2019-01-01

Cross-Language Activation And Integration Of Concepts In Text Passages

Karly Meillyn Schleicher
University of Texas at El Paso

CROSS-LANGUAGE ACTIVATION AND INTEGRATION OF CONCEPTS IN TEXT PASSAGES

KARLY MEILLYN SCHLEICHER

Doctoral Program in Psychology

APPROVED:

Ana Schwartz, Ph.D., Chair

Wendy Francis, Ph.D.

Iva Ivanova, Ph.D.

Veronica Whitford, Ph.D.

Connie Summers, Ph.D.

Stephen L. Crites, Jr., Ph.D.
Dean of the Graduate School

Dedication

For my family. Thank you all for your endless patience, love, and support on my academic journey. I couldn't have done it without you.

CROSS-LANGUAGE ACTIVATION AND INTEGRATION OF CONCEPTS IN TEXT PASSAGES

by

KARLY MEILLYN SCHLEICHER, M.A.

DISSERTATION

Presented to the Faculty of the Graduate School of

The University of Texas at El Paso

in Partial Fulfillment

of the Requirements

for the Degree of

DOCTOR OF PHILOSOPHY

Department of Psychology

THE UNIVERSITY OF TEXAS AT EL PASO

August 2019

Abstract

Learning from text requires the ability to efficiently activate and retrieve relevant concepts from long-term memory and connect these with new information that is being presented in the text. It is assumed that memory representations built from text can be influenced by both surface level information (i.e., word forms), or deeper, conceptual level information. The goal of the present study was to investigate the role of surface level features (i.e., language) influence memory representations developed from text. By recruiting Spanish-English bilinguals, the present study investigated how surface level features from a reader's two lexicons influences the activation and integration of concepts across text passages. To do this, participants' eye-movements were monitored while reading pairs of text passages containing novel terms that varied in their consistency. After each passage pair, participants completed a series of true-false comprehension questions. The language match across the text passages within each pair was manipulated, as well as the language of true-false comprehension questions at test (Experiment 1 & 2). In Experiment 2, the structure of the texts was also manipulated. Results across both experiments suggest that participants built a more language-dependent text representation for the novel terms that were contradicted, but built a deeper, more conceptually-dependent text representation for the novel terms that remained consistent across the passage pairs.

.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

LEVELS OF TEXT REPRESENTATIONS

Mental representations of text are built gradually, requiring a reader to integrate incoming information to form a memory representation of the text. Current theories of text representation make a distinction between different levels of representation, ranging from superficial-form representation to deeper meaning representations (Kintsch, & van Dijk, 1978; van Dijk, & Kintsch, 1983). The first level, the surface representation, is the most superficial and primarily contains representations of word forms from the text, devoid of the larger meaning of the text in which they are presented. With this level of representation connections are made based solely on superficial word form overlap, irrespective of the overall larger contextual meaning in which that section of text is embedded. Information represented at this level is considered to be "context independent" since it is not represented in terms of the overall meaning of the larger text. As a consequence, it will become reactivated when text overlaps in superficial word form, even if there is not overlap at the deeper, conceptual level (Raney, 2003, Carr, Brown, & Charalambous, 1989).

At a deeper level, information is represented in terms of the overall meaning of the text, and is considered "context dependent" (Raney, 2003). These context dependent representations are thought to form an episodic memory trace, incorporating conceptual information from the text, as well as source information (Gernsbacher, 1991). As a consequence, these meaningful representations become re-activated when texts are read that are meaningfully related, and the reactivation is not bound to overlap in superficial word form.

Finally, at the deepest level, the reader forms a coherent representation of the propositions within the text-based representation and integrates it with prior knowledge, forming a situation model (Kintsch, & van Dijk, 1978; van Dijk, & Kintsch, 1983). This includes meaning beyond the text, incorporating prior knowledge with the content of what is being read. This level of representation allows for the widest range of integration of a text.

Evidence for these different levels of text representation has come primarily from studies using a repeated reading paradigm. In this paradigm, participants read identical or related passages while reading times are measured, to investigate whether the information from one passage facilitates processing of another. Participants read pairs of passages that overlap in word form, conceptual information, or both to investigate how the different levels of information influence reading times. Facilitation of second passage reading times indicates that the text representation built from the first passage facilitated the development of the text representation from the second passage. In such studies, a text representation would be considered context independent if facilitation was observed despite the two passages only sharing word-form information, not conceptual information (Carr, et al., 1989). A text representation would be considered context dependent if greater facilitation was observed when the passages were conceptually related compared to passages that only shared word-forms (Levy, Campsall, Browne, Cooper, Waterhouse, & Wilson, 1995; Levy, & Burns, 1990). In general, reading times for a second passage are facilitated when the first passage shares word forms (Carr, et al., 1989) and conceptually related (Levy et al., 1995; Levy, & Burns, 1990) suggesting that text representations are made up of both word-form and conceptual level information (Raney, 2003). Facilitation seems to be greatest when passages share conceptual overlap, rather than when they only share word-overlap (Levy, & Burns, 1990). These findings indicate that memory representations built from text can vary in the degree to which they are context independent or context dependent (Raney, 2003).

Most of the research supporting these different levels of text representation have been conducted with monolinguals. The current research base does not consider key characteristics that are unique to bilinguals and likely to influence how they form text representations. First, even highly proficient bilinguals tend to have one language that is more dominant than the other. There is evidence that development of memory representations from text is modulated by proficiency in the language of text (Raney, Obeidallah, & Miura, 2002; Raney, & Bovee, 2016). There has not been a systematic examination of how comparable the processes of building text representations are across the dominant language (L1) versus the weaker language (L2). A second key characteristic of bilingualism is that bilinguals encounter information in texts of different languages. The current literature lacks a thorough examination of how the building of text representations is influenced by changes in the language of text. To the best of our knowledge, there is only one published study that specifically tested whether the language of the text influences the degree to which bilingual readers build surface level versus situation model representations of text (Friesen & Jared, 2007). In that study, two groups of French-English bilinguals who differed in their relative proficiency in the L2 read pairs of passages of five different types, that differed in their language form and meaning overlap while their eye-movements were recorded. At one extreme the passage pairs were identical repetitions and at the opposite extreme were pairs that were completely unrelated in form and meaning. The critical comparisons were between three conditions in which the pairs of passage either overlapped in meaning or language form. In two of these conditions the passages were translations of each other, one included cognates and one included non-cognate synonyms. In this way the latter had only overlap in meaning. These two conditions were compared with a fifth condition in which the pair of passages were in different languages and were unrelated in their meaning, but contained repeated cognates. The reasoning was that if a representation was comprised of surface level features (what they referred to as word level transfer), then greater facilitation, in the form of faster reading times, would be observed for identical passages relative to translated passages. Also, facilitated reading of cognates in the second passage should be observed even when the passages were unrelated in meaning. If, on the other hand, representations were based more on a situation model (which the authors referred to as message level transfer), then facilitated reading time on second passages should be observed for any pair of passages that were related in meaning, regardless of word-form overlap.

The pattern of results were different across the two proficiency groups. For the less proficient (less balanced) group reading times of the second passage were shorter for translated passages relative to completely unrelated passages. However, this reduction was smaller in magnitude relative to when the passages were identical. For the more proficient group, on the other hand, the reduction in reading time was similar for identical passages and translated passages. This suggests, that the representations built by the more proficient group were more at the level of a situation model. Also, the less balanced group showed slower reading times for repeated cognates in the second passage when the two passages were unrelated in meaning. This suggests that they had built a more surface level representation of the passages and the word-level transfer produced competition across the cognate representations The more balanced group did not show this effect, providing further evidence that the two proficiency groups differed in the levels of representation that they had built of the passages.

The present study extends this line of research by going beyond repeated passages, which does not capture the natural reading comprehension process. Rather than reading a passage repeatedly, readers typically need to integrate information across different texts, such as across paragraphs or entire text passages. To this end, we examined the impact that the match in language has on the ability to integrate information across passages. It is hypothesized that if the representation a reader builds from text is primarily text-based, or strongly connected to form, this will limit their ability to integrate information when the text passages are in different languages. However, if the reader has a situation-based representation, with stronger conceptual connections, then surface features like the language of the text should not hinder their ability to integrate information across text passages.

ACTIVATION OF CONCEPTS DURING TEXT COMPREHENSION

According to the Landscape Model (LM) the relative activation of concepts fluctuates over time during reading comprehension (Linderholm, Virtue, Tzeng, & van den Broek, 2004; van den Broek, Young, Tzeng, & Linderholm 1998; Tzeng, van den Broek, Kendeou, & Lee, 2005; Yeari, & van den Broek, 2011). The current reading cycle of a text can cause readers to reactivate concepts that were processed in earlier reading episodes or activate prior knowledge related to the text (van den Broek, Rapp, & Kendeou, 2005). Activation from prior knowledge or information from previous reading cycles occurs when the concepts are strongly associated with the text in the current reading cycle, or when that information is necessary to comprehend the text. Weakly activated concepts from the current reading cycle may not be strong enough to activate related information from prior knowledge or a previous text. Additionally, if the current text exhausts the reader's limited working memory resources dedicated to conceptual activation, there may not be enough additional resources to activate prior knowledge or reactivate concepts from previous reading cycles (e.g., a previous paragraph). This could prevent the reader from integrating information across multiple text passages, or updating prior knowledge.

The LM assumes that activation of information across reading cycles depends on the overlap between superficial information as well as deeper, contextual information. If there is little conceptual overlap between two reading cycles, connections may not be built between them (Britt, Perfetti, Sandak, & Rouet, 1999). Beker and colleagues (2016) extended these assumptions to examine activation and integration of concepts across text passages. Pairs of passages were read, with the first passage providing information that either did or did not explain an inconsistency that appeared in the second passage. This manipulation allowed them to see how conceptual activation from the first passage influenced activation of related but inconsistent information in the second passage. In addition to this, a comprehension test was administered after the passage pairs were completed, to see if the passage inconsistencies influenced recall.

To investigate whether information from the first passage influenced the second passage, reading times for target sentences in the second passage were recorded (Beker, et al., 2016). These target sentences contained information that was inconsistent between the two passages. They found that reading times for the target sentence were faster when the participants read the text that explained the inconsistency in the target sentence. This suggests that concepts from the first text were activated when reading the second text, influencing how the inconsistent target sentence was processed. The faster reading times suggest that explanatory concepts from the first text was integrated with the inconsistent concepts from the second. However, their results did not show that this facilitation later benefited participant's comprehension, such that there was no difference in recall scores between the different passage conditions. While the explanatory concepts may facilitate processing, it did not seem to influence later activation of the information at recall. This study demonstrates that the activation of conceptual information across texts can influences text processing, however it does not address the degree to which superficial information (e.g., lexical information) influences cross-text conceptual activation and integration. The present study seeks to address this by manipulating superficial information (i.e., language of text) to investigate how new information is integrated across text passages.

REFUTATION TEXTS

The LM's assumes that conceptual activation across reading cycles depends on both superficial and conceptual overlap. As such, the structure of a text, which manipulates both word-level features and the presentation of deeper, conceptual information, is fundamental to passage comprehension (Chambliss, 2002). Previous research has found refutation texts to be a useful tool for facilitating information updating and integration when reading (Hynd, & Alvermann, 1989; Lombardi, Danielson, & Young, 2016; Van Boekel, Lassonde, O'Brien, & Kendeou, 2017). Refutation texts are designed to activate (or re-activate) prior knowledge or previously read information by making explicit statements that overlap in both surface level and conceptual level features with the previously read or learned information. Once activated, the refutation text updates that information by making direct connections between the old information and new information.

Previous research has shown refutation texts to be effective at generating conceptual change for science misconceptions by clearly stating the misconception and directly connecting it to the new, correct information (Kenedou, & van den Broek, 2007, Alvermann, & Hague, 1989; Guzzetti, Snyder, Glass, & Gamas, 1993). This refutation typically occurs over the course of two to three sentences. The first sentence clearly identifies the reader's misconception and identifies it as incorrect. The following sentence or sentences then explain the correct information. In contrast, non-refutation texts only explain the correct information, but fail identify the reader's misconception. Critically, previous research on refutation texts predominantly use real science misconceptions, meaning readers' prior knowledge often influenced the overall findings for the studies (Kenedou, & van den Broek, 2007; Alvermann, & Hague, 1989).

In addition to facilitating comprehension, refutation texts may also be processed differently compared to non-refutation texts. Some studies suggest that explanatory sentences are read faster in refutation texts compared to non-refutation texts (Kendeou, & van den Broek, 2007; Ariasi, Hyönä, Kaakinen, & Mason, 2017). Refutation passages may also be read faster overall, compared to non-refutation passages matched in length (Broughton, Sinatra, & Reynolds, 2010). However, some portions of a refutation text may lead to longer reading times (Ariasi, & Mason, 2011; Ariasi, et al, 2017). More specifically, sentences that directly refute a contradicted or misunderstood concept may be read slower in refutation texts compared to non-refutation texts (Ariasi, et al, 2017). It is important to note that studies examining reading times for refutation texts vary widely in their methodology, with some using eye-movement analyses (e.g., Ariasi, & Mason, 2011; Ariasi, et al, 2017), and others using more general measures of reading time for sentences (Kendeou, & van den Broek, 2007; van den Broek, & Kendeou, 2008; Broughton, et al, 2010).

The present study sought to contribute to the existing literature on refutation texts by controlling for prior knowledge and recording eye-movements to capture on-line reading processes. By using novel (fictional) terms related to science topics, we were able to control participants' prior knowledge for the contradicted information within the text passages. Through eye-movement analyses, we were able to capture precise processing times for specific regions of text (i.e., the novel terms). In addition to this, previous refutation text research has focused exclusively on monolingual readers. As stated above, it is unknown how comparable the processes of building text representations are across a bilingual's L1 and L2. The overlap in both surface features (e.g., word repetition) and conceptual features in refutation texts may be particularly beneficial for bilingual readers when integrating concepts in a text representation. The present study examined the influence of language by manipulating the language match between pairs of text passages.

BILINGUAL CONCEPTUAL ACCESS

There is a large body of research demonstrating that a bilingual's two languages are linked to a single conceptual store (Kroll, & Stewart, 1994; Kroll, & Tokowicz, 2005; van Hell, & de Groot, 1998; Francis, 1999b). Evidence for a single conceptual store comes in part from the consistent observation of cross-language conceptual repetition priming for translation-equivalent words across a wide variety of tasks and paradigms (e.g., category generation, Francis, Fernandez, & Bjork, 2010; semantic classification, Francis, & Goldmann, 2011, Zeelenberg & Pecher, 2003; fragment completion, Smith, 1991; verb generation, de la Riva, Francis, & García, 2012, Seger et al., 1999; antonym generation, Taylor, & Francis, 2017). While a bilingual's two languages share conceptual representations, these concepts are connected to at least two different lexical items.

Although, currently there is not a model that specifically addresses bilingual conceptual activation during text comprehension, the distributed features model (DFM) provides an account of how conceptual features may come to be linked to word forms across a bilingual's two languages (Van Hell, & De Groot, 1998; de Groot, Delmaar, & Lupker, 2000; Kroll, & Tokowicz, 2005). According this model, conceptual and lexical features exist in an interconnected network. These lexical and conceptual features have varying degrees of overlap across languages. Portions of conceptual features may be linked to translation equivalent words across an individual's two languages, while other translation equivalent words may not share the same conceptual features. For example, the word *ambitious* in English is associated with positive attributes, used to describe someone who is hardworking or driven. In contrast, the Spanish translation *ambicioso* has a more negative association, describing someone who is not only driven, but also greedy or selfish. The two words (ambitious/ambicioso) have clear lexical overlap, but limited conceptual overlap.

If conceptual features do not necessarily overlap completely across languages, then different subsets of conceptual features may be activated across texts of different languages. . This could influence how concepts from multiple text passages are integrated across languages.

THE PRESENT STUDY

The overarching goal for the present study was to investigate the role of language on conceptual integration and retrieval during text comprehension. By recruiting bilingual readers, the present study was able to investigate the influence of surface level information (i.e., language form) on conceptual integration when reading pairs of text passages. It is unknown whether the ability to integrate conceptual information across texts is influenced by the match in language across texts. The present study focuses specifically on whether mismatches in the language of texts influences whether reader build a text-based versus situation model representation of a text.

Across two eye-tracking experiments highly proficient Spanish-English bilinguals read pairs of text passages that presented novel (made-up) scientific concepts that either remained consistent across both passages or contradicted in the second passage. Accurate comprehension of the passages with contradicted information required the ability to update the ongoing mental representation of the passages. To examine if this process is influenced by the language of text in which new information is acquired the language of the first and second passages as well as the language of the comprehension questions was manipulated. Experiment 1 was designed to test for general effects of language and the match in language between passages and test. Experiment 2 was designed to test whether the advantage of refutation texts observed for monolinguals in a single language extends to bilinguals who are encoding information across texts in different languages.

The main hypothesis for the study posits that the reader's language dominance determines the strength of influence of the text-based information and the situation model during text integration. If a text representation is comprised of text-based, lexical level information, then the lack of word-level overlap may prevent it from being integrated with a text representation developed in a different language. If this is the case, processing of information from the second passage should not reactivate the previous representations developed from the first passage. As such, the first passage would not be integrated with the second passage if they are read in different languages. Moreover, it is hypothesized that a memory representation developed from texts read in the nondominant language (L2) will rely on more lexical-level information compared to memory representations developed from texts read in the dominant language (L1). As such, if the language of the passage pair mismatches, there will be less cross-text integration, evidenced by reading times in the second passage as well as lower accuracy at test. More specifically, reading times in the second passage should not be delayed by the conflicting information presented in the first passage.

However, if a text representation is comprised of a situation model, or conceptual level information, then it should be successfully integrated with a text representation developed from a previous passage. If this is the case, then information from the first passage should be integrated with information from the second passage regardless of the language of the text passages. If this is the case, processing of information from the second passage would be influenced by the conflicting text representation developed from the first passage. If a text representation is more situation-based, the lack in lexical-level overlap for a passage pair that mismatches in language should not hinder the integration of those two texts. This would result in higher accuracy at test, as well as delayed reading times in the second passage due to the conflicting information presented in the first passage.

Chapter 2: Experiment 1

METHODS

Participants

Highly proficient, Spanish-English bilingual students from the University of Texas at El Paso were recruited to participate in Experiment 1 (N = 166). Due to a programming error comprehension responses from being recorded for 45 participants and their data were excluded from analyses. Calibration procedures were not successful for another 6 participants. One participant was excused from the study due to an inability to read in Spanish. Also, data from participants whose accuracy scores on follow-up comprehension questions were not at least 60% accurate were excluded from analyses (N = 9). Finally, data from one additional participant who had a native language other than English and Spanish was excluded.

This reduced the final sample size to 104 participants. Given a small effect size (d = .25, based on findings from Friesen & Jared, 2007), a sample size of 82 participants was required to obtain power of .8, indicating that the current sample size is appropriate. The majority of the participants learned Spanish first (86%, M_{AOA}= 1.69 years), and about half of the participants identified English as their strongest language (53%, M_{AOA}= 6.01years). Assignment to the each condition was counterbalanced.

Language dominance was determined by the participant's highest score on the Picture Naming Vocabulary subtest of the Woodcock-Muñoz Language Survey Revised (WMLSR; Woodcock, Muñoz-Sandoval, Ruef, & Alvarado, 2005). If a participant scored equivalently on the Spanish and English versions of the Picture Naming Vocabulary subtest, their highest score on the Passage Comprehension subtest of the WMLSR was used to determine dominance. Averages can be seen for participants' age equivalencies for both subtests of the WMLSR, divided by language dominance (Table 1). The Spanish dominant group had a higher age equivalency for the Passage Comprehension subtest in the dominant language compared to the English dominant group, F (1, 102) = 21.17, MSE = 44.16, $p < .001$. There was no difference between the two dominance groups' age equivalency scores for the Picture Naming subtests (in L1 or L2, F's < 1) or the Passage Comprehension subtest in the L2 ($F < 1$).

Additional language history and demographic information was collected using a modified version of the English-Spanish Proficiency and Dominance Assessment (ESPADA; Francis & Strobach, 2013). The majority of participants were female (72%) and Hispanic (99%), with an average age of 21.09 years old. When asked about how frequently they used both languages, the majority reported speaking English (84%) and Spanish (82%) every day, but they read more regularly in English (84% read in English daily) compared to Spanish (32% read in Spanish daily; see Table 2). On average, participants had more years of education in English (M= 10.75 years) than Spanish (M= 4.93 years). The majority reported they would prefer to take a science class in English (89%). Parent education levels varied across all participants (Table 3). There was no significant difference when comparing parent education across the dominance groups for mother's education, X^2 (6, N = 104) = 5.02, p = .542, or father's education, X^2 (6, N = 103) = 5.06, p = .536.

Stimuli

Text Passages.

English versions of 11 pairs of passages were developed and normed (see below). After norming, eight of the 11 passage pairs were translated into Spanish, then back translated into English by two separate Spanish-English bilingual research assistants.

Passage pairs were based on science topics that are typically encountered by high school in the United States (e.g., stars), and are familiar to most students in higher education. Each passage within the pair was made up of four paragraphs. The first introduced the science topic (e.g., stars). The second paragraph introduced a made-up term with two made-up facts. The third paragraph introduced another made-up term with two made-up facts. The final paragraph consisted of one sentence which mentioned both of the new terms, relating them to the overarching science topic. In the second passage facts related to one of the made-up terms were contradicted, while the facts regarding the other term remained consistent. A brief explanation for the contradicted facts was also provided in the second passage. Each of the two made-up terms was repeated 4 times in the first passage and 4 times in the second passage.

The made-up terms were selected from a list of pseudo-words which were rated by two Spanish-English bilingual research assistants on their pronounceability in each language, as well as their similarity to other real words in either language. The terms used in both experiments were selected due to their permissibility in both Spanish and English, as well as their lack of overlap with real words in either language. All terms had a length of six letters.

Norming of text passages

A total of 11 text passages were written in English, and normed using Amazon's Mechanical Turk. Mechanical Turk workers could only participate in the study once, and work was rejected if they had an accuracy below chance (50%) or failed an attention check. Participants (N= 48) read a total of 11 passage pairs through Qualtrics survey software, and were paid $4.50 for their time. Participants were all fluent in English, on average reporting that 97.42% of their day was spoken in English. Three participants reported speaking more than one language fluently, but all reported their English as their native language.

After consenting to the norming study, participants read instructions then began the experiment. They read the first passage on one screen at their own pace, then advanced to a new screen where they answered five multiple choice questions about the first passage, to ensure they were paying attention and reading for comprehension. Once done, they advanced to read the second passage, again at their own pace. After reading the second passage, they advanced to the next screen where they rated each passage on comprehensibility and described any contradiction they noticed between passage 1 and passage 2. Directly following their ratings, they answered 16 true-false comprehension questions. This procedure repeated for all 11 passage pairs.

Eight passage pairs out of the 11 were selected for the present study, based on comparable true-false accuracy and the overall clarity of the contradiction. Participants were able to identify the contradiction in each of the eight passage pairs at least 88% of the time, and average true-false accuracy ranged from 70% to 84% (see Table 4 for summary statistics). This suggested that passages were similar in their difficulty, and that it was possible to identify the contradiction between the passages in any given passage pair. From the eight pairs selected, four were used in Experiment 1. All eight pairs were used in Experiment 2.

Comprehension Test

A series of true-false questions were used to measure comprehension of each passage pair. Each comprehension test consisted of 20 true-false comprehension questions. Half of these questions were presented in Spanish, and half were presented in English. Of the 20 questions, eight questions targeted the new consistent term (four in Spanish, four in English), eight questions targeted the new contradicted term (four in Spanish, four in English), and four questions targeted prior knowledge related to the overarching science topic (2 in Spanish, 2 in

English). The true-false questions were presented on a computer monitor. Participants responded to each statement using the “A” key for TRUE and the “L” key for FALSE.

Materials and Apparatus

Woodcock-Munoz Language Survey- Revised

Two subtests from the (Woodcock, et al., 2005) were used as objective measures of proficiency in English and Spanish. The first subtest, Picture Naming Vocabulary, measures general vocabulary knowledge. The second subtest, Passage Comprehension, measures general reading comprehension ability and vocabulary knowledge through a sentence completion task. Vocabulary and comprehension scores were used to determine language dominance.

ESPADA

In addition to these objective measures, participants also completed a language history questionnaire, using an abbreviated form of the (Francis, & Strobach, 2013). Within this questionnaire, participants rated their language ability, age of acquisition, frequency of language use, and provided other demographic information.

Apparatuses

An EyeLink 1000 desktop mounted eye-tracking system with a sampling rate of 1000 Hz measured eye-movements while participants read the text passages and comprehension questions on a computer monitor. The 24 inch monitor (1680 x 1050 pixel resolution, 60 Hz refresh rate) was placed 83.5 cm from the participants. Text was black, 18-point Courier New font presented on a white background using Experiment Builder software (SR-Research). The text passages were double spaced and presented with one to four sentences per display screen, depending on sentence length. No more than nine lines of text were shown on a display screen. A camera was placed directly in front and beneath the monitor, tilted upwards to measure participant eye-movements. Viewing was binocular, but only the right-eye was recorded. A keyboard was used to advance through the experiment.

Procedure

Experimental Session Procedure

Upon completing the consent form, the subtests of the WMLSR (Woodcock, et al., 2005) was administered to the participant by a trained experimenter. Scores were used to determine the participant's dominant (L1) and non-dominant language (L2), which in turn was used to counterbalance assignment of the order of the four possible language conditions of the text passage pair (i.e., L1-L1, L2-L2, L1-L2, L2-L1) and the language of the comprehension questions. Participants were then brought into an individual testing room and seated in front of the display monitor of the eye-tracking system and rested their chin on the chin bar. They read the task instructions on the screen.

Next the eye-tracking system was calibrated to their eye movements. The calibration sequence used a total of nine dots on the screen. Dots appeared once in each of the four corners of the screen as well as, top center, bottom center, far left center, far right center, and the middle of the screen. Participants looked at each dot, presented in a random sequence. Calibration took approximately three minutes at the beginning of the study, and participates were re-calibrated as needed throughout the experiment.

Once successfully calibrated participants started the experimental task. Once done with all experiment trials, the participant completed a brief language questionnaire on the computer or on paper (depending on their preference). Upon completing the questionnaire, they were debriefed and thanked for their time

Trial Procedure

Passage reading was self-paced and participants pressed the spacebar on a keyboard to advance. Once calibrated, participants began reading the first passage. After completing the first passage, they answered a multiple choice question to ensure they were paying attention. Once done, they began reading the second passage for that passage pair.

After completing the second passage, participants completed a comprehension test consisting of 20 true-false questions. In the comprehension test, they first read a question at their own pace, then pressed the spacebar to advance to the next screen. On the following screen, they determined if the statement was TRUE or FALSE using the keyboard ("A" and "L" keys, respectively). This procedure was repeated until they answered all 20 true-false comprehension questions.

When the comprehension questions were completed, the participant repeated the above procedure, reading a total of four passage pairs. Breaks were offered after each trial (i.e., passage pair), and participants were re-calibrated as necessary.

Analyses and Data Treatment

True-false comprehension responses

As responses to the comprehension questions were dichotomous (true or false), a difference score was used to account for guessing. The difference score was created by subtracting the number of incorrect responses from the number of correct responses. Difference scores for questions targeting consistent facts and questions targeting inconsistent facts were submitted into a 2 (fact consistency) x 2 (match in language between test question and first passage) x 2 (match in language between test question and second passage) x 2 (test question language) repeated measures ANOVA.

Total reading times for novel terms

Total reading times (TRT) for the novel terms were submitted to two analyses. We focus solely on TRT rather than other measures such as fist fixation duration and gaze duration, because it is assumed to capture semantic integration processes that occur after lexical access in which the word. The other two measures are more directly linked to lexical access, since these are novel terms, there is no lexical representation that is being accessed. All durations less than 100 ms were excluded from analyses (3.6% of all TRT data).

The first analysis assessed whether reading times changed from the first passage to the end of the second passage after the contradiction of the contradicted term had been processed. The two interest areas consisted of the third occurrence of the new term in the first passage and the third occurrence of the term within the second passage. Third occurrences within each passage were selected as opposed to first occurrences to avoid inflated processing time that is typically observed for nouns at the beginning of paragraphs. Also, third occurrences were selected instead of second occurrences to ensure that the term in the second passage was after the contradiction was introduced. TRT's were submitted to a 2 (passage: first passage vs second passage) x 2 (language of passage: L1 vs L2) x 2 (term consistency: consistent vs inconsistent) repeated measures ANOVAs.

To address the more specific question of whether processing a contradicted term in the second passage is influenced by the match in language across the two passages, a second analysis was conducted on the average TRT of the novel terms from the second passage. The average TRT was submitted to a 2 (language match of passage pair) x 2 (language of second passage) x 2 (term consistency) repeated measures ANOVA.

RESULTS AND DISCUSSION

True-False Question Accuracy

Performance was significantly better for consistent facts (M = 2.84) compared to contradicted facts (M = .94), F (1, 103) = 201.27, MSE = 7.45, p < .001. There was also a main effect of match in language between the test and second passage (F (1, 103) = 8.36, MSE = 1.66, p = .005), qualified by an interaction between fact consistency, F (1, 103) = 4.09, MSE = 2.41, p = .046. There was a significant interaction between the test language, match in language between test and the first passage, and the match in language between the test and second passage, F (1, 103) = 8.29, MSE = 2.25, p = .005. Two follow-up repeated measures ANOVA's, split by fact consistency, were conducted to investigate the role of language on retrieval of the consistent facts and contradicted facts.

Consistent facts

For the consistent facts, there was no significant main effects. The interaction between test language and the match in language for the test and second passage was significant, F (1, 103) = 5.49, MSE = 2.55, p = .021.

Contradicted facts

Performance on questions targeting contradicted facts was significantly higher when the language of the test matched the language of the second passage (M = 1.11) compared to when it mismatched (M = .77), F (1, 103) = 8.08, MSE = 2.92, p = .005. As seen in the initial ANOVA, there was a significant three-way interaction between the test language, the match in language between the test and first passage, and the match in language between the test and second passage, F (1, 103) = 6.07, MSE = 3.25, p = .015.

Total Reading Time

Analysis of change in reading time across passages

When comparing the third occurrence for each term in the first and second passage, TRT was significantly shorter in the second passage (M = 479 ms) compared to the first passage (M = 655 ms), $F(1,76) = 76.28$, $MSE = 62{,}691$, $p < .001$. TRT was also significantly shorter when the second passage was in the dominant language (M = 521 ms) compared to the non-dominant language (M = 613 ms), $F(1,76) = 12.07$, $MSE = 106245$, $p = .001$. No other main effects or interactions were significant (F's < 1).

Analysis of total reading time in second passages

When looking at the average for all occurrences of each term in the second paragraph, TRT was significantly shorter when the second passage was read in the dominant language (M = 547 ms) compared to the non-dominant language (M = 613 ms), $F(1,83) = 11.78$, $MSE = 63{,}614$, $p = .001$. There was also a significant effect of term consistency, $F(1,83) = 7.39$, $MSE = 52{,}919$, $p = .008$, such that contradicted terms (M = 604 ms) were processed longer than consistent terms (M = 556 ms). The main effect of match in passage language was not significant, $F(1,83) = 1.05$, $MSE = 46{,}399$, $p = .309$, nor were any interactions significant.

Experiment 1 Discussion

Performance on comprehension questions and reading times both reflected enhanced comprehension for novel facts that were kept consistent throughout both passages relative to those that were contradicted, serving as an important manipulation check. The language of passages and test had only a minimal effect on comprehension performance for facts that remained consistent across passages Specifically, performance on questions pertaining to consistent facts was superior when the second passage was in the dominant language. The language of the second passage may have been particularly influential as it was the most recently encountered information and thus more highly activated in the memory trace at recall. Comprehension performance for consistent facts was unaffected by the match in language either across the two passage or with test. This suggests that participants were able to build a situation-based memory representation of the portions of text that were semantically-consistent.

When readers encountered new, contradicted information, the patterned changed. The interaction between the test language, the match in language between the test and first passage, and the match in language between the test and second passage for the retrieval of new, contradicted terms shows that the text representation developed for the inconsistent concepts was more reliant on surface features (i.e., language). This suggests that readers had developed a more text-based representation of the passages, that included language form information. This dependency on language form was evident only in the retrieval of inconsistent terms, suggesting that different levels of representation may be built for different portions of text.

There was also an effect of language dominance, such that reading time was faster and comprehension performance improved when the second passage was in the dominant language. Despite having high proficiency in both languages, participants clearly benefited from using their dominant language.

The reading times of the novel terms and true-false comprehension performance results in Experiment 1 showed that a bilingual reader's ability to integrate the novel facts was affected by language dominance and a match in test language and passage language. Experiment 2 sought to replicate and expand upon the findings of Experiment 1. To do this, the structure of the second passage in the passage pairs was manipulated. Half of the second passages mirrored the structure of Experiment 1. The other half were structured as *refutation texts*. Refutation texts in

Experiment 2 were designed to re-activate previously developed memory traces by restating information about a novel term from the first passage, and then to provide an explicit reason for the contradiction. One hypothesis is that the additional contextual support provided by the refutation passages could enhance comprehension of refuted terms and potentially reduce costs in processing and recall associated with changes in language.

Table 1. Experiment 1 Average WMLSR age equivalencies for the Picture Naming Vocabulary and Passage Comprehension subtests.

		Picture Naming Vocabulary	Passage Comprehension
English Dominant (n = 58)	L1	14.61	13.25
	L2	9.43	12.12
Spanish Dominant (n = 46)	L1	14.34	19.57
	L2	9.50	12.17

Table 2. Experiment 1 Frequency of speaking and reading in English and Spanish

	English		Spanish	
	Speaking	*Reading*	*Speaking*	*Reading*
Daily	84%	84%	82%	28%
Several days a week	14%	13%	13%	37%
Weekly	2%	1%	1%	14%
Bi-weekly	0%	0%	1%	7%
Every few months	0%	0%	0%	13%
Once or twice a year	0%	0%	1%	2%
Less than once or twice a year	0%	0%	0%	0%

Table 3. Experiment 1 Parent education levels

	Mother	Father
Middle school	11%	15%
Some high school	13%	7%
Graduated high school	20%	19%
Some college	18%	16%
Graduated college	28%	25%
Master's degree	7%	13%
PhD/MD/JD	4%	4%

Table 4. Descriptive statistics from Experiment 1 stimuli norming

Selected passage pairs	Contradiction Identified	Average true-false accuracy
1. Stars	100%	76%
2. Fossils	90%	76%
3. Herbal medicine	96%	70%
4. Tumors	94%	84%
5. Plant growth	94%	71%
6. Ocean life	86%	77%
7. Dairy	88%	73%
8. Rainforest	94%	76%

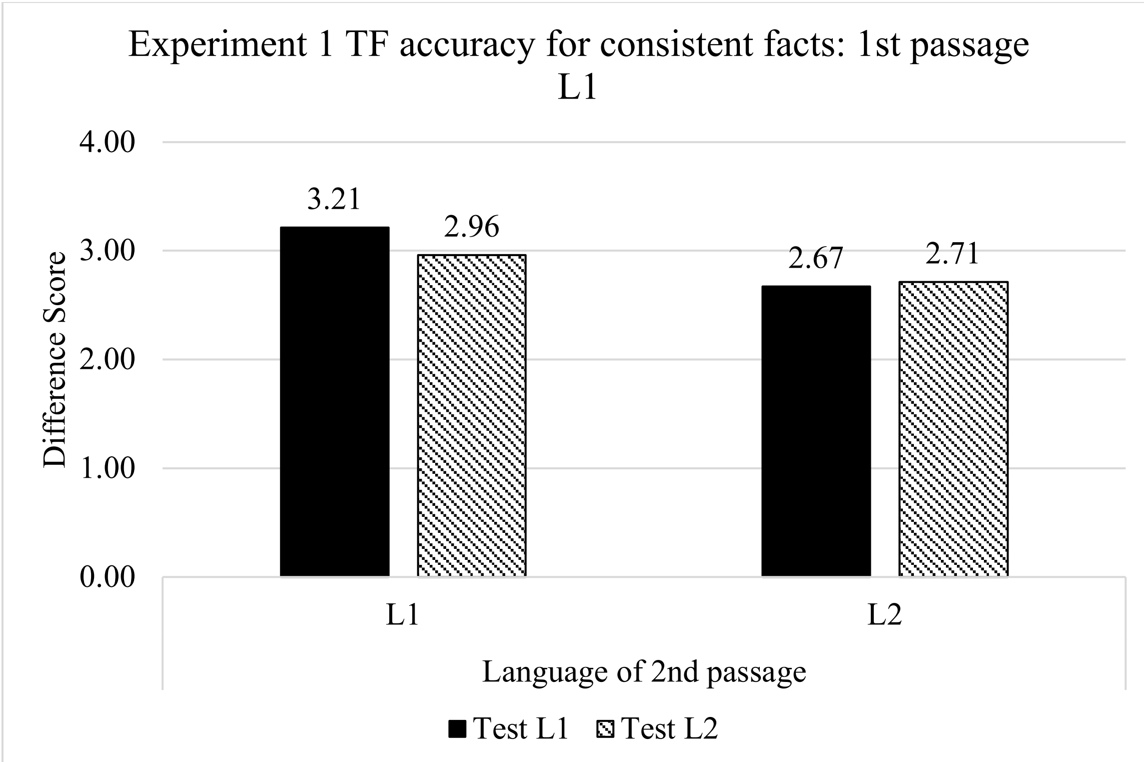

Figure 1. Experiment 1: Difference scores for true-false questions targeting the consistent facts when the first passage was in the dominant language

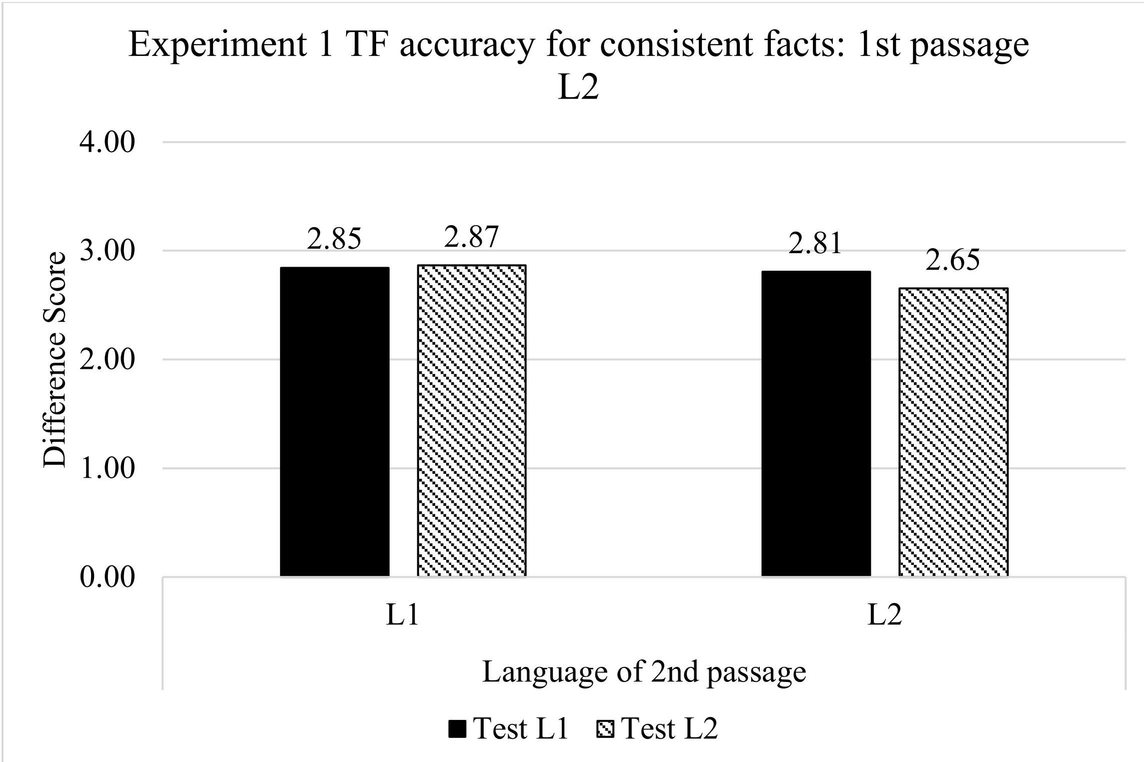

Figure 2. Experiment 1: Difference scores for true-false questions targeting the consistent facts when the first passage was in the non-dominant language.

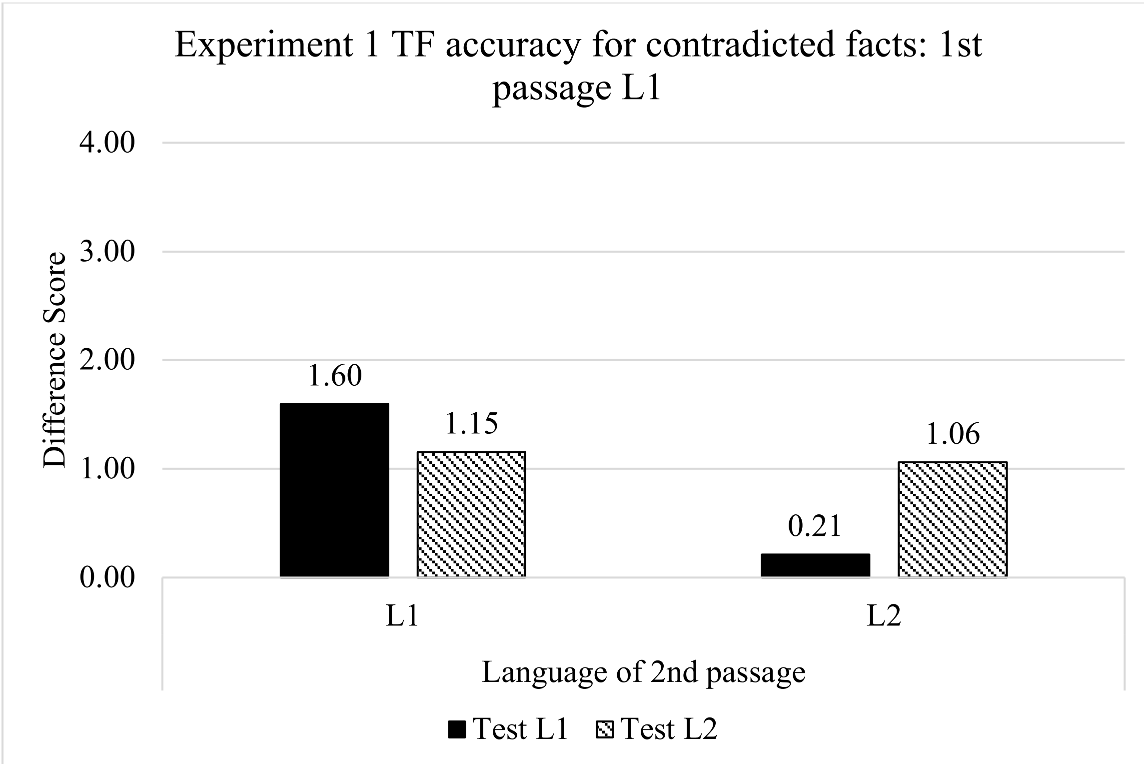

Figure 3. Experiment 1: Difference scores for true-false questions targeting the contradicted facts when the first passage was in the dominant language.

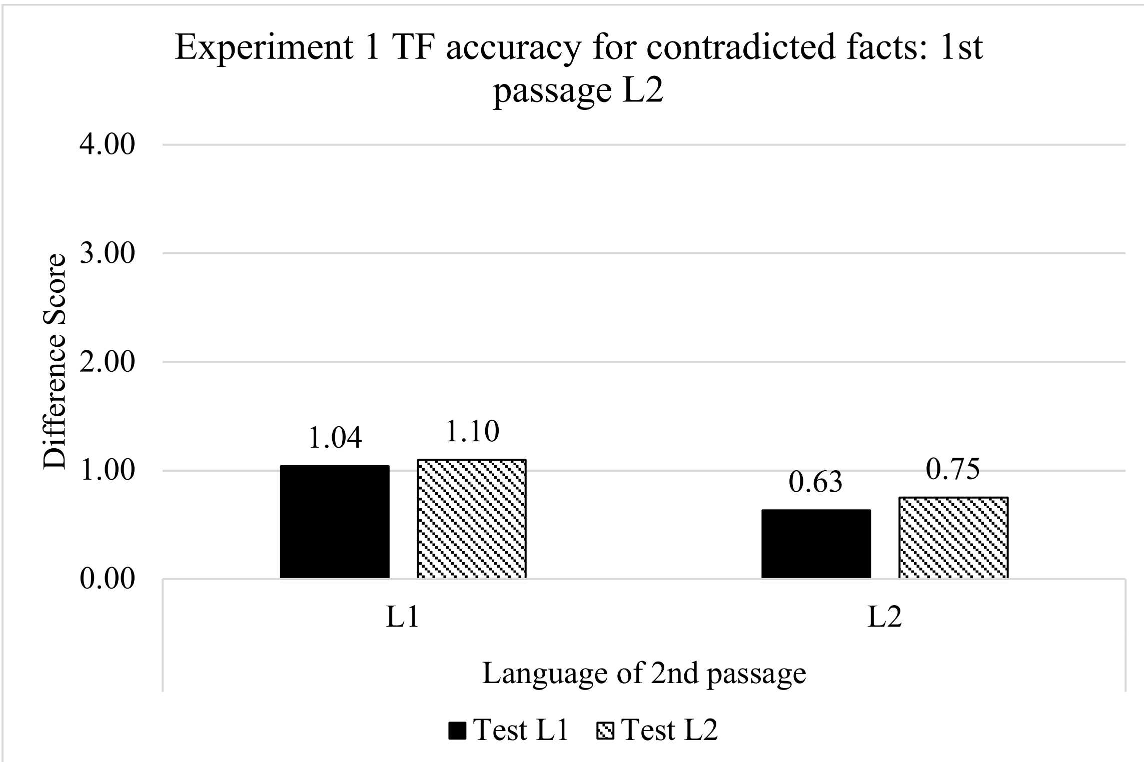

Figure 4. Experiment 1: Difference scores for true-false questions targeting the contradicted facts when the first passage was in the non-dominant language.

Chapter 3: Experiment 2

METHODS

Participants

Undergraduate Spanish-English bilinguals from the University of Texas at El Paso were recruited to participate in the study (*N* = 94). A total of 7 participants were removed due to incomplete data either due to experiment error or failed calibration procedures. Data from participants whose accuracy scores on follow-up comprehension questions were not at least 60% accurate were excluded from analyses (N = 7). Two participants did not complete the study as they were not literate in Spanish.

This reduced the final sample size to 78 participants. Experiment 2 used the same language assessment procedures and determined language dominance using the same methodology as Experiment 1. The majority of the participants learned Spanish first (93%, M_{AOA}= 2.03 years), and about half of the participants identified English as their strongest language (53%, M_{AOA}= 8.03 years). Average age equivalency for the Picture Naming Vocabulary subtest of the WMLSR was similar in English (M= 11.39) and Spanish (M= 11.44). Table 5 displays participants' age equivalencies for both subtests of the WMLSR, divided by language dominance. Similar to participants in Experiment 1, the Spanish dominant group had a higher age equivalency for the Passage Comprehension subtest in the dominant language compared to the English dominant group, F (1, 72) = 11.90, MSE = 48.60, p = .001. There was no difference between the two dominance groups' age equivalency scores for the Picture Naming subtests in L1 (F < 1) or L2, F (1,72) = 3.15, MSE = 5.98, p = .080, or the Passage Comprehension subtest in the L2, F (1,72) = 1.47, MSE = 26.53, p = .229.

The majority of participants were female (68%) and Hispanic (100%), with an average age of 21.82 years old. Similar to the participants in Experiment 1, the majority reported speaking English (82%) and Spanish (81%) with daily frequency, but they read more regularly in English (84% read in English daily) compared to Spanish (47% read in Spanish daily; see Table 6). On average, participants had more years of education in English (*M*= 11.79 years) than Spanish (*M*= 5.99 years). The majority reported they would prefer to take a science class in English (77%). Parent education levels varied across all participants (Table 7). There was no significant difference when comparing parent education across the dominance groups for mother's education, X^2 (6, N = 74) = 7.56, p = .272, or father's education, X^2 (6, N = 74) = 2.88, p = .824.

Stimuli

Text Passages.

The same passages used in Experiment 1 were used in Experiment 2, with an additional four passages added to the experiment (for a total of eight passage pairs). The second passages in each pair were also edited such that they all had a control version and a refutation version. Passages were written in English and translated into Spanish.

The first passage of each pair of text passages was the same across Experiment 1 and 2. The second passage, however, varied in text structure. One passage type was structured like a refutation text (e.g., Broughton, et al, 2010), while the control passage reflect the structure of a traditional expository text (identical to those shown in Experiment 1). Refutation texts differ from traditional expository texts in that they clearly identify the contradictory term, then explain why that term is contradicted by restating the original information from the first passage, and "correcting" it. The control texts stated the contradicted term, but did not reference any of the previous (contradicted) information from the first passage. Critically, both the refutation structure and the non-refutation structure provided an explanation for the contradicted facts.

Norming of text passages

All eight passage pairs used in Experiment 2 were re-normed to ensure both versions of the passages (i.e., refutation structure and non-refutation structure) were understandable. As each passage pair had a refutation version and a non-refutation version, a total of 16 passage pairs were normed.

As in Experiment 1, participants were recruited through Amazon's Mechanical Turk using identical rejection criteria and compensation. Participants (N=70) read a total of eight passage pairs via the Qualtrics survey software.

Norming procedures for Experiment 2 differed slightly from Experiment 1, to ensure the comprehensibility of the passage pairs was tested, rather than testing participants recall of the passages. Participants first read an entire passage pair (on the same screen) at their own pace, then advanced to a new screen to answer an attention check question. After successfully completing the attention check, participants proceeded to a new page, where they were able to re-read the passage pair (if necessary), rate the passages, and answer 20 true-false comprehension questions. This procedure was repeated until the participant read a total of eight passage pairs. Participants were randomly assigned to read either a refutation version or non-refutation version of each passage pair.

Results showed that true-false accuracy and participants ability to detect the contradiction was equivalent for refutation passage pairs and non-refutation passage pairs. A summary of the means for all 16 passage pairs can be seen in Table 8.

Comprehension Test

The same true-false comprehension measure from Experiment 1 was used in Experiment 2. The refutation passage pairs and non-refutation passage pairs used identical comprehension questions.

Materials and Apparatus

Experiment 2 used the same language proficiency measures and apparatuses as described in Experiment 1.

Experiment 2 used the same apparatuses, hardware specifications, and viewing set-up as in Experiment 1. Text was black, 18-point Courier New font and text passages were triple spaced. One to four sentences appeared on a display screen at a time, depending on sentence length. No more than seven lines of text were shown on any given display screen.

Procedure

The experimental session was the similar across Experiment 1 and Experiment 2 with one exception. Due to the length of the experiment, participants were given a break half-way through the experimental trials (after completing four passage pairs). During this break, participants completed the ESPADA questionnaire on paper to reduce eye-strain from the computer screen. After completing the questionnaire, participants were re-calibrated and completed the remaining passage pairs. The trial procedures for Experiment 2 was the same as in Experiment 1. Participants read a total of eight passage pairs in Experiment 2. A counterbalanced design determined the language of each passage, the passage pair's text structure type, and the language of the true-false comprehension questions for each participant.

Analyses and Data Treatment

True-false comprehension responses

As in Experiment 1, a difference score was created from the true-false responses, subtracting the number of incorrect responses from the number of correct responses. Difference scores were submitted into a 2 (text passage structure) x 2 (fact consistency) x 2 (match in language between test question and first passage) x 2 (match in language between test question and second passage) x 2 (test question language) repeated measures ANOVA.

Total reading times for novel terms

Similar to Experiment 1, reading fixation analyses focused on total reading time (TRT). Durations shorter than 100 ms were excluded from analyses (5.5% of all TRT data). Average TRT for all occurrences of the novel terms in the second passage were averaged and submitted into a 2 (passage structure: refutation vs non refutation) x 2 (match in passage language) x 2 (language of second passage) x 2 (fact consistency) repeated measures ANOVA.

RESULTS AND DISCUSSION

True-False Question Accuracy

Performance was significantly higher for the refutation text structure ($M = 1.94$) compared to the non-refutation structure ($M = 1.70$), F (1, 77) = 6.16, $MSE = 5.40$, $p = .015$. Performance was also significantly higher for consistent facts ($M = 2.52$) compared to contradicted facts ($M = 1.12$), F (1, 77) = 136.84, $MSE = 8.99$, $p < .001$. There was a significant interaction between fact consistency and match in language between the test and the first passage, F (1, 77) = 4.26, MSE = 2.06, p = .042. There was a significant three-way interaction between text structure, fact consistency, and test language, F (1, 77) = 6.27, MSE = 2.36, p = .014. There was also a significant three-way interaction between fact consistency, test language, and match in language between the test and second passage $F(1, 77) = 4.44$, $MSE = 6.10$, $p = .038$. As with Experiment 1, two follow-up repeated measures ANOVA's were conducted, to investigate the role of language on accurate retrieval of consistent and contradicted facts.

Consistent facts

There was no significant main effects or interactions for consistent facts. Figures 5 and 6 display the average difference scores for consistent concepts.

Contradicted facts

There was a main effect of text structure, $F(1, 77) = 5.89$, $MSE = 9.06$, $p = .018$, showing better performance for the refutation text structure ($M = 1.32$) compared to the non-refutation structure ($M = .91$). The effect of text structure was qualified by a significant interaction with test language, $F(1, 77) = 8.01$, $MSE = 2.37$, $p = .006$. There was also a main effect of match in language between the test and the first passage, $F(1, 77) = 4.60$, $MSE = 1.96$, $p = .035$. There was a main effect of match in language between the test and the second passage, $F(1, 77) = 6.02$, $MSE = 2.25$, $p = .016$, which was qualified by an interaction with test language, $F(1, 77) = 4.15$, $MSE = 9.86$, $p = .045$. Figures 7 and 8 display the average difference scores for the contradicted facts.

Total Reading Time

TRT was slower when the language of the passage pairs matched ($M = 567$ ms) compared to when they differed ($M = 535$ ms), $F(1, 72) = 6.75$, $MSE = 46{,}415$, $p = .011$. This was qualified by a significant interaction with the language of second passage, $F(1, 72) = 4.13$, $MSE = 73{,}058$, $p = .044$. Follow-up t-tests showed that TRT was faster when both passages were in the dominant language ($M = 529$ ms) compared to when both passages were in the non-dominant language ($M = 596$ ms), $t(76) = 2.90$, $p = .005$. However, when the passage languages mismatched, TRT was equivalent regardless of the language of the second passage, *t* (76) = .368, *p* = .714. Average TRT for the consistent terms and contradicted terms are displayed in Figures 7 and 8, respectively.

Match in passage language also interacted with fact consistency, *F* (1, 72) = 5.84, *MSE* = 51,731, *p* = .018. Follow-up t-tests showed that for consistent terms, TRT was slower when the language of the passages matched (*M* = 573 ms) compared to when they differed (*M* = 509 ms), *t* (76) = 3.55, *p* = .001. However, for contradicted terms, match in passage language did not influence reading time, *t* (76) = .319, *p* = .751.

There was no main effect of passage structure, *F* (1, 72) = 3.14, *MSE* = 74,355, *p* = .080, however the pattern of means was in the expected direction, such that TRT was faster in the refutation passages (*M* = 537) compared to the non-refutation passages (*M* = 565). There was no main effect of second passage language, *F* (1, 72) = 2.91, *MSE* = 73,716, *p* = .092, nor fact consistency (*F* < 1). The remaining interactions were also not significant.

Experiment 2 Discussion

Experiment 2 replicated findings from Experiment 1, demonstrating that a match in language between the passages and test influenced participants' ability to accurately retrieve information about the contradicted facts. This influence of language did not extend to the retrieval of consistent facts, suggesting that readers developed a deep, conceptual-level representation of consistent facts, but had a shallower, more form dependent representation of contradicted facts.

Expanding on Experiment 1, we saw that true-false comprehension accuracy improved for the contradicted facts if the readers were giving a refutation passage compared to the non-refutation passage. This is consistent with previous research, as refutation style passages are designed to improve comprehension of contradictory information or misconceptions.

Similar to Experiment 1, there was also an overall effect of language dominance observed in total reading time, showing that participants' reading was facilitated by their dominant language. Unexpectedly, consistent terms were read more slowly when the passage language matched. This may indicate the consistent terms required more processing time. Critically, the consistent terms appeared before the contradicted terms in five out of the eight passage pairs. Previous research on novel word learning has shown that novel words learned earlier in the experiment had longer total reading times compared to novel words learned later in the experiment (Joesph, Wonnacott, Forbes, & Nation, 2014). This could be one contributing factor to why the consistent terms took longer to process in the dominant language.

Table 5. Experiment 2 Average WMLSR age equivalencies for the Picture Naming Vocabulary and Passage Comprehension subtests.

		Picture Naming Vocabulary	Passage Comprehension
English Dominant (n = 37)	L1	14.16	14.40
	L2	9.26	12.09
Spanish Dominant (n = 34)	L1	13.80	19.78
	L2	8.38	10.62

Table 6. Experiment 2 frequency of speaking and reading in English and Spanish

	English		Spanish	
	Speaking	*Reading*	*Speaking*	*Reading*
Daily	82%	85%	81%	47%
Several days a week	12%	10%	14%	18%
Weekly	4%	3%	3%	12%
Bi-weekly	0%	1%	1%	12%
Every few months	1%	1%	0%	8%
Once or twice a year	0%	0%	0%	3%
Less than once or twice a year	0%	0%	0%	0%

Table 7. Experiment 2 Parent education levels

	Mother	Father
Middle school	11%	7%
Some high school	11%	7%
Graduated high school	16%	26%
Some college	26%	21%
Graduated college	26%	18%
Master's degree	7%	19%
PhD/MD/JD	3%	3%

Table 8. Descriptive statistics from Experiment 2 stimuli norming

Selected passage pairs	Non-refutation structure		Refutation structure	
	Contradiction identified	*Average TF accuracy*	*Contradiction identified*	*Average TF accuracy*
1. Stars	85%	78%	81%	79%
2. Fossils	81%	83%	78%	88%
3. Herbal medicine	94%	77%	91%	76%
4. Tumors	85%	84%	88%	81%
5. Plant growth	86%	73%	90%	75%
6. Ocean life	88%	73%	73%	80%
7. Dairy	87%	72%	82%	73%
8. Rainforest	82%	66%	86%	76%

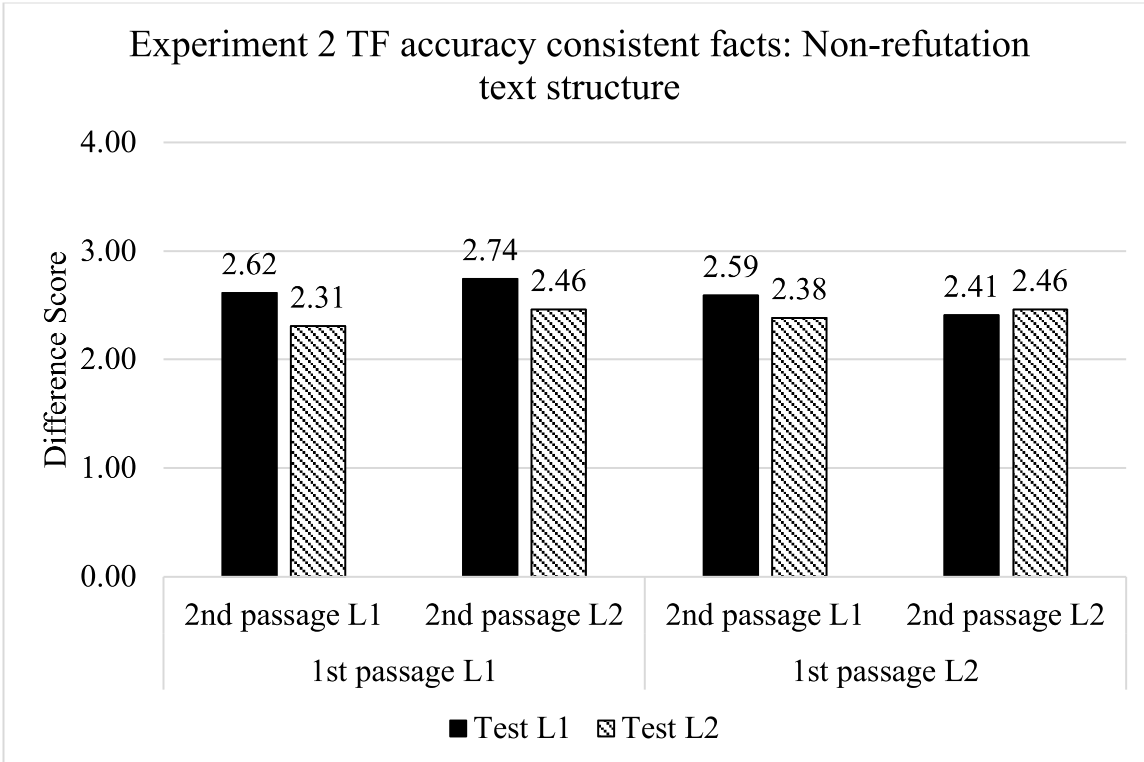

Figure 5. Experiment 2 true-false difference scores for the consistent facts in the non-refutation passages.

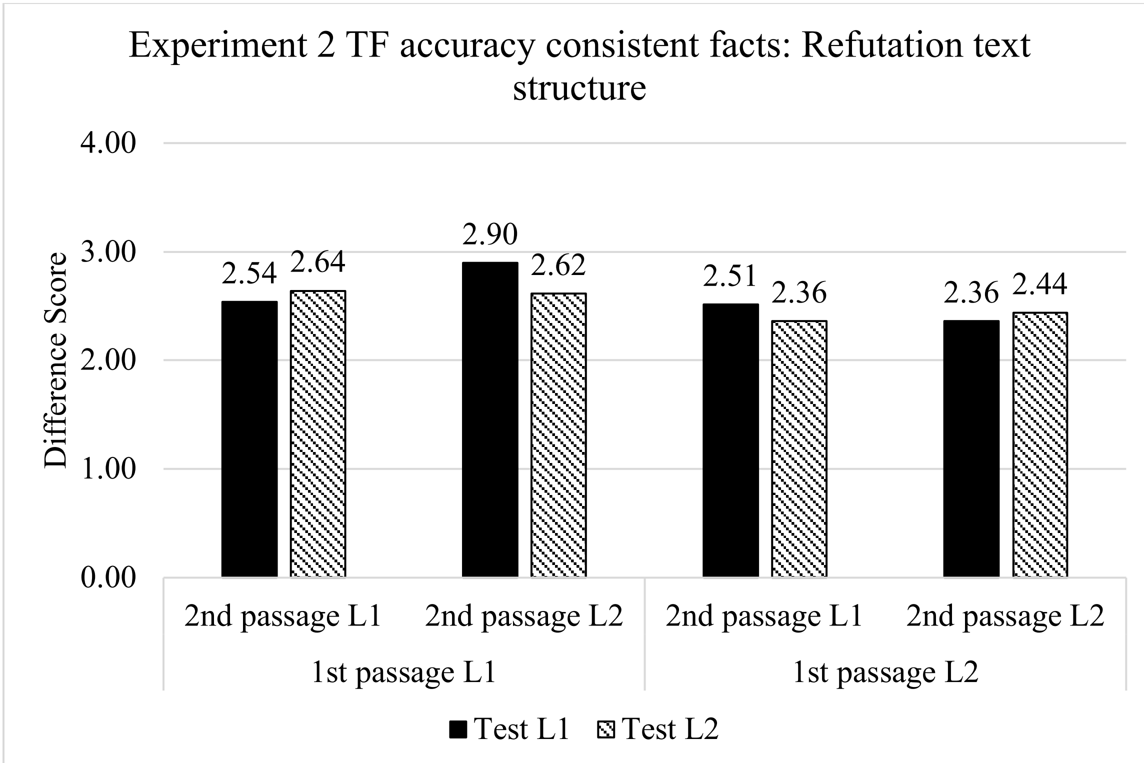

Figure 6. Experiment 2 true-false difference scores for the consistent facts in the refutation passages.

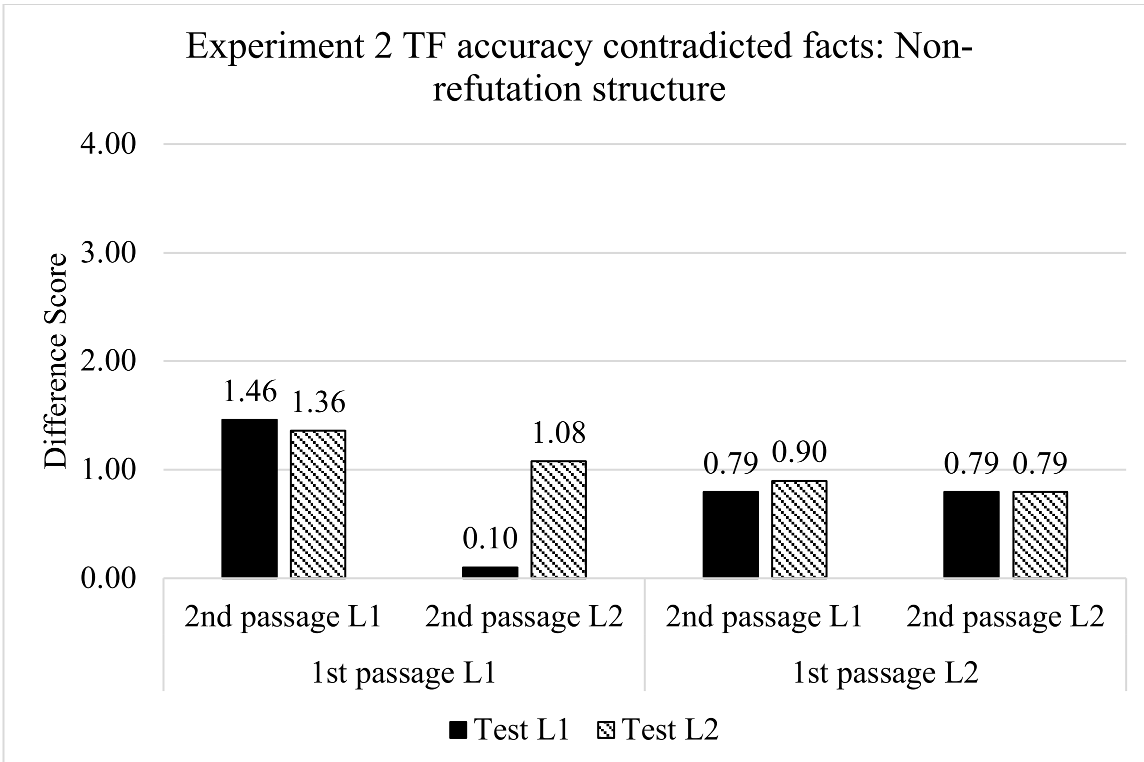

Figure 7. Experiment 2 true-false difference scores for the contradicted facts in the non-refutation passages.

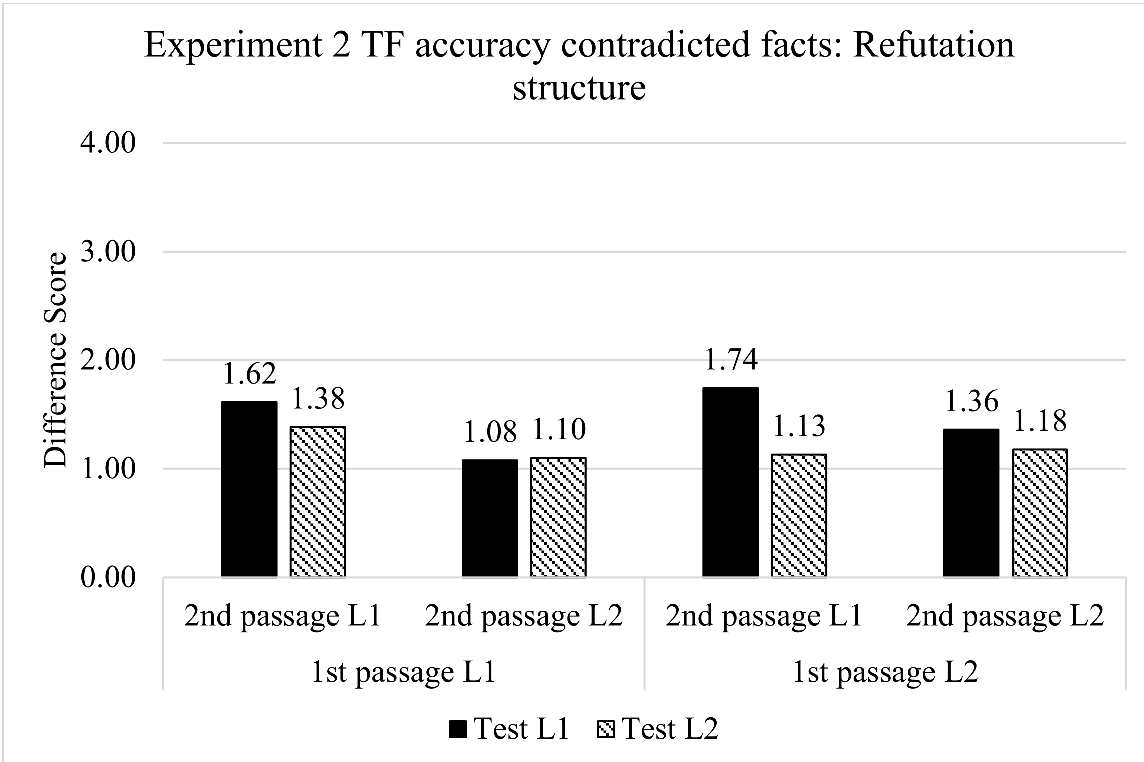

Figure 8. Experiment 2 true-false difference scores for the contradicted facts in the refutation passages.

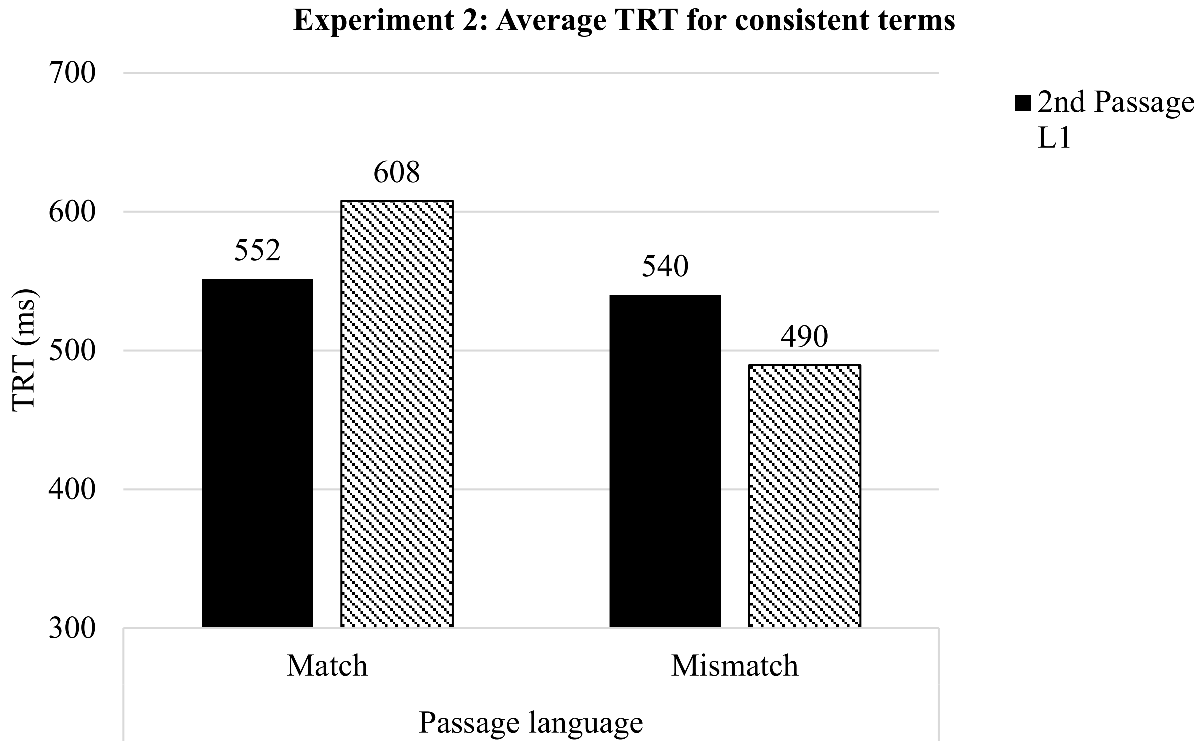

Figure 9. Average TRT in Experiment 2 for consistent terms in the second passage.

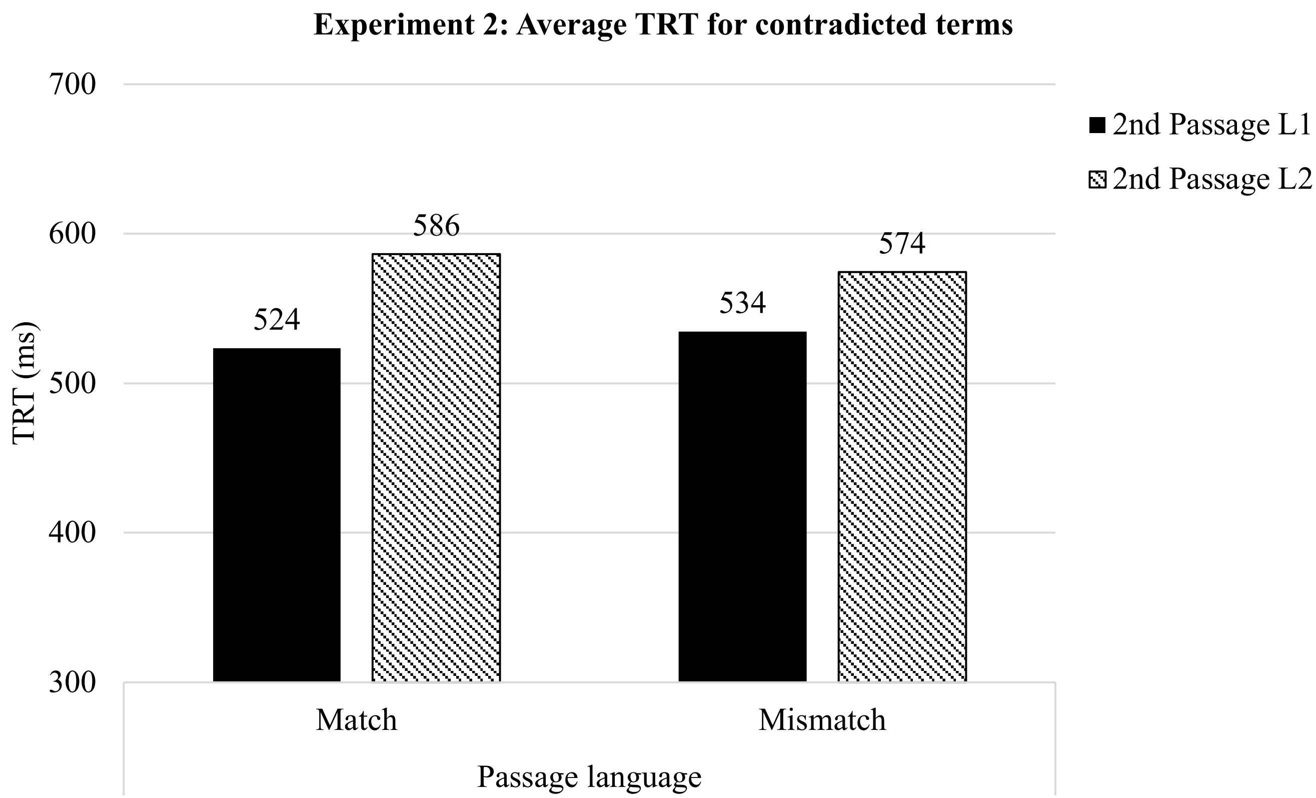

Figure 10. Average TRT in Experiment 2 for contradicted terms in the second passage.

Chapter 4: General discussion

The present study sought to investigate the influence of language on conceptual integration when reading. Based on previous research demonstrating that representations of text often include word form information, we tested whether conceptual integration is hindered when texts are in different languages. The main hypothesis for this study was that both, proficiency in the language of text and the match in language across texts influences the extent to which readers develop a situation-based memory representation during reading, and therefore influence the likelihood that concepts from passages would be accurately integrated. In terms of general effects of the language of text, we found evidence that, although the bilingual participants were highly proficient, processing faster when passages were in the L1. Across both experiments, total reading times of the novel terms were faster when these were embedded in L1 passages relative to L2 passages. Since these novel terms were fictional, they should not have had any distinct language assignment in the lexicon, thus, the difference in reading time reflects the surrounding language context and not differences in accessing the word per se.

More central to the goal of the present study, we found evidence that match in language does in fact influence how well bilingual readers can integrate information across passages. Supporting our hypothesis, retrieval of contradicted terms in Experiment 1 improved when the language of the second passage matched the test language. This suggests that recently updated information had a more text-based memory representation. Critically, this dependency on language form was not observed for consistent terms. Experiment 2 replicated this pattern, showing that performance on true-false questions targeting contradicted terms decreased when the language of second passage mismatched the language of test. This suggests that the text representation built for the contradicted facts was more affected by surface level language features. As in Experiment 1, consistent terms in Experiment 2 did not show a dependence on language features. This suggests that varying levels of representations can be built for different portions of text coming from the same passage. It could be that the repeated exposure of the consistent information, even if presented in different languages, lead to a deeper, conceptual-level representation of the text. In contrast, the contradicted information required more updating across the two passages, contributing to a shallower, more language-dependent text representation.

According to the Landscape Model, both surface features and conceptual features influence meaning integration during text comprehension (van den Broek, Young, Tzeng, & Linderholm, 1998). It also states there is a continual fluctuation of conceptual activation during reading. If a concept from the text is activated strongly enough, the activation can spread to related cohorts of concepts. In the present study, consistent terms may have been activated strongly enough to spread to related cohorts of concepts (such as prior knowledge), strengthening the situation-based memory representation of the consistent terms. In contrast, the lack of conceptual overlap from passage one to passage two for the contradicted terms may have weakened the concepts overall activation, and thus its ability to connect to related concepts. This would create a weaker conceptual representation of the contradicted terms, allowing surface features (i.e., language) to have a stronger influence on the memory representation for these contradicted terms. The stronger influence of surface features would cause language to influence processing and comprehension (Raney, 2003). Reflecting this, both experiments in the present study showed a stronger influence of language features in comprehension of contradicted terms, but not consistent terms.

In similar study looking at bilingual expository text comprehension, recognition memory for text passages, measured through true-false questions, was not influenced by language (Vander Beken, & Brysbaert, 2018). However, this study did not look specifically at information updating nor did they manipulate the match in language between the text passage and test. The present study's findings for the true-false accuracy for consistent terms extends the findings of Vander Beken and Brysbaert (2018), showing that retrieval performance is not hindered even when the language of the text mismatched the language of the text passage. The present study goes further to show that the match in language is critical when testing newly updated (i.e., contradicted) facts. It is also worth noting that Vander Beken and Brysbaert (2018) demonstrated that the language of a text passage does influence free recall at test, showing lower performance when the text passage (and test) was in the non-dominant language. Future studies should investigate the influence of language match when using free recall. If a more language dependent text representation is built when updating conceptual information in the L2, a free recall question may lack the lexical information necessary to retrieve the text representation at test, resulting in lower performance.

As stated in the introduction, bilingual conceptual access theories assume that a bilinguals two lexicons share a single conceptual store. Of particular relevance to the present study, evidence of a single-conceptual store has been observed in cross-language problem solving (Francis, 1999a). Using an analogical transfer paradigm, two experiments tested bilinguals' ability to use information from an initial story to solve a target problem at test. They found that participants were able to transfer conceptual information from the initial story to the target problem, even when the language of the initial story differed from the language of the target problem. However, they observed that language influenced participants' ability to solve the target problem when there were competing solutions presented in the initial stories. Similar to Francis (1999a), the present study demonstrated that competing information (i.e., contradicted facts) were influenced by language features at test, but consistent information was accessible across both languages. It appears that the process of updating or resolving inconsistent information during passage comprehension contributes to a more language-dependent memory representation of a text.

Experiment 2 also sought to investigate the role that text structure played in conceptual integration during reading. To do this, some passage pairs used refutation passages, while others had non-refutation passages.

Comprehension performance for the contradicted concepts showed overall, participants benefited from the refutation text structure. This is consistent with previous research, as refutation texts are designed to help readers integrate contradictory information. This higher performance on refutation text passages persisted even when passage language and test language mismatched. By reactivating information from the first passage, readers may be better able to integrate the new contradictory information at a deeper conceptual level.

In addition to improved comprehension, refutation passages may also facilitate reading times. Although the effect of text structure was not statistically reliable, the pattern of means suggested that refutation passages facilitated processing of the novel terms, compared to the non-refutation style passages. Previous research has shown that refutation texts facilitate reading for portions of the text dedicated to the correction to a science misconception, but that reading is slowed for the refutation portion of the text (Ariasi, et al, 2017; Ariasi, & Mason, 2011). The present study's focus on the novel terms may be why we did not see significant facilitation in TRT for the refutation passages.

In sum, the present study demonstrated that language influences memory representations built from text passages, but that this influence depends on the type of information. Our findings suggest that information which requires updating (i.e., contradicted facts) lead to a more text-based memory representation, while consistent information from the same text passage has a deeper, more situation-based memory representation.

References

Alvermann, D. E., & Hague, S. A. (1989). Comprehension of counterintuitive science text: Effects of prior knowledge and text structure. *Journal of Educational Research,* 83(4), 197-202.

Ariasi, N., Hyönä, J., Kaakinen, J. K., & Mason, L. (2017). An eye-movement analysis of the refutation effect in reading science text. *Journal of Computer Assisted Learning*, 33, 202–221. doi: 10.1111/jcal.12151.

Ariasi, N., & Mason, L. (2011). Uncovering the effect of text structure in learning from a science text: An eye-tracking study. *Instructional Science,* 39, 581-601. DOI 10.1007/s11251-010-9142-5.

Armbruster, B. B. (1986). Schema theory and the design of content-area textbooks. *Educational Psychologist,* 21(4), 253-267.

Beker, K., Jolles, D., Lorch, R. F., & van den Broek, P. (2016). Learning from texts: activation of information from previous texts during reading. *Reading and Writing, 29,* 1161-1178

Britt, M. A., Perfetti, C. A., Sandak, R. I., & Rouet, J. F. (1999). Content integration and source separation in learning from multiple texts, in Goldman, S. R., Graesser, A. C., & van den Broek, P. (Eds.), *Narrative Comprehension, Causality, and Coherence: Essays In Honor of Tom Trabasso* (pp.209–233). Mahwah, NJ: Lawrence Erlbaum Associates.

Broughton, S. H., Sinatra, G. M., & Reynolds, R. E. (2010). The nature of the refutation text effect: An investigation of attention allocation. The Journal of Education Research, 103, 407-423.

Carr, T. H., Brown, J. S., & Charlambous, A. (1989). Repetition and reading: Perceptual encoding mechanisms are very abstract but not very interactive. Journal of Experimental Psychology: Learning, Memory, and Cognition, 15(5), 763-778.

Chambliss, M. J. (2002). The characteristics of well-designed science textbooks. In J. Otero, J. A. Leon, A. C. Graesser (Eds) *The Psychology of Science Text Comprehension* (pp. 51-72). New York, NY: Routledge.

De Groot, A. M. B., Delmaar, P., & Lupker, S. J. (2000). The processing of interlexical homographs in translation recognition and lexical decision: Support for non-selective access to bilingual memory. The Quarterly Journal of Experimental Psychology, 53A(2), 397-428.

de la Riva López, E. M., Francis, W. S., & García, J. (2012). Repetition priming within and between languages in verb generation: Evidence for shared verb concepts. *Memory, 20,* 358-373.

(a) Francis, W. S. (1999). Analogical transfer of problem solutions within and between languages in Spanish–English bilinguals. *Journal of Memory and Language, 40*(3), 301-329. doi:10.1006/jmla.1998.2610

(b) Francis, W. S. (1999). Cognitive integration of language and memory in bilinguals: Semantic representations. *Psychological Bulletin, 125*(2), 193-222.

Francis, W. S., Fernandez, N. P., Bjork, R. A. (2010). Conceptual and non-conceptual repetition priming in category exemplar generation: Evidence from bilinguals. *Memory, 18*(7), 787-798. DOI: 10.1080/09658211.2010.511234

Francis, W. S., & Goldmann, L. L. (2011). Repetition priming within and between languages in semantic classification of concrete and abstract words. *Memory, 19*(6), 653-663, DOI: : 10.1080/09658211.2011.595724

Francis, W. S., & Strobach, E. N. (2013). Prediction of objective bilingual language proficiency: Can self-report measures suffice? Presentation at the 54th Annual Meeting of the Psychonomic Society (Toronto, ON).

Friesen, D. C. & Jared, D. (2007). Cross-language message- and word-level transfer effects in bilingual text processing. *Memory & Cognition, 35*(7), 1542-1556.

Gernsbacher, M. A.(1991). Cognitive processes and mechanisms in language comprehension: The Structure Building Framework. *The Psychology of Learning and Motivation, 27*. 217-263

Guzzetti, B. J., Snyder, T. E., Glass, G. V., & Gamas, W. S. (1993). Promoting conceptual change in science: A comparative meta-analysis of instructional interventions from reading education and science education. *Reading Research Quarterly,* 28 (2), 116-159.

Hynd, C., & Alvermann, D. E. (1986). The role of refutation text in overcoming difficulty with science concepts. *Journal of Reading, 29*(5), 440-446

Joseph, H. S. S. L., Wonnacott, E., Forbes, P., & Nation, K. (2014). Becoming a written word: Eye movements reveal order of acquisition effect following incidental exposure to new words during silent reading. *Cognition,* 133, 238-248. http://dx.doi.org/10.1016/j.cognition.2014.06.015.

Kendeou, P., Rapp, D. N., & van den Broek, P. (2003). The influence of reader's prior knowledge on text comprehension and learning from text. *Progress in Education, 13*, 189-209.

Kendeou, P., Walsh, E. K., Smith, E. R., & O'Brien, E. J. (2014). Knowledge revision processes in refutation texts. *Discourse Processes, 51*(5-6), 374-397.

Kintsch, W., & van Dijk, T. A. (1978). Toward a model of text comprehension and production. *Psychological Review, 85,* 363-394

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. Journal of Memory and Language 33, 149-174.

Kroll, J. F., & Tokowicz, N. (2005) Models of bilingual representation and processing: Looking back and to the future. In Kroll, J. F., & De Groot, A. M. B. *Handbook of Bilingualism: Psycholinguistic Approaches*. 531-553. New York: Oxford University Press.

Levy, B. A., & Burns, K. I. (1990). Reprocessing text; Contributions from conceptually driven processes. Canadian Journal of Psychology, 44(4), 465-482. Levy, Campsall, Browne, Cooper, Waterhouse, & Wilson, 1995

Levy, B. A., Campsall, J., Browne, J., Cooper, D., Waterhouse, C., & Wilson, C. (1995). Reading fluency: Episodic integration across texts. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 12*(5), 1169-1185.

Linderholm, T., Virtue, S., Tzeng, Y., & van den Broek, P. (2004). Fluctuations in the availability of information during reading: Capturing cognitive processes using the landscape model. *Discourse Processes, 37*(2), 165-189.

Lombardi, D., Danielson, R. W., & Young, N. (2016). A plausible connection: Models examining the relations between evaluation, plausibility, and the refutation text effect. *Learning and Instruction, 44,* 74-86.

Raney, G. E., & Bovee, J. C. (2016). Reading integration in bilingual speakers in Heredia, R. R., Altarriba, J., Cieslicka, A. B., *Methods in bilingual reading comprehension research*. (pp. 157-181). New York, NY: Springer Science & Business Media

Raney, G. E. (2003). A context-dependent representation model for explaining text repetition effects. *Psychonomic Bulletin & Review, 10*(1), 15-28.

Raney, G. E., Obeidallah, S. M., & Miura, T. K. (2002) Text comprehension in bilinguals: Integrating perspectives on language representation and text processing. *Advances in Psychology, 134,* 165-183.

Seger, C. A., Rabin, L. A., Desmond, J. E., & Gabrieli, J. D. E. (1999). Verb generation priming involves conceptual implicit memory. *Brain and Cognition, 41*(2), 150-177.

Smith, M. C. (1991). On the recruitment of semantic information for word fragment completion: evidence from bilingual priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17*(2), 234-244.

Taylor, R., & Francis, W. S. (2017). Between-language repetition priming in antonym generation: evidence that translation equivalent adjectives have shared conceptual representations across languages. *Memory,* DOI: 10.1080/09658211.2016.1173704

Tzeng, Y., van den Broek, P., Kendeou, P., & Lee, C. (2005). The computational implementation of the landscape model: Modeling inferential processes and memory representations of text comprehension. *Behavioral Research Methods, 37*(2), 277-286.

Van Boekel, M., Lassonde, K. A., O'Brien, E. J., & Kendeou, P. (2017). Source credibility and the processing of refutation texts. *Memory and Cognition, 45,* 168-181.

van den Broek, P., & Kendeou, P. (2008). Cognitive processes in comprehension of science texts: The role of co-activation in confronting misconceptions. *Applied Cognitive Psychology, 22,* 335-351.

van den Broek, Rapp, D. N., & Kendeou, P. (2005). Integrating memory-based and constructionist processes in accounts of reading Comprehension. Discourse Processes, 39, 299-316.

van den Broek, P., Young, M., Tzeng, Y., & Linderholm, T. (1999). The Landscape Model of reading: Inference and the online construction of a memory representation, in van Oostendorp, H., & Goldman, S. R. (Eds.), *The Construction of Mental Representations During Reading,* (pp. 71-98). Mahwah, NJ: Erlbaum.

Vander Beken, H., & Brysbaert, M. (2018). Studying tests in a second language: The importance of test type. *Bilingualism: Language and Cognition,* 21 (5), 1062-1074.

Van Hell, J. G., & De Groot, A. M. B. (1998). Conceptual representation in bilingual memory: Effects of concreteness and cognate status in word association. *Bilingualism: Language and Cognition, 1*(3), 193-211.

Woodcock, R.W., Muñoz-Sandoval, A.F., Ruef, M.L., & Alvarado, C.G. (2005). Woodcock-Muñoz Language Survey-Revised. Itsaca, IL: Riverside Publishing.

Yeari, M., & van den Broek, P. (2011). A cognitive account of discourse understanding and discourse interpretation: The Landscape Model of reading. *Discourse Studies, 13*(5), 635-643.

Zeelenberg, R., Pecher, D. (2003). Evidence for long-term cross-language repetition priming in conceptual implicit memory task. *Journal of Memory and Language, 49,* 80-94.

Vita

Karly Meillyn Schleicher earned her Bachelor of Arts in Psychology and Spanish from the University of Missouri- Kansas City. In 2013, she entered the doctoral program at the University of Texas at El Paso's Department of Psychology, where she earned her MA and PhD. While at UTEP, she conducted research on bilingual reading comprehension under the mentorship of Dr. Ana Schwartz.

Dr. Schleicher was the recipient of the UTEP Graduate School's Dodson Research Award, which helped fund her dissertation, "Cross-language activation and integration of concepts across text passages". In addition to her research, Dr. Schleicher also pursued numerous teaching opportunities. She has established a strong teaching record, evidenced by UTEP's Outstanding Teaching Award in 2018. In the fall of 2019, she will begin her academic career as an Assistant Professor at Heritage University in Toppenish, WA.