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BILINGUAL BENEFIT IN COGNITIVE FLEXIBILITY

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## **Abstract**

The purpose of this study is to examine the relationship between cognitive flexibility and the number of languages that a person speaks. We focused on comparing monolinguals and bilinguals to examine cognitive flexibility differences between them. Through this, we aim to investigate whether bilinguals have improved cognitive flexibility. Based on the literature, we hypothesized that second language learners have higher cognitive flexibility than monolinguals. The data did not support our hypothesis, we did not find any significant difference between the monolingual and bilingual participant groups. This could be due to a number of limitations of our experiment, including the ongoing COVID-19 pandemic.

## **Theoretical background**

Cognitive abilities vary greatly across individuals due to many factors including genetic predisposition, education, upbringing, and other challenges. Second language users who are bilingual speakers are faced with the additional challenge of having to resolve the competition that may arise from simultaneous activation of representations from both languages (Colome & Miozzo, 2010; De Groot, 2011; Kroll, Bobb, Misra, & Guo, 2008). Such coactivation and the need to eliminate non-salient information may occur at any stage of the language production process. A growing body of research examines how facets of the bilingual experience, such as the age of language proficiency, and language usage may mediate improved executive functions (Kapa & Colombo, 2013). Bialystok (2011) suggested that bilingual individuals have improved language control processes and executive functions (that is, skills that allow an individual to inhibit dominant responses, shift between mental sets, and monitor and update information in working memory), due to the constant practice in language coordination, monitoring, and switching.

## **Cognitive flexibility**

Cognitive flexibility refers to the ability to switch between thinking about two different concepts or to think about multiple concepts simultaneously. In animal models and also for humans, cognitive flexibility generally refers to the ability to switch a behavioral response according to the context of a situation (Scott, 1962). Cognitive flexibility plays a role when we face an obstacle, is responsible for updating our belief system to update new or better information, and helps us analyze a situation or decide a plan to fulfill our goals. The difference between monolingual and bilingual is that bilinguals have a bicultural perspective because using two languages means understanding both countries' cultures combined. Like the switching system going on between language and cultural perspectives, language use causes cognitive

flexibility to be improved. As evidence, “There are suggestions that the increased levels of proficiency and usage enable increased switching languages that lead to higher practice effects and improved executive control. It fits with other suggestions that bilingual individuals have higher improved language control processes and executive functions.” (Bialystok, 2011)

Executive function (EF) includes working memory and flexibility. This is also relevant to multitasking which is a concept that can focus on one or more tasks and activities at the same time. EF is correlated with cognitive and multitasking abilities. Human cognition and human action become controlled mechanisms that lead to the goal. Crucially, multitasking is also strongly dependent on EF. The central argument of the current study, therefore, is that bilingual language use is a special case of multitasking and the claim is that the use of EF to manage attention to two languages strengthens EF processes for other purposes. This implies that bilinguals should be better multitaskers than monolinguals. This argument is supported by a large body of evidence showing that all the EF components are enhanced in bilinguals, both for children (for meta-analysis, see Adesope, Lavin, Thompson, & Ungerleider, 2010), and adults. Research has shown, for example, that during task switching, bilinguals recruit more brain areas related to language control than monolinguals, which implies that the neural circuitry involving control differs for monolinguals compared to bilinguals (Rodri' guez-Pujadas et al., 2013).

Moreover, lifelong bilingualism was found to be associated with a general improvement in selecting goal-relevant information from among competing, goal-irrelevant information (Colzato et al., 2008; Hommel, Colzato, Fischer, & Christoffels, 2011; Khare, Verma, Kar, Srinivasan, & Brysbaert, 2013). These research findings show that bilinguals demonstrate improved EF, multitasking, and other cognitive performances compared to monolinguals. This study aims to find whether second language learners have higher cognitive flexibility than monolinguals. In the context of this study, we define native speakers (who have not learned a

second language) as monolingual and second language learners, with high proficiency in their second language, as bilingual.

The present study hypothesizes that second language learners have higher cognitive flexibility than native speakers. For this experiment, we will recruit one group of participants who speak only Korean, and another group consisting of Koreans who learn English as a second language, and are proficient enough in their second language to attend University in English. Cognitive flexibility will be measured through the Stroop test and Reading Span test.

The Stroop test (Stroop, 1935) is designed to compare the interference of conflicting color and word meaning. The participants are instructed to name the ink color of the words, while the word meanings refer to different colors than the actual color of the ink. This test was used to measure the ability to inhibit cognitive inference and measure processing speed and overall executive processing abilities. The Reading Span test will be used for measuring working memory related to cognition and language abilities and we used a Korean Reading Span test modified after the one used by Park et al. (2016). The operation span test will be used to measure non-linguistic cognitive abilities.

## **Methods**

### **Participants**

For this experiment, a total of 60 participants were recruited through email, 30 monolingual Korean-speaking participants, and 30 bilingual speakers of Korean and English. All participants were informed and provided the opportunity to ask questions before they voluntarily consented to participate. This study was approved by the University of Utah IRB.

### **Procedure**

We met participants both in-person and online after having a discussion about how they

wanted to participate in this experiment. We made the experiment material with a presentation showing the Reading Span, Operational Span, and the Stroop test in order. Park, et al (2016) introduced Korean Reading Span (KRST), therefore we used it for the participants whose first language was Korean. Operation span is another version of remembering numbers instead of language like KRST, and this measurement was also used after reading span. For the RS and OS, we made the answer sheet and checked the answer immediately that the participant responded. Also, for the Stroop test, we measured the time and checked the answer at the same time. The control version is that the ink color and the words are identical and the experimental version is that the ink color and the words are different. After we collected all of the participants' answers and the times, we used SPSS to analyze the statistics.

## Result

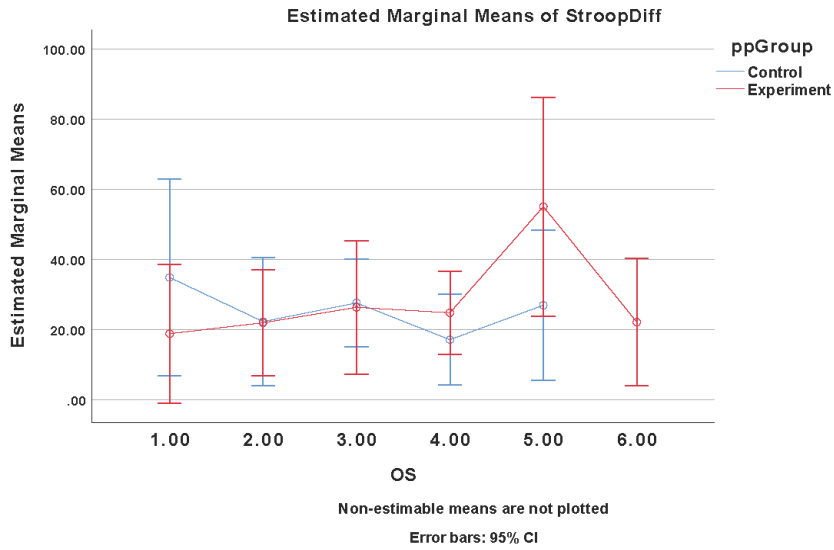


Figure 1: In this graph, the difference in Stroop response times (StroopDiff) is graphed as a function of Operation Span score (OS) for the two participant groups: The control group is the Monolinguals (blue line) and the Experiment group is the Bilinguals (red line).

### Descriptive Statistics

Dependent Variable: StroopDiff

ppGroup	Mean	Std. Deviation	N
Control	24.3000	17.78831	30
Experiment	24.9333	11.06387	30
Total	24.6167	14.69012	60

### Tests of Between-Subjects Effects

Dependent Variable: StroopDiff

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2116.043 <sup>a</sup>	7	302.292	1.481	.195
Intercept	1159.628	1	1159.628	5.680	.021
ppGroup	73.564	1	73.564	.360	.551
RS	143.920	1	143.920	.705	.405
OS	94.634	1	94.634	.464	.499
ppGroup * RS	109.047	1	109.047	.534	.468
ppGroup * OS	958.000	1	958.000	4.692	.035
age	38.128	1	38.128	.187	.667
ppGroup * age	206.121	1	206.121	1.010	.320
Error	10616.141	52	204.157		
Total	49091.000	60			
Corrected Total	12732.183	59			

a. R Squared = .166 (Adjusted R Squared = .054)

Table 1: Summary of the ANCOVA between-subject effects. There was only one significant interaction between ppGroup and Os ( $p=0.035$ ).

The goal was to investigate whether the monolingual and bilingual group scored differently on our measure of cognitive flexibility: the difference between the baseline Stroop test (without color/word incongruence) and the interfering Stroop test (with color/word incongruence) from here on referred to as StroopDiff. In order to investigate potential differences between the monolingual and bilingual participant groups, a between-group ANCOVA was performed on the StroopDiff data, with covariates Reading Span (RS), Operation Span (OS), and age. The between-subject effects are listed in Table 1. There is no significant main effect of the participant group (ppGroup), i.e. the StroopDiff did not differ significantly between groups, even when compensating for RS, OS, and age. Each covariate, OS, RS, and age did not appear to affect Stroop Diff significantly either.

We were curious to see whether there might be a significant interaction between the covariates and ppGroup, and as you can see from Table 1, only the interaction between ppGroup and OS was significant ( $F(1)=4.692$ ,  $p=0.035$ ). See Figure 1 for a graph of the StroopDiff for each of the groups (control=monolingual in blue, and experimental=bilingual in red) as a function of OS. The significant interaction appears to be driven by the difference between monolingual and bilingual participants with an OS score of 5 only, for the rest of the OS scores, the two lines appear to fully overlap, suggesting that the “significant interaction” is most likely not a real effect, but due to outliers or measurement noise.

## **Discussion and Limitation**

Due to COVID-19, the environment when participating in the experiment was different from the usual experiments. There were insufficient participants because it was difficult to recruit subjects due to the COVID-19 situation. There were 30 people per group ( $n=60$ ). Also, there were some complicated situations when the experiment was conducted at home, in a cafe, or in a classroom because of COVID-19. In research from Klatte et al. (2013, p. 3), the unstable



situation might have affected the participant's concentration and comfort to take a test. Irrelevant sounds with a changing state characteristic automatically interfere with the maintenance of item or order information in short-term memory. For example, there is a difference in concentration between outside cafes with noise around and comfortable rooms in the house since there was a difference between experiments conducted face to face and online. Concerning tasks that do not involve auditory targets, studies with adults have consistently shown that especially short-term memory is sensitive to the negative effects of noise. Immediate serial recall of visually presented verbal items is reliably impaired task-irrelevant sounds (Hughes and Jones, 2001; Beaman, 2005; Schlittmeier et al., 2012 as cited in Klatte et al., 2013)

In the current studies, the participants were classified as bilingual and monolingual. However, within the bilingual group, the familiarity of the languages of the participants was different for each of them. Some participants were comfortable with Korean, however, some of the participants were not very fluent like the other Koreans that are using Korean in their native language because the participants grew up in other countries with other language uses. According to Souza, Byers-Heinlein, & Poulin-Dubois (2013), both monolingual and bilingual preschoolers preferred to be friends with native-accented speakers over speakers who spoke their dominant language with an unfamiliar foreign accent. This result suggests that both monolingual and bilingual children have strong preferences for in-group members who use a familiar language variety and that bilingualism does not lead to generalized social flexibility. Therefore, for the participants who are more familiar and comfortable with Korean, the experiment was conducted under more favorable conditions than for those who are not. Furthermore, the criteria for determining whether the participants were bilingual or monolingual were very ambiguous. It is difficult to distinguish that participants are bilingual only with the time they are exposed to

English. There are differences between each person because of the differences in their life patterns. It happened even if people were enrolling in English universities.

Therefore, a clear distinction of language use between the two groups was needed. Bilingual participants should have been based on people who speak both English and Korean fluently enough. It was hard to produce accurate results unless with the strict standard with determining the participant bilingual or monolingual. It is also important with a person's adaptability to the experiment. It was one of the factors that determined the result. When the experiment was started without full adaptation to the participant, the higher level goes, the higher understanding that participants get. This is the learning effect and it occurred when the participants gradually understood the experiment and adapted to it so that they could easily solve the problem and get higher scores than before. Since then, the score has been better when they are fully understood by the experiment. There were cases where the person did not understand at first, but the higher the level, the better the score was.

In sum, there was a lack of participants because it was difficult to recruit subjects due to COVID-19, and the environment when participants participated in the experiment was inevitably different due to COVID-19. In addition, when the participants were classified as bilingual, their familiarity with their own language, which the person mainly used, was different. Since the exposure to each other's language was different, this affected the experimental results. Furthermore, the criteria for monolingual and bilingual were not clear. When it comes to being bilingual, the English skills differ from person to person depending on how well they use English. An accurate baseline was needed to distinguish this. Moreover, the speed that the person adapts to the experiment also influences the results. Even if the difficulty level increased, after the participant adapted to the experiment, the accuracy of the answer increased.

## **Future research**

For future research, our recommendation is to certainly clarify the hypothesis. If the future research aims to connect language with the cognitive level, it would be more certain to be based on the ability to speak a second language than the number of languages. Secondly, the researcher should determine the criteria strictly for bilingual classification. For example, it is important to set the level of ability in all four areas such as reading, writing, listening, and speaking to be defined for a second language. Distinguishing the bilingual and monolingual by accurate and strict criteria, significant results may come out. In advance, if the future research is conducted by setting the monolingual participants with only from Korea or the United States like the present research, the experiment should be set in one language for each participant; Korean or English (in this case, you have to make sure of the bilingual classification as we mentioned above). However, if the future research is conducted by setting the participants including both native Korean and American monolinguals, the experiment should be conducted within two languages; Korean and English. For the present research, among bilingual participants, the experiment should have been conducted in Korean for the participants who are more comfortable or familiar with Korean and also in English for the participants who are more comfortable or familiar with English. In addition, for the number of participants in the present research, the low number of the subjects might have affected the result inevitably. Increasing the number of subjects will be needed in future research for significant results. The difference in the environment of the participants while they did the experiment might have affected the results. Therefore, unifying the experimental environment, for example, in the laboratory or in a quiet room for the participants to concentrate on it will be necessary to the future experiment.

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