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# Cross-language conceptual activation and development through text passages

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CROSS-LANGUAGE CONCEPTUAL ACTIVATION AND DEVELOPMENT  
THROUGH TEXT PASSAGES

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Master's Program in Experimental Psychology

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Karly M. Schleicher

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## **Dedication**

To my parents, Rochelle, Dan, and Janolyn. None of this would have been possible without the endless love and support all three of you have shown me. To my siblings, Abby and Kyle, you both continue to motivate me to keep pursuing my goals. And to Sean and Avry, thank you for your constant patience, love, and support.

CROSS-LANGUAGE CONCEPTUAL ACTIVATION AND DEVELOPMNET  
THROUGH TEST PASSAGES

by

KARLY MEILLYN SCHLEICHER, B.A.

THESIS

Presented to the Faculty of the Graduate School of

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## **Abstract**

The present study begins to bridge the gap between bilingual education practices and cognitive frameworks of bilingual conceptual access. A reading comprehension task was used to investigate how bilingual undergraduate students activate and develop academic information across their two languages when reading expository text. Using scientific texts, participants ( $N = 128$ ) read two distinct passages pertaining to prior knowledge, as well as new, related conceptual information. At test, the participants were asked to complete true-false questions and elaborate on the reasons for their responses. A counterbalanced, mixed factorial design was used to infer how language dominance influences encoding and retrieval of expository information in bilinguals' two languages. Results indicate that prior academic knowledge is better recalled in the dominant language and when the language of text and test match. Furthermore, Spanish dominant participants were better able to develop new conceptual features in their less dominant language. Importantly, Spanish dominant participants' proficiency scores indicated they were less balanced across their two languages. This difference in language proficiency may benefit the development of new information, by decreasing interference from prior knowledge acquired in their dominant language.

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## **Chapter 1: Introduction**

### **Bilingual education practices**

Traditionally, language education has focused on immersing second language learners in the language of interest, rather than using their first language to improve their second (Flood, Lapp, Tinajero, & Hurley, 1997). These practices are driven by an assumption that mixing the two languages would serve as a detriment to the learner, rather than a benefit. However, there is evidence that a bilingual's two languages can be used to benefit one another, particularly when developing the second language. Several theories assume that a speaker's first language influences their second (e.g., Cummins 1979; Cummins, 1981; Hornberger, & Link, 2012) and numerous studies have demonstrated strong associations between first language (L1) and second language (L2) proficiency (e.g., Lee, & Leomnier-Schallert, 1997; Sparks, Patton, Ganschow, & Humach, 2012; Comeau, Cormier, Grandmaison, & Lacroix, 1999; Geva, Wade-Woolley, & Shany, 1997).

A variety of reading skills have been shown to transfer across a bilingual's two languages, ranging from single word processing to the implementation of reading strategies. For example, L1 reading ability and L2 proficiency predict L2 reading ability (Lee & Lemonnier-Schallert, 1997). How frequently an individual reads uniquely predicts both L2 reading comprehension and general L2 proficiency, even after controlling for early L1 ability and cognitive ability (Sparks, Patton, Ganschow, & Humach, 2012). Also, phonological skills from the L1 transfer to the L2 when both have similar alphabets (e.g., French and English; Comeau et al., 1999). Bilinguals are able to utilize L1 reading strategies to benefit reading comprehension in their L2, as long as they are highly proficient in their L2 (Lee & Lemonnier-Schallert, 1997).

It should be noted that the degree to which language skills transfer across languages depends on L2 language proficiency. Those with low L2 proficiency demonstrate little

association between their first and second language reading ability. This suggests that at a certain point in L2 acquisition, L1 reading strategies are applied to L2.

Most of the research examining language transfer effects has focused on the influence of language processing. Atón and colleagues (2015) expanded research on the benefits of cross-language transfer to acquiring new concepts. Balanced Basque-Spanish bilingual participants learned common features of new objects in either monolingual or bilingual settings. Two distinct feature descriptions of novel tools were provided to the participants in either bilingual or monolingual conditions. For example, two features commonly associated with the word *key*, such as “the definitions ‘it is kept in the pocket’ and ‘it unlocks doors’ locks”, were used in monolingual or bilingual contexts (pg 5, Atón, et al., 2015). In the bilingual condition, participants read one feature description in Basque, and the other in Spanish. The monolingual condition had both features described in Spanish. Monolingual learning groups were compared to the bilingual groups in a recognition task, asking participants to identify the object associated with the common features. The groups did not differ in accuracy, indicating that mixed-language learning settings do not serve as a detriment when learners are highly proficient in both languages. However, while no detriment was demonstrated, the mixed-language learning setting did not outperform the single language learning setting. This indicates that while dual-language learning settings don’t necessarily lead to improved comprehension or strengthened memory traces, they also don’t inhibit conceptual development.

Educational research has demonstrated that learners benefit when learning in mixed language settings (Baker, et.al., 2012). Baker and colleagues (2012) conducted a longitudinal study following first grade English learners in monolingual (i.e., taught English only) or bilingual classrooms (i.e., taught both Spanish and English) through the third grade. Results from

a linear growth model indicated that the children in the bilingual classroom had higher English reading fluency growth rates compared to the monolingual classroom in both their second and third years in the program. Despite being in a bilingual classroom, which would inherently limit time dedicated to English instruction, students still demonstrated English learning gains above those of the monolingual classroom. These findings demonstrate that bilingual educational settings benefit learners acquiring their L2, despite limiting their L2 exposure time.

While these language transfer effects have been examined extensively in children (for a review, see Durgunoğlu, 2002), little research has been conducted to investigate the benefit of using a bilingual's first language to improve learning in their second with adult populations (Yamashita, 2002; Elston- Güttler, Paulmann, & Kotz, 2005; Atón, et al., 2015). In bilingual populations, it is common for adults to acquire conceptual information in one language, but then need to access and build on those concepts in their second language. For instance, second-language speaking students attending universities in the United States often learned the basic conceptual information regarding a topic (e.g., biology) in their native language, but then need to access and build on that information in their English university courses. The conceptual information was predominantly associated with their L1, and now must be accessed through their L2. Using text passages, the present study will investigate transfer between the L1 and L2 in conceptual access of information predominantly associated with one language. The main hypothesis for the study is that using prior knowledge from the L1 will benefit acquisition of new related conceptual information in the L2 when reading.

The next sections are reviews of text-based comprehension and learning and bilingual conceptual access. First, conceptual access during reading will be explained through monolingual text comprehension models. Next, processes necessary to learn from a text will be

described, to better understand how comprehension can lead to conceptual encoding. Finally, models of bilingual conceptual access will be reviewed to describe how individuals learning in their L2 access information.

### **Text comprehension models**

In order to better understand conceptual activation during reading, it is necessary to have a framework for text comprehension processes. One of the most prominent models of reading comprehension is the Landscape Model. In this paper, two models of reading comprehension will be used to illuminate how prior knowledge is integrated with textual information. The first model focuses on semantic structure of the text and how this information is used by readers to generate inferences (Kendeou, Rapp, & van den Broek, 2003; Kintsch, & van Dijk, 1978). Linderholm and colleagues (Linderholm, Virtue, Tzeng, & van den Broek, 2004) extended this framework by specifying the source of the episodic memory traces that are generated during comprehension within the Landscape Model. Specifically, they distinguish memory traces that are based on prior knowledge, based on the text, or based on a combination of these two sources.

In order to comprehend a text passage, one needs to develop appropriate memory representations of the text. Surface level representations are representations of lexical forms in a text (Kendeou, et al., 2003). Text-based representations are representations of the meanings of individual words and sentences. They do not include inferential connections across sections of text. Therefore, surface and text-based representations are characterized as the microstructure of a text (Kintsch, & van Dijk, 1978). A microstructure representation can be built without fully comprehending the text as a whole.

In order to fully comprehend a text passage, a situational model, or macrostructure, needs to be developed (Kintsch, & van Dijk, 1978). At this level, semantic information across regions

of text is integrated. By integrating prior knowledge with the new textual information, a reader begins to comprehend the information at hand. Once information is comprehended, it can then be applied in novel settings, indicating that it was not only comprehended but learned (Kendeou, et al., 2003).

The Landscape Model (LM) integrates both on-line and off-line processing (Linderholm, et al., 2004). While reading, the activation of concepts varies depending on the information being read and the reader's understanding of that concept. Concepts either maintain activation, are reactivated, or decline in activation. This variation in conceptual activation occurs throughout the text passage and the reading cycles of the text.

According to the LM, conceptual activation can arise from the text that is currently being read as well as previous reading cycles of the text passage, and this activation can occur through two different mechanisms. Information from the current text and carried-over information is activated through *cohort activation* and is assumed to be quick and passive. For example, if the first sentence of a paragraph activates your concept of a dog, the second sentence in that paragraph might also maintain the conceptual activation of 'dog'. As a reader progresses through each cycle of the text, they build an episodic memory trace, influenced by the spreading activation of concepts within the text. This information can be activated either explicitly by the actual text or implicitly through the reader's inferences. As concepts are activated within a cycle, their associates, or their cohort, are also activated.

The second mechanism of conceptual activation occurs through *coherence-based retrieval*. Unlike the first mechanism, coherence-based retrieval is an active process in which the reader uses prior knowledge to interpret the text. Activation from reinstatement involves effortful application of information from earlier in the passage to create a coherent representation of the

text. Similarly, background knowledge activation involves the reader applying prior knowledge to the text, creating coherent conceptual representations.

In coherence-based retrieval, activation utilizes memory representations that are more developed, not simply relying on working memory but also on long-term, semantic memory. Memory representations of the text as a whole, from paragraphs or pages read previously, act as a source of activation, reinstating concepts previously activated. Background knowledge related to the information at hand can also act as a source of activation. This final source of activation is an effortful process that involves the reader retrieving related information from semantic memory.

To successfully comprehend a text passage, information from the text is integrated with the reader's prior knowledge to create a distinct memory representation of that text (Kendeou, et al., 2003). When that memory representation is applied in a novel situation, Kendeou and colleagues (2003) claim the individual has learned the information. For example, an individual may read a text passage about the influence of pesticides on ecosystems. Prior knowledge from a science class informs the reader what an ecosystem is, and that it encompasses a wide range of living things. This prior knowledge becomes associated with new memory traces regarding the information in the new text. Finally, this information may be re-activated when discussing agricultural influences on the environment in a class, activating both the prior knowledge and the newly developed memory trace. This application demonstrates that text was not only comprehended, but also learned.

The language in which bilinguals encounter and therefore activate concepts can vary by language. For example, a bilingual might have learned the concept of a neuron exclusively in one language and later encounter it in another language. This mismatch in language might make it

more difficult to access the relevant concept and associated features. In order to understand this mismatch, it is important to investigate bilingual conceptual access and development across languages. The following section will describe relevant theories of bilingual conceptual access, and how their assumptions explain conceptual development across languages.

### **Bilingual conceptual access**

Theories of bilingual conceptual access share the assumption that words across languages are linked to a single conceptual store (Kroll, & Stewart, 1994; Kroll, & Tokowicz, 2005; van Hell, & de Groot, 1998). Evidence for a single conceptual store (Francis, 1999b) 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, in press). Moreover, evidence for a single conceptual store has also been demonstrated through studies investigating cross-language transfer of more complex information (e.g., problem solving, Francis, 1999a; text processing, Friesen & Jared, 2007). Most studies demonstrating cross-language conceptual priming or transfer have been based on single-word paradigms. Of particular interest to the present study, one group of researchers investigated this effect in transfer of text comprehension across languages (Friesen, & Jared, 2007).

Previous studies assume that metrics of reading time of words, sentences, and passages reflect conceptual comprehension of text (e.g., Levy, Nicholls, & Kohen, 1993; Graesser, & Bertus, 1998; Friesen, & Jared, 2007). Investigating cross-language transfer effects in passage comprehension, Friesen and Jared (2007) examined the effect of repeated passage presentation



on reading time across languages. Pairs of passages were presented to participants, and their relatedness varied in both language and content. In general, they found that conceptual representations of the text were available across languages, with first passages, regardless of language, facilitating reading time of the second passage when the content was related. Of the five passage pairs, the pair most relevant to the present study consisted of translation equivalent passages void of any cognates (only non-cognate translation equivalents) demonstrating facilitation in second passage reading time. This facilitation was greatest when the first passage was presented in the L1 and the second passage presented in the L2. This implies that non target language can activate the episodic memory trace developed from the initial passage, especially when that memory trace was initially developed in the L1. Additionally, related passage pairs containing cognates facilitated reading times across languages, above that of the non-cognate translation equivalents. This indicates that both word-level and concept-level representations are transferred across languages. However, the present study is most interested in the transfer of conceptual-level representations. It is unknown whether such conceptual-level transfer would occur when the representations come from prior knowledge.

According to the Revised Hierarchical Model (RHM), unbalanced bilinguals have asymmetrical links from lexical items to their corresponding concepts, depicted in Figure 1 (Kroll, & Stewart, 1994). Lexical representations from an unbalanced bilingual's dominant language (L1) have stronger conceptual links (represented with the bold line in Figure 1) compared to lexical representations from their non-dominant language (L2; represented with the dashed line in Figure 1). For example, in order to activate the concept of an apple when reading in English, a Spanish dominant bilingual would first activate the Spanish translation, "manzana", and then activate the concept of the word. Consistent with the assumption of weaker conceptual

links in a less dominant language, numerous cross-language conceptual priming studies have seen stronger priming effects from L1 to L2 than from L2 to L1, when investigating immediate semantic priming (e.g., Basnight-Brown, & Altarriba, 2007; Keatley, Spinks, & de Gelder, 1994; Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009; Sholl, Sankaranarayanan, & Kroll, 1995;). This implies that a speaker's dominant language has stronger conceptual links compared to the speaker's nondominant language.

Complementary to the RHM, the Distributed Features Model (DFM), highlights the representation of conceptual features in bilingual memory (Van Hell, & De Groot, 1998; de Groot, Delmaar, & Lupker, 2000; Kroll, & Tokowicz, 2005). According to this model conceptual and lexical features exist in an interconnected network, displayed in Figure 2. The extent of conceptual overlap is therefore graded, that is, a portion of conceptual features may be linked to translation-equivalent words from both languages, while another portion may not be shared by translation equivalents. This graded overlap may lead to cross-language interference (de Groot, et al., 2000).

These graded or asymmetrical connections between concepts and associated features across languages within the DFM and RHM imply that some concepts may not be as easily accessible in one language relative to another. This effect may be exacerbated if the concept to be accessed in L2 was previously used exclusively by the L1.

### **The present study**

The overall goal of the proposed study is to extend cognitive models of text comprehension to bilingual conceptual learning. The primary hypothesis was the language used to encode prior knowledge influences the content and strength of episodic memory traces created

during reading comprehension. That is to say, the language in which concepts are most strongly represented in long-term memory influences the episodic memory trace built from the text.

Specifically, based on the RHM assumption that L2 words are weakly linked to concepts, the first hypothesis is that new conceptual features will be more weakly associated with the relevant concept when the text is in the L2. As a consequence, recall in within-language conditions will be worse for L2 texts relative to L1 texts.

The Landscape Model assumes that readers create text-based surface representations. Based on this assumption, it is hypothesized that bilingual readers form episodic memory traces in which new conceptual features are connected to the lexical features of the specific words in which those features were presented. As a consequence text recall will be better overall when the language of recall matches that of the text.

According to the DFM, conceptual features become co-activated during language processing, and links between lexical and conceptual items may lead to interference across languages (de Groot, et al., 2000). Following this assumption, it is hypothesized that when existing conceptual features are accessed through the L2, there will be costly competition from existing L1 lexical-conceptual links. These existing links in the L1 will need to be suppressed, limiting their interference with the L2, and allowing the L2 links to be available. Therefore, later retrieval of these conceptual features will be inhibited if being accessed across languages.

**Table 1.**

Table 1.1: Counterbalancing for assignment to conditions

<i>Counterbalancing for assignment to conditions</i>			
	Language of text passages	Test for passage 1	Test for passage 2
Condition 1	L1	L1	L2

Condition 2	L1	L2	L1
Condition 3	L2	L1	L2
Condition 4	L2	L2	L1

*Note:* Each participant was assigned to one of the four conditions.

**Figure 1.**

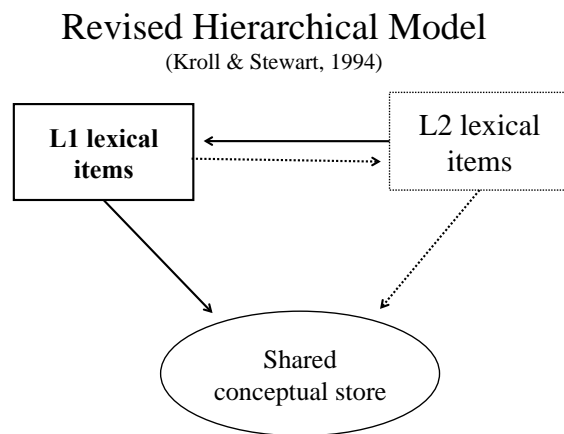


Figure 1: Revised Hierarchical Model (Kroll, & Stewart, 1994)

**Figure 2.**

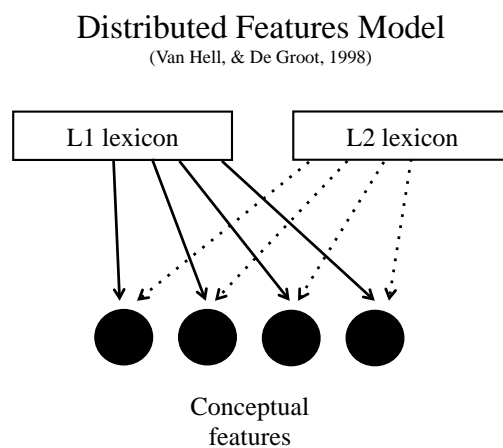


Figure 2: Distributed Features Model (Van Hell, & De Groot, 1998)

## Chapter 2: Methods

### Participants

Undergraduate Spanish-English bilingual psychology students and English for Speakers of Other Languages (ESOL) students from the University of Texas at El Paso were recruited to participate in the study ( $N = 128$ ;  $M_{\text{age}} = 20.9$ , 78% female). Data from four participants were removed due to not completing the experiment (1), or incomplete data due to experimenter error (3), reducing the sample size to 124 participants ( $n_1 = 31$ ,  $n_2 = 31$ ,  $n_3 = 29$ ,  $n_4 = 33$ ). Given a small effect size ( $d = .25$ , based on findings from Atòn et al., 2015 and Friesen & Jared, 2007), a sample size of 120 participants was required to obtain power of .8, indicating that the current sample size is appropriate. The majority of the participants learned Spanish first (87%,  $M_{\text{AOA}} = 2.29$  years), however the majority also identified English as their strongest language (59%,  $M_{\text{AOA}} = 5.76$ ).

Language dominance was determined according to years of education in Spanish and English. Ninety-nine participants reported more years of education in English, and were classified as academically English dominant. The remaining 25 reported more years of education in Spanish, and were classified as academically Spanish dominant. Performance on objective measures of reading comprehension (Passage Comprehension subtest) and vocabulary (Picture Naming Vocabulary subtest) on the Woodcock-Munoz Language Survey Revised (Woodcock, Muñoz-Sandoval, Ruef, & Alvarado, 2005) in English and Spanish were compared within each group to see if the pattern was consistent with the self-reported dominance. Independent samples  $t$ -test comparing the English dominant and Spanish dominant participants confirmed that the English group performed higher on English Picture Naming Vocabulary,  $t(122) = 6.236$ ,  $p < .001$ , and English Passage Comprehension,  $t(122) = 2.93$ ,  $p = .004$ , compared to the Spanish

group. Similarly, the Spanish group performed higher on the Spanish Picture Naming Vocabulary,  $t(122) = -4.977, p < .001$ , and Spanish Passage Comprehension,  $t(122) = -3.927, p < .001$ , compared to the English group. This confirms that language dominance based on academic experience was consistent with dominance based on objective proficiency measures.

Independent samples t-tests were also used to investigate whether one dominance group was more balanced than the other across their two languages. Spanish dominant participants scored significantly higher on L1 Picture Naming Vocabulary ( $M_{\text{Spanish L1}} = 520.3, M_{\text{English L1}} = 513.8$ ),  $t(122) = -1.964, p = .052$ , and L1 Passage Comprehension ( $M_{\text{Spanish L1}} = 520.8, M_{\text{English L1}} = 511.9$ ),  $t(122) = -4.214, p < .001$ . Although the patterns of means for the English-dominant group reflected better performance in their L1 relative to their L2, the scores between their two languages did not differ significantly. In terms of relative proficiency in the L2 across the two groups, there was no significant difference between the two groups on their respective L2 Passage Comprehension scores, ( $M_{\text{Spanish L2}} = 503.3, M_{\text{English}} = 508.0$ ),  $t(122) = 1.428, p = .156$ , indicating that both groups had similar levels of reading comprehension proficiency in their L2. However the English-dominant group had higher Picture Vocabulary scores in their L2 relative to the Spanish-dominant group, ( $M_{\text{Spanish L2}} = 489.6, M_{\text{English L2}} = 504.2$ ),  $t(122) = 4.423, p < .001$ , suggesting that the English-dominant group had greater vocabulary in their L2.

## **Design**

To test the hypothesis that memory for new conceptual information in text is strongest when it's presented in the language in which the relevant prior knowledge was acquired, participants read text passages in either their dominant or nondominant language, and answered a follow-up comprehension test that was either in the dominant or nondominant language. The

language of passage was manipulated between-subjects, while the language of test was manipulated within-subjects. To test the hypothesis that the language in which new information is encoded influences the strength of the episodic memory trace of text, two types of comprehension questions were included. One set probed prior knowledge, concepts that participants were assumed to be familiar with. The second set probed new concepts, through new information regarding related, fictional words introduced in the text passage. This variable of question type was manipulated within-subjects. Finally, due to the distinct dominance groups within bilingual sample, English dominant and Spanish dominant, with the latter group demonstrating less balance between their two languages, language dominance group was included as a between-subjects' factor.

### **Materials and Apparatus**

*Language Proficiency Measures.* Bilingual language proficiency was measured using both objective and self-report measures. Two subtests from the Woodcock-Munoz Language Survey Revised (Woodcock, et al., 2005) were used as objective measures of proficiency in English and Spanish. The first subtest involved a picture naming task, measuring general vocabulary knowledge. The second subtest involved a passage comprehension task, asking participants to complete sentences cohesively. The second subtests measures reading comprehension ability and vocabulary knowledge.

In addition to these objective measures, participants completed a language history questionnaire, the ESPADA (Francis, & Strobach, 2013). As part of this measure participants reported the years of education they spent in each language, which was used to assess language dominance (dominant language of education). This measure included self-report ratings on reading, writing, speaking, and speech comprehension in both Spanish and English. These

ratings were measured on a 1-10 scale, with 10 indicating fluency. The questionnaire also measured self-reported age of acquisition for both Spanish and English.

*Text Passages.* An initial set of four passages were drafted, covering introductory science topics (ecosystems, erosion, tectonic plates, and the atmosphere). These four topics were chosen due to their introductory level to basic scientific information. These passages were designed to activate prior knowledge, and then build on that prior knowledge with new conceptual features. Each text passage consisted of three paragraphs. The first sentence introduced a common Earth science topic to the reader (e.g., the atmosphere) and was designed to serve as the overarching theme for the first two paragraphs. The second sentence described the main topic in further detail (e.g., the atmosphere is made of multiple layers containing various gasses). This served to activate prior knowledge acquired in basic science classes. Following these two introductory sentences, the main topic was expanded upon with two new, fictional terms. These new terms served as new conceptual features related to the overarching theme. These two terms were described and connected to the main topic. The second paragraph followed the same pattern. It was related to the overarching theme, with two new, fictional terms created that were relevant to the topic. Finally, the last paragraph connected the four fictional words, relating them all to the overarching topic. The four passages can be found in Appendix A.

In order to identify a pair of passages similar on difficulty, interest and novelty, a sample of Spanish-English bilinguals from the same target population as the critical experiment ( $N = 27$ ) read the passages, answered follow-up comprehension questions and rated the passages on difficulty, interest and novelty. Paired samples t-tests indicated that three of the four passages were equivalent, with no significant differences in recall (for descriptive statistics, see Table 5). Paired samples t-tests indicated that the erosion text passage ( $M = 20.6$ ) had higher



comprehension scores compared to the atmosphere passage ( $M=17.9$  ;  $t(26)=2.5$   $p=.018$ ) and was marginally higher compared to tectonic plates passage ( $M=18.5$ ;  $t(26)=1.8$   $p=.078$ ). Subjective ratings did not differ across the four passages (for descriptive statistics, see Table 6). The passage about tectonic plates and the passage about the atmosphere were chosen for the critical passages due to the lack of differences between their comprehension scores and subjective ratings.

*Reading Comprehension Measure.* Eight, true-false comprehension questions were developed for each of the four passages (see Appendix B). These questions were developed to target eight, key concepts from each text passage. The first four questions referenced prior knowledge (e.g., the atmosphere surrounds the Earth) and the last four questions referenced the new, fictional terms learned in the text passage (e.g., *brame* is a type of ozone that protects the Earth). Each question required that the participant provide a brief elaboration (a justification) of the response.

## **Procedure**

Following the informed consent procedures, the experimenter administered the ESPADA language history questionnaire (Francis & Strobach, 2013). Responses regarding language of schooling on this measure were used to determine the academic dominant language and assignment to the appropriate text passage language condition. If the participant was taught equally in Spanish and English, the researcher asked which language they would prefer to take a science class in, and recorded that as their dominant academic language. Following the questionnaire, the experimenter administered the objective language proficiency measure (Woodcock, Muñoz-Sandoval, Ruef, & Alvarado, 2005).

After measuring language proficiency, the participant read the first text passage at their own pace. They were asked to read it as if they were reading material for a class. To ensure that participants were in fact retrieving information at test (rather than repeating verbatim the content from short term memory) they completed a Sudoku distractor task for 15 minutes and then completed the reading comprehension task, in either the same language or different language as the text (depending on their condition, see Table 1). During the comprehension task, the participants were instructed to determine whether each statement was true or false, then elaborate their decision with anything they remember related to the text. Participants were asked to use their own words, and add any additional information they felt was relevant, in one to two sentences. This was followed by another ten-minute Sudoku distractor task and then the procedure was repeated for the second passage. Finally, participants were debriefed and dismissed.

### **Analyses**

Responses were coded on a scale from 0 to 2, earning 1 point for correct true/false decision, and 1 point for appropriate elaboration. The experimenter was blind to the conditions of each participant. Rather than coding the responses for each participant individually, the experimenter coded the same question for all participants before moving on to the next question. This method was used to ensure consistent criteria across all participants for each question. Each passage consisted of eight questions, for a total of 16 points possible per comprehension test.

For true statements, participants earned one point for a correct decision (true), and another point for an accurate elaboration. Elaborations had to include conceptual information not directly referenced in the original statement. If the participant simply repeated the statement, but provided no additional conceptual information, no point was awarded. For false statements,

participants earned one point for a correct decision (false), and another point for correcting the statement in their elaboration. Elaborations had to be completely correct. Partially correct elaborations were not awarded the point. For details on criteria for each question, see Appendix C.

To investigate how language of text passage and language of test influence the recall of prior knowledge and new concepts, two scores were derived. The comprehension measure was divided into questions targeting prior knowledge, and questions targeting new conceptual information (i.e., fictional words). Each of these sections consisted of four questions, and could earn a total of 8 points (2 points per question).

**Table 2.**

Table 2: Descriptive statistics for language proficiency

<i>Descriptive statistics for language proficiency</i>				
	<i>English Dominant</i>		<i>Spanish Dominant</i>	
	<i>English (L1)</i>	<i>Spanish (L2)</i>	<i>English (L2)</i>	<i>Spanish (L1)</i>
Age of acquisition	5.1 (0.28)	2.4 (0.22)	8.2 (0.96)	2.2 (0.37)
<u>Woodcock-Muñoz</u>				
<u>Objective measure</u>				
Picture Naming	513.8 (1.57)	504.2 (1.39)	489.6 (3.63)	520.3 (2.15)
Vocabulary				
Passage	511.9 (0.94)	508.0 (1.41)	503.3 (3.44)	520.76 (1.88)
Comprehension				
<u>ESPADA ratings</u>				
Reading	9.0 (0.10)	7.7 (0.18)	7.3 (0.40)	9.0 (0.34)
Writing	8.8 (0.13)	7.0 (0.20)	7.13 (0.33)	8.7 (0.35)
Speaking	9.2 (0.09)	8.4 (0.16)	7.25 (0.32)	9.5 (0.20)
Comprehension	9.4 (0.09)	8.9 (0.15)	8.17 (0.27)	9.7 (0.13)

*Note:* ESPADA ratings were self-reported on a 1-10 scale to measure proficiency levels in Spanish and English. A score of 1 indicated not literate or fluent, and a score of 10 indicated very literate or fluent.

**Table 3.**

Table 3: Descriptive statistics for passage norming comprehension scores

<i>Descriptive statistics: Passage norming comprehension scores</i>		
Passage Topic	<i>M</i>	<i>SE</i>
Ecosystem	18.6	4.086
Erosion	20.6	5.252
Atmosphere	17.9	5.110
Tectonic Plates	18.5	4.671

*Note:* All scores are out of 32. They earn 1 point for correctly identifying “true” or “false”. They earn another 3 points depending on the content of their fill in the blank statement.

**Table 4.**

Table 4: Descriptive statistics for passage norming subjective ratings

<i>Descriptive statistics: Passage norming subjective ratings</i>		
	<i>M</i>	<i>SE</i>
<u>Passage 1: Ecosystem</u>		
Interest	3.8	0.323
Difficulty	1.8	0.154
Novelty	2.8	0.373
<u>Passage 2: Erosion</u>		
Interest	3.4	0.289
Difficulty	1.9	0.206
Novelty	2.3	0.266
<u>Passage 3: Atmosphere</u>		
Interest	3.6	.289
Difficulty	2.1	.311

Novelty	2.5	.291
<u>Passage 4: Tectonic Plates</u>		
Interest	3.0	.363
Difficulty	2.4	.269
Novelty	2.1	.312

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*Note:* Interest, difficulty, and novelty were rated on a 5-point scale. For interest, 5 indicated very interesting. For difficulty, 5 indicated very difficult. For novelty, 5 indicated they knew all of the material already.

## Chapter 5: Results

Participant comprehension scores were submitted into a 2 (language dominance group) x 2 (passage language) x 2 (test language) x 2 (question type) mixed ANOVA to examine recall scores. There was no main effect of language dominance group or passage language, nor did these two between-subjects factors interact,  $F_s < 1$ .

The main effect of test language was not significant,  $F(1, 120) = 1.701$ ,  $MSE = 3.625$ ,  $p = .195$ ,  $\eta^2 = .014$ . The effects of test language and dominant academic language did not interact,  $F < 1$ . A marginally significant interaction was observed between test language and passage language,  $F(1, 120) = 3.240$ ,  $MSE = 3.625$ ,  $p = .074$ ,  $\eta^2 = .026$ , such recall scores were higher when the language of passage and language of test matched.

There was a significant main effect of question type,  $F(1, 120) = 7.722$ ,  $MSE = 2.031$ ,  $p = .006$ ,  $\eta^2 = .060$ , reflecting better scores for prior knowledge. The interaction between question type and dominant academic language was not significant,  $F(1, 120) = 2.820$ ,  $MSE = 2.031$ ,  $p = .096$ ,  $\eta^2 = .023$ . The pattern of means suggests that English dominant participants scored significantly higher for prior knowledge ( $M = 5.33$ ) compared to new concepts ( $M = 4.59$ ),  $t(99) = 5.219$ ,  $p < .001$ , but Spanish dominant participants did not demonstrate this difference in recall between prior knowledge ( $M = 5.18$ ) and new concepts ( $M = 5.22$ ),  $t(24) = -.125$ ,  $p = .902$ .

The effects of question type and passage language did not interact,  $F(1, 120) = 1.834$ ,  $MSE = 2.031$ ,  $p = .178$ ,  $\eta^2 = .015$ . However, a significant three way interaction between question type, dominant academic language, and passage language was observed,  $F(1, 120) = 5.560$ ,  $MSE = 2.031$ ,  $p = .020$ ,  $\eta^2 = .044$ . The pattern of means suggested that recall of new concepts was facilitated when presented in the L2 for the Spanish dominant group (Figure 4). To investigate this interaction, two follow-up 2 (passage language) x 2 (question type) mixed ANOVA's were

conducted on recall for the Spanish dominant and English dominant groups. For the Spanish dominant group, there was no main effect of passage language or question type ( $F$ 's < 1). However, there was a marginally significant interaction between passage language and question type for the Spanish dominant participants,  $F(1, 23) = 3.717$ ,  $MSE = 1.150$ ,  $p = .066$ ,  $\eta^2 = .139$ . For the English dominant group, there was a significant main effect of question type,  $F(1, 97) = 28.277$ ,  $MSE = .984$ ,  $p < .001$ ,  $\eta^2 = .226$ . However, there was no significant effect of passage language,  $F(1, 97) = 1.436$ ,  $MSE = 2.727$ ,  $p = .234$ ,  $\eta^2 = .015$  nor was there a significant interaction between passage language and question type,  $F(1, 97) = 1.433$ ,  $MSE = .984$ ,  $p = .234$ ,  $\eta^2 = .015$ .

Test language and question type did not interact, nor was there a three-way interaction between test language, question type and dominant academic language,  $F$ 's < 1. However, a significant three-way interaction was observed for test language, question type, and passage language,  $F(1, 120) = 4.682$ ,  $MSE = 4.006$ ,  $p = .032$ ,  $\eta^2 = .038$ . To investigate this interaction, two follow-up 2 (passage language) x 2 (test language) ANOVA's were conducted on recall of prior knowledge and recall of new concepts separately. For recall of prior knowledge, there was no significant main effect of passage language,  $F(1, 122) = 1.11$ ,  $MSE = 2.452$ ,  $p = .294$ ,  $\eta^2 = .009$ , nor test language,  $F < 1$ . Similarly, the interaction between passage language and test did not reach significance,  $F(1, 122) = 2.946$ ,  $MSE = 4.928$ ,  $p = .089$ ,  $\eta^2 = .024$ . The pattern of means suggest that recall for prior knowledge was better when the language of test matched the passage language (Figure 5), but that this language match did not facilitate recall of new concepts (Figures 4).

**Figure 4.**

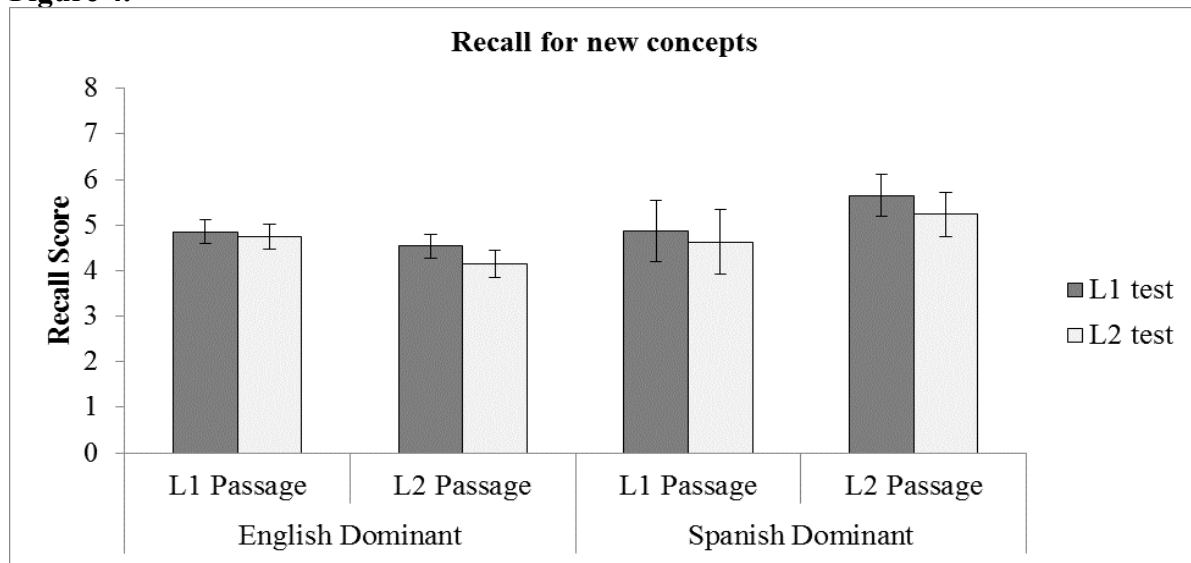


Figure 4: Recall scores for new concepts

**Figure 5.**

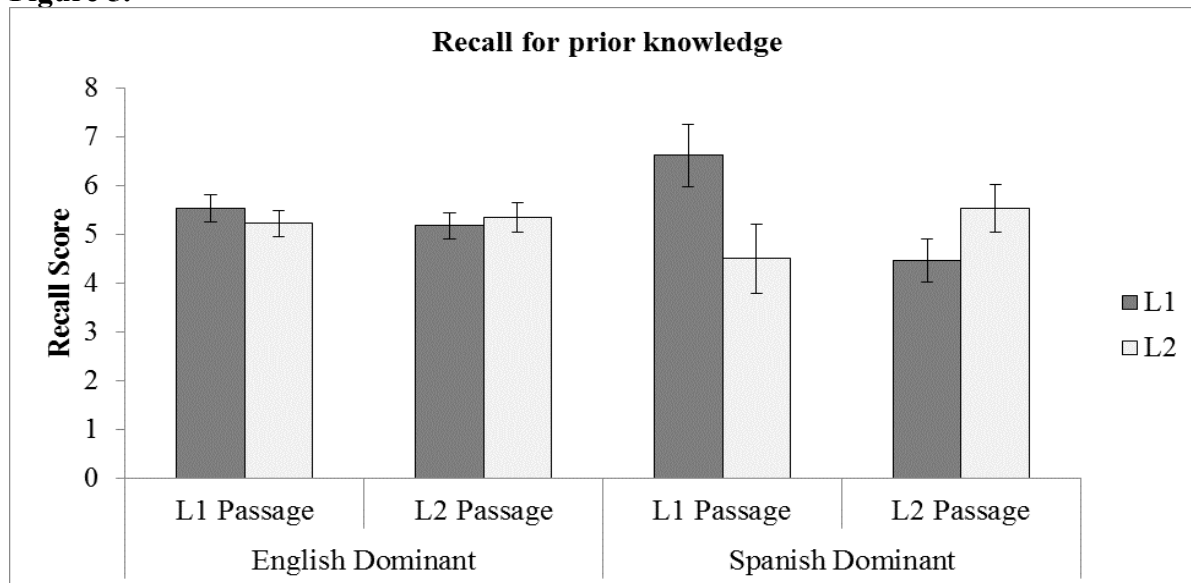


Figure 5: Recall scores for prior knowledge



## **Chapter 6: Discussion**

The present study sought to extend cognitive models of text comprehension to bilingual conceptual learning. To do this, bilingual participants read, and subsequently recalled, expository test passages. These text passages were designed to activate the episodic trace of prior knowledge, and generate new episodic traces of related conceptual information. To investigate how bilingual models of conceptual access applied to text comprehension models, the language of passage and test were manipulated.

The first hypothesis was that new conceptual features would be more weakly associated with the relevant concept when the text was in the L2. This hypothesis was not supported: language of the text passage did not affect recall. This finding indicates that new episodic traces of related conceptual information can be encoded effectively across a bilingual's two languages.

The second hypothesis was that bilingual readers would form episodic memory traces in which conceptual features are connected to the lexical features of the specific words in which those features were presented. This hypothesis was supported, as demonstrated through a benefit of matched language of passage and test. Importantly, this effect was only observed for prior knowledge. This finding demonstrates that episodic memory traces in long-term memory are strongly related to the language used at initial encoding. This effect of language match on prior knowledge also supports the DFM, such that the prior knowledge, possessing stronger conceptual links, was retrieved more successfully compared to new concepts.

Previous text comprehension models assume that the microstructure of the text is reliant on lexical information (Kendeou, et al., 2003; Kintsch, & van Dijk, 1978). The benefit of matched language conditions for prior knowledge demonstrates that the macrostructure of a text also relies on lexical-level information. However, when coherence based retrieval (Linderholm,

et al., 2004) integrated new conceptual information with related prior knowledge, matched language conditions did not benefit recall above that of the mismatched conditions. It is unclear how the newly generated episodic memory traces regarding new concepts are related to the language used at initial encoding.

The third hypothesis was that when existing conceptual features were accessed through the L2, there would be costly competition from existing L1 lexical-conceptual links. These existing links in the L1 would need to be suppressed in order to make the L2 links available. The present study demonstrated partial support for this hypothesis: recall of new concepts may be facilitated when presented in the weaker language for the less balanced bilinguals. Supporting the DFM (de Groot, et al., 2000), conceptual features of prior knowledge closely linked to the L1 did not interfere with the new (weak) conceptual features being developed in the L2, facilitating the retrieval of these new concepts with the Spanish dominant bilinguals.

This finding suggests that language proficiency in a bilingual's two languages influences the effect of conceptual development of new, related conceptual features. When a less balanced bilingual develops new conceptual features in an L2, they may experience less interference from related conceptual features from prior knowledge. When these new conceptual features are developed in the L1, spreading activation from related prior knowledge may compete with the new information. This pattern was not observed for the more balanced group of English dominant bilinguals, indicating that language proficiency may be a factor when developing concepts across languages.

Importantly, the two language dominance groups were not equal in size. While the pattern of means suggested an advantage for L2 presentation, follow-up analyses did not demonstrate a significant difference between L1 and L2 conditions. Future studies need to

address how language proficiency, specifically with less balanced bilinguals, influences the development of new conceptual information.

The present study investigated the effect of language on encoding and retrieval of episodic memories developed when reading expository information. Similarly, Atòn and colleagues (2015), investigated the effect of mixed-language settings at encoding, using both on-line and off-line measures. They demonstrated that mixed-language learning environments did not hinder the development of conceptual information, nor did they facilitate it. The present study built on these findings, suggesting that language plays a role in accessing prior knowledge, and dominance may influence the development of new concepts. The present results are also consistent with the results of Francis (1999a), which demonstrated that conceptual transfer was greater when tested in the L1, but language of encoding did not influence performance.

It is unclear how language influences on-line processing of expository information at retrieval. More sensitive measures of on-line processing, such as reaction time studies (RT) or eye-tracking methodology, may elucidate the differential effects of language on conceptual access and development when reading. Future studies should investigate how both the language of encoding and the language of retrieval influence on-line processing.

The goal of the present study was to bridge the gap between monolingual text comprehension models and bilingual models of conceptual access, to better inform both bilingual researchers and bilingual educators. The primary hypothesis was that the language used to encode prior knowledge influences the content and strength of episodic memory traces created during reading comprehension. The present study found partial support for the primary hypothesis, as demonstrated through effects of language match for accessing prior knowledge. This suggests that the language in which concepts are most strongly represented in long-term

memory influences the episodic memory trace built from the text. These findings can be translated into education settings, suggesting that bilinguals be tested in the same language used to encode information when reading.

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## Appendix A

### Passages for Norming

#### Spanish Text Passages

*Note:* Bolded titles indicates it was used in the critical study

#### **Pasaje 1: La ecosistema**

Un ecosistema es un arreglo complejo de organismos vivos, tales como las plantas y los animales, que viven en un entorno compartido. Los cambios hacia una parte de un ecosistema por lo general afectan a otros. Algunas relaciones en el ecosistema son benéficas mientras que otras pueden ocasionar daño a algún organismo. A las relaciones benéficas en un ecosistema se les llama crades. En la mayoría de las crades un organismo produce un desecho que otro organismo consume para energía. En contraste, las proles son relaciones en las que se daña un organismo. Las proles se crean porque un organismo consume mucho más que los demás. Muchas proles se originan con la interrupción, típicamente humana, en un ecosistema, tales como el uso de pesticidas.

Un ejemplo de un cambio en un ecosistema, es el uso de pesticidas. Los pesticidas son sustancias químicas que se utilizan por los agricultores para matar insectos o plantas que son nocivos para los cultivos. Los pesticidas pueden beneficiar a los cultivos pero al mismo tiempo puede dañar otras plantas y animales. Algunos pesticidas están dirigidos a los animales, como a los insectos. Otros pesticidas son para plantas. Un tipo de pesticidas llamado angien, se utiliza para matar insectos. Los angien matan a los insectos liberando una neurotoxina que destruye el sistema nervioso del insecto. Otro tipo de pesticidas, llamado pranes, mata a las plantas. Los pranes matan a las plantas evitando que crezcan células de nuevas plantas.

En resumen, un ecosistema tiene muchas relaciones entre organismos incluyendo crades y proles. Un ejemplo de una prole es el uso de pesticidas angien y prane por humanos.

#### **Pasaje 2: La Erosión**

La erosión es un proceso por el que el agua que fluye transporta tierra y roca de un lugar y lo deposita en otro. Debido a la erosión, el planeta Tierra siempre está cambiando. La erosión cambia el entorno en dos fases. En la fase beón, la tierra y las rocas se quiebran por el agua. La fase beón hace que la tierra y las rocas sean lo suficiente pequeñas para ser transportadas a través del agua en movimiento. En la fase trage la tierra y las rocas que fueron movidas, construyen una nueva formación de tierra en otra parte.

La erosión origina el sedimento. El sedimento es un material que se desintegra y es transportado por el agua. El sedimento es una mezcla de materiales que puede ser compuesto de materiales vivos o muertos. El tipo de sedimento llamado roop, está formado por segmentos de roca. Las pequeñas porciones de roca son extraídas en astillas de rocas más grandes por medio de fuerzas naturales, como la erosión creando un roop. Otro tipo de sedimento, llamado clast, está compuesto de desechos de los organismos. Mientras los organismos vivos forman desechos en su entorno tales como la piel que deja una víbora, las fuerzas naturales rompen los desechos y los convierten en clast.

En resumen, la erosión cambia nuestro suelo durante el beón y el trage. El beón y el trage alteran el sedimento tales como el roop y el clast.

#### **Pasaje 3: La Atmósfera**

La atmósfera es una capa de gases que rodea un planeta. La atmósfera de la tierra tiene diferentes capas de gases. Algunas capas en la atmósfera están formadas de gases pesados y otras de gases ligeros. Los gases pesados se encuentran en la capa spove, que está más cercana a la superficie terrestre. La capa spove es donde ocurren las formaciones del clima. Los gases más ligeros están en la capa thill, que está más lejos de la superficie terrestre. La capa thill sirve de protector, quemando los meteoritos que se dirigen a la atmósfera terrestre.

El ozono es uno de los gases de la atmósfera terrestre. El ozono es un gas incoloro compuesto de tres átomos de oxígeno. Algún ozono absorbe los dañinos rayos UV del sol. El ozono puede estar en dos lugares diferentes en la atmósfera. El brame es un tipo bueno de ozono que se presenta en la atmósfera superior. El brame nos protege de los dañinos rayos ultravioletas del sol. Otro tipo de ozono es calt, ubicado cerca de la superficie terrestre. EL calt es un tipo malo de ozono que es dañino tanto para las personas como para el ambiente y está compuesto por químicos industriales.

En resumen, la atmósfera terrestre está compuesta por diferentes capas de gases. Los gases thill ligeros como el brame, se presentan lejos de la superficie terrestre en la atmósfera exterior. Los gases spove pesados como el calt, se dan cerca de la superficie terrestre.

#### **Pasaje 4: Placas Tectónicas**

La tierra está compuesta por placas tectónicas que son capas de roca y sedimento. El movimiento de las placas tectónicas puede ocasionar nuevas formaciones geológicas y causar una actividad sísmica. Estas capas trabajan juntas, causando cambios geológicos en todo nuestro planeta. La capa exterior llamada ruzor es una capa fría y rígida de la corteza y el manto terrestres. La capa Ruzor está compuesta de aproximadamente 8 placas tectónicas principales, todas moviéndose lenta pero constantemente. Estas placas se mueven a través de la tierra que flota en la capa brove, localizada debajo de la capa exterior. La capa brove es una tierra caliente parecida al líquido que mueve las placas tectónicas al transferir calor a las capas superiores y frías de la corteza terrestre.

Existen diferentes tipos de movimiento en las placas. El movimiento ocurre en las zonas localizadas entre las placas donde las placas reaccionan entre sí, pero este movimiento puede sentirse en grandes distancias. El movimiento de las placas es distinto en la forma en que interactúan dos o más placas tectónicas entre sí. Las placas pueden moverse hacia otras placas, ocasionando el mocal. Cuando se da el mocal, las placas se empujan juntas lentamente creando nuevas formaciones geológicas, tales como las montañas. Las placas también pueden alejarse entre sí, ocasionando fablic. Cuando el fablic se da, las placas se separan produciendo enormes fisuras en el suelo del océano, causando terremotos que pueden sentirse a miles de millas de distancia.

En resumen, nuestro entorno está cambiando lentamente debido a las diferentes capas de rocas que forman la Tierra. Las placas tectónicas en ruzor pueden empujar juntas durante el mocal. Las placas tectónicas también pueden alejarse entre sí durante el fablic, ocasionando que la roca caiga en una capa fundida de brove.

#### English Text Passages

*Note:* Bolded title indicates it was used in the critical study

##### **Passage 1: Ecosystem**

An ecosystem is a complex arrangement of living organisms, such as plants and animals, living within a shared environment. Changes to one part of an ecosystem often affect another.

Some relationships in an ecosystem are beneficial. Other relationships cause harm to one organism. Beneficial relationships in an ecosystem are called crades. In most crades one organism produces a waste that another organism consumes for energy. In contrast, proles are relationships in which an organism is harmed. Proles are typically created because one organism consumes much more than others. Many proles are due to human disruption to an ecosystem, such as through the use of pesticides.

An example of a change made to an ecosystem is pesticide use. Pesticides are toxic chemical substances used by farmers to kill insects or plants that are harmful to crops. Pesticides can benefit crops while at the same time harming other plants and animals. Some pesticides target animals such as insects. Other pesticides target plant life. One type of pesticide, called an angien, is used to kill insects. The angien kills insects by releasing a neurotoxin that destroys the insect's nervous system. Another type of pesticide, called pranes, kill plants. Pranes kill plants by preventing growth of new plant cells.

In summary, an ecosystem has many relationships among organisms including crades and proles. An example prole is the use of angien and prane pesticides by humans.

### Passage 2: Erosion

Erosion is the process by which flowing water transports soil and rock, from one location and deposits it elsewhere. Because of erosion, the Earth is always changing. Erosion changes the landscape in two phases. In the beon phase soil and rock are broken down by water. The beon phase makes the soil and rock small enough to be transported through moving water. In the trage phase the soil and rock that were moved build a new land formation elsewhere.

Erosion creates sediment. Sediment is material that is broken down and transported by water. Sediment is a mixture of materials. It can be made up of living or non-living materials. One type of sediment, called roop, is made up of segments of rock. Small portions of rock are chipped away from larger rock through natural forces, such as erosion, creating roop. Another type of sediment, called clast, is made up of waste from organisms. As living organisms create waste in their environment, such as skin shed from a snake, natural forces break the waste into clast.

In summary, erosion changes our land during beon and trage. Beon and trage alter sediment such as roop and clast.

### Passage 3: Atmosphere

An atmosphere is a layer of gases surrounding a planet. The Earth's atmosphere has different layers of gases. Some layers in the atmosphere are made up of heavy gases, other are made up of lighter gases. Heavy gases are found in the spove layer, which is closest to the Earth's surface. The spove layer is where weather formations take place. Lighter gases are in the thill layer, which is farther from Earth's surface. The thill layer acts as a protectant, burning up meteors that approach Earth's atmosphere.

One of the gases in the earth's atmosphere is ozone. Ozone is a colorless gas that is made up of three oxygen atoms. Some ozone absorbs the harmful UV rays of the sun. Ozone can occur in two different places in the atmosphere. Brame is a good type of ozone, occurring in the upper atmosphere. Brame protects us from the sun's harmful ultraviolet rays. Another type of ozone is calt, located close to Earth's surface. Calt is a bad type of ozone that is harmful to both people and the environment, made through industrial chemicals.

In summary, the Earth's atmosphere is made up of different layers of gases. Lighter gases, such as helium, occur far from Earth's surface in the outer atmosphere. Heavier gases, such as carbon dioxide, occur close to Earth's surface.

#### **Passage 4: Tectonic Plates**

The Earth is made up of tectonic plates which are layers of rock and sediment. The movement of tectonic plates can lead to new geological formations and cause earthquake activity. These layers all work together, causing geological changes across our planet. The outer layer, the lithosphere, is a cool, rigid layer of Earth's crust and mantle. The lithosphere is made up of around 8 major tectonic plates, all slowly, but constantly, moving. These plates move through the flowing asthenosphere in the asthenosphere layer, located underneath the outer layer. The asthenosphere is hot, fluid-like earth that moves tectonic plates by transferring heat to the cool, upper layers of Earth's crust.

There are different types of plate movement. Movement occurs in zones between plates where plates act on one another, but this movement can be felt over large distances. Plate movement differs in how two or more tectonic plates interact with each other. Plates can move toward one another, causing a convergent boundary. When a convergent boundary occurs, plates slowly push together building new geological formations, such as mountains. Plates can also move away from one another, causing a divergent boundary. When a divergent boundary occurs, plates separate causing large fissures in ocean floor, leading to earthquakes that can be felt thousands of miles away.

In summary, our landscape is slowly changing due to the different layers of rock that make the Earth. Tectonic plates in the lithosphere can push together during a convergent boundary. Tectonic plates can also move away from one another during a divergent boundary, causing rock to fall into the molten layer of the asthenosphere.

## Appendix B

### Passage Comprehension Questions for Norming

*Note:* Bolded title indicates it was used in the critical study

#### True/False Passage 1: Ecosystem

1. Each ecosystem consists of many different types of organisms.
2. Changes to an ecosystem can only benefit one organism in that ecosystem.
3. Pesticides change an ecosystem by killing harmful organisms to protect a farmer's crops.
4. Pesticides only kill insects.
5. Crades are harmful relationships between organisms in an ecosystem, one organism's waste hurts another organism.
6. When one organism consumes more than the other organisms, their relationship is called a prole. This is harmful to an ecosystem.
7. An angien is a type of pesticide that kills insects by destroying their nervous system.
8. Pranes are a type of pesticide that kills plants by destroying their roots.

#### True/False Passage 2: Erosion

1. Water moves soil and rock through the process of erosion, changing Earth's landscape.
2. During erosion, water destroys soil and rock, but does not transport it.
3. Sediment is only made up of nonliving materials.
4. Water breaks down and transports sediment to new locations.
5. Soil and rock are broken down prior to the beon phase.
6. The trage phase involves the transport of broken down soil and rock, not the formation of new land.
7. Small pieces of rock make up a type of sediment called roop.
8. Clast sediment is made up of inorganic material, such as metals.

#### True/False Passage 3: Atmosphere

1. Atmosphere is one large layer of different gases surrounding Earth.
2. Gases in the atmosphere are different weights, some are heavy and some are light.

- Ozone is a type of gas occurring in one layer of the atmosphere.
- Made up of three oxygen atoms, ozone protects us from harmful UV rays.
- The spove layer of the atmosphere consists of lighter gases and is close to Earth's surface.
- Thill gases are found high in the atmosphere, protecting us from meteors that approach Earth.
- Good ozone, called brame, occurs in the upper atmosphere.
- Calt is a type of ozone located close to Earth's surface, and protects both people and the environment from pollution.

### True/False Passage 4: Tectonic Plates

1. Rock and sediment form tectonic plates, which move around our planet causing geological changes.
2. Tectonic plate movement does not change our earth nor cause natural disasters such as earthquakes.
3. Tectonic plates never interact with one another, they stay separated.
4. When tectonic plates move, it can be felt over large distances.
5. Ruzor is made up of 24 major tectonic plates, located on Earth's outer layer of crust.
6. The molten layer of brove moves tectonic plates through heat transfer.
7. Mocal is when plates quickly crash together, causing natural disasters.
8. When plates move away from one another, fablic occurs, creating large fissures in the Earth.

### Falso/Verdadero Pasaje 1: Ecosistema

1. Cada ecosistema está integrado de diferentes tipos de organismos
2. Los cambios a un ecosistema solo pueden beneficiar a un organismo en ese ecosistema.
3. Los pesticidas cambian un ecosistema matando a organismos que sean dañinos para proteger los cultivos de los agricultores.
4. Los pesticidas solo matan a los insectos.
5. Los crades son relaciones dañinas entre organismos de un ecosistema, los desechos de un organismo dañan a otro organismo.
6. Cuando un organismo consume más que otros organismos, su relación se llama prole. Esto es dañino para un ecosistema.

7. Un angien es un tipo de pesticida que mata insectos destruyendo su sistema nervioso.
8. Los pran es son un tipo de pesticidas que mata plantas destruyendo sus raíces.

#### **Falso/Verdadero Pasaje 2: Erosión**

1. El agua mueve la tierra y las rocas mediante el proceso de erosión, cambiando el entorno terrestre.
2. Durante la erosión, el agua destruye la tierra y la roca pero no las transporta.
3. El sedimento está compuesto de organismos muertos, únicamente.
4. El agua desintegra y transporta el sedimento a una nueva ubicación.
5. La tierra y la roca se desintegran antes de a la fase beón.
6. La fase trage involucra transportar tierra y roca desintegrada, no la formación de nueva tierra.
7. Los pequeños pedazos de roca forman un tipo de sedimento llamado roop.
8. El sedimento de clast está compuesto de material inorgánico, como los metales.

#### **Falso/Verdadero Pasaje 3: Atmósfera**

1. La atmósfera es una capa grande de diferentes gases que rodean la tierra.
2. Los gases en la atmósfera son de diferentes peso, algunos son pesados otros son ligeros.
3. El ozono es un tipo de gas que se presenta en una capa de la atmósfera.
4. Compuesto de tres átomos de oxígeno, el ozono nos protege de los dañinos rayos UV.
5. La capa spove de la atmósfera está compuesta de gases más ligeros y se encuentra cerca de la superficie de la tierra.
6. Los gases thill se localizan en la atmósfera superior, protegiéndonos de los meteoritos que se dirigen a la Tierra.
7. El ozono bueno llamado brame se presenta en la atmósfera superior.
8. El calt es un tipo de ozono localizado cerca de la superficie de la tierra y protege de la contaminación tanto a las personas como al medio ambiente.

#### **Falso/Verdadero Pasaje 4: Placas Tectónicas**

1. La roca y el sedimento forman las placas tectónicas que se mueven alrededor de nuestro planeta ocasionando cambios geológicos.

2. El movimiento de las placas tectónicas no cambia nuestra tierra ni causa desastres naturales como los terremotos.
3. Las placas tectónicas nunca interactúan entre sí, se mantienen separadas.
4. Cuando las placas tectónicas se mueven, puede sentirse a gran distancia.
5. El ruzor está compuesto de 24 placas tectónicas principales localizadas en la corteza exterior de la tierra.
6. La capa líquida de brove mueve las placas tectónicas mediante la transmisión de calor.
7. El mocal se da cuando las placas chocan rápidamente provocando desastres naturales.
8. Cuando las placas se alejan entre sí, se presenta el fablic que origina grandes fisuras en la tierra.



## Appendix C

### Coding Criteria for Comprehension Measure

#### True/False Comprehension:

- Two points per question
  - True statements
    - 1 point correct decision
    - 1 point accurate elaboration
  - False statements
    - 1 point correct decision
    - 1 point accurate correction

#### **True/False Comprehension: Atmosphere**

Questions from the comprehension quiz and their associated answers directly quoted from the text passage:

- 1) Atmosphere is **one large layer** of different gases surrounding Earth.
  - a. False. “The Earth’s atmosphere has different layers of gases.”
  - b. Elaboration: “Some layers in the atmosphere are made up of heavy gases, other are made up of lighter gases.”
- 2) Gases in the atmosphere are different weights, some are heavy and some are light.
  - a. True. “Some layers in the atmosphere are made up of heavy gases, other are made up of lighter gases.”
  - b. Elaboration: “Heavy gases are found in the spove layer, which is closest to the Earth’s surface. Lighter gases are in the thill layer, which is farther from Earth’s surface.”
- 3) Ozone is a type of gas **occurring in one layer** of the atmosphere.
  - a. False. “Ozone can occur in two different places in the atmosphere.”
  - b. Elaboration: “Brame is a good type of ozone, occurring in the upper atmosphere... Another type of ozone is calt, located close to Earth’s surface.”
- 4) Made up of three oxygen atoms, ozone protects us from harmful UV rays.
  - a. True. “Ozone is... made up of three oxygen atoms. Some ozone absorbs the harmful UV rays of the sun.”
  - b. Elaboration: “Ozone is a colorless gas that is made up of three oxygen atoms. Some ozone absorbs the harmful UV rays of the sun.”

- 5) The spove layer of the atmosphere consists of **lighter** gases and is close to Earth's surface.
  - a. False. "Heavy gases are found in the spove layer, which is closest to the Earth's surface."
  - b. Elaboration: "Heavy gases are found in the spove layer, which is closest to the Earth's surface."
- 6) Thill gases are found high in the atmosphere, protecting us from meteors that approach Earth.
  - a. True. "Lighter gases are in the thill layer, which is farther from Earth's surface. The thill layer acts as a protectant, burning up meteors that approach Earth's atmosphere."
  - b. Elaboration: "Lighter gases are in the thill layer, which is farther from Earth's surface. The thill layer acts as a protectant, burning up meteors that approach Earth's atmosphere."
- 7) Good ozone, called brame, occurs in the upper atmosphere.
  - a. True. "Brame is a good type of ozone, occurring in the upper atmosphere."
  - b. Elaboration: "Brame protects us from the sun's harmful ultraviolet rays."
- 8) Calt is a type of ozone located close to Earth's surface, and **protects both people and the environment from pollution**.
  - a. False. "Another type of ozone is calt, located close to Earth's surface. Calt is a bad type of ozone that is harmful to both people and the environment..."
  - b. Elaboration: "Calt is a bad type of ozone that is harmful to both people and the environment, made through industrial chemicals."

### **True/False Comprehension: Tectonic Plates**

Questions from the comprehension quiz and their associated answers directly quoted from the text passage:

1. Rock and sediment form tectonic plates, which move around our planet causing geological changes.
  - a. T: "...tectonic plates... are layers of rock and sediment... These layers all work together, causing geological changes across our planet."

- b. Elaboration: "The movement of tectonic plates can lead to new geological formations and cause earthquake activity. These layers all work together, causing geological changes across our planet."
2. Tectonic plate **movement does not change our earth nor cause natural disasters** such as earthquakes.
  - a. F: "The movement of tectonic plates can lead to new geological formations and cause earthquake activity."
  - b. Elaboration: "These layers all work together, causing geological changes across our planet... There are different types of plate movement (paragraph 2)."
3. Tectonic **plates never interact** with one another, they stay separated.
  - a. F: "Movement occurs in zones between plates where plates act on one another..."
  - b. Elaboration: "Movement occurs in zones between plates where plates act on one another, but this movement can be felt over large distances."
4. When tectonic plates move, it can be felt over large distances.
  - a. T. "Movement occurs in zones between plates where plates act on one another, but this movement can be felt over large distances."
  - b. Elaboration: "Movement occurs in zones between plates where plates act on one another ..."; "The movement of tectonic plates can lead to new geological formations and cause earthquake activity."; "...causing geological changes across our planet.";
5. Ruzor is made up of **24 major tectonic plates**, located on Earth's outer layer of crust.
  - a. F. "Ruzor is made up of around 8 major tectonic plates..."
  - b. Elaboration: "Ruzor is made up of around 8 major tectonic plates, all slowly, but constantly, moving."
6. The molten layer of brove moves tectonic plates through heat transfer.
  - a. T. "Brove is hot, fluid-like earth that moves tectonic plates by transferring heat to the cool, upper layers of Earth's crust."
  - b. Elaboration: "These plates [ruzor] move through the flowing earth in the brove layer, located underneath the outer layer. Brove is hot, fluid-like earth that moves tectonic plates by transferring heat to the cool, upper layers of Earth's crust."
7. Mocal is when plates **quickly** crash together, **causing natural disasters**.
  - a. F. "When mocal occurs, plates slowly push together building new geological formations, such as mountains." [Fabcic causes natural disasters.]
  - b. Elaboration: "Plates can move toward one another, causing mocal. When mocal occurs, plates slowly push together building new geological formations, such as mountains."
8. When plates move away from one another, fabcic occurs, creating large fissures in the Earth.
  - a. T. "Plates can also move away from one another, causing fabcic. When fabcic occurs, plates separate causing large fissures in ocean floor..."
  - b. Elaboration: "When fabcic occurs, plates separate causing large fissures in ocean floor, leading to earthquakes that can be felt thousands of miles away."

## **Vita**

Karly M. Schleicher is a doctoral graduate student at the University of Texas at El Paso. She is interested in conceptual access of academic information across a bilingual's two languages when reading. Her research investigates a bilingual reading processes in young adult bilinguals. She hopes to pursue a career in academia, teaching undergraduates and continuing her research on reading and bilingualism.

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