The International Research Foundation
for English Language Education

Title of Project:
Bilingualism and Cognitive Control: A Comparison of Sequential and Simultaneous Bilinguals

Researcher:
Jin Bi
University of Utah
qxiaoqing@gmail.com

Research Supervisor:
Dr. MaryAnn Christison
University of Utah

Jin Bi

Final Report

Motivation for the Research

Previous studies on bilingualism and cognitive control suggest that mastering a new language brought about positive transfer to general cognitive processing in young bilinguals. However, late bilinguals (i.e., people who acquire a second language later in life), who make up the majority of bilinguals in United States, were underrepresented in these studies. Some studies (e.g., Luk, De Sa, & Bialystok, 2011) used a small sample size and concluded that there was no cognitive processing difference between late bilinguals (second language learners who started relatively later in life and who had not achieved advanced proficiency) and monolinguals. This dissertation study compared an early bilingual group with two late bilingual groups—one with high and low proficiency—in order to examine whether the cognitive processing advantage observed in bilinguals was associated with age of acquisition (AOA), language proficiency, or with innate phonological working memory (WM) capacity. In addition, previous studies often used interference control tasks as a measurement. This study added a response inhibition task to examine whether a positive transfer could be observed in a different type of cognitive processing task.

Research Questions

1. Do the three groups of bilinguals differ in WM capacity, as measured by the reading span task?
2. Are there significant differences in the three groups of students' performances on the stop-signal paradigm, which measures response inhibition?
3. After dividing students into high and low span groups based on their Reading Span score, are there significant differences in their performance on the stop-signal paradigm and the Simon task?

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4. What are the relationships among the dependent variables (reaction times [RTs] and Accuracy) in the stop-signal paradigm?
5. Are there significant differences among the three groups of students in their performance on the Simon task?
6. What are the relationships among the dependent variables (the RTs and Accuracy) in the Simon task?
7. Can WM capacity predict performances in the stop-signal paradigm and the Simon task?

Methodology

Data were collected from 181 college students between the ages of 18 and 35. They were divided into three groups based on their AOA, namely early bilinguals, late high proficiency bilinguals, and late low proficiency bilinguals. Data on cognitive control capacity were collected through three lab tasks that measured working memory capacity (WMC), response inhibition, and interference control, respectively. Experiments were conducted in a computer lab, and participants completed three tasks in the following order: Reading Span, Stop-signal Paradigm, and Simon task. All tasks were conducted in English. A five-minute break was given between each task, and participants were free to take longer breaks if requested. At the end of the experiment, participants were asked to complete an online questionnaire about their language background, proficiency level, and language learning experiences. The entire experiment session for each participant took between 1.5 and 2 hours.

Data Analysis

In Reading Span task, participants with reading accuracy that fell below 85% were excluded from analysis. In Stop-signal paradigm, participants with overall no-signal correct response accuracy (NS-HIT) <66%, or probability of inhibiting (p(r|s)) <13% or >85% were excluded from analyses. In Simon task, trials with RTs <200ms or >1500ms were excluded from all analyses. Data from all three tasks were analyzed with SPSS 22 for descriptive and inferential statistics (*T*-tests, ANOVA, and regression). Then structural equation modeling (SEM) was used to examine the effect of WMC by formulating three conceptual models. These models were later tested using AMOS 21 to see how well these data fit.

Summary of Findings

1) No significant difference in WMC was found among the three language groups with varying age of acquisition (AOA) and foreign/second language (L2) proficiency.
2) While no significant influence of WMC on interference control was found, individuals with high WMC showed greater flexibility at balancing automatic and controlled processes to cope with task demands, and had better resistance to distracting stimuli.
3) Successful inhibition of prepotent responses was associated with higher WMC, later AOA, and higher language proficiency. Compared with early bilinguals, late bilinguals were able to tolerate higher levels of automatic response activation and had a cognitive processing edge in tasks requiring response inhibition.
4) Successful interference suppression was associated with higher WMC, earlier AOA, and

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higher language proficiency. Early bilinguals exhibited a processing edge in interference control when attentional demands were high.

Implications

This study adds to the existing literature related to the cognitive processing of bilinguals by including bilinguals that were not commonly studied in previous research, such as late bilinguals with diverse AOA, some as late as 19-years-old, and bilinguals who were not proficient in their L2. In addition, rather than strictly controlling the language background, the present research incorporated participants who spoke a diverse range of L2s and who self-identified as non-native speakers of English but were highly fluent or native-like in English. Therefore, a diverse sample added to the generalizability of this research.

Additionally, the present study found an early bilingual advantage in interference suppression, and a late bilingual advantage in response inhibition. Although neither was statistically significant due to the small sample size and a lack of power, this finding suggests that late bilinguals with low to intermediate proficiency should not be put in the same category as monolinguals, as some earlier studies have done (e.g., Luk et al., 2011). Furthermore, the late bilingual advantage in response inhibition seems to suggest that a relatively late AOA and high L2 proficiency may produce a cognitive processing network distinct from that of an early bilingual, although this needs to be confirmed by imaging studies. The finding that different language processing demands lead to distinct patterns of cognitive processing provides support for the adaptive control hypothesis (Green & Abutalebi, 2013). It is also likely that factors that have not been considered in previous studies, such as motivation, shape the neural network for cognitive control, as in general, it takes more effort for individuals with late AOA to achieve high L2 proficiency, compared with early bilinguals. Findings from the current study point to the possibility of long-term cognitive benefits of different types of foreign language programs (i.e., both immersion and traditional classroom learning), suggesting that people with late AOA can still benefit from traditional classroom instruction. The differences in cognitive processing patterns between early and late bilinguals would suggest that they may have relied on different learning strategies to achieve proficiency. Therefore, foreign language instructors should be aware of the fact that heritage language learners who may have been exposed to the target language from birth and traditional foreign language learners have different ways of processing languages even if their proficiency levels are similar. Although researchers have not yet looked into monolingual adults who started learning a new language at advanced ages, it is possible that learning new languages could enhance cognition regardless of age.

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