6-2012

An Evaluation of the Revised Hierarchical Model (RHM): How Quickly do we Learn to Associate Clock with Uhr?

Sierra Fuller
Union College - Schenectady, NY

An Evaluation of the Revised Hierarchical Model (RHM): How Quickly do we Learn to Associate Clock with Uhr?

Sierra R. Fuller

Union College

Abstract

The goal of the current study was to examine the Revised Hierarchical Model of bilingual language representation proposed by Kroll and Stewart (1994) by exploring the connection between the lexicon for one's native language (L1) and the lexicon for one's second language (L2) in novice bilinguals. Forty-three participants were taught 30 German words and then given a Translation Recognition Task to conjecture which pathways of the RHM were being utilized in the language acquisition process. The results supported our hypothesis, showing that there was greater interference for the monolinguals from the orthographically similar translations than the unrelated translations. The discovery of interference means that the participants were translating the German words into their English translations to access the conceptual store in order to determine if the translation was correct or incorrect. These results support the RHM's prediction that novice bilinguals utilize this lexical pathway when learning a second language.

Keywords: Revised Hierarchical Model, bilinguals, monolinguals

An Evaluation of the Revised Hierarchical Model (RHM): How Quickly do we Learn to Associate Clock with Uhr?

How do we learn a second language? Is the process similar to learning our native language? There are many unanswered questions in the field of language acquisition. Because the process of language acquisition is mostly subconscious, researchers can only theorize to the underlying mechanisms involved. Some researchers debate that there is a shared lexicon (mental dictionary) for both languages while others separate them into two independent lexicons. While there are as many models as opposing theories, this paper will only focus on the Revised Hierarchical Model (RHM) for the purpose of its evaluation.

The Revised Hierarchical Model (RHM), proposed by Kroll and Stewart (1994), suggests that information of one's native language (L1) and second language (L2) uses different pathways to travel throughout the memory store (see Figure 1). The model, however, does not apply to balanced bilinguals. The RHM is broken up into two levels: (1) a lexical level and (2) a semantic or conceptual level. Each language is hypothesized to have its own lexicon. The lexicon for L1 is assumed to be larger than the L2 lexicon because bilinguals know more words in their native language than their second acquired language (Kroll & Stewart, 1994). There are connections between the two lexicons and between the lexicons and the conceptual store. There is a strong connection between L1 and the conceptual store, but a weak connection between L2 and the conceptual store. This is because the pathway between L1 and the conceptual store has been utilized before the development of the connection from L2 to the conceptual store and the connection between L1 and the conceptual store is utilized much more frequently. The connection between L2 and the conceptual store is hypothesized to strengthen with proficiency

in the second language. This theory suggests an explanation for the variation in bilinguals' performance in regards to L2 proficiency.

The RHM also theorizes that at the lexical level there is a weak connection from L1 to L2, but a strong connection in the opposite direction (L2 to L1) (Kroll & Stewart, 1994). The reasoning behind this is when learning a second language, it is believed that people tend to translate the newly acquired words into their native language in order to access the concept of that word, and therefore, to help remember it. It is not as common to translate from the native language to the second language.

There are some findings in the language research that the RHM explains very well. For example, some studies have found that bilinguals require more time to translate from L1 to L2 (forward translation) than from L2 to L1 (backwards translation) (e.g. Kroll & Stewart, 1994). Because L1 is hypothesized to have a strong link with the conceptual store, translation from L1 to L2 is semantically mediated; however, translation from L2 to L1 does not require semantic access and can be achieved through lexical mediation instead. The RHM also explains the asymmetry found between the performance of novice and proficient monolinguals (Kroll, Van Hell, Tokowicz, & Green, 2010). Because the connection between L2 and the conceptual store is assumed to strengthen with proficiency, the shorter translation latencies for proficient bilinguals is accounted for because they are hypothesized to be able to access the conceptual store without translating into their native language first (Kroll et al., 2010).

Over the last 16 years, however, many problems with the RHM have been highlighted. One is that there is little evidence to support the RHM's suggestion of two separate lexicons (Brysbaert & Duyck, 2010). There is some research that shows an influence of L2 knowledge on L1 knowledge and vice versa, proposing that people cannot just activate one language and inhibit

the other language not currently in use (Brysbaert & Duyck, 2010). Dijkstra, Timmermans and Schriefers (2000) explored this phenomenon in Dutch-English bilinguals. Participants first viewed a string of Dutch and English words on a computer screen. Then, they were asked to press a button when a Dutch word was presented and another button when an English word was presented. If the RHM holds true, then their knowledge of the English language should have no impact on their Dutch knowledge. However, participants required more time to decide if a word that appeared in both languages, or a homograph (e.g. *room* in English means "cream" in Dutch) was in fact also a Dutch word than words that only exist in the Dutch language (Dijkstra et al., 2000). The RHM cannot justify this interference effect. The RHM has two different lexicons, one for each language, suggesting bilinguals can select one of the languages to use and ignore the other. Therefore, the knowledge of a second language should have no affect on one's native language or vice versa. The results from Dijkstra et al. (2000) contradict these claims of the RHM.

Both L1 and L2 naming and translations were examined by Duyck and Brybaert (2004) using forward and backward translation of number words in both balanced and unbalanced, (both languages weren't learned simultaneously) bilinguals. Dutch-French bilinguals were presented with a number stimulus on a computer screen. The stimuli consisted of numbers one through 12 and could appear in one of the three formats: (1) Arabic symbol, (2) Dutch, or (3) French. The numbers were presented in language blocks. For example, participants were asked to respond in French for one block of trials and then in Dutch for the second block. Therefore, both L1 and L2 naming and translations were examined.

Duyck and Brybaert (2004) were looking for the presence of a "magnitude effect" (p. 891). In other words, larger numbers would take more time to translate than smaller numbers.

Because they have discovered that numbers activate the semantic store during specific types of tasks and because forward translation requires semantic mediation, Duyck and Brybaert (2004) expected to find a "magnitude effect" when participants translated from Dutch to French (e.g. the number two in Dutch should take less time to be translated into French than the number eight). However, when translating from French to Dutch, they expected participants to experience no "magnitude effect", as backward translation is proposed to rely on word-to-word associations and not need semantic mediation. The results showed that there was a "magnitude effect" for both balanced and unbalanced bilinguals for both forward and backward translations. This implies that both connections require semantic mediation, which contradicts the RHM.

A "magnitude effect" was also found in novice bilinguals who had been taught the numbers in French only minutes before (Duyck & Brybaert, 2004 (Exp. 3)) Therefore, there is evidence that suggests that even the L2 connection for number words to the conceptual store develops almost instantly, which conflicts with the claims of the RHM.

Hernández, Costa, Caño, Juncadella, and Gascón (2010) investigated forward and backward translation in a Catalan-Spanish balanced bilingual with semantic impairment due to dementia, JFF. JFF was asked to translate words from Catalan to Spanish and vice versa. Hernández et al., (2010) were not entirely sure what they would find as a result of this case study because they did not know the extent of impairment. However, they speculated that JFF could either produce the correct translation or produce no response. According to the RHM, if JFF says the correct answer, it is because he is utilizing the lexical connection between the L1 and L2 stores, which remained intact in JFF. If JFF provides no response, it is because his brain is giving him two conflicting responses to the question: one from his impaired semantic connection and one from his fully functioning lexical connection.

The results showed that JFF was only able to translate 56% of the stimuli in the forward translation task and only 68% in the backward translation task (Hernández et al., 2010). Most of the errors committed were semantic errors (saying a word semantically similar to the target response) or "nonwords" (adding morphemes to words to create non-existing words). Because semantic errors were observed, the results suggest that JFF could not solely rely on his lexical connection, but required mediation from the semantic system to complete the task. This provides evidence against the RHM model, which states that these two connections function independently of one another. Both pathways may, in fact, interact to assist in accurate translation between languages.

Another controversy with the RHM is determining when the connection between L2 and the conceptual store develops. Some studies have found that this connection is only present in proficient bilinguals (e.g., Kroll & Stewart, 1994; Ferré, Sánchez-Casas & Guasch, 2006), but there has been emerging research that has found the existence of this connection in relatively novice bilinguals (Altarriba & Mathis, 1997; Ferré et al., 2006).

Ferré et al. (2006) explored this connection between the L2 lexicon and the conceptual store and found mixed results. Using a translation recognition task, three groups of Spanish-Catalan bilinguals were tested: (1) early bilinguals, (2) late proficient bilinguals, and (3) late "nonproficient" bilinguals (p. 583). "Nonproficient" meant these participants had not lived in a Spanish-speaking country for over two years and had not taken over a year of Spanish classes in school. Each trial consisted of a word in Catalan (L2) followed by a Spanish word (L1). The participants were asked to decide if the Spanish word was the correct translation of the word in Catalan. The second word could fall into one of seven categories including a variation of semantically related, form-related, and unrelated.

Based on the RHM, Ferré et al. (2006) expected to find that the form-related stimuli would have more influence on the "nonproficient" bilinguals' performance than the semantically related stimuli because participants would rely on word-to-word associations between the two lexicons and not on meaning. They also expected the reverse for the proficient and early bilinguals because, due to their proficiency in L2. They should have a relatively strong link between L2 and the conceptual store, resulting in no need for lexical mediation. The results supported their second hypothesis and thus the RHM. However, the results showed that "nonproficient" participants were more likely to judge semantically related words as the correct translations than the other stimuli (Ferré et al., 2006). This finding, which suggests that the connection between L2 and the conceptual store is stronger earlier in the acquisition process than the RHM assumes, supports the results obtained by Altarriba and Mathis (1997).

Altarriba & Mathis (1997) evaluated the RHM in a series of three experiments. In the first experiment, monolingual participants were taught a list of Spanish words. Then, the monolinguals and Spanish bilinguals were tested using a translation recognition task. Participants were shown a series of the Spanish words they had just learned. The words appeared individually. Participants were asked to decide if the English translation that followed each Spanish word was the correct translation. The translation could fall in one of three categories: (1) the correct English translation, (2) an orthographically (visually) similar translation, or (3) an unrelated translation.

Based on the RHM, Altarriba and Mathis (1997) expected that there would be greater interference for the monolinguals from the orthographically similar translations than the unrelated translations because the model predicts the development of lexical connections before conceptual connections. The procedure of the second experiment was identical to the first, but

semantically (conceptually) similar translations replaced the orthographically similar translations from the first experiment. It was hypothesized that the semantically similar translations would have no interference affect on the monolinguals due to the fact that this connection had not developed yet (Altarriba & Mathis, 1997). However, the fluent bilinguals were expected to experience interference from both the orthographically similar and semantically similar translations because their link between L2 and the conceptual store would be much stronger than the monolinguals connection due to their proficiency in their second language.

The results were mixed. The hypotheses based on the bilinguals' performances were supported and thus, so was the RHM. Also, monolinguals did experience a greater interference effect with the orthographically similar translations than the unrelated translations. However, one finding contradicted the RHM: monolinguals, not just bilinguals, experienced an interference affect with the semantically related translations. This suggests that the connection between the L2 and conceptual stores develops much earlier than the model predicts.

In the same article, Altarriba and Mathis (1997) used a Stoop task to examine the connection between L2 and the conceptual store in novice bilinguals. Monolinguals were taught the four color words red, blue, green, and yellow in Spanish (*rojo, azul, verde*, and *amarillo,* respectively). Then the monolingual and bilingual participants were given a Stroop color-word task. One of the eight stimuli (four English, four Spanish) appeared on the screen written in either red, blue, green, or yellow ink. Participants were asked to say the color of the ink of the written word in English, not read what the word said (Altarriba & Mathis, 1997). Because the Stroop effect is due to semantic interference, the RHM would say that only proficient bilinguals would experience an interference effect because novice bilinguals would not have developed this connection yet. However, it took the novice participants significantly more time to name the ink

color of a Spanish word than an English word, resulting in an interference effect (Altarriba & Mathis, 1997). Novice participants were not able to inhibit the concept associated with the color word, so the decision took longer then was expected. This finding proposes that the L2-conceptual store connection exists prior to when the model suggests.

The current study was a replication of the first experiment conducted by Altarriba and Mathis (1997). However, a different language was utilized to investigate if similar results could be obtained with a language that differs more phonologically and orthographically from English than Spanish. In addition, the current study, excluded emotion (sad, happy, angry, etc.) and emotion-laden words (death, war, spider, etc.) as stimuli. These types of words have been shown to have lower context availability than concrete words but higher than abstract (Altarriba, Bauer & Benvenuto, 1999). Also, these words have more word associations than both concrete and abstract words (Altarriba et al., 1999). Emotion words are also recalled better than both abstract and concrete (Altarriba & Bauer, 2004). These findings insinuate that emotion and emotion-laden words are there own class of words, not a part of the abstract category. Therefore, to prevent invalid results due to these words acting as a confounding variable, they were left out. In addition, nouns are more concrete than verbs and other parts of speech because they refer to specific objects. Therefore, nouns have faster recognition times than other words (Gentner (1981). Nouns were solely used as stimuli to avoid variation in parts of speech, which could influence the results.

A recent study conducted by Altarriba and Knickerbocker (2011) looked at the relationship between different teaching stimuli and learning a second language. Participants were taught L2 words using colored pictures, black and white pictures, and word-to-word associations. Altarriba and Knickerbocker (2011) discovered that reaction times were significantly faster for

word-to word learning condition than the two picture conditions. In the current experiment, the acquisition phase is based on word-to-word L2 learning to ensure that the results obtained were due to the independent variables being manipulated, not due to the participants' inability to learn the second language. The current study examines the development of this connection by testing the semantic and orthographic knowledge of novice German bilinguals. It was expected that there would be greater interference for the monolinguals from the orthographically similar translations than the unrelated translations because the RHM predicts the development of lexical connections before conceptual connections.

Method

Participants

Forty-seven Union college students participated in the current experiment (29 females, 14 males). The data of four participants were disregarded due to low quiz scores. Only three of the participants were left-handed. The age range for these participants was from 18 to 21 with a mean age of 18.65. The participants received class credit for their participation in the current experiment.

Materials

A frequency dictionary of German words (Jones & Tschirner, 2006) was used to pick 30 of the most frequent German nouns for the acquisition phase of the current experiment. All 30 words were very frequent with a rank frequency value between 103 and 1,002. German nouns similar in spelling to English words were excluded. Each German noun was paired with three types of English words: (1) the correct English translation, (2) an orthographically similar English word, or (3) an unrelated English word (see Appendix A). The orthographically similar words were created by changing one letter of the English translation. For example, the German

word SPIEL was paired with its correct translation GAME, an orthographically similar word, FAME, and an unrelated word TIRE. The English Lexicon Project (ELP) database was used to determine the HALlog frequency of the orthographically similar words (Balota et al., 2007). Using ELP, the unrelated words were chosen to match the orthographically related words in both word length and word frequency. Matching was done on a pair by pair basis. The mean word length for the orthographically similar words was 3.97 and the word frequency was 9.36. The mean word length for the unrelated words was 3.97 and the word frequency was 9.37. All of the orthographically related and unrelated words were also nouns to control for part of speech. All emotion and emotion-laden words were excluded.

The word pairs were counterbalanced across three lists. Ten pairs from each of the three categories (correct English translation, orthographically similar word, and unrelated word) appeared on each list, resulting in a total of 30 word pairs per list. Each word pair appeared only once per condition. The program was created using E Prime software (Schneider, Eschman, & Zuccolotto, 2002). The words were displayed on a computer screen in white font on a black background.

Procedure

The procedure of the current study is similar to the procedure of the Altarriba and Mathis (1997) study described previously. The first part of the current experiment was the acquisition phase. Monolinguals were seated in front of a computer screen and a trial proceeded as follows: (1) participants saw a "+" that was presented on the screen for 1000 milliseconds (ms), which was used to help the participants focus their attention on the appropriate part of the screen, (2) a German word was presented slightly above the fixation point for 500 ms, (3) while the German word was still on the screen the correct English translation appeared slightly below the fixation

point with words remaining on the screen for 7000 ms. Each participant wore headphones and heard each German word spoken twice by a native German speaker while it was shown on the screen. Participants learned the 30 German words in sets of 10. After the first 10 words, participants were given the matching test where they had to write the German word that matched the given English word. A list of the 10 German words was provided as a word bank (see Appendix B). Then, the test was graded and handed back to the participants, so that they could look over any mistakes. Next, participants were given a second quiz in which they had to choose the correct German word to fill a blank in an English sentence (see Appendix C). This quiz tested both the semantic relationship between the English and German words as well as the orthography of the German words because the participants were writing and reading them. Finally, they were given a quiz in which they had to pair the correct German word (e.g., "Uhr" which means clock) with an English definition (e.g., a device for measuring time) (see Appendix D). This procedure was repeated for two more sets of 10 words until they learned all 30 German nouns. After learning all 30 words, participants were given one collective test containing all 30 words and they had to match the German word to the correct English word. Only the data from participants who scored 90% or better on the final test were included in the analyses to ensure that the participants had learned the German words.

After the acquisition phase, participants were given an intervening task, which consisted of math problems from a Graduate Record Examination (GRE). The intervening task lasted approximately 6 minutes. Following this task, participants returned to their computers for the experimental trials. All participants were randomly assigned to one of three lists upon arriving. Participants sat in front of a computer screen and instructions appeared in English. The experimental trials proceed as follows: (1) the fixation point "+" was presented only at the

beginning of the experiment to warn the participants that the trial was about to begin, (2) a German word was presented on the screen for 500ms, (3) the German word was replaced by an English word for 2000 ms. Using their dominant hand, participants were instructed to press "1" if the English word presented was the correct translation of the previous German word and "2" if it was not. Participants were asked to respond as quickly and accurately as they could. If participants provided no response the word "INCORRECT" appeared on the screen for 1500 ms.

After the completion of the experimental trials, the participants were asked to complete a questionnaire on demographics and prior history with the German language. The data of any participants confirming previous exposure to the German language were not included in the following analysis.

Results

For each participant three mean reaction times were computed: (1) one for the correct translation condition (M = 809.01), (2) one for the orthographically similar condition (M = 845.74), and (3) one for the unrelated condition (M = 744.81). A one-way analysis of variance (ANOVA) was computed to compare the reaction times in each condition. The effect of translation condition was significant, $F(2, 120) = 3.536$, $p < .05$. Planned comparisons revealed that the difference between the correct and unrelated conditions was significant, $t(40) = 3.687$, $p < .05$. The difference between the orthographic and unrelated conditions was also significant, $t(40) = 7.385$, $p < .05$. However, the difference between the correct and orthographic conditions was not significant, $t(40) = -1.777$, $p = .083$.

Discussion

The goal of the current study was to examine the Revised Hierarchical Model of bilingual language representation proposed by Kroll and Stewart (1994) by exploring the connection

between the two lexicons in novice bilinguals. The current experiment evaluated the lexical links between the two languages, English and German. The results supported our hypothesis, showing that there was greater interference for the monolinguals from the orthographically similar translations than the unrelated translations. The discovery of interference means that the participants were translating the German words into their English translations to access the conceptual store in order to determine if the translation was correct or incorrect. Therefore, participants required more time to distinguish between words orthographically similar to the correct translation. These results support the RHM's prediction that novice bilinguals utilize this lexical pathway when learning a second language.

Unfortunately, the external validity of the experiment was hampered due to the fact that approximately 66% of the participants were female and 93% were right-handed. This sample is not ideal in representing society in its entirety. Male and female brains differ in their rates of development and layout (Allen, Richey, Chai, & Gorski., 1991). For example, research has discovered that females have bilateral localization for language in their brains, whereas language is generally localized only in the left hemisphere for males (Shaywitz et al., 1995). Handedness could also affect brain functioning and organization (Knecht, 2000). Therefore, the results of the current experiment cannot be generalized to the rest of the population. Perhaps, the results should just be considered for right-handed, females in order to be more accurate. Future research should examine how male brains and left-handed people acquire and utilize a new language.

Another drawback of the current experiment was that the number as well as the type of languages in which participants were proficient was not considered. Perhaps acquiring a third language requires less time and effort than acquiring a second (Thomas, 2010). Some participants were fluent in Urdu, Hindi, Spanish or Hebrew. Certain previously studied

languages could potentially facilitate the learning of the German language like Latin, which has a similar morphology, or Swedish or Dutch, which has similar phonology (Thomas, 2010). In the current study 11 out of the 43 participants stated that they were proficient in a language other than English. Future studies should use those who are proficient in more than one language as a comparison group to investigate if /how the acquisition of a third language differs from that of a second language.

Future research should replicate the second experiment conducted by Altarriba and Mathis (1997) to evaluate the conceptual level of the model. In this experiment the orthographically similar stimuli would be substituted for stimuli conceptually, or semantically, similar to the correct English translation. The model would predict that there would be no interference found for monolinguals in this experiment due to the fact that this connection has not yet developed in their memory stores. However, if an interference effect was found, as Altarrbia and Mathis (1997) discovered, these results would suggest that semantic information is coded earlier in the language acquisition process than what the model stipulates. Therefore, this part of the model could require a revision to account for these conflicting results.

These results could be useful when applied to teaching a foreign language. Knowledge on how the brain codes information and how it transfers this information into long-term memory is crucial in discovering effective teaching strategies. Perhaps teaching words in orthographically similar groups may help alleviate some of the confusion between these words because students could discover the differences in these words when they are side by side. Also, if semantic information influences the learning process earlier than what the RHM predicts, maybe learning words based on categorical pictures may assist in a faster acquisition. In summary, there are

some data that contradict the RHM, but more research is still needed before conclusions can be drawn.

References

Allen, L. S., Richey, M. F., Chai, Y. M., & Gorski, R.A. (1991). Sex Differences in the Corpus Callosum of the Living Human Being. *The Journal of Neuroscience,11,* 933-942.

Altarriba, J. & Bauer, L. M. (2004). The distinctiveness of emotion concepts: A comparison between emotion, abstract, and concrete words. *The American Journal of Psychology, 117*, 389-410.

Altarriba, J., Bauer, L. M., & Benvenuto, C. (1999). Concreteness, context-availability, and imageability ratings and word associations for abstract, concrete, and emotion words. *Behavior Research Methods, Instruments, & Computers*, *31*, 578-602.

Altarriba, J. & Knickerbocker, H. (2011). Acquring second language vocabulary through the use of images and words. In P. Trofimovich, K. McDonough (Eds). Applying priming methods to L2 learning, teaching, and research: Insights from Psycholinguistics (pp. 21-48). Amsterdam: John Benjamins Publishing Company.

Altarriba, J. & Mathis, K. (1997). Conceptual and lexical development in second language acquisition. *Journal of Memory and Language, 36*, 550-568.

Balota, D.A., Yap, M.J., Cortese, M.J., Hutchison, K.A., Kessler, B., Loftis, B., Neely, J.H., Nelson, D.L., Simpson, G.B., & Treiman, R. (2007). The English Lexicon Project. Behavior Research Methods, 39, 445-459.

Brysbaert, M. & Duyck, W. (2010). Is it time to leave behind the Revised Hierarchical Model of bilingual language processing after fifteen years of service? *Bilingualism: Language and Cognition, 13*, 359-371.

Dijkstra, T., Timmermans, M., & Schiefers, H. (2000). On being blinded by your other language: Effects on task demands on interlingual homograph recognition. *Journal of Memory and*

Language, 42, 445-464.

Duyck, W. & Brysbaert, M. (2004). Forward and backward number translation requires conceptual mediation in both balanced and unbalanced bilinguals. *Journal of Experimental Psychology: Human Perception and Performance*, 30, 889-906.

Ferré, P., Sánchez-Casas, R., & Guasch, M. (2006). Can a horse be a donkey? Semantic and form interference effects in translation recognition in early and late proficient and nonproficient Spanish-Catalan bilinguals. *Language and Learning, 56,* 571-608.

Gentner, D. (1981). Some interesting differences between verbs and nouns. *Cognition and Brain Theory, 4,* 161-178.

Hernández, M., Costa, A., Caño, A., Juncadella, M., & Gascón-Bayarri, J. (2010). On the translation routes in early and highly proficient bilingual people: Evidence form an individual with semantic impairment. *Aphasiology, 24*, 141-169.

Jones, R. L. & Tschirner, E. (2006). A frequency dictionary of German: Core vocabulary for learners. Abingdon, Oxon : Routledge.

Knecht, S., Dräger, B., Deppe, M., Bobe, L., Lohmann, H., Flöel, A., ... Henningsen, H. (2000) Handedness and hemispheric language dominance in healthy humans. *Brain, 123*, 2512-2518.

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., Van Hell, J. G. Tokowicz, N., & Green, D. (2010). The Revised Hierarchical Model: A critical review and assessment. *Bilingualism: Language and Cognition, 13*, 373-381.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). E-Prime user's guide. Pittsburgh:

Psychology Software Tools Inc.

Shaywitz, B. A., Shaywitz, S. E., Pugh, K. R., Constable, R.T., Skudlarski, P., Fullbright, R. K., ... Katz, L. (1995). Sex differences in the functional organization of the brain for language. *Nature, 373,* 607-609.

Thomas, J. (2010). The role played by metalinguistic awareness in second and third language learning. *Journal of Multilingual and Multicultural Development, 9*, 235-246.

Appendix A

Stimuli used for current study.

German Word	English Translation	Orthographically Similar Word	HAL Frequency	Unrelated Word	HAL Frequency
Uhr	Clock	Block	10.4	Stone	10.4
Spiel	Game	Fame	8.7	Tire	8.7
Stunde	Hour	Pour	9.4	Gift	9.4
Kraft	Power	Tower	10.1	Scale	10.1
Mund	Mouth	Month	11.2	Field	11.2
Stadt	City	Pity	7.5	Axle	7.5
Spaβ	Fun	Bun	6.8	Wig	6.8
Erde	Soil	Soul	10.4	Tool	10.4
Reise	Trip	Trap	9.2	Sand	9.2
Kopf	Head	Bead	7.5	Veil	7.5
Geschite	Story	Store	10.9	Brain	10.9
Arbeit	Work	Word	11.8	Idea	11.8
Hinweis	Hint	Pint	7.3	Calf	7.3
Seite	Page	Cage	9.0	Drum	9.0
Geld	Money	Honey	9.1	Bread	9.1
Himmel	Sky	Ski	9.4	Pot	9.5
Teil	Part	Dart	7.4	Swan	7.4
Frau	Wife	Wine	9.5	Icon	9.5
Mensch	Man	Fan	10.5	Ice	10.6
Ziel	Goal	Goat	7.8	Nest	7.9
Luft	Air	Aid	9.8	Den	9.8
Bein	Leg	Log	10.1	Ray	10.1
Recht	Law	Paw	7.6	Ivy	7.6
Junge	Boy	Buy	11.8	Web	11.9
Boden	Floor	Flour	8.4	Essay	8.4
Kunst	Art	Arm	9.9	Tag	9.9
Tisch	Table	Cable	10.6	Peace	10.6
Weg	Path	Bath	8.5	Corn	8.5
Zug	Train	Trait	7.6	Pasta	7.6
Auge	Eye	Eve	9.0	Pen	9.0

Appendix B

An example of one of the three matching quizzes.

Uhr Stunde Kraft Mund Spiel Stadt Kopf Erde Spaß Reise

1. Clock_____

2. Game_____

3. Hour _____

4. Power _____

5. Mouth_____

6. City _____

7. Fun _____

8. Soil_____

9. Trip_____

10. Head _____

Appendix C

An example of one of the three sentence completion quizzes.

Auge Tisch Zug Recht Kunst Weg Junge Bein Boden Luft

21. When setting the kitchen _____ the spoon should always be placed on the right side of the plate.

22. The girl wandered down the _____ in the forest, picking wild flowers.

23. The old man had to use a cane to walk because his _____ was weak.

24. According to the _____, only adults 21 years old and older can drink alcohol.

25. The _____ in the museum was very colorful and had many abstract designs.

26. On top of mountains the _____ has less oxygen and it is harder to breathe.

27. The sleepy cat opened one _____ when it heard the can opener.

28. The _____ departed the station late so everyone was late to work.

29. The young _____ played with his dog in the back yard.

30. The ocean _____ is covered with many sea creatures of different sizes.

Appendix D

An example of the definition quizzes.

Hinweis Mensch Frau Geld Himmel Seite Arbeit Ziel Geschite Teil

11. A portion or segment of a whole _____

12. A tale or fable_____

13. Female spouse _____

14. The upper atmosphere _____

15. Currency _____

16. An indirect suggestion or indication of something _____

17. A sheet of paper as in a book _____

18. An assignment or task _____

19. An adult male human _____

20. An objective _____

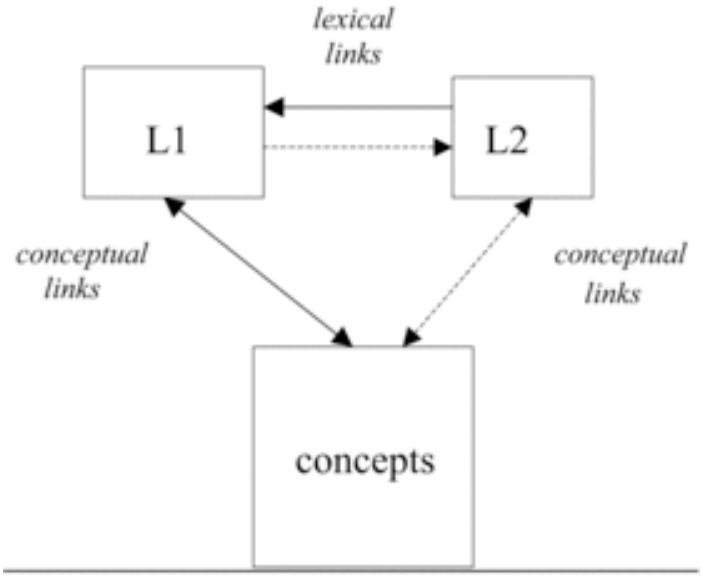

Figure 1. The Revised Hierarchical Model. A model, proposed by Kroll and Stewart (1994), that demonstrates word representations of a native and second language in bilingual memory.