition memory as had been observed in Experiment 2. It was hypothesized that low-frequency words and concrete words would produce recognition advantages relative to high-frequency words and abstract words. The other major goal was to replicate the recent finding of an advantage for L2 words over L1 words in an item recognition task (Francis & Gutiérrez, 2012; Francis & Strobach, 2013). It was hypothesized that L2 words would exhibit better discrimination than L1 words.

4.1 Method

4.1.1 Participants

The sample consisted of 64 English-Spanish bilingual students (32 English dominant and 32 Spanish dominant) from the University of Texas at El Paso. Language dominance was determined using the Woodcock-Muñoz Language Survey Revised (Woodcock, Muñoz-Sandoval, Ruef, & Alvarado, 2005) Picture Vocabulary and Verbal Analogies tests (see Table 4). Participants were recruited from psychology courses and earned their choice of either course credit or $10 per hour of participation. The sample included 48 women and 16 men with a median age of 19. Two additional participants who completed the protocol were excluded and replaced for failure to follow test instructions (i.e., using only one of the two response buttons).

Table 5: Average Woodcock-Muñoz composite age equivalency scores and ESPADA self-report language proficiency information.

Measure	English Dominant	Spanish Dominant
Woodcock-Muñoz		
English age equivalency	17.2	11.6
Spanish age equivalency	11.1	15.7
ESPADA		
Age exposed to English	4.7	6.6
Age exposed to Spanish	1.7	0.9
Time speaking English	58%	34%
Time speaking Spanish	31%	53%
Time speaking mixture	11%	13%

4.1.2 Design

The experimental conditions formed a 2 (concreteness) x 2 (frequency) x 2 (language) x 2 (item status) repeated-measures design. The concreteness factor divided stimuli into concrete and abstract words and the frequency factor divided stimuli into high- and low-frequency words. The language factor was determined by whether the words were studied in English or Spanish. Half of the words of each type were studied, and half were used as foils at test. Dependent variables included hit rates, false-alarm rates, d', and RT.

4.1.3 Materials

Stimuli were selected from four published sources (Altarriba, Bauer, & Benvenuto, 1999; Miller & Roodenrys, 2009; Tokowicz & Kroll, 2007; Tolentino & Tokowicz, 2009) in which normed abstract and concrete words were provided. English word frequency information for the stimuli was obtained using CELEX (Baayen et al., 1995), and Spanish word frequency information was obtained using ANEXOS (Alameda & Cuetos, 1995). Median word frequencies for each stimulus category are provided in Table 5. The final stimulus set included 128 target words (28 words for each stimulus category) that were randomly distributed across 16 lists (4 lists for each stimulus category) of 8 targets each. These lists were rotated through language and item status conditions across participants using a Latin square. Demographic and language background information were obtained using two self-report questionnaires. The demographic questionnaire was used to collect information on gender, age, ethnicity, and socioeconomic status. Language background information was collected using the ESPADA (Francis & Strobach, 2013b). This questionnaire was used to collect information on age of acquisition, frequency of usage, and other characteristics of participants' language proficiency and background.

Table 6: Median word frequencies and average CLOZE probabilities for Experiments 3 and 4.

	Concrete High-Frequency	Concrete Low-Frequency	Abstract High-Frequency	Abstract Low-Frequency
Word Frequency English	160.06	19.57	178.37	20.25
Word Frequency Spanish	176.25	12.25	197.75	20.75
CLOZE English	.04	.03	.04	.04
CLOZE Spanish	.07	.03	.08	.03

4.1.4 Apparatus

Stimuli were presented on a Macintosh computer, and the experiment was programmed using PsyScope X software (Cohen, MacWhinney, Flatt, & Provost, 1993). Responses were recorded using an ioLab Systems button box.

4.1.5 Procedure

Participants were tested individually in sessions lasting approximately 45 minutes. Participants were first provided an informed consent form to review and sign. Next, the researcher administered the English Picture Vocabulary and Verbal Analogy tests in English and Spanish. After these assessments were finished, the participants completed the language and demographic background questionnaires while the experimenter scored the assessment. Once the assessment and questionnaires were completed the main experiment began. Participants were seated in front of the computer and button box set up in a small experiment room. In the study phase, participants completed two blocks of 32 trials, one in English and one in Spanish. The trials in each block were grouped by stimulus category with 8 trials of each stimulus type. Orders of language blocks and orders of target word types within blocks were counterbalanced across participants. Participants were asked to read each target word aloud and to try and commit the target words to memory.

Immediately after the study trials were completed, instructions were given for the test. In the test phase, participants completed a yes/no recognition task. The test trials consisted of two blocks of 64 trials, one in English and one in Spanish, with the language order consistent with the language order at study. The test blocks contained all stimuli, including the target words that were not studied. (The language of the words was always consistent from study to test.) Participants were instructed to press one of two buttons on the button box to indicate whether they recognized each word from the study phase or not. Upon completion of the test trials, the experimenter debriefed the participant and answered any questions they may have had.

4.2 Results

For all analyses, English and Spanish scores were recoded as L1 and L2 scores, according to the dominant language of each participant as assessed using the Woodcock-Muñoz composite age equivalency scores.

4.2.1 Discrimination

The detection parameter *d'* was calculated in each condition for each participant using the equal variance model (see Table 6). These scores were then submitted to a 2 (concreteness) x 2 (frequency) x 2 (language) repeated measures ANOVA. There was a significant effect of concreteness, $F(1, 63) = 4.29$, $MSE = 2.10$, $p = .042$, such that concrete words were better discriminated than abstract words. A significant main effect of frequency, $F(1, 63) = 64.49$, $MSE = 32.03$, $p < .001$, revealed that low-frequency words were better discriminated than high-frequency words. A significant main effect of language, $F(1, 63) = 5.38$, $MSE = 4.33$, $p = .024$, indicated that L2 words were better discriminated than L1 words. No interactions reached significance, *ps* > .05.

4.2.2 Hit rates

Hit rates (see Table 6) were analyzed via a 2 (concreteness) x 2 (frequency) x 2 (language) repeated measures ANOVA. A main effect of frequency, $F(1, 63) = 27.71$, $MSE = .921$, $p < .001$, revealed that low-frequency words had higher hit rates than high-frequency words. No other main effects or interactions reached significance, *ps* > .05.

4.2.3 False alarm rates

False alarm rates (see Table 6) were submitted to a 2 (concreteness) x 2 (frequency) x 2 (language) repeated measures ANOVA. There was a significant effect of frequency, $F(1, 63) =$

25.11, *MSE* = .399, $p < .001$, such that low-frequency words had lower false alarm rates than high-frequency words. No other main effects or interactions reached significance, *p*s > .05.

4.2.4 Response times

Response times (see Table 6) were recorded for in each condition for each participant but only correct responses were analyzed. Response times for hits were submitted to a 2 (concreteness) x 2 (frequency) x 2 (language) repeated measures ANOVA. There was a significant effect of frequency, $F(1, 63) = 6.40$, $MSE = 785544$, $p = .014$, such that responses to low-frequency words faster than responses to high-frequency words. No other main effects or interactions reached significance, *p*s > .05.

Correct rejection response times were also submitted to a 2 (concreteness) x 2 (frequency) x 2 (language) repeated measures ANOVA. There was a significant effect of concreteness, $F(1, 63) = 4.19$, $MSE = 383953$, $p = .045$, such that responses to concrete words were faster than responses to abstract words. There was also a marginally significant interaction of frequency and concreteness, $F(1, 63) = 3.94$, $MSE = 238591$, $p = .051$, such that the concreteness effect on correct rejection response times was larger for low-frequency words than for high-frequency words.

Table 7: Mean (SE) recognition performance for Experiment 3.

Concreteness Frequency Language	Hit rate	FA rate	d'	RT Hits	RT Correct Rejections
Concrete					
Low frequency					
L1	.791 (.02)	.126 (.02)	2.21 (.10)	1077 (88)	1147 (44)
L2	.820 (.02)	.097 (.01)	2.45 (.10)	1086 (51)	1199 (60)
High frequency					
L1	.715 (.03)	.187 (.02)	1.72 (.10)	1149 (52)	1251 (51)
L2	.700 (.03)	.168 (.02)	1.76 (.12)	1260 (72)	1246 (60)
Abstract					
Low frequency					

L1	.754 (.02)	.151 (.02)	1.95 (.10)	1044 (39)	1213 (43)
L2	.810 (.02)	.128 (.02)	2.27 (.10)	1114 (62)	1329 (69)
High Frequency					
L1	.691 (.03)	.189 (.02)	1.63 (.10)	1081 (36)	1222 (49)
L2	.729 (.03)	.182 (.02)	1.77 (.12)	1145 (63)	1299 (77)

4.3 Discussion

As expected, detection (d') scores were significantly higher for concrete words than for abstract words. However, there were no significant differences between concrete and abstract words in hit rates or false alarm rates. Previous work has demonstrated that manipulations of concreteness sometimes produce mirror effects in recognition memory (Glanzer & Adams, 1985). However significant concreteness effects for hit rates are not consistently observed (Hirshman & Arndt, 1997). The present study did not produce the concrete advantage in false alarm rates that has been reported consistently in previous research. The experiments reported by Hirshman and Arndt (1997) were most similar to Experiment 3 as they also manipulated both word frequency and word concreteness. Thus, although the false alarm effect did not reach significance the pattern of results matches the findings reported by Hirshman and Arndt (1997).

Low-frequency words exhibited significantly higher discrimination scores than high-frequency words, with both higher hit rates and lower false rates. Thus, these findings replicate the low-frequency recognition advantage as well as the word-frequency mirror effect. These findings match what would be expected under both the source of activation confusion theory (Reder et al., 2000) and the memory based explanation (Hirshman & Arndt, 1997).

L2 words exhibited significantly higher discrimination scores than words in L1, although language differences in hit rates and false alarm rates did not reach significance. The advantage in discrimination replicates a previously reported L2 recognition advantage (Francis & Gutiérrez, 2012; Francis & Strobach, 2013).

Lastly, although I did not make specific a priori predictions about response times, the response time analysis revealed some significant effects. Hit responses were faster for low-frequency words than for high-frequency words, consistent with the low-frequency advantage in hit rates. Concrete words produced significantly faster response times than abstract words for correct rejections, consistent with the concrete advantage in false-alarm rates.

Chapter 5: Experiment 4

Experiment 4 was conducted concurrently with Experiment 3. Experiment 4 examined the same factors as Experiment 3 with the major difference being that in Experiment 4 participants studied targets in the context of sentence frames rather than in isolation. Thus, the major goal of Experiment 4 was to examine the impact of sentence context on the effects of word concreteness, frequency, and bilingual language dominance in item recognition. As discussed in Chapter 3, Experiment 2 was the first experiment known by the author to examine the impact of sentence context on concreteness effects in item recognition. Therefore, Experiment 4 built on Experiment 2 by further examining the impact of sentence context on concreteness effects in recognition memory. Based on prior findings of concrete advantages in recognition and the results observed in Experiment 2, it was predicted that concrete words would be better discriminated than abstract words.

Additionally, although the effects of word frequency in item recognition have been examined in numerous experiments, the impact of sentence context on this frequency effect has not yet been established. The potential impact of context availability in word-frequency effects has not been considered in theories explaining the low-frequency advantage in item recognition. The results of Experiment 2 suggest that context availability may indeed impact word-frequency effects in item recognition. Thus, another goal of Experiment 4 was to further examine the effects of word frequency in recognition for targets presented in sentence context at study. The logic of the context availability account led to the original prediction that the low-frequency recognition advantage would be reduced in sentence context (see Introduction). However the results of Experiment 2 suggested that context availability might impact the frequency effect in recognition such that the L2 advantage is increased. Therefore, it was predicted that low-frequency words would be better discriminated than high-frequency words.

Finally, the potential impact of context availability on the recent finding of an L2 item recognition advantage has yet to be examined. Considering that the logic of the source of activation confusion theory explaining the word frequency effect has been applied to this L2 advantage it is reasonable to investigate a potential role of context availability. However, a recent revision to this logic suggests that the L2 item recognition advantage may rely mostly on the base factor, rather than the fan factor where the impact of context availability was reasoned to potentially operate. Thus, it was predicted that L2 words would be better discriminated than L1 words.

5.1 Method

5.1.1 Participants

Participants were 64 English-Spanish bilingual students (32 English Dominant and 32 Spanish Dominant) from the University of Texas at El Paso. Language dominance was determined using the Woodcock-Muñoz Language Survey Revised (Woodcock, Muñoz-Sandoval, Ruef, & Alvarado, 2005) Picture Vocabulary and Verbal Analogies tests (see Table 7). Participants were recruited from psychology courses and earned their choice of either course credit or $10 per hour of participation. The sample included 49 women and 15 men with a median age of 21. Four additional participants who completed the protocol were excluded and replaced for failure to follow test instructions (i.e., using only one of the two response buttons).

Table 8: Average Woodcock-Muñoz composite age equivalency scores and ESPADA self-report language proficiency information for Experiment 4.

Measure	English Dominant	Spanish Dominant
Woodcock-Muñoz		
English age equivalency	15.2	11.6
Spanish age equivalency	11.5	17.6
ESPADA		
Age exposed to English	5.4	8.9
Age exposed to Spanish	1.6	0.9
Time speaking English	59%	39%
Time speaking Spanish	24%	48%
Time speaking mixture	17%	13%

5.1.2 Design

The design of Experiment 4 was identical to that of Experiment 3.

5.1.3 Materials

Experiment 4 utilized the same set of target words as in Experiment 3. However, in Experiment 4, the target words were studied in the context of low-constraint sentences (see Table 5). The sentence frames were borrowed from Experiments 1 and 2. The reason for using low-constraint sentences was that in Experiment 2, low-constraint sentences produced better discrimination of target words than high-constraint sentences or words presented in isolation.

5.1.4 Apparatus

Experiment 4 used the same apparatus as Experiment 3.

5.1.5 Procedure

The procedure of Experiment 4 was identical to that of Experiment 3 with the exception that words were studied in sentence context rather than in isolation. Thus, when given instructions participants were asked to read each sentence aloud and told that the final word in each sentence would be in all capital letters and that they were to try and commit these words to memory.

5.2 Results

As in Experiment 3, for all analyses, English and Spanish scores were recoded as L1 and L2 scores, according to the dominant language of each participant.

5.2.1 Discrimination

The detection parameter *d'* was calculated (see Table 8) in each condition for each participant using the equal variance model. These scores were then submitted to a 2 (concreteness) x 2 (frequency) x 2 (language) repeated measures ANOVA. The main effect of concreteness was significant, $F(1, 63) = 18.72$, $MSE = 9.20$, $p < .001$, such that concrete words exhibited better discrimination than abstract words. The main effect of frequency was also significant, F(1, 63) = 93.18, MSE = 45.94, p < .001, such that low-frequency words were better discriminated than high-frequency words. There was also a significant main effect of language, $F(1, 63) = 8.39$, $MSE = 4.902$, $p = .005$, indicating that L2 words were better discriminated than L1 words. No interactions reached significance, *p*s > .05.

5.2.2 Hit rates

Hit rates (see Table 8) were analyzed using a 2 (concreteness) x 2 (frequency) x 2 (language) repeated measures ANOVA. There was a significant effect of frequency, $F(1, 63) = 35.79$, $MSE = 1.19$, $p < .001$, indicating that low-frequency words exhibited higher hit rates than high-frequency words. There was also a significant effect of language, $F(1, 63) = 7.53$, $MSE = .171$, $p = .008$, such that L2 words exhibited higher hit rates than L1 words. No other main effects or interactions reached significance, *p*s > .05.

5.2.3 False alarm rates

False alarm rates (see Table 8) were submitted to a 2 (concreteness) x 2 (frequency) x 2 (language) repeated measures ANOVA. There was a significant main effect of frequency, $F(1, 63) = 34.83$, $MSE = .676$, $p < .001$, indicating that low-frequency words exhibited lower false alarm rates than high-frequency words. There was also a significant main effect of concreteness, $F(1, 63) = 14.38$, $MSE = .276$, $p < .001$, such that concrete words exhibited lower false alarm rates than abstract words. No other main effects or interactions reached significance, *p*s > .05.

5.2.4 Response times

Response times (see Table 8) were recorded in each condition for each participant but only correct responses (hits and correct rejections) were submitted for analysis. Response times for hits were submitted to a 2 (concreteness) x 2 (frequency) x 2 (language) repeated measures ANOVA. There was a significant effect of frequency, $F(1, 63) = 7.37$, $MSE = 1023082$, $p = .009$, such that responses to low-frequency words were faster than responses to high-frequency words. There was also a main effect of concreteness, $F(1,63) = 9.04$, $MSE = 829988$, $p = .004$, such that responses to concrete words were faster than responses to abstract words. No other effects reached significance, *p*s > .05.

Correct rejections were also submitted to a 2 (concreteness) x 2 (frequency) x 2 (language) repeated measures ANOVA. There was a significant effect of frequency, $F(1, 63) = 12.87$, $MSE = 1194769$, $p = .001$, such that responses to low-frequency words were faster than responses to high-frequency words. There was also an interaction of frequency and concreteness, $F(1, 63) = 12.70$, $MSE = 814183$, $p = .001$, such that the low-frequency advantage was larger for concrete words than for abstract words. No other effects reached significance, *p*s > .05.

Table 9: Mean (SE) recognition performance in Experiment 4.

Concreteness Frequency Language	Hit rate	FA rate	d'	RT Hits	RT Correct Rejections
Concrete					
Low frequency					
L1	.727 (.02)	.115 (.01)	2.02 (.09)	1077 (88)	1177 (55)
L2	.783 (.02)	.095 (.01)	2.32 (.08)	1086 (51)	1209 (47)
High frequency					
L1	.665 (.03)	.165 (.02)	1.61 (.09)	1023 (32)	1338 (52)
L2	.663 (.03)	.162 (.02)	1.61 (.09)	1100 (57)	1401 (63)
Abstract					
Low frequency					
L1	.708 (.02)	.150 (.01)	1.80 (.10)	1136 (45)	1285 (72)
L2	.763 (.02)	.124 (.01)	2.08 (.09)	1224 (58)	1341 (49)
High Frequency					
L1	.615 (.03)	.233 (.02)	1.21 (.10)	1223 (50)	1388 (71)
L2	.652 (.03)	.215 (.02)	1.41 (.10)	1239 (60)	1272 (49)

5.3 Discussion

In Experiment 4, concrete words were better discriminated than abstract words when presented in low-constraint sentence contexts. This effect was driven by a significant advantage for concrete words in false alarm rates, but not in hit rates. These findings closely match previous reports of concreteness effects in hit and false alarm rates (Hirshman & Arndt, 1997). This finding also matches the results of Experiments 1 and 2 of the present study. Specifically, as in Experiments 1 and 2, presenting words in a low-constraint sentence context did not eliminate the advantage for concrete words in explicit memory performance.

Low-frequency words were better discriminated, had higher hit rates, and had lower false alarm rates than high-frequency words. Additionally L2 words were better discriminated and had higher hit rates than L1 words. These results replicate the well-documented low-frequency advantage and mirror effect as well as more recent findings of an L2 item recognition advantage (Francis & Gutiérrez, 2012; Francis & Strobach, 2013). Furthermore, these results extend the previously reported findings of word frequency and bilingual language proficiency by extending the results to targets presented in a sentence context. Experiment 4 is the first to show an advantage for L2 in recognition of words presented in sentence contexts.

The analysis of response times also revealed some significant effects. For hits, responses were faster for low-frequency words than for high-frequency words and faster for concrete words than for abstract words, consistent with patterns in the accuracy data. For correct rejections, responses were faster for low-frequency words than for high-frequency words, again consistent with the accuracy data. There was also a significant interaction of concreteness and frequency such that the low-frequency advantage was larger for concrete words than for abstract words.

Chapter 6: Experiments 3 and 4

Experiment 3 examined the effects of concreteness, frequency, and language in item recognition for words studied in isolation while Experiment 4 examined these factors for words studied in sentence contexts. A between-subjects variable of context was created by randomly assigning participants to the two experiments. The context availability account proposes that access to contextual information benefits processing and comprehension (Kieras, 1978). Placing stimuli into sentence and paragraph contexts has been reported to reduce or eliminate concreteness effects in recall (Holmes & Langford, 1976; Marschark, 1985; Wattenmaker & Shoben, 1987) and lexical decision (Schwanenflugel & Shoben, 1983; van Hell & de Groot, 2008).

It is also possible that context availability moderates the effects of word frequency and bilingual language proficiency in item recognition, considering that the source of activation confusion theory discusses the importance of the number of associated pre-experimental episodic contexts. Indeed, in Experiment 2, there was an interaction showing that the low-frequency advantage was larger for target words presented in high-constraint sentences than for target words presented in isolation. Thus, the goal of examining the combined results of Experiments 3 and 4 was to investigate the potential impact of sentence context on the manifestation of word concreteness, word frequency, and bilingual language proficiency effects in item recognition.

6.1 Results

6.1.1 Discrimination

The detection parameter *d'* was calculated (see Tables 6 & 8) in each condition for each participant using the equal variance model. These scores were then submitted to a 2 (context) x 2 (concreteness) x 2 (frequency) x 2 (language) mixed ANOVA. . There was a significant main effect of context, $F(1, 126) = 7.83$, $MSE = 11.69$, $p = .006$, such that targets in isolation were better discriminated than targets in sentence context. There was a significant effect of concreteness, $F(1, 126) = 20.49$, $MSE = 10.05$, $p < .001$, such that concrete targets were better discriminated than abstract targets. There was also a significant effect of frequency, $F(1, 126) = 156.30$, $MSE = 77.34$, $p < .001$, such that low-frequency words were better discriminated than high-frequency words. The main effect of language was also significant, $F(1, 126) = 13.28$, $MSE = 9.22$, $p < .001$, such that L2 words were better discriminated than L1 words. The only significant interaction was a two-way interaction of frequency and language, $F(1, 126) = 5.19$, $MSE = 2.34$, $p = .024$, such that the L2 advantage was larger for low-frequency words than for high-frequency words. No other interaction reached significance, *ps* > .05.

6.1.2 Hit rates

Hit rates (see Tables 6 & 8) were analyzed using a 2 (context) x 2 (concreteness) x 2 (frequency) x 2 (language) mixed ANOVA. There was a significant effect of context, $F(1, 126) = 8.63$, $MSE = .752$, $p = .004$, such that targets in isolation had higher hit rates than targets in sentence contexts. There was a significant effect of frequency, $F(1, 126) = 63.24$, $MSE = 2.10$, $p < .001$, such that low-frequency words had higher hit rates than high-frequency words. There was also a significant main effect of language, $F(1, 126) = 8.57$, $MSE = .260$, $p = .004$, such that L2 words produced higher hit rates than L1 words. No other main effects or interactions reached significance, *p*s > .05.

6.1.3 False alarm rates

False alarms (see Tables 6 & 8) were analyzed using a 2 (context) x 2 (concreteness) x 2 (frequency) x 2 (language) mixed ANOVA. There was a significant effect of concreteness, $F(1,126) = 15.30$, MSE = .267, $p < .001$, such that concrete words had lower false alarm rates than abstract word. There was a significant effect of frequency, $F(1, 126) = 59.89$, $MSE = 1.06$, $p < .001$, such that low-frequency words had lower false alarm rates than high-frequency words. Finally, the effect of language was significant, $F(1, 126) = 4.87$, $MSE = .082$, $p = .029$, such that L2 words produced lower false alarm rates than L1 words. No other main effects or interactions reached significance, $ps > .05$.

6.1.4 Response times

Response times (see Tables 6 & 8) were recorded in each condition for each participant but only correct responses were analyzed. Response times for hits were submitted to a 2 (context) x 2 (concreteness) x 2 (frequency) x 2 (language) mixed ANOVA. There was a significant main effect of frequency $F(1, 126) = 13.77$, $MSE = 1800792$, $p < .001$, such that responses to low-frequency words faster than responses to high-frequency words. There was also a significant interaction of concreteness and context, $F(1, 126) = 7.51$, $MSE = 1039034$, $p = .007$, in which responses were faster for concrete words than for abstract words when target words were presented in sentence contexts, but not when they were presented in isolation.

Response times for correct rejections were also submitted to a 2 (context) x 2 (concreteness) x 2 (frequency) x 2 (language) mixed ANOVA. There was a significant main effect of frequency, $F(1, 126) = 12.61$, $MSE = 1061040$, $p = .001$, such that responses were faster for low-frequency words than for high-frequency words. A significant effect of concreteness was produced, $F(1, 26) = 5.95$, $MSE = 579630$, $p = .016$, such that responses were faster for concrete words than for abstract words. There was a significant interaction of frequency and concreteness, $F(1, 126) = 15.52$, $MSE = 967133$, $p < .001$, such that there was a low-frequency advantage for concrete words but not for abstract words. No other effects reached significance, ps > .05.

6.2 Discussion

The combined results of Experiments 3 and 4 expanded on the findings of each experiment individually by adding context as a between subjects factor and adding more power to detect the effects of the other factors and their interactions. This analysis revealed that studying target words in a sentence context leads to lower discrimination scores and hit rates than studying targets in isolation. These findings match the results reported in an earlier study in which placing target words in sentence contexts reduced recognition performance relative to words in isolation (Schwartz, 1975).

The combined results also revealed no significant interactions between context and concreteness. The context availability explanation of the concreteness effect proposes that it is easier to access associated context information for concrete words than for abstract words. Previous work supporting this account has suggested that providing context information in the form of a sentence or paragraph can reduce or eliminate the concreteness effect. Thus, the results of Experiments 3 and 4 do not support the context availability account.

The logic of context availability can also be applied to effects of word frequency and bilingual language proficiency in recognition by expanding on the source of activation confusion theory framework that has been used as an explanation. Indeed, Experiment 2 produced a significant interaction of frequency and context suggesting that context availability may impact the frequency effect in recognition. In contrast, the combined results of Experiments 3 and 4 produced no significant interactions of context with frequency or language. The present results therefore provide little support for the role of context availability in the effects of word frequency or language proficiency on recognition memory. This finding does support the revision to the source of activation confusion logic as it is applied to the L2 item recognition advantage. Specifically, if the L2 advantage relies mainly on the base (familiarity) factor and contextual associations are made at the language-general conceptual level, then no impact of context availability on language effects would be expected.

The additional power provided by including all 128 participants from Experiments 3 and 4 in the analysis revealed patterns that did not emerge in the results of either experiment individually. First, the combined analysis revealed significant effects of language in both hit and false alarm rates. In particular, there was a mirror effect for language proficiency such that L2 words produced higher hit rates and lower false alarm rates than L1 words. Second, the combined analysis revealed a significant interaction of language and frequency such that the L2 advantage was larger for low-frequency words. These results replicate and extend the findings of a previous study reporting an advantage for L2 words in item recognition (Francis & Strobach, 2013). Specifically, although the means of the prior study trended in the direction of an increased low-frequency advantage in L2 words, the interaction did not reach significance. Indeed, individually, neither Experiment 3 or Experiment 4 of the current study produced a significant interaction, it was only the power obtained by combining the results of both experiments into one analysis that revealed the effect. Despite the increased power of the combined analysis, there was no mirror effect for concreteness. Concrete words had higher discrimination scores and lower false alarm rates than abstract words, but there was no significant effect of concreteness in hit rates. It is worth noting that although prior literature has demonstrated a concrete advantage in recognition, the effect in false alarms has been more consistent than the effect in hit rates.

Although no a priori predictions were made, the response time analysis produced some interesting patterns for hit and correct rejection trials. On hit trials, responses were faster for low-frequency words than for high-frequency words, consistent with the low-frequency advantage in hit rates. Response times for hit trials also exhibited a significant interaction of concreteness and context. However, the pattern was opposite to what would be predicted by the context availability account. Specifically, the pattern of faster responses to concrete words than to abstract words was only reliable for target words presented in sentence contexts. On correct rejection trials, response times were faster for low-frequency words than for high-frequency words and faster for concrete words than for abstract words, thus matching the pattern of advantages observed in the accuracy data. Lastly, the correct rejection response times revealed a significant interaction of frequency and concreteness such that the low-frequency advantage was reliable for concrete words but not for abstract words.

Chapter 7: General discussion

The present experiments examined the mechanisms underlying the effects of word concreteness, word frequency and bilingual language dominance in tasks of explicit memory. Specifically, across 4 experiments, sentence context was manipulated to examine its role as a potential moderating factor in these effects on free recall and item recognition performance as would be expected under the context availability account. Table 10 presents a summary of these effects and their interactions with sentence context across the four experiments.

Table 10: Summary of results from Experiments 1 - 4.

	Experiment 1	Experiment 2	Experiments 3 and 4
Sentence Context Effect	▯	▯	▯
Concreteness Effect	▯	▯	▯
Frequency Effect	▯	▯	▯
Language Effect	--	--	▯
Context x Concreteness	✗	✗	✗
Context x Frequency	✗	▯	✗
Context x Language	--	--	✗

Note: ▯ = effect found; ✗ = effect not found; -- = effect not tested

In free recall, words studied in isolation were recalled at a higher rate than words presented in low-constraint sentences, and words presented in low-constraint sentences were better recalled than words presented in high-constraint sentences. Although a previous study examining the effects of semantic constraint in recall reported that high-constraint sentences led to better recall than low-constraint sentences (McFalls & Schwanenflugel, 2002), an examination of the substantial methodological differences between that study and Experiment 1, namely different criteria for defining low-constraint sentences, showed that the results are not contradictory, even if the conclusions were different. The recall results of Experiment 1 more closely match those of other studies in which recall of items studied in a sentence context was diminished relative to items studied in isolation (Cofer, 1968; Wood, 1970). An explanation given in this prior work was that embedding words in sentence contexts at study disrupted participants' ability to form new inter-item associations, thereby negatively affecting recall. The present results are consistent with this explanation, especially if we reason that high-constraint sentences should lead to even more intra-item processing than low-constraint sentences due to the stronger semantic connection between the sentence frame and the target word. This increase in intra-item processing for high-constraint sentences would further reduce inter-item processing relative to low-constraint sentences and have a stronger negative impact on recall performance.

In recognition, words studied in low-constraint sentences were better discriminated than words studied in isolation and words studied in high-constraint sentences. There has been little prior work examining the effects of sentence context on recognition memory. In one prior study, placing items in a sentence context at study significantly decreased recognition as compared to words studied in isolation (Schwartz, 1975), but it was not clear in that study what level of constraint the sentences provided. An important difference between that study and Experiment 2 is that in Experiment 2, context was manipulated within subjects and within study sequences, but in the prior study, context was manipulated between subjects. In contrast, Experiments 3 and 4 incorporated a between-subjects manipulation of context. Under that manipulation, words studied in a sentence context had decreased recognition accuracy relative to words studied in isolation as was reported by Schwartz (1975). It may therefore be the case that the impact of sentence context on recognition outcomes depends on whether the sentences are studied in a sequence that also includes isolated words.

The sensitivity of the context manipulation to the within-subject or between-subjects design makes sense if one considers context availability not as an absolute property of a word but as a property that is defined relative to other items. Specifically, under a within-subjects manipulation, targets presented in sentence contexts are committed to memory along with targets presented in isolation, potentially making the sentence contexts more salient at test. Alternatively, under a between-subjects manipulation, targets presented in sentence contexts are not compared to items presented in isolation. When context does not differentiate some items from others, its utility in retrieval is diminished.

7.1 Implications for the impact of context availability on concreteness effects

The current experiments replicated the classic concreteness effect. Specifically, concrete words demonstrated advantages over abstract words across all four experiments in recall proportion, discrimination, and response times. The only exception was that in Experiment 2, there was an abstract-word advantage in hit rates and response times for hits, but findings of an abstract advantage in hits are not uncommon in prior literature (Hirshman & Arndt, 1997). These results serve not only to replicate an established effect but also verify that the stimulus classifications used in the current experiments were valid.

According to the context availability framework, the concrete advantage arises due to a differential availability of associated contextual information for concrete and abstract words. Specifically, it is assumed that it is easier to access associated context information for concrete words than for abstract words, thereby leading to benefits in word identification, comprehension, and production as well as memory. Under this logic, a reduction in the concrete advantage would have been expected when target words were embedded in sentence contexts at study, especially for high-constraint sentences. Across all four experiments there were significant main effects of concreteness and context, but the factors did not interact. Thus the present results provide little support for the context availability framework. The only aspect of the results that might be construed as support for the context availability account comes from a significant three-way interaction in recall. Here, low-frequency words exhibited a numerical, but only marginally significant, reduction in the concrete advantage in the high-constraint condition relative to the isolated condition, but this pattern was not observed for high-frequency words. Although the context availability account would predict the reduction in the concreteness effect the fact that it was only marginally significant and limited to low-frequency words severely limits its evidentiary value.

While the present results indicate that context availability is not the primary factor underlying concreteness effects in explicit memory, the present results do not speak to the role of context availability in the effects of concreteness on lexical processing. Also, it may be the case that context availability plays a minor role in concreteness effects in explicit memory. To our knowledge, the present study is the first to systematically examine whether sentence context moderates concreteness effects in recognition memory, and the results of prior studies examining this question in free recall have been mixed. When concrete and abstract nouns were studied in sentence contexts, more concrete sentences were recalled than abstract sentences, and more words were recalled from concrete sentences than from abstract sentences (Holmes & Langford, 1976). However, placing these types of sentences in the context of a coherent paragraph led to equivalent recall of concrete and abstract sentences (Marschark, 1985; Wattenmaker & Shoben, 1987). Matching stimuli on participant context availability ratings also produced mixed results, with the concrete advantage being reduced only when participants were instructed to focus on context availability at study (Schwanenflugel, Akin, & Luh, 1992). That is, the effect did not generalize to other encoding tasks.

One of the context manipulations utilized in Experiments 1 and 2, sentence constraint, has not been applied in previous studies of concreteness effects on explicit memory. However, this manipulation had been shown to reduce concreteness effects in lexical processing tasks (van Hell & de Groot, 2008), showing that it is a powerful enough context manipulation to reduce or eliminate concreteness effects. Therefore, it would be difficult to argue that the manipulation of context was not strong enough in the present study, but it is possible that manipulations of entire paragraphs (as in Marschark, 1985; Wattenmaker & Shoben, 1987) would produce the reduction in concreteness effects predicted by the context availability framework.

It is also important to note that Experiment 4 utilized low-constraint sentences. Some might argue that the low-constraint sentence frames do not provide sufficient context to increase context availability enough to reduce concreteness effects, thus limiting the ability to speak to the explanatory power of the context availability account. There are three important counterpoints to this argument. First, much of the prior work supporting the context availability account of word concreteness effects did not manipulate, or control for, sentence constraint. Second, low-constraint sentences produced main effects in the current experiments suggesting that they do in fact provide sufficient context information to change recognition performance. Third, the original formulation of the context availability account (see Kieras, 1978) does not specifically address semantic constraint, and it is therefore not clear whether the account would suggest that low-constraint sentences provide insufficient context availability or simply less than that provided by high-constraint sentences. Considering this final point, it may be most accurate to say that the context availability account may need to be further specified.

7.2 Implications for the impact of context availability on word frequency effects

The present experiments replicated previous findings of frequency effects in explicit memory. High-frequency words exhibited the expected advantage in free recall and low-frequency words exhibited the expected advantage in recognition memory, including the *mirror effect,* with advantages in hit rates as well as false alarm rates. Importantly, these findings confirm that the manipulation of word frequency was strong enough.

Although neither the memory-based explanation nor the source of activation confusion theory explicitly details how context availability might moderate frequency effects in recognition, there is a logical basis to predict that these two factors might interact. Specifically, under the source of activation confusion theory, high-frequency words are thought to be associated with more pre-experimental contexts than low-frequency words. This property is thought to benefit low-frequency words by making the study context more salient because there are fewer potential pre-experimental contexts that could serve as sources of confusion. Thus, it was initially predicted that increasing context availability would serve to reduce or eliminate frequency effects in item recognition by boosting the salience of the study context from its more numerous competitors and thereby improving recognition performance. The results of Experiment 2 did reveal a significant interaction of frequency and context. However, this interaction was not manifested as predicted. In particular, the low-frequency advantage was larger for targets presented in high-constraint sentences than for isolated words. Although the pattern of this finding was unexpected, it may be possible to explain it in a consistent manner. It may be the case that the extra contextual information in a high-constraint sentence activates related information from the more numerous pre-experimental episodic contexts for high-frequency words. Alternatively, a low-frequency word has fewer pre-experimental exposures with which information in the sentence frame may overlap thus increasing the salience of the exposure in the study context. This "and the rich get richer" process would serve to explain why the low-frequency advantage is increased for targets presented in a high-constraint sentence.

Although the results of Experiment 2 support the notion that context availability may play a role in the frequency effect in recognition, the combined results of Experiments 3 and 4 failed to replicate the interaction. Here it is again important to note that design differences may have played a role. Experiments 3 and 4 manipulated context as a between-subjects variable whereas Experiment 2 utilized a within-subjects manipulation. As discussed above, it is a reasonable proposition that this design difference may have had a substantial impact on the manifestation of context effects. Thus, although it is possible that the lack of an interaction between frequency and context across Experiments 3 and 4 provides evidence that context availability does not impact frequency effects in recognition it may also simply be a result of the type of manipulation implemented.

7.3 Implications for the impact of context availability on bilingual language effects

Experiments 3 and 4 demonstrated advantages for L2 words in discrimination and the combined results revealed a mirror effect, with higher hit rates and lower false alarm rates for L2 words than for L1 words. These results replicate and extend the recent studies demonstrating an L2 item recognition advantage (Francis & Gutiérrez, 2012; Francis & Strobach, 2013). First, Experiment 4 showed for the first time that the L2 advantage extends to words studied in a sentence context. Second, the combined results of Experiments 3 and 4 show an interaction of language and frequency, such that the L2 advantage was larger in low-frequency words, an effect that did not reach significance in the Francis and Strobach (2013) study. Overall, this pattern of results provides support for the *frequency-lag hypothesis* (Gollan, Montoya, Cera, & Sandoval, 2008; Gollan et al., 2011), which proposes a common mechanism for language and frequency effects. In particular the theory assumes that the lower level of exposure to, and usage of, low-frequency words and L2 words leads to weaker links between those word forms and their associated concepts. This theory leads to the prediction that frequency effects should be magnified in a less fluent language because low-frequency L2 words should have the least prior exposure, and therefore the weakest links of all.

Although Experiments 3 and 4 showed better recognition for L2 words over L1 words, this effect did not interact with context. Thus, the results do not provide evidence that context availability plays a role in the L2 recognition advantage. Although the idea that L2 words are processed in a manner similar to low-frequency words and the application of the source of activation confusion logic might lead to the prediction that context availability will impact the L2 item recognition advantage, the observed lack of an interaction is also informative. A recent revision of the theoretical explanation of the effect suggests that the L2 item recognition advantage may rely mainly on the familiarity (base) component of the source-of-activation-confusion theory and that contextual associations are made at the conceptual level (Francis et al., 2016). Under this interpretation, an interaction of language and context would not be expected because conceptual representations of translation equivalents in a bilingual individual are language general and because effects of context availability would likely operate on the fan factor (number of associated episodic contexts) and not the base factor. Thus, the results of Experiments 3 and 4 support the revision to the source-of-activation-confusion logic used to explain the L2 item recognition advantage.

7.4 Implications for other relevant theories

An alternative explanation for the advantages for concrete words and low-frequency words in recognition memory is the memory-based explanation (Hirshman & Arndt, 1997). The present results do not speak directly to the possibility that concrete words or low-frequency words have lower strength in memory, more precise meanings, or more distinctive phonology and orthography. However, in Experiment 2, the finding that abstract words had higher hit rates but concrete words had lower false alarm rates matches the results that served as the main support for the memory-based explanation in prior research (Hirshman & Arndt, 1997). Also, the memory-based explanation does not directly specify a role for context availability in the effects of concreteness and word frequency in item recognition. Thus, the lack of interactions of concreteness and context across the four current experiments suggests that it is not necessary to incorporate the construct of context availability in explanations of the concrete advantage in explicit memory. Overall the findings from Experiments 2, 3, and 4 match what would be expected under the memory-based explanation.

Experiment 2 did show an interaction of word frequency and sentence constraint, suggesting that context availability might play a role in explaining word frequency effects in recognition memory. In particular, the low-frequency advantage was larger for targets presented in high-constraint sentences than for targets studied in isolation. This finding may be most relevant for the source of activation confusion theory, which describes the number of associated pre-experimental episodic contexts (fan factor) as a contributor to the low-frequency recognition advantage. The current finding from Experiment 2 suggests that describing the availability of context information that serves to specify meaning (i.e. sentence constraint), and not just the associated number of episodic contexts, may prove beneficial to the source of activation confusion theory. Specifically, the finding from Experiment 2 seems to suggest that increasing the availability of context information further benefits low-frequency words and increases the frequency effect in recognition memory. However, the interaction of frequency and context was not replicated in the combined results of Experiments 3 and 4. This failure to replicate the interaction as a between subjects factor, suggests that if a consideration of context availability is added to the source of activation confusion theory, it should be considered as a relative construct.

A second alternative explanation for the concreteness effect in explicit memory, and the most cited explanation, is dual coding theory (Paivio, 1991). The present study does not directly address its main assumption that coding concrete words in both imaginal and verbal processing systems but encoding abstract words only in verbal processing systems is the source of the concrete advantage. However, if we consider that one of the major criticisms of dual coding theory was its difficulty in explaining how providing a rich semantic context could reduce or eliminate concreteness effects, the present results do not add to that criticism. Therefore, although the results of the present study do not conflict with predictions of the dual coding theory, they also do not provide evidence to support it.

Finally, in models of bilingual memory, it has been proposed that abstract concepts may share a lesser degree of overlap between languages than concrete concepts (de Groot, 1992; van Hell & de Groot, 1998b). If this is the case, it might be expected that abstract words, which are thought to have lower context availability compared to concrete words, might be at an even greater disadvantage in L2 than in L1. The results of Experiments 3 and 4 revealed no interactions of language dominance and concreteness. This finding opposes the idea that abstract concepts have a lower degree of overlap across languages and instead supports the notion that both abstract and concrete concepts are shared across languages (Francis & Goldmann, 2011).

7.5 Conclusions

The effects of word concreteness, word frequency, bilingual language dominance and sentence context were examined in free recall and recognition memory tasks. Although there were significant effects of concreteness and context in all experiments, providing a low- or high-constraint sentence context at study did not reduce the concreteness effect relative to studying words in isolation. These results do not support extensions of the context availability framework from lexical processing to explicit memory performance. The present study shows that context availability is not the primary mechanism underlying concreteness effects in explicit memory but suggests that it may be fruitful to explore whether it helps to explain word frequency effects and that context availability might be best considered as a relative construct. Lastly, the current experiments replicated recent findings of an L2 item recognition advantage and provide further evidence to suggest that the effect is best explained by the base factor of the source of activation confusion theory.

If context availability does not appear to be a valid explanation for concreteness effects in explicit memory, then the next question that arises is what does lead to the effect? Context variability is a variable that may be of interest as a focus for future research. The current study focused on manipulating semantic constraint as a proxy measure of context availability, which was defined as similar to the semantic richness of the sentence frame. Alternatively, context variability refers to the number of different contexts in which a word appears pre-experimentally (Marsh, Cook, & Hicks, 2006). High context variability words are encountered in many contexts whereas low context variability words are encountered in only a few contexts. For example, the word *violent* may easily occur in a variety of contexts such as discussions of the behavior of humans or animals, the severity of a weather phenomenon, or even rhetorical or communicative style. On the other hand, the word *champion* most commonly appears only in the context of sports or competition more generally.

Context variability has been shown to produce robust effects in explicit memory. Words with low context variability were better recalled than words with high context variability, whether context variability was manipulated within or between subjects (Hicks, Marsh & Cook, 2005). Additionally, words with low context variability produced higher hit rates and lower false alarm rates in recognition memory than words with high context variability in a remember-know recollection task (Cook, Marsh & Hicks, 2006). There is some evidence suggesting that context variability may play a moderating role in the impact of high and low frequency cues in cued recall (Criss, Aue & Smith, 2011). Considering that humans tend to learn more concrete words earlier in life than abstract words (Morrison, Chappell & Ellis, 1997), it may also be the case that concrete words tend to appear in a greater number of contexts than abstract words. If so, one might expect that equating concrete and abstract words on context variability, or studying abstract words in varying contexts (e.g. studying the same target word in different sentences or languages) may reduce or eliminate the concrete advantage. One prior study examining concreteness and context variability reported no interaction of the two variables (Marsh, Meeks, Hicks, Cook & Clark-Foos, 2006). However, that study manipulated context variability as changes in the environment in which targets were studied and tested. An environmental context manipulation is quite different from a manipulation of semantically rich contexts, because environmental contexts are separate from and unrelated to the target words, whereas semantic contexts are integrated with, and semantically related to, the target words. Indeed, manipulating context semantically is better served to tap into the more varied exposures across different contexts throughout a lifetime.

Thus, although the current experiments do not support the context availability explanation of the concrete advantage in recall and recognition, future research may be well served to investigate whether *context variability* might explain the concreteness effects found in explicit memory performance. In particular, future investigations that incorporate manipulations of the number of semantic contexts in which words are encountered at study will be important in understanding how context may serve to explain the concreteness effect.

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