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The Cognitive Benefits of Multilingualism on the Executive Function of Inhibition

Multilingual individuals have been observed to possess enhanced cognitive capabilities in comparison to monolingual individuals. In this study, we compared the abilities to inhibit automatic, obvious answers between monolingual and multilingual individuals. It was hypothesized that monolinguals will have more difficulty inhibiting automatic correct answers than multilinguals. Forty-five monolinguals and 44 multilinguals were assessed for cognitive control. Participants were shown 24 individual images of a coloured object (e.g., shown a green apple) and were simultaneously told the colour of the depicted object (e.g., the experimenter said, "green apple"). For half the shown objects, the colour mentioned was the same as the colour shown (e.g., a green apple is shown and the experimenter relays "green apple") and for the other half, the colour depicted was different from the colour relayed (e.g., a red apple is shown and the experimenter relays "green apple"). Participants had to evaluate whether the image matched the verbal description and say the incorrect answer; if the image depicted matched the relayed statement, the participant had to say "false" (e.g., seeing an image of a green apple and hearing "green apple") and if the image depicted did not match the relayed statement the participant had to say "true" (e.g., seeing an image of a red apple and hearing the statement "green apple"). Multilingual individuals performed significantly better on the inhibition task compared to monolingual individuals ($t_{(87)}$ = 9.8, $p < 0.0001$, $d = 2.08$). These results corroborate past findings that multilingual individuals show enhanced cognitive control required in inhibition. The acquisition and maintenance of many languages appear to be of significant benefit to cognitive abilities.

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BACKGROUND

Executive function is a set of higher-order functions that optimize and schedule lower-order functions necessary for cognitive control (Miller, 2001). A type of cognitive control is inhibition; it is defined as the resistance to interference from attention-capturing processes or contents (Lustig et al., 2007; Harnishfeger, 1995). The executive function system directs attention, allowing us to maintain focus, switch focus, and hold information. Inhibition is the method by which one is able to attend, process, and respond to selective stimuli when many other sources of information must be suppressed in order to avoid undesired responses or behaviours. This type of cognitive control is an intrinsic daily requirement of multilingual individuals. This study examines whether multilingualism confers an advantage to the cognitive control of inhibition even when dealing with visual stimuli.

Research conducted by Marian and Shook (2012) has shown that, compared to monolinguals, bilingual individuals have more effective attention and task-switching capacities. When a multilingual person is using one language, their other known language(s) are not in cognitive use and models of bilingual language processing have postulated that active cognitive inhibition occurs to suppress the non-target language (Green, 1998). The multilingual brain frequently accesses cognitive control mechanisms while switching between different languages (Marian & Shook, 2012; Bialystock, 2009). While inhibition is necessary for all individuals, its necessity for multilingual individuals is constant and recurrent as it is exercised every time an individual engages in verbal or auditory actions in either language.

Within the surveyed research, studies on multimodal inhibition in multilingual individuals have not been widely explored. The present study aims to add to the previously discussed body of literature by examining whether the suggested inhibitory advantages of multilinguals can be generalized to cognitive domains, such as the visual and auditory domains.

This article examines whether multilingual individuals have enhanced cognitive inhibitory mechanisms as measured by an inhibitory control task. The inhibition task chosen is inspired by Knott et al. (2011) who used a true and false recall mechanism as a measure of cognitive inhibition in adults and children as it pertains to memory. In their study, participants were shown flash cards of matched events—viewed an image and heard its correct description (e.g., viewed a grocery list and heard "this is a grocery list")—or of unmatched events—viewed an image and heard a description providing an incorrect description (e.g., viewed a grocery list and heard "this is a price tag"). Participants were asked to answer "false" to the matched events, and "true" to the unmatched ones; spontaneous, correct answers had to be inhibited in order for the incorrect answers to be relayed. The researchers concluded that although adults inhibited more correct answers better than children, children over the age of 5 still possess the inhibitory mechanisms needed to succeed in the task.

Presumably, multilinguals would do well at a similar task. It is postulated that this will be the case for multilinguals who have been using their non-native languages for a long time and do so frequently in their activities of daily living. Luk and Bialystok (2013) show that multilingualism is a multidimensional construction with two linked parts: language proficiency and language use. These two parts would interplay for good inhibitory control. Indeed, Heidlmayr et al. (2014) suggest that the efficiency of bilinguals' inhibitory control is impacted by the frequency of use of their second language in their daily life. In this study, the multilingual participants will be individuals who speak English as their first language in addition to having been speaking one or more non-English languages for at least eight years at home, school, or work (language proficiency) and have been speaking more than one language regularly and consistently in their daily life (language use).

Multilingual brains may have more efficient inhibitory control function due to years of maintaining conversations in one target language while reducing interference between languages. Heidlmayr et al. (2014) concluded that multilinguals were better able to suppress interfering information to complete the task at hand. If multilingualism results in an increased efficiency of the executive cognitive control of inhibition, it is here predicted that multilingual participants will be more accurate at giving the incorrect answer instead of the automatic, obviously correct one in comparison to monolingual participants (e.g., stating "false" when seeing a red apple and hearing "red apple").

METHODOLOGY

Participants

Undergraduate students from Glendon College, York University in Toronto, Canada, were recruited. Forty-five monolingual English-speaking students (21 females; 24 males) between the ages of 18 and 26 years old (M=22.08, SD=2.30), and 44 multilingual students (26 females; 19 males) between the ages of 18 and 26 years old (M=20.93, SD=2.37) participated. To be classified as multilingual, participants had to match the following definition: "A multilingual individual is someone who has been consistently speaking more than one language for the last eight years in a home, school or work environment." The mother tongue of all multilingual participants was English and they additionally identified all other languages in which they were fluent. Out of the multilingual students who participated, 27 were fluent in two languages, 15 in three languages, two in four languages, and one in six languages.

Materials

Six simple objects (a heart, a chair, a shirt, a pencil, a book, a flower) were drawn on flashcards. Each object was shown twice—each time in a different colour (red, green, black, or blue)—for a total of 12 flashcards. Each flashcard had an illustration of a coloured object on its front (e.g., a red apple) and a written description of what the experimenter would say on its back side, which would not be visible to the

participant. The back always described the object shown (e.g., an apple) but with a matched (e.g., red, Figure 1) or unmatched (e.g., green, Figure 2) colour. Two flashcards were used during practice trials (Figures 1 and 2).

Figure 1. Example Flashcard of a MATCHED Scenario

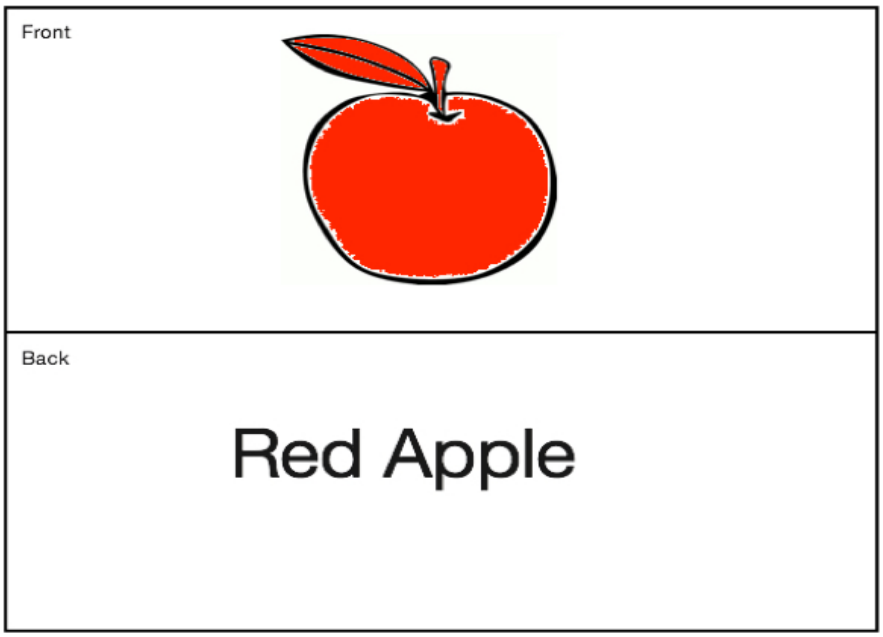
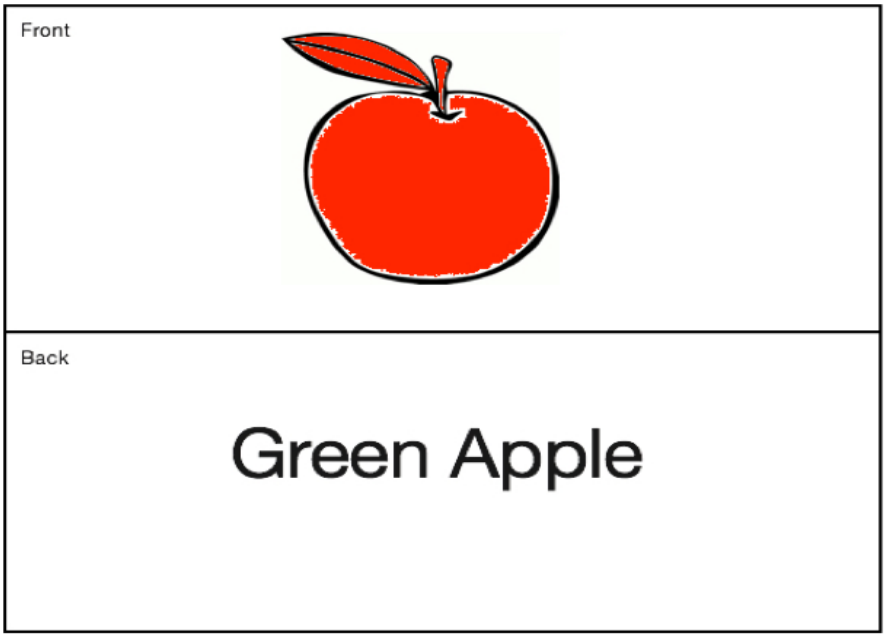


Figure 2. Example Flashcard of an UNMATCHED Scenario



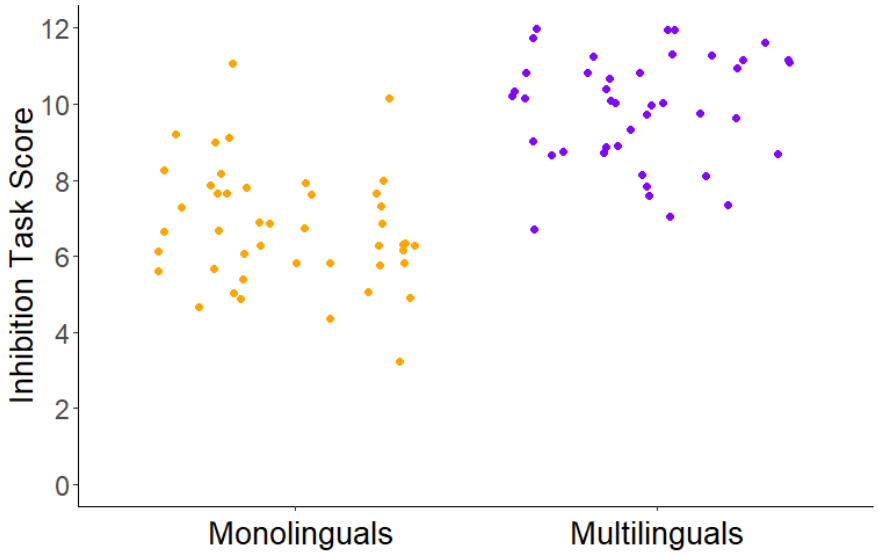
PROCEDURE

Each participant was shown the 12 flashcards in a different randomized order. After seeing each card and hearing its description, they had to say the reverse from the automatic, obviously correct answer—that is, if the description matched the object, they had to say "false" and if the description did not match the object, they had to say "true." Thus, for example, counter-intuitively, when a red book was seen and described as a red book, participants had to say "false," and when a black chair was seen and described as a green chair, they had to say "true." Participants had two seconds to state their answer. One point was awarded for each given answer that was the reverse from the automatic, obvious one. No point was given if an answer was not provided within two seconds. The participant total score was out of 12 and will be hereafter referred to as the inhibition task score.

RESULTS

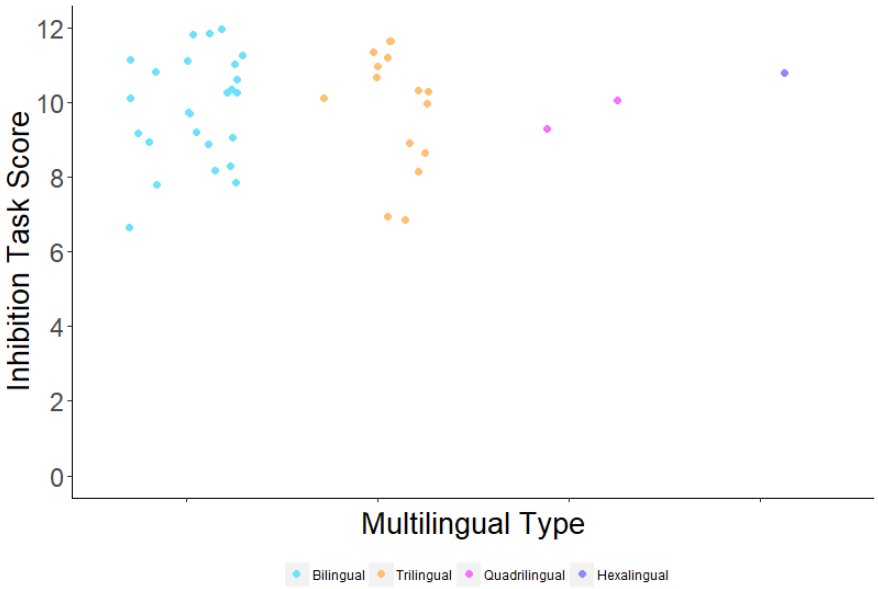
Forty-five monolingual and 44 multilingual participants were compared on their inhibition task score (Figure 3). One multilingual male participant was excluded from the analysis due to obtaining an extremely low score of 3 out of 12 on the inhibition task. A one-tailed t-test was conducted to compare the two samples. Inhibition task scores of monolingual participants (M=6.778, SD=1.565) were significantly lower than that of multilingual participants (M=8.326, SD=1.444), $t_{(87)} = 9.8$, $p < 0.001$, $d = 2.08$. This analysis rendered a large effect size.

Figure 3. Individual Participant Scores on the Inhibition Task, of Both Monolingual and Multilingual Participants Presented Separately



The results of the multilingual participants were further analyzed (Figure 4). The inhibition task scores of bilingual participants (n=26) were compared to those of participants who spoke three or more languages (hereafter referred to as "trilingual-plus"; n=18).

Figure 4. Individual Participant Scores of the Multilingual Sample, on the Inhibition Task, Separated by Degree of Multilingualism



A one-tailed t-test was conducted to compare the bilingual participants and the trilingual-plus participants. Inhibition task scores of bilingual participants (M=9.923, SD=1.440) were not significantly different from those of trilingual-plus participants (M=9.889, SD=1.491), $t_{(42)} = 0.08$, $p = 0.468$, $d = 0.023$. However, bilingual individuals did achieve a slightly higher average score compared to trilingual-plus individuals on the inhibition task.

CONCLUSION AND DISCUSSION

The results indicate that multilinguals are better at inhibiting the automatic correct response and relaying the incorrect response when compared to monolingual individuals. This suggests that multilinguals have enhanced inhibitory control mechanisms.

This cognitive advantage may be due to training of executive control in multilinguals. Marian and Shook (2012) suggest that due to the essential switching between languages and/or maintaining communication in a specific one, the multilingual brain is constantly engaging in various cognitive control mechanisms, such as attention and inhibition. Since these control mechanisms are being used

more frequently in multilingual than monolingual individuals, multilingual individuals may benefit from a training effect due to the frequent exercise of this type of executive function.

There is no doubt that in the current task, participants needed to use inhibition in order to relay the incorrect answer instead of the automatic and obvious answer. Monolingual individuals who do not have equivalent continuous daily demands of inhibitory control would have less practice at inhibiting some spontaneous answers. In agreement with our results, the previously mentioned work by Heidlmayr et al. (2014) determined that bilinguals perform better than monolinguals on the Stroop task—which clearly requires inhibition—when conducted in their first language.

Nevertheless, it is important to consider that inhibition may not be the only function required in these tasks, nor trained in multilinguals. Other higher executive cognitive functions such as selecting, shifting, and/or updating, are also superior in multilinguals compared to their monolingual counterparts. Indeed, research by Prior and MacWhinney (2010) demonstrates that enhanced executive functions in 47 bilingual individuals extend beyond inhibition into the realm of mental flexibility and shifting. This has also been confirmed by several other empirical studies (Costa et al., 2006; Philipp et al., 2008).

The richness of our multilingual sample allowed for further analysis, enabling us to look for a possible significant effect of number of known languages on inhibitory control. We analyzed whether increased cognitive gains are associated with a larger number of known languages. Due to the small sample size of the trilingual (n=15), quadrilingual (n=2), and hexalingual (n=1) samples, participants who spoke three or more languages fluently were classified as trilingual-plus. In this study, no significant difference was found between the performance of individuals who spoke two languages and those who spoke three or more on the inhibition task. A small effect size was obtained for this part of the analysis, suggesting that an increasing number of known languages does not render a more effective inhibitory mechanism. It is important to keep in mind the limitation of the sample size available in this study for investigating this avenue of research. Perhaps increasing the number of languages is not the best method of increasing one's inhibitory control. It is possible that in order to further improve executive control, multilingual individuals must practice tasks that require different cognitive demands than the ones involved in their language skill sets, such as learning to play a musical instrument and/or becoming an expert at playing chess.

Without a doubt, our data show that knowing two languages or more renders advantages of cognitive function such as enhanced inhibitory control. In fact, being bilingual seems to benefit performance in language-independent tasks such as working memory (Blom et al., 2014). Strong empirical evidence confirms that multilingualism comes with cognitive advantages. Multilingual education needs to be supported, whether at home or in schools, through immersion programs or other

curricula that emphasize learning in more than one language as learning many languages leads to cognitive enhancement as suggested by Bialystock et al. (2004). Moreover, it has been shown that bilingual individuals have an onset of dementia on average four years later than monolinguals (Bialystock et al., 2012). Not only does multilingualism enhance cognitive functions but it may also provide some cognitive reserve. Further research could explore the relationship between the number of known languages and inhibitory control. It would also be interesting to see whether bilingualism can help individuals with atypical cognitive development.

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