"A new model must be proposed that is not based on one language's strong link and the other language's weak link to the concept, but rather a dynamic link, which can switch strengths (or the amount of neurological activity it receives from the brain) between the two languages, regardless of the proficiency level in either language based on the active language."

BILINGUAL LEXICAL ORGANIZATION

JULIE MCNAMARA

THIS EXPERIMENT STUDIED LEXICAL ORGANIZATION WITHIN BILINGUALS UNDER THE CONCEPT HEADING OF COLOR. THIS EXPERIMENT WAS CARRIED OUT USING A COMPUTER PROGRAM, THE BILINGUAL STROOP TASK, WHICH ASKED USERS TO NAME THE COLOR OF A WORD THAT WAS FLASHED ON A COMPUTER SCREEN, REGARDLESS OF WHAT THE WORD ITSELF SAID. IT SOUGHT TO COMPARE VARYING AMOUNTS OF INTERFERENCE TIME GENERATED BY THE STROOP EFFECT ACROSS DIFFERENT CATEGORIES OF WORDS: WORDS THAT WERE COLOR RELATED AND WORDS THAT WERE NOT COLOR RELATED. IT WAS FOUND, HOWEVER, THAT THE MERE PRESENCE OF INTERFERENCE IN RELATION TO CATEGORIES OF WORDS WAS NOT SUFFICIENT FOR EXPLAINING THE PSYCHOLINGUISTIC ISSUES SURROUNDING COMMUNICATION BETWEEN THE TWO LANGUAGES OF A BILINGUAL, BUT RATHER THE DEEPER STUDY OF AMOUNTS OF INTERFERENCE WITH RESPECT TO EACH LANGUAGE WAS NECESSARY.

> *"The Stroop effect was used to examine several leading hypotheses about lexical organization in bilinguals."*

This paper will attempt to draw some inferences on lexical organization in the bilingual brain based on a study of French-English, Greek-English, and Spanish-English bilinguals through analysis of the amount of interference observed through a computer program, the Bilingual Stroop Test (BST). Interference is defined as the difference of time between the naming of the ink color of a word and the average time required to read color-naming words and to name ink colors. The Stroop effect was used to examine several leading hypotheses about lexical organization in bilinguals.

This experiment sought to research questions such as: Is there a separate lexicon which is activated by stimuli of one language and not another? Is there any interplay between the two languages at all? What is the nature of the link between the bilingual's two languages, if there is one?

The difficulty in proposing and supporting a model for lexical organization for bilinguals is manifold. First and foremost, the model must explicitly state whether or not it is going to argue for two distinct lexica, one for each language, or a mutated super-lexicon that is twice the size than that of a monolingual's and has its own system for demarcating L1 words from their L2 counterparts[i], where L1 is the English language and L2 is the foreign language. Much research has been done on both sides of the issue. In a 1969 experiment which sought to understand the organization of the bilingual lexicon, the conclusion of total autonomy was reached due to results from a lexical decision task. In the task, study participants had to determine whether a string of letters formed a legitimate word or not. In that particular experiment, about half of the words were real and the other half, although phonologically sound, were not real words.[ii] When considering the reaction times, which were within the expected timeframe of that of monolinguals, the researches were led to question how one could search through two lexica in the same amount of time that it took a monolingual to search through one. This was known and referred to as "the mantiness problem [since] how could we decide so rapidly that mantiness was not a word in English [or in the L2?]"[iii]

Another study, which argues for a single integrated lexicon, done in 1966 "showed that in recalling lists of unrelated words, subjects are influenced by the frequency of the presentation of a word even when it is presented in the other language."[iv] A lexical priming effect, which occurs when a presented word stimulates related lexemes of a concept, was evidenced in this experiment trough the difficulty experienced in recalling a list of unrelated words. It follows that a word that shows up once in L1 and once in L2, but which activates the same concept in the mind twice, is easier to remember than a word and its related concepts that are only shown once.

There exist several theories that attempt to explain the relationship between words and their representations within the bilingual lexicon. Of these, the Concept Mediation Model, and its two subordinate theories of bilingual lexical representation will be examined herein.

The Concept Mediation Model and its subordinates assume a relationship between words in the lexicon that are organized not by phonological or orthographic similarities, but rather by association with abstract concepts. Instead of the word "room" jointly activating the word "boom" (due to their phonological similarity), the Concept Mediation Model, the Word Association Model, and the Multiple Access Model would argue that "room" would activate something more like "house". These three models share many similar characteristics except for their theories on the interplay between the L1 and L2.

Multiple Access Model VIII

CONCEPT

L1

L2
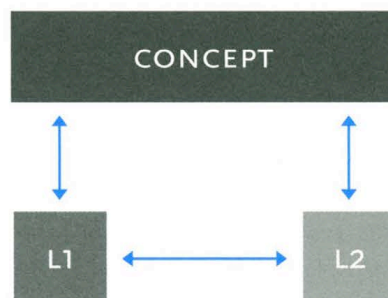
the bilingual lexicon. First published in 1935 by J. Ridley Stroop,[ix] the task had college students perform different identifying tasks involving color naming words written in different colored ink on different colored backgrounds. The students were asked to name the printed word, the colored ink, and the colored background.

For the purposes of the BST, a modified Stroop task was implemented. The tasks were adjusted to take advantage of the assistance of computers and to investigate the concept of interest. Control data was collected by recording the average time needed to read color-naming words printed in black ink and the amount of time needed to identify the color of an arbitrary symbol (cf. XXXX). The background was a neutral color, to decrease the number of variables. In addition, words that were outside the concept of color were used alongside of the color naming words to verify whether or not there was an effect on lexical interference. The most significant aspect of the BST was the implementation of variable languages with respect to the stimuli and the completion of the task.

This experiment sought to assess the validity of the various types of concept-based models. The testing of words outside the concept of color was done deliberately with the expectation that the interference would be

higher than that from the mismatched color pairings. The reaction times for these tasks would be significantly higher than the test completed with color naming words because the color naming words would provide an additional lexical prim-ing effect. The two conditions in which the color naming word matched the color of the ink in which it was presented were expected to yield the lowest reaction times. All of these hypotheses were held across the cross-linguistic perspective, although the Greek-English bilin-gual times were expected to be slower overall due to a compensation for the orthography of Modern Greek.

MATERIALS AND METHODS

The experiment was conducted using sixteen test subjects. Subjects were chosen based on the criterion that they were bilingual with English and either French, Spanish,or Modern Greek. Ideally the participant would have grown up hearing and learning both languages simultaneously, however exceptions were made for three subjects who had at least ten years of active partici pation with the second language. A control group of two participants also completed the task that did not have significant exposure to the L2. They were required to complete the experiment, with the exception that they were not asked to name the colors in a foreign language.

FIGURE 1

CONCEPT

L1 ⟷ L2
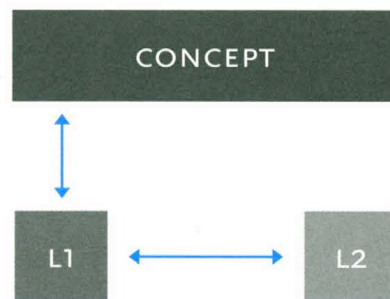
Word Association Model [VI]

The Word Association Model, as illustrated in Figure 1.1, argues that "languages interact at the lexical level, based on translation equivalents"[V] where the L2 is subordinate to the L1 by means of a subconscious translation effect. Figure 1.2 depicts the Concept Mediation Model, which argues that both L1 and L2 have direct access to the overarching concept that is controlling lexical activation. The Multiple Access Model shares the same characteristics as Concept Mediation Model except for a key difference shown in Figure 1.3 that asserts that there is a connection between not only the shared concept, but also between L1 and L2.

To accept any of the concept-driven models, regardless of which of the three one chooses to support, a valid and in-depth definition of the "concept" must be established. For this experiment color was chosen because it has a complete one to one translation ratio between all languages. Color was important as the overarching concept for another reason: colors exist everywhere in the world and everyone has had equal exposure to them. Therefore, it was clear that the differences in reaction times between different languages was a function of the language or the mental processes involved in finding the right word as opposed to a function of categorizing and identifying a constituent of a category.

Having chosen to study concept mediation models and to use color as the concept, it seemed only natural to use the Stroop task to unearth findings about the mechanisms of

FIGURE 1

CONCEPT

L1   L2
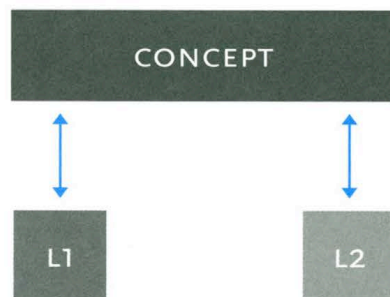
Concept Mediation Model [VII]

FIGURE 1
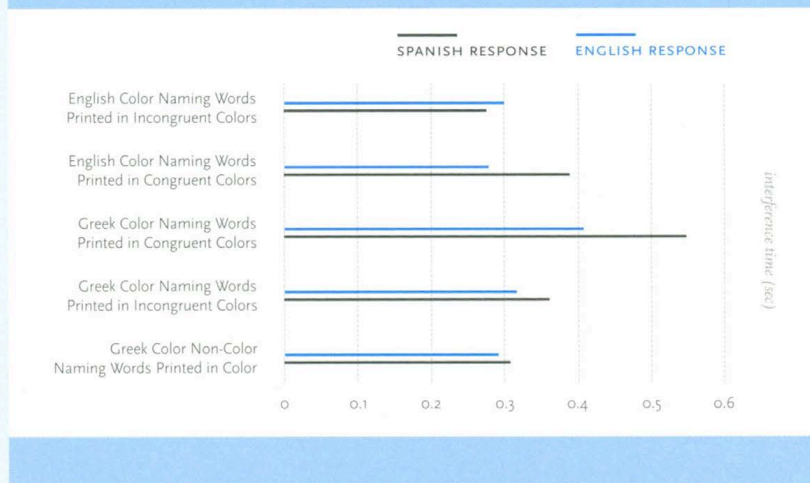
Spanish Billingual Interference Time

The task was presented on a laptop computer using a specifically designed program, Bilingual Stroop Task, BST. All interviews were recorded on a tape recorder for further data analysis and interpretation of results. A short tutorial session was administered on how to use the program and to get acquainted with the laptop. The participant was encouraged to complete a practice application to familiarize him or herself with the mechanics of the program. The importance of rapid response was also stressed to encourage applicable results.

In the first task, the participant will press a button labeled "English" and read a list of five English color-naming words printed in black ink (blue, green, red, orange, yellow) pressing the space bar to advance the screen. In the second task, the participant will press a button labeled "XXX" in which a series of Xs are presented that have been colored in with different colors (yellow, blue, green, red, orange) once again pressing the space bar to advance. The computer recorded the amount of time between space bar presses to calculate the data. They will name the color of those Xs. In the third task, the participant will be asked to name the color of a series of 25 words that are presented. This step is repeated, with the inclusion of instructions in the foreign language, except that the participant is instead asked to name the color of the ink in his or her L2.

RESULTS

This graph shows little conclusive data. Over all of the categories, the test seems to have a generally longer interference effect when the task is completed in Spanish, independent of the type of stimuli. The astonishing predominance of longer reaction times for the Spanish language portion of this test can possibly be explained by the extreme variance of language competency seen among the Spanish speakers. Since earlier attempts to classify bilinguals based on their individual skill levels proved to be impossible, grouping weak Spanish speakers who weren't speaking Spanish regularly with extremely strong Spanish speakers who professed that an English-Spanish hybrid - "Spanglish" — was part of their daily speech pattern contributed to conflicting results. In addition, these results are suspect as two out of the six participants admitted to attempting to focus at a point on the screen to name colors without having to read the word. Since these participants constituted one third of the sample set, no viable data are gleaned from this group, without further testing.

This graph shows a strong trend: when the stimulus is in English, the interference time for naming the word in French is noticeably higher than the interference time for naming the word in English. The reverse is shown to hold true in naming French words in English. An exception is

the middle bar graph that shows that interference time for naming French words is considerably higher in French. This is firstly an indication that working with a small group of participants is likely to provide inconsistencies and secondly is a result of many of these data points being misnamed by participants. Although in all (cross-linguistically) of the trials, the second word was the non-English word for 'orange' printed in orange, in the case of French, that word is printed with the same orthography as the English word. Thus, it was ambiguous as to which language it belonged. By the time the next French color naming word printed in the same color appears on the test, it is the sixth word of the test. Most participants, expecting difficulty with reading the color were thrown off guard by the congruency of the colors, and were likely to misname it. There were only five French speakers who completed the test, and three of them made mistakes in this data set. The speakers who named the colors correctly could have been slower, more cautious test takers overall, which would have contributed to a longer reaction time.

It is interesting to see in this graph that as predicted, orthography does have a noticeable effect. The average time for reading colors and words was 1.058 seconds, as compared to the Spanish average time of 0.755 seconds and the French average time of 0.678 seconds. Almost all of the Greek bilinguals, when compared to the Spanish bilinguals were considered to be very strong. The reaction times for naming colors was proportionally larger, but the amount of interference seen is about the same as the other two language groups, as the longer control reading time is equally balanced by the longer experiential reaction times. In this data set, the trend that was hinted in the French data set becomes glaringly apparent. Stimuli that were printed in Greek took much longer to complete in English and vice versa.
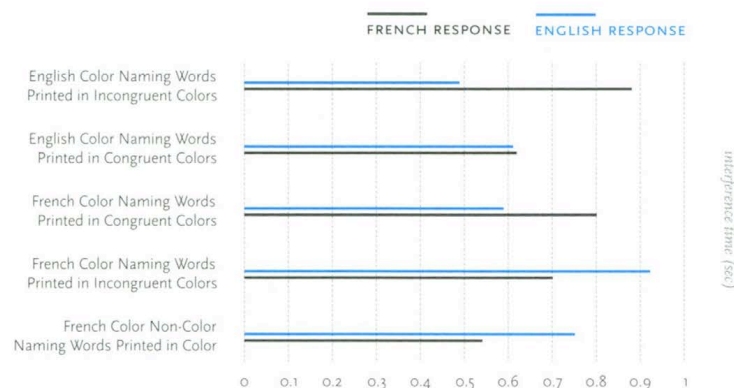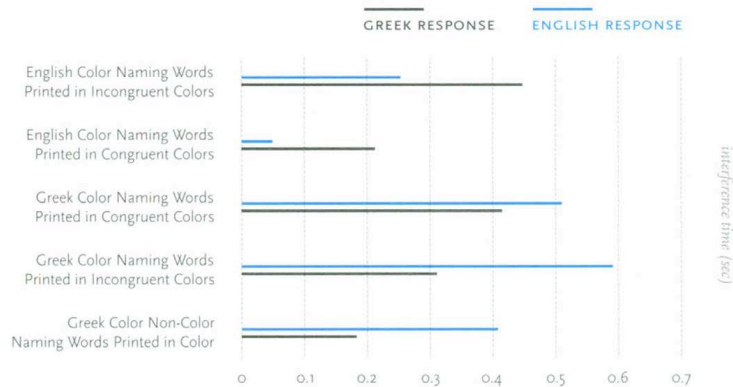
DISCUSSION

In considering the results and their relevance to the various posited models of lexical organization, conflicts arise. The Concept Mediation Model seems to be an unlikely candidate for explaining bilingual lexical organization because of the differences in interference times observed for the L1 and L2 responses. If language competition were not a factor and both languages could have equal access to the concept, then there would be no disparity in interference times for stimuli of L1 while the task was being completed in L2, or vice-versa. This was clearly not the case, so an ideal situation in which two separate lexica are permitted equal access to the overarching concept is not supported by these results.

In considering the Multiple Access Model, the results obtained do not seem to support the idea of two lexica, which both compete and communicate equally with each other. Some evidence was gained for this view, such as speech errors during testing where during the English version of the BST a bilingual would accidentally lapse into his or her L2 and name the correct word in the incorrect language, but that view holds that one language is constantly dominating

FIGURE 1.5

French Billingual Interference Time

FRENCH RESPONSE   ENGLISH RESPONSE

English Color Naming Words Printed in Incongruent Colors

English Color Naming Words Printed in Congruent Colors

French Color Naming Words Printed in Congruent Colors

French Color Naming Words Printed in Incongruent Colors

French Color Non-Color Naming Words Printed in Color

interference time (sec.)

0   0.1   0.2   0.3   0.4   0.5   0.6   0.7   0.8   0.9   1

FIGURE 1

GREEK RESPONSE   ENGLISH RESPONSE

English Color Naming Words
Printed in Incongruent Colors

English Color Naming Words
Printed in Congruent Colors

Greek Color Naming Words
Printed in Congruent Colors

Greek Color Naming Words
Printed in Incongruent Colors

Greek Color Non-Color
Naming Words Printed in Color

interference time (sec)

0   0.1   0.2   0.3   0.4   0.5   0.6   0.7

**Greek Bilingual
Interference Time**

over the other, which would have to manifest itself in strong communication between the two languages. If the two lexica were able to communicate with each other so completely, it would be unusual to see the difference in the amount of interference based on language, as shown in the French and Greek data sets. If the lexica for each language were really equal and granted the same amount of access to the concept, there should have been no difference in interference time. Further, it would seem that due to the vast amount of communication available through the two lexica, that reaction times overall would be slower between both languages, even if the L2 was significantly weaker than the L1.

The Word Association Model, however, is capable of ex-

plaining the results reasonably well. It does not assert that the two languages are always balanced and equal, instead it suggests that being a "perfectly balanced" bilingual is nearly impossible. There must be a stronger L1, which has the most direct link to the concept. If this is the case, however, that must mean that some degree of "back translation,"[x] the cognitive process of calling up a word in the stronger language, and then 'translating' to its equivalent in the weaker language, is going on between the L1 and the L2. This brings up an entirely different psycholinguistic issue, which reaches beyond the scope of this paper, but which is interesting to consider nevertheless. With the idea of "back translation" in mind, Kroll and Stewart propose a "Revised Hierarchical Model"[xi] (Fig 1.4) which seems to be the most accurate model of bilingual lexical representation

FIGURE 1

CONCEPT

L1   L2
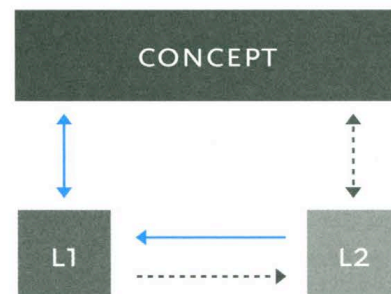
**Revised Hierarchical
Model XII**

FIGURE 1.8

McNamara's
Proposed Revision

CONCEPT

L1 ⟵·····⟶ L2
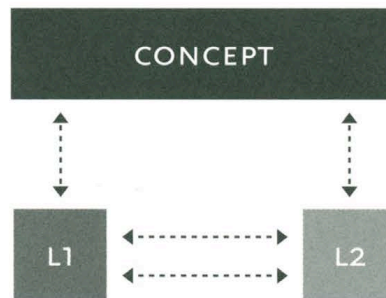
in that it offers the predominant link to the concept from the stronger L1 but still allows for a weaker link from the L2. Overall the experiment was highly enlightening and a success, but there were a few aspects that could have resulted in discrepancies in the data. The Greek language test was unsuccessful in the Control Group subjects, since over half of the words were written in the Greek alphabet and the subjects did not even attempt to read the words before deciding in which color the words were printed. This was a process acknowledged by the participants and shared with the interviewer. The result was an observed decrease in interference in the BST. In addition, in one example it took more time to read the ink color of the colored 'Xs' than it did to read the color of the Greek word. The Greek test was originally chosen as a control element because of the average person's limited exposure to the Greek language. It is clear from the sparse interference effects that were observed in the Control Group that taking the time to test monolinguals in a language whose alphabet they could at least sound out (and therefore would take the time to read) a much stronger Stroop effect would have been noticed.

In the cross-linguistic perspective, the greatest interference seems to have come in the experience of French-English bilinguals, who show almost one second of measurable interference in the fourth data. It was expected that the reaction times for the Greek-English bilinguals would have been significantly higher than those of the other two bilin-

gual groups, due to the added variable of orthography, but, as aforementioned, the initial delay in reading the control words balanced out the later delay in naming colors. In the case of the foreign non-color naming words printed in colored inks, a significant spike in reaction time was expected, but experientially it had a comparatively average amount of interference. This is doubly surprising because it seems to violate the rules of cognitive efficiency (in that a definition for a word from a completely different concept must be found, discarded, and then reanalyzed in terms of its ink color) but also because, at the conclusion of the test, many participants expressed the difficulty in naming the color of those particular words, because they were surprised by non color-naming words.

While most of the data are extremely valid and telling, there is still the problem of the Spanish data set. Based on the extreme sensitivity of the Stroop effect that the very nature of the Spanish bilingual test was flawed. For example, when a Spanish bilingual saw the word "orange" anywhere on the test, they might say "anaranjado," an extremely long word that takes a large amount of time on the Stroop effect scale. This is because, when taking the test that was Spanish color-naming words printed the same color ink, "anaranjado" came up as the second word, and slowed down the reaction time. This is significant when compared to the one and two-syllable words that were predominant on the French test. Although Greek words are comparatively long,

the test self-corrected for this as discussed earlier. The poly-syllabic nature of Spanish, when compared to the monosyl-labic nature of English and French affected all of the groups of data points. It would have been a better choice to have used the word "naranja," since many Spanish bilinguals substituted it anyway when orange reappeared on the test as a later data point.

Another difficulty was found in the location and placement of the actual test data. The BST used two colors that the original Stroop test did not: pink and yellow. Pink was the color most often forgotten by weaker bilinguals. In addi-tion, the specific hues for black and brown caused some confusion in that they were both identified as black or both identified as brown for 3 out of the 16 participants. The col-ors should have been calibrated to eliminate ambiguity. As a result, some of the data collected which were completely inconsistent due to outside stimuli and unrelated to lexical organization, were discarded.

CONCLUSION

This experiment hypothesized that interference times would be relatively stable across all tested categories with a huge spike of interference in the category that included non-color naming words since a completely different cog-nitive process is suspected to be involved in retrieving words from a different category. This hypothesis was not supported, as the non-color naming word results were of comparable interference times to the others. Following from this conclusion, attention was deflected from compar-ing simple amounts of reaction time to where and why in-terference was occurring.

The varying competency levels of the participants posed a significant problem, as well as the multiplicity of languages studied. An in-depth study of one language would be more beneficial for future research. In addition, a more precise method for having the participants self-assess their own language ability should have been used: most notably the Likert scale, utilized by Delia Kothmann in her Stroop ef-fect experiment, which asks a series of questions relating to perceived ability in speaking, writing, and auditory compre-hension, as opposed to the nebulous interview questions

posed by the researcher in this experiment. It is necessary for further research to separate the subjects based on their language skills. If bilingual competency can be quantita-tively established, then the study can more evenly compare interference times, which would provide more telling re-sults, and could perhaps support a different model of bilin-gual organization.

The results of this study have shown that the Revised Hier-archical Model is not an adequate representation of lexicon organization. A new model (c.f. Fig 1.5) must be proposed that is not based on one language's strong link and the other language's weak link to the concept, but rather a dy-namic link, which can switch strengths (or the amount of neurological activity it receives from the brain) between the two languages, regardless of the proficiency level in either language based on the active language. This revision fully supports the results: if the stimulus is an English word and the task must be completed in a different language, there should be an easily measurable interference effect. In this experiment, it was found that the amount of interference between the two languages is completely dynamic. Since there is more interference when naming foreign mis-col-ored words in English, some type of different language mode is "switched on." With the results observed from the later part of the experiment, in which the English mis-col-ored words took longer to name in French or Spanish, it is evident that the bridge between the language and the con-cept is able to "switch back." Once in the French or Greek language mode (and vice-versa for results observed while in the English mode) it seems as if the brain suddenly decides to treat English words as if they are foreign and need to be translated before a decision about their ink colors can be made. In this way, the true complex nature of the bilingual is discovered, because if there are back-translating effects, they are happening from both directions.

In this model the stronger link which is shown in the Revised Hierarchical model is here intended to be dynamic and able to become the stronger or the weaker link depend-ing on what type of input is coming in. In addition, this model attempts to show the constant, bidirectional, back-translation effect.

To take this study of bilingual lexical organization further, it is clear that much attention and focus needs to be shifted from the various concept mediation models, all of which have some basis for merit, although the Revised Hierarchical Model, along with the recently revised model, based on the results of this experiment stand out as the most relevant and satisfactory. They focus on the mechanics and cognitive psychology surrounding "back translation" and its relevance to the idea of concept mediation, as discussed in Salamoura and William's paper. There is obviously a deeper neurological network that connects words to each other, as Kothmann notes in her "hidden units" in a parallel cognitive processing model. Parallel in that the Stroop task is taxing the attention, visual, and language centers of the brain, which far exceeds the scope of this psycholinguistic paper. This demonstrates that there is much going on below the surface of even the most intricate processing models.[xiii] The results provided by the interference in both the French-English bilingual task and the Greek-English bilingual task point to a strong correlation between the input language of the stimulus, the output language of the participant, and the related Stroop induced interference effects therein.

ENDNOTES

i Grosjean (1982)
ii Nicol (2001)
iii Nicol (2001)
iv Grosjean (1982)
v Bhatia and Ritchie (2004)
vi Kothmann (2004)
vii Kothmann Delia (2004)
viii Kothmann (2004)
ix http://psychclassics.yorku.ca/Stroop/
x Salamoura and Williams (2001)
xi Salamoura and Williams (2001)
xii Salamoura and Williams (2001)
xiii Salamoura and Williams (2001)

REFERENCES

Bhatia, Tej K., and Ritchie, William C.. 2004. *The Handbook of Bilingualism*. Blackwell Publishing Ltd.

Grosjean, Francois. 1982. *Life With Two Languages*. Harvard University Press, Cambridge, MA.

Kothmann, Delia. 2004. "Stroop Effect in Spanish English Bilinguals." MA thesis. Rice U.

Nicol, Janet L. 2001. *One Mind, Two Languages*. Blackwell Publishing Ltd., 2001

Rosselli, Monica, Alfredo Ardila, Mirtha Santisi, Maria Del Rosaria Arecco, Judy Salvatierra, Alexander Conde, and Bonnie Lenis. *Stroop Effect in Spanish-English Bilinguals*. Department of Psychology, Florida Atlantic University, Davie, FL. November 2001.

Salamoura, Angeliki., and John N. Williams. *Backward Word Translation: Lexical vs. Conceptual Mediation or 'Concept Activation' vs. 'Word Retrieval?'*. Research Center for English and Applied Linguistics, University of Cambridge.

http://psychclassics.yorku.ca/Stroop/