RUNNING HEAD: Second-Language Proficiency and Cognitive Advantages

Does Learning a Second Language Give College Students a Cognitive Advantage?

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Abstract

A correlation between the proficiency in a second language and performance on a divided attention task were investigated. College students were given a Spanish language test that measured language proficiency. The difference in scores between a primary task condition and the condition when the two tasks were completed together, paper and pencil mazes and digit monitoring, were hierarchally regressed against other variables such as Spanish ability and cognitive scores. A trend towards significance was found between the participant's Spanish proficiency and their performance on the divided attention task ($R^2 = .10$, $p = .08$). Implications from the study include support against the critical period hypothesis and for school second language requirements.

Does Learning a Second Language Give College Students a Cognitive Advantage?

Since the Middle Ages, educators have placed learning a foreign language on the periphery of their curricula. In the church, logic and mathematics were emphasized because they were thought to train the mind. Foreign language learning was focused on Latin and Greek and enabled students to read the Holy Scriptures. Modern languages were not introduced into schools until the 18^{th} century and were considered to be less of a "mental discipline" then logic and mathematics (Mora, 2002). Even today a pragmatic approach to second language acquisition dominates the thinking of educators: a second language introduces the student to another culture and fosters multicultural understanding, however, it does not train the mind as logics and mathematics do.

Research, however, is surfacing that looks at a deeper benefit of learning a second language, a cognitive advantage. An array of activities has shown a bilingual advantage. Hamers and Blanc (1989) cited in Bialystok (1992, p. 501) compiled evidence that demonstrates how bilinguals outperform monolinguals in reconstructing perceptual situations, verbal and nonverbal intelligence, verbal originality, symbol substitution, Piagetian concept formation, among others. Goetz (2003) found that bilinguals performed significantly better than monolinguals on "theory of mind" tasks, the ability to be aware of the intentions and beliefs of others (p. 10). One example of this is the false belief task. Children enter a room with a researcher. The researcher hides a pencil under a couch cushion in the room. The children are asked if their mother would know where the pencil was placed if they entered the room. Children with a "theory of mind" are able to discern that the information they have is not available to the mother. Although the participant knows the pencil is under the couch cushion because they viewed the entire scenario, they are able to take the perspective of the mother and recognize where her information ends.

On the surface the items seem disparate, but a longer look reveals that they all require attention. William James cited in Reed (2000) writes, "Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness is of its essence" (p.51). The quote focuses in on the necessity of humans to take possession of only one object with their mind despite the several options present. The limited capacity of the human information-processing system requires individuals to select the information they deem most important to attend to.

Daniel Kahneman's model of attention stresses its limited capacity. At any given moment, one is flooded with more stimuli than they are capable of attending to. Attention is explained with the use of a capacity model. With this type of model, individuals have a pool of attentional resources. The reservoir has a limited capacity yet allows freedom to the individual in deciding how to allocate mental resources, based on the present stimuli. Activities require different levels of mental capacity and individuals must choose how to allocate the energy based on present stimuli. Two types of activities, enduring dispositions and momentary intentions, require different amounts of energy. Enduring dispositions are automatic activities that attract our attention such as an object moving in our periphery or a sudden, loud noise whereas momentary dispositions reflect one's immediate goals (Reed, 2000, p. 61).

Selectivity must be utilized when dealing with a world of constant stimuli and a limited information-processing system. Since bilinguals perform better at tasks requiring attention and since selectivity is the backbone of attention, studies should focus on the selective attention of bilinguals. Bialystok (2004) suggests that a general bilingual advantage is seen in tasks that have misleading information and the necessity of choosing between competing responses, therefore requiring selection. For example Bialystok, (1986) and Bialystok & Codd (1997), showed that bilinguals performed better than monolinguals at grammatical judgment tasks where the sentences contained semantic anomalies. These sentences were grammatically correct and required children to avoid paying attention to the meaning of the sentence and rather control their attention towards the grammaticality (Bialystok, 2004, p. 326).

As one item is selected to be attended to, the individual must inhibit the competing items. Inhibition is, thus, a critical feature of attentional control. Both deal with the concept that many tasks require fixed attention to certain aspects of the problem while ignoring the other. Inhibition is used daily, for example, when choosing an outfit to wear. When the closet is opened a variety of shirts are presented. One must inhibit the motor act of removing the undesired shirts from the closet so that the chosen shirt can be simply picked. Bilinguals are constantly required to use this skill when speaking and listening to one language and ignoring the other. An example of the role of inhibition is demonstrated in the Simon Effect (1969). The concept refers to the idea that individuals will respond faster when the stimulus is in the same area as the response (Francis, et al., 2004, p. 4). Therefore, when the stimulus is predictable, less inhibition is needed. For example, if one computer key is used to signal that a red square is seen and another key on the opposite side of the keyboard is used with a blue square, responses will be more accurate and quick when the stimulus square is on the same side of the screen as the response on the keyboard. Bialystok (2004) found that bilinguals produced a smaller Simon effect, required less time to respond to incongruent stimuli, than monolinguals indicating greater inhibitory control with the misleading information.

Integration of future plans with past experiences in order to create a present course of action involves inhibition. Focus must remain on the task at hand. The dimensional change card sort developed by Zelazo and his colleagues (1995) places individuals in the presence of conflicting rules and requires attention to be only placed on one of them. When Bialystok (1999) used the dimensional change card sort task on bilingual children, they were asked to sort cards first on one perceptual dimension (i.e. color) and then subsequently sort the cards on another dimension (i.e. shape). When the participant was asked to sort based on opposite dimensions the bilinguals outperformed the monolinguals.

The many advantages of bilinguals have been linked to their selective attention abilities. Since an individual's information-processing system is limited, the ability to divide attention will be difficult and selection is required when stimuli compete for resources. Individuals who speak multiple languages must also constantly select the language they wish to communicate in while inhibiting the other. This added practice of language selection results in an advantaged cognitive component.

In the present study the effect the proficiency in a second language plays in an individual's ability to divide attention. Hakuta (2003) used census forms to look at immigrants' English ability as well as their age, age at immigration, and educational background. The results did not support the critical period hypothesis, but rather saw a steady decline in second language acquisition throughout one's life. I would like to further this finding, by studying whether the cognitive advantages are a function of one's ability in the second language and if the age the participants began learning the language played a role in the cognitive advantage. Is there a continuum between proficiency and cognitive abilities on tasks that demonstrate a bilingual advantage?

For the current study, I will be using Spanish students of all levels. A measure of Spanish proficiency will be acquired from a Spanish ability test. This will be correlated with the difference in the participant's ability to complete a primary task, mazes, and when dividing attention between the primary task and a secondary task, digit monitoring. Because the mazes do not require verbal skills they will be able to show cognitive advantages void of verbal abilities. I hypothesize that a relationship will be found between the level of the participants' proficiency in the second language (Spanish) and their performance on a divided attention task as seen in the speed they complete the mazes.

Method

Participants

There were 30 participants attending a small liberal arts college in the Midwest. The participants were between the ages of 18 and 21. There were women and men. The participants began learning Spanish between the ages of 5 and 18 with a mean of 14.

Materials

Cattell Culture Fair IQ Test

A culturally sound test that measures the individual intelligence of a wide range of ages was used. The test was used to look at abilities of the individuals beyond those of a verbal capacity. The test was administered in a group setting. The test provided percentiles (by age) and IQ. The four subtests were perceptual tasks (Completing Series, Classifying, Solving Incomplete Designs and Evaluating Conditions).

Questionnaire

The questionnaire asked for the participant's demographic information (age, sex, and primary language). The following questions were a personal assessment of the participant's Spanish ability. (See Appendix A)

Pencil and Paper (The Everything Kids' Mazes Book)

A series of pencil and paper mazes of varying difficulties were used. The goal of the task will be to correctly make it from the beginning to the end of the maze in 57 seconds. Two sets of nine mazes were matched for difficulty. The participants received two folders, each containing one set of mazes with one maze presented on each page. (See Appendix B)

Spanish Proficiency Assessment ((Cracking the AP Spanish Exam, 2004-2005 Edition (Princeton Review Series))

This test covers grammar, vocabulary, and sentence structure of the Spanish language. The test was paper and pencil and was comprised of multiple choice problems.

Procedure

The test involved two, one hour sessions. On the first testing day, the participants completed the tasks in a group. The consent form was signed; the evaluator administered the Spanish proficiency test. When this was completed, the cognitive test was given.

The participants were called randomly for the second portion of the experiment. The participant filled out the questionnaire before completing the divided attention task. The participant was read instructions about the components of the divided attention task (Appendix C). The researcher and research assistant sat behind and to the right of the participant. The primary task, the paper and pencil mazes first without the secondary task, was completed. The researcher collects data on the time taken to complete the mazes, stopping the participant when 57 seconds had elapsed. Before the divided portion of the task was run, a practice set of two mazes were given for the participant to become accustomed monitoring the digits. Data was not collected from this portion of the test.

The second half of the session involved the participant completing the primary task while also completing a secondary task. The secondary task was digit monitoring. A random series of digits were played on a tape player. When three odd digits were heard in a row, the participant was given the instruction to say “hit”. Hits, misses, and false alarms were recorded from the digit monitoring task; however, participants only received feedback on misses and false alarms. Data was collected on this task to ensure that the participant reached the threshold of activity. False alarms were also collected. The participants randomly completed the divided attention task first or second and the set of mazes with which they divided their attention was also randomized to account for order effects. Once the participant completed the maze activity they were given a debriefing form and were free to leave.

Results

Demographics were collected on the participants. There were six male participants and twenty-four females with ages ranging from eighteen to twenty-one. The Cattell Culture Fair Series test also had a fairly representative spread ranging from the 50^{th} to the 99^{th} percentile and a mean of 87.47 (SD = 13.60) The high value of the mean is validated due to the use of college aged participants on a measure of intelligence. The mean age that the participants began learning Spanish was 14.20, an average beyond the critical period. The range of 5 to 18 years indicated that some of the participants began learning the language during the critical period, but looking at the frequencies it showed that only one participant fell into the critical period range.

On the Spanish assessment participants answered between 27 and 80 percent of the questions correctly with a mean of 48.15 percent (SD = 14.12). Significant correlations between the participants' perception of their Spanish ability and their score on the Spanish assessment verified the validity of the measure. The correlation were as follows, Spanish & speaking($r=.58$, $p<.001$), Spanish & verbal comprehension($r =.57$, $p<.001$), Spanish & writing($r =.744$, $p<.001$), and Spanish & reading($r = .54$, $p<.002$).

Descriptives of the divided attention task were also looked at. In the digit monitoring task participants got a mean percentage of 46.79 (SD = 12.79) of the digits ranging from 24 to 84.30 percent. The mean of false alarms was 1.77 (SD = 3.45). Looking at the frequencies of the false alarms, two participants stood out as outliers; one having ten false alarms and the other sixteen.

In the mazes in which the participants divided their attention, the mean percentage completed was 59.25. In the undivided condition the mean was 60.36 percent.

Difference between the number of mazes completed in the divided attention was subtracted from the number of mazes completed in the undivided attention. The mean difference from this calculation was 5.56 percent (SD = 22.17). Figure 3 displays the mean percentage completed in the two conditions.

No significant difference between the numbers of mazes completed in the two conditions was found. This issue will be further talked about in the discussion. Due to this, data was looked at showing the difference in time the participants took to complete the mazes. When subtracting the time to complete the undivided mazes was subtracted from the time to complete the divided mazes a mean of .81 seconds (SD = 10.78) was seen.

A form of multiple regression, a hierarchical regression, was run on the data. A hierarchical regression allows for the researcher to enter the variable blocks individually and view the unique significance each block adds to the final model. The order in which the variable are entered is determined the theoretical importance the researcher places on each variable. In the present study, the data was broken up into four blocks. Spanish was the primary variable looked at in regards to the amount of variance it created in the difference in time the participants took to complete the mazes. The following block was the cognitive percentile score the individuals received on the Cattell Culture Fair Series Test. Third was the age the participant began learning Spanish. Finally, percent of digits hit and the number of false alarms were entered as the fourth block.

Table 2 shows the Beta, the unstandardized regression coefficient, β, the standardized regression coefficient, R, R^2, and R^2 change of each model. The first model, with only the Spanish variable, demonstrates a trend towards significance, $p = .08$, that is not seen in any of the following models. Ten percent of the variance ($R^2 = .10$) was a result of the Spanish test. The R^2 change demonstrates what the additional variable adds to the prior model. With model 2, the cognitive variable had an $R^2 = .07$; cognition only added seven percent to the variance in the time it took participants to finish the mazes, thus the $R^2 = .17$ when the entire model is observed. The change in $R^2 = .07$ is not significant. Therefore, cognition does not add to our ability to predict one's ability on the maze task based on their proficiency. In looking at table 2, no other variables beyond Spanish significantly increased the R^2.

Discussion

Roughly ten percent of the variance in the participant's time to finish the mazes was accounted for by their proficiency on the Spanish assessment alone. A trend towards significance was seen with the Spanish assessment ($p = .08$). It is important to note that ten percent allows for many other factors to be involved in dividing attention. However, the ten percent variance does illustrate that learning a second language does produce a cognitive advantage.

The divided attention task did not seem to evoke complete divided attention from the participant. The measure of the difference in percent of the mazes completed uncovers the lack of manipulation. When observing figure 3, the performance in the divided mazes conditions was not significantly different from performance that you would expect with the divided mazes. Due to the lack of other stimuli, the undivided condition can be considered the baseline. The divided attention condition nearly hits the baseline. The mean number of mazes completed was roughly fifty percent in both conditions indicating that the mazes were difficult enough. The secondary task does not seem to have been demanding enough to see differences in the amount of mazes completed. The mean score of hits from the participants was 46.79 percent and a minimum of 24 percent. In many cases participants must surpass seventy to eighty percent of hits in such digit monitoring tasks.

Various aspects of the method could be at fault for participants not dividing their attention. The use of a researcher and research assistant is one possible cause. These individuals sat behind and to the right of the participant in or to avoid distracting the participant; however, the use of two individuals may have been a distraction in and of itself. Thibaut and Kelley (1959) and Zajonc (1965) did research on the relationship between arousal and the presence of others. They found "arousal increases dominant responses, resulting in enhancement of simple or well-learned tasks but impairment of complex or unlearned tasks". Carver and Scheier's (1981) theory illustrates how self-evaluation can explain facilitation and inhibitory effects of the presence of others. If one is evaluated positively, the individual will continue to do well in a task. However, is the evaluation is negative the individuals motivation will decrease and will inhibit their ability to do well on the task (Blascovich, et al., 1999). The researcher only gave feedback on the misses in the digit monitoring task. This task was not well learned and the participant was only receiving negative feedback, possibly causing the participants' performance on the task to decrease.

One way to increase performance on the secondary task may be not limiting the time that the participants have to complete the mazes. This may result, however, in the participant's decreased motivation to finish the mazes as quickly as possible. They may, instead, focus more on the secondary task, digit monitoring, knowing that they are not being limited on time to finish the primary task, the mazes.

The trend towards significance suggests that significance would have been found with more participants. Tabachnick and Fidell's (2000) textbook, *Using Multivariate Statistics*, suggests that in such regressions there should be a minimum of four to five participants for each independent variable, although twenty participants is encouraged. In the current study, many more participants would be needed to see the true effects of a second language on an individual's ability to divide attention.

Debates continue to exist in regards to the critical period hypothesis for learning a second language. Researchers such as Penfield and Roberts (1959) and Lenneberg (1967) support the idea of a critical period for second language acquisition. The years before puberty are considered the years where the brain is most malleable to learn the second language to fluency, the same mechanisms that are at work after brain trauma (Hakuta, 2003). The study done by Hakuta, Bialystok, and Wiley (2003) used U.S. Census information of Spanish and Chinese immigrants. The findings showed that rather than a sharp decline in abilities, the ability to learn a second language steadily declined, rejecting the critical period hypothesis. In the current study, only one participant began learning the language before puberty, suggesting that the participants were still able to receive the cognitive benefits of a second language beyond the critical period. In future research, a cross-sectional design should be used to look at the differences between individuals who learned a second language during the critical period and those who began second language education beyond it. Perhaps the advantage seen in the current study is smaller than what would be seen in those who began the education earlier.

Prior literature deals mainly with bilingual children. The present study dealt with college students that were in the midst of gaining fluency in a second language. Finding a trend towards significance in the research suggests the cognitive advantage to be found despite neither the age when the education began nor the complete fluency of the individual.

Also, prior studies deal mainly with semantic tasks. For example, in Bialystok's (2004) study of bilingual children, she used a task of grammatical judgments. When looking at sentences that were grammatically correct but had semantic anomalies, bilingual were able to inhibit attention to the strange meaning and focus on the correctness of the grammar. When learning a second language, much emphasis is placed on understanding the minute details of the grammar. Therefore, a task of semantics would be much easier for the bilinguals. In the present study, the cognitive test and the divided attention task were void of all verbal components. This allowed the advantages to be attributed to cognitive as opposed to education.

Seeing that more proficient participants were better able to divide their attention than participants with less fluency suggests many advantages. The ability to divide attention leads to more efficient work in all aspects of life, not to mention their ability to communicate with the ever diversifying world. In group conversations, the individual would capable of keeping pace with the multiple directions of the talk. This may lead to quicker accumulation of knowledge and understanding. In the school or workplace, these individuals may be more qualified to do multiple tasks simultaneously such as absorb a lecture while also taking notes. The affect seen may have been small, but over a lifetime this information accrues and leads to large benefits for the individual. Noting that this research may be added to the multiple other advantages shown in individuals with second-language knowledge, the argument for increasing school requirements in this area would be amply supported.

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Table 1
Correlations of Score on the Spanish Proficiency Measure and Individual Scores of Spanish Abilities

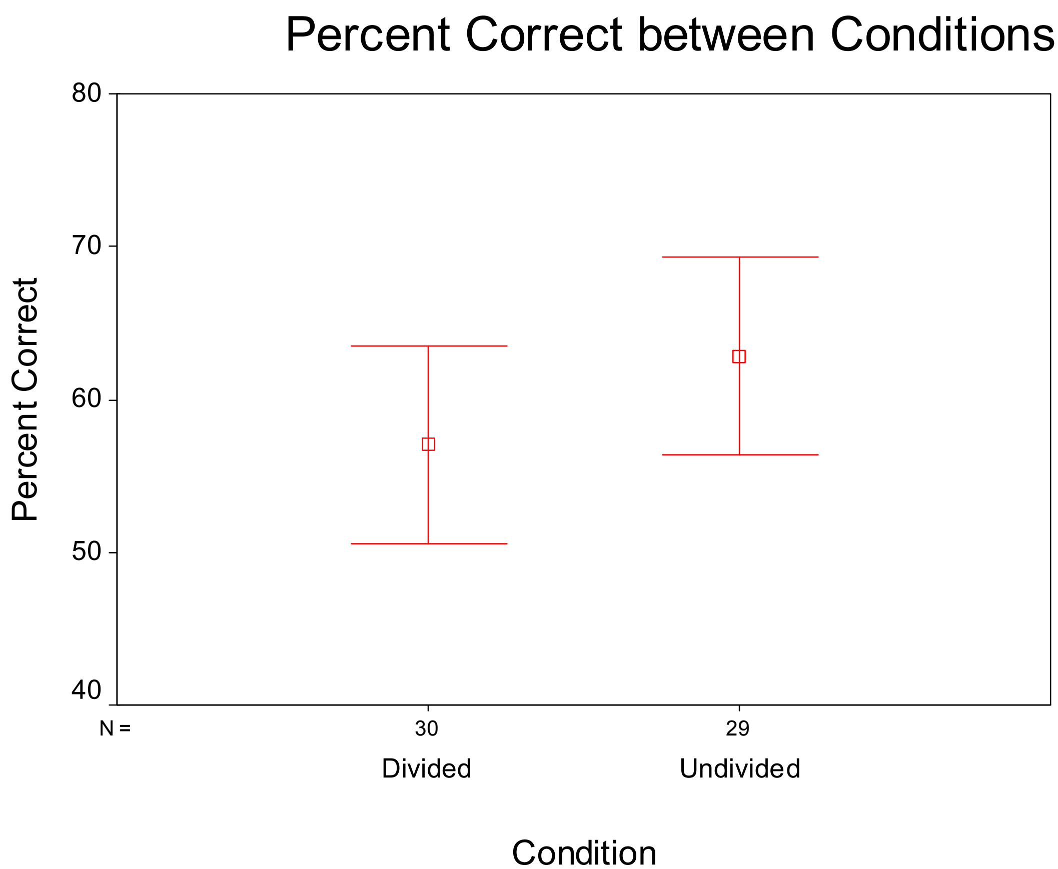
		Spanish	Cognitive	Age	Digit	False Alarms
Spanish	r	1	.18	-.41	.15	-.01
	p	.000	.351	.026	.418	.949
Cognitive	r	.18	1	-.33	.06	-.39
	p	.351	.000	.074	.771	.03
Age	r	-.41	-.33	1	.05	.01
	p	.026	.074	.000	.795	.964
Digit	r	.16	.06	.05	1	-.22
	p	.400	.765	.79	.000	.25
False Alarms	r	-.1	-.40	.01	-.22	1
	p	.949	.030	.964	.245	.000

Table 2

Hierarchical Regression on Difference in Time to Complete Mazes

		B	β	*p*
Model 1: Constant		12.58		
Spanish		-24.46	-.32	.08
	$R = .32$			
	$R^2 = .10$			
Model 2: Constant		-4.84		
Spanish		-28.19	-.37	
Cognitive		.22	.28	.07
	$R = .42$			
	$R^2 = .18$			
	R^2 change = .08			
Model 3: Constant		19.48		
Spanish		-35.84	-.47	
Cognitive		.16	.20	
Age		-1.09	-.28	.07
	$R = .49$			
	$R^2 = .24$			
	R^2 change = .06			
Model 4: Constant		33.17		
Spanish		-32.04	-.42	
Cognitive		9.79E-02	.12	
Age		-1.06	-.27	
Digit Percent		.20	-.23	
False Alarms		-.67	-.22	.1
	$R = .55$			
	$R^2 = .31$			
	R^2 change = .07			

Table 3
Percent of Mazes Correct in the Undivided and Divided Conditions



Appendix A

Questionnaire

Date of Birth: ____

Sex: (circle) M F

Occupation: ______________

Native Language: _______________

What is the primary language you use with your mother? __________________

What is the primary language you use with your father? _________________

What is the primary language you use with your grandparents? _____________

In what context(s) have you studied Spanish? (at home, at school, etc.)

____

At what age did you first begin taking Spanish classes? _____

How many years have you studied Spanish? _____

What was the average grade you received in your Spanish courses? _____

How many hours of Spanish homework did you complete per week? _____

Have you ever visited a Spanish-speaking country? For how long?

____

How often did you use the Spanish language while in the country?

(0% of the time) 1 2 3 4 5 (100% of the time)

Use the following scale for next four questions

(Poor) 1 2 3 4 5 (Strong)

How would you rate your Spanish speaking abilities? ________

How would you rate your Spanish verbal comprehension abilities? ______

How would you rate your Spanish written abilities? _____

How would you rate your ability to read Spanish text? _______

Appendix B

Appendix C

In this experiment, you are asked to complete a maze task. Complete each maze as quickly and efficiently as you can.

As you complete half of the mazes you will be asked to monitor a string of digits. I will play an initial practice tape recording of digits for you to practice the digit monitoring task. After this practice we will begin the task. Listen to the digits and when you hear a string of three odd digits, such as “1, 3, 5” or “9, 1, 7,” say, “hit.” Speak loud enough for me to hear you. Remember the odd digits are 1, 3, 5, 7, and 9. Once you have detected a string of three odd digits, start listening for the next string of three odd digits.

If you miss a string of odd digits, I will say, “miss.” This is to remind you to monitor the digits. If you say, “hit” when there was not a string of three odd digits, I will say, “false.” This is to remind you to be careful. Try to do well on both the mazes and digit monitoring. Don’t just focus on one task and forget to do the other.

You will be given 57 seconds to complete each maze. Don’t worry about keeping time; I will tell you when the 57 seconds has elapsed. If you finish a maze in less than 57 seconds, signal that you are finished and wait for my assistant to reset the watch before you begin the next maze. This will assure that you spend no more than 57 seconds on each maze. Please do not go back and attempt to solve a problem that you have worked on previously.