The relationship between second language acquisition and mathematics accomplishment among second graders

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Original Article

Abstract

Introduction: Study of bilingualism will enhance the understanding of the cognitive and neural mechanisms responsible for learning. Cognitive correlates of bilingualism such as enhancement of attention control, problem solving and working memory would be worth studying especially among young children to improve their future performances. Among the wide range of advantages of bilingualism, working memory enhancement was the focus of this study. The positive impact of working memory on mathematical skills has been highlighted in previous surveys. Hence, the present study intended to investigate the potential relation between second language acquisition (becoming bilingual) and mathematics achievement.

Methods: In this correlational study, 31 bilingual second graders who were selected randomly participated in the experimental group after a placement test that homogenized their second language learning background. The controls were also selected randomly from among the peers with no second language learning background. After eliminating the potentially influencing factor of intelligence, using Raven's test, a standardized math test was administered to the groups. The data was analyzed using SPSS program version 17. An independent t-test was applied to compare the results of the two groups.

Results: The experimental group (with a mean of 7.3529) outperformed on the Mathematics test than did the control group (with a mean of 7.0000). Yet the difference between the performance results was statistically insignificant ($P > 0.05$)

Conclusion: Since the finding of this study was contrary to the literature regarding the outperformance of bilingual children, the reason of such result would be worth seeking in further studies.

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Introduction:

There is a wide range of definitions for bilingualism as presented by different scholars: Bloomfield (1) considers bilingualism as native-like control of two languages with no shortcomings involved. Baker (2) defines bilingualism as not simply the ability to speak two languages but also the mastery over component of written expression. Other linguists are less strict. For instance, Titone claims that a bilingual has the capacity to hold a conversation in a different language (3). He maintains that such people manage to communicate without being perfectly proficient. Haugen expresses that "bilingualism begins when the speaker can produce complete, meaningful sentences in another language (4). Accordingly, anyone that acquires a foreign language is bilingual. Diebold considers anyone who knows a few words in another language as bilingual (5). He mentions "incipient bilingualism" which is the initial stage of contact between two languages. Diebold has a very open view on bilingualism and sees anyone who solely knows a few words of a foreign language as bilingual even if he/she is not able to link the words together. Edwards has also the same view and declares that anyone who speaks a few words of another language is bilingual (6).

Becoming bilingual is an economic and social asset in today's communication era when expressing one's thoughts could lead to arising international integration. On the other hand, since bilingualism and cognitive development are closely linked, it would be worth studying especially among children with the intention to improve their future performance. Bilingual individuals and children in particular, are valuable to study because of the fundamental issues that can be addressed, such as how language is represented in the mind and brain (7).

According to scholars who have a broader definition of bilingualism (5,6), we could consider children who benefit from early second language acquisition and have a little knowledge of a second language as bilinguals whose cognitive abilities could be studied. The developmental differences and cognitive benefits between monolingual and bilingual children in terms of awareness (8,9), enhanced meta cognitive skills (10); reasoning skills (11,12), problem solving skills (8,10), creative thinking skills (13), better learning strategies (14), enhanced cognitive flexibility (15) and last but by no means least, working memory (16-18) are distinctly highlighted. Different studies have indicated that bilingual perform significantly better on tasks that require managing attentional demands (7) also, Bilinguals benefit from advanced inhibitory control skills compared to monolinguals (19).

Bilingual children take advantage of a uniquely advanced skill called "executive functioning" (20). As it is presented, executive functioning is "an awareness to operate intentionally and an inhibition mechanism to suppress the more automatic responses of the lower levels" (19). This skill is vividly detected in bilingual children's ability to switch from one task to another efficiently. There is strong evidence that executive functioning is dependent on the neural systems of the prefrontal cortex (7) Studies on the improvement of critical thinking abilities due to bilingualism (3) recommend the necessity of bilingual education programs in elementary schools. Some scholars (21) even report how bilingualism casts changes on a person's native language. For instance, one of people's automated skills, reading in one's native language, is improved by the knowledge of a second language. This result would be encouraging especially for the improvement of children's school performance in this skill.

Since the link between bilingualism and cognitive development involves a wide range of benefits, it would be more practical if one of its aspects is considered at a time. Moreover, as the literature conveys, the cognitive advantages of bilingualism and early language acquisition have positive impacts on a person's performance. Children's school performance, which is under the influence of cognitive development, could be the basis of their future accomplishments. Hence it would be considered a main advantage that is followed by language acquisition and becoming bilingual. In addition to the cognitive advantages of bilingualism that were mentioned in the literature, it will be presented that working memory , especially has a close association with mathematics accomplishment as a school performance. Therefore, working memory was chosen as the cognitive correlate of bilingualism in this study.

There are inclusive findings that claim bilinguals' ability to inhibit one language while they use the other, may increase their working memory efficiency as working memory resources are controlled through such inhibitory processing (6,17,18). Other studies have been even more accurate by focusing on the "nature of the task" and concluding that bilinguals have greater working memory capacity on the tasks that require more attentional control (22). To get a better understanding of the relationship between working memory and early language acquisition, or as it is sensed in this study, bilingualism, it would be beneficial to have a closer view of working memory.

Working memory refers to a mental workspace that controls, regulates and maintains relevant information to fulfill complex cognitive tasks, for instance mathematical processing (23). Working memory is mainly specialized for storage and manipulation of information (24). The three-component model of working memory (25) expresses that at the core, there is the central executive which is responsible for controlling, regulating and monitoring cognitive complex tasks. There are two subsidiary subsystems, also called slave systems that have more limited capacities and are used for temporary storage of phonological and passive information. Both of these subsystems are in close contact with the central executive and are considered as "analogous to the original short-term memory concept" (26).

The contributions of main components of working memory to the development of mathematical skills in young children have been under research which has led to the conclusion that working memory plays an important role in both mathematical performance and skill development in young children (27). It has been reported that the central executive and phonological components predict mathematical reasoning skills (28). Yet, some reports are even more specific by adding that the executive system is the main predictor of children's mathematical problem solving (29). Scholars in this field maintain that working memory is closely correlated to many aspects of learning mathematics (30-32) and that children who progress excessively in early mathematics learning tend to have high working memory capacity (28). Working memory is proved to serve not only as assistance for mathematical problem solving in preschoolers, but also for complicated mathematical activities in older children and adults (Swanson, 2004).

On the other hand, surveys on mathematical disabilities in young children also prove its link with working memory (31,33,34). Differences in cognitive functioning between children who have math disabilities were also correlated primarily with the working memory. The role that working memory has in mathematics performance could be useful for treating "poor math skills in young children" and correct their disabilities (35).

According to the literature presented, positive impacts of bilingualism and second language acquisition on cognitive abilities, especially working memory is crystal clear. (16-18). Also the close link between working memory and mathematics accomplishment is evident. Hence, it could be concluded that second language acquisition is indirectly associated with the development of mathematical skills. There have been surveys in this field which claim that foreign language learners outperform monolingual control groups (36-37).

They emphasize that after one semester of foreign language study, 90 minutes a week, students got higher grades in math. Yet, the findings have remained to be confirmed and highlighted. In this regard, this study was conducted with an intention to assess the relationship between second language acquisition and mathematics accomplishment. This study was conducted on second graders who had a two-year background of second language acquisition. According to some scholars (3,5) that consider any person who knows even a few words of another language as bilingual, the participants of this study were considered bilinguals since they had the experience of second language learning.

Methods:

Based on the concept that second language acquisition develops working memory and the fact that mathematical skills are managed by working memory, the potential relationship between second language acquisition and mathematics achievement was investigated through this cross sectional study. In this regard, 50 second graders were selected randomly. Since the potential impact of early second language acquisition on mathematical skills was to be assessed, based on the reports of previous studies that were conducted on 7-to-11 year old children, second graders were selected. Children at this age, are already familiar with basic simple mathematical concepts.

A placement test was given to the participants in order to get a homogeneous group who are in the same level of L2. They were interviewed based on "Let's Go" series which is a proper textbook for this age group to learn English as a second language. The series starts with a "Starter" level and advances up to "Let's Go 5". Each of the volumes is usually taught in a 3-month term. The students who were in the level of "Let's go 2" were selected as the experimental group based on the literature that indicates after a semester of studying a foreign language, which was 90 minutes a week, students got higher grades in math (Armstrong and Roggers, 1997; Saunders, 1998; Andrade, 1989). After the placement test, 31 students were eligible to participate in the experimental group. Hence, 31 other students from among the participants' peers were chosen as the control group. The members of the control group were the same as the members of the experimental group regarding age and sex but did not have L2 acquisition background and were monolinguals.

In order to exclude the potential influencing factor of intelligence, an IQ test was administered. Raven intelligence test was given to both control and experimental groups. The mean and standard deviation were obtained to get a homogeneous group in terms of intelligence. Then a standardized math test containing 10 multiple choice items were given to the participants of both groups. Based on Shapiro-Wilks test and its histogram, the extreme grades were excluded and a normal distribution of grades was gained. Once the results were normalized, independent t-test was applied to compare the results obtained from the control and experimental group.

Results:

Fifty second graders were selected randomly in the first place. After the placement test, 31 students were in the same level of L2 (Let's Go 2) and were assigned as the experimental group. With the hypothesis that L2 learning and becoming bilingual has acted as a variable to increase working memory and mathematical achievement. Therefore, 31 other students from the participants' classmates who had no L2 learning background and were totally monolingual were assigned as the control group. Raven test was given to all the participants to exclude the potential impact of intelligence on math skills. Table 1 demonstrates the mean and standard deviation obtained from Raven test.

A normal range of students in terms of intelligence was found in which 24 students from the experimental group and 17 from the control group participated in the study. Then, a standardized math test which was exactly suitable for this group of participants was administered. The grades from the tests were normalized by Shapiro-Wilks test. The first step in using the independent-samples t-test is to test the assumption of normality. To test the assumption of normality, we can use the Shapiro-Wilks test. From this test, the Sig. (p) value is compared to the a priori alpha level (level of significance for statistics) and a determination is made as to reject ($p < a$) or retain ($p > a$) the null hypothesis. Null hypothesis is that there is no significant departure from normality, as such; retaining the null hypothesis indicates that the assumption of normality has been met for the given sample. The Alternative Hypothesis is that there is a significant departure from normality, as such; rejecting the null hypothesis in favor of the alternative indicates that the assumption of normality has not been met for the given sample. For this case, where $a = .001$, given that $P = .346$ for the Math result of control group and $P = .078$ for the Math result of Experimental group, we would conclude that each of the levels of the Independent Variable (Math test) are normally distributed. Therefore, the assumption of normality has been met for this sample. Table 2 illustrates the results.

Another significant step prior to using the independent-samples t-test statistical analysis is to test the assumption of homogeneity of variance. The Levene's F Test for Equality of Variance is most commonly used to test the assumption of homogeneity of variance. Based on the findings from table 3 and 4, ultimately, 17 students remained in the experimental group and 14 in the control. An independent t-test was applied on the results from the control and experimental groups the results of which are also present below.

According to the results, the t value is 0.997, which indicates that the experimental group got higher grades than the control group. However, a

Sig. (p) value that was greater than our alpha of .05 (P > .05) was gained.

Table 1. Mean and standard deviation from Raven Test

N		Mean	Std. Error of mean	Median	Mode	Std. Deviation	Variance	Minimum	Maximum
Valid	Missing								
57	0	25.33	0.836	26.60a	31	6.311	39.833	12	36

Table 2. Tests of Normality

	Kolmogorov-Smironv[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Math C	0.214	14	0.081	0.934	14	0.346
Math E	0.203	14	0.124	0.901	14	0.115

Table 3. Group Statistics

Group	N	Mean	Std. Deviation	Std. Error mean
Math control	14	7.0000	1.03775	0.27735
Experimental	17	7.3529	0.93148	0.22592

Table 4. Independent samples test

	Levene's test for equlity of variances		t-test for equality of means						
	F	Sig.	T	Df	Sig.(2-tailed)	Mean difference	Std. Error difference	95% confidence interval of the difference	
								Lower	Upper
Mat equal variances hassumed	0.060	0.808	-0.997	29	0.327	-0.35294	0.35388	-1.07671	0.37083
Equal variances not assumed			-0.987	26.496	0.333	-0.35294	0.35772	-1.08757	0.38169

Hence it was concluded that the control and experimental group didn't differ significantly on their Mathematic test performance. By examining the group means for this sample of subjects (as shown in the table 3), it is evident that the experimental group (with a mean of 7.3529) outperformed on the Mathematics test than did the control group (with a mean of 7.0000). Yet the difference between the performance results of the two groups is statistically insignificant.

Conclusion:

This was a cross sectional study in which the potential relationship between second language acquisition and mathematics achievement was under research. Recent surveys in neuroscience expand its link to education and explain that brain is a dynamic system. It is also stated that education plays a crucial role in shaping the brain's abilities. Neuroscience also sheds light on how language, literacy and mathematics are learnt (38). It has been highlighted that the brain makes and breaks connections, growing and strengthening the synapses that connect neurons to their neighbors, or shrinking them back. As a person is actively learning, the making of new connections outweighs the breaking of old ones (39). On the other hand, bilingualism and its cognitive correlates have been the focus of many studies and the cognitive developments such as attention control and problem solving have been highlighted (40). Systematic review Some scholars consider anyone who knows a few words of another language or has just begun to learn a foreign language, as a bilingual person (4,5). This was also the concept based on which the participants of this study were selected randomly from among children who had the background of learning English as a second language for at least 3 terms. The participants were considered bilinguals who benefited from the development of their working memory due to second language acquisition. Learning a second language increases the density of grey matter in the left inferior parietal cortex which leads to an enhancement in performance. However what is worth noting is that the age at acquisition affects grey-matter density. In a way that the younger the age of acquisition, the more dense the grey matter gets (41).

One of the important cognitive correlates of bilingualism is the development of working memory (16-18). It has also been demonstrated that math disabilities are linked to poor working memory (26). A lot of research has been conducted on children and has concluded the same (26,31) especially among children aged 7 to 11 years old (26-27) that was why the participants of this study were second graders. Since no literature was found to express the significant influence of gender on second language acquisition or math achievement, the participants were both male and female. After the potential influencing factor of intelligence was excluded from the field of the study, a standardized multiple choice mathematics test was administered among the participants and the results were compared with that of their peers who were assigned as the control group.

The findings of this study indicate that the children who had benefited from second language acquisition, outperformed in mathematics test compared with the ones who were monolingual and knew just their mother tongue. This result is just as was predicted from the reports of other studies in terms of the development of working memory due to second language acquisition systematic review and also the fact that math achievements are increased under the influence of enhanced working memory (26-27).

Consistent with previous studies (34,42) the results from the present study provides evidence for the relationship between working memory and math achievement. Yet the difference between the math performance of control and experimental group was statistically insignificant which makes the findings contradictory to the hypothesis that second language acquisition has a positive impact on working memory and hence on math achievement.

Therefore further investigation is suggested in this regard. This might be worthy to note that this was a retrospective cross sectional study which had little monitoring over the process of second language acquisition and working memory development. Hence the nature of the relationship between working memory and math achievement under the influence of second language acquisition could not be determined thoroughly. It is suggested to monitor these two influencing factors of math achievement over a follow up period of at least one year so that the results could be more accurate.

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