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Summary
Bilingualism and Task Switching: The Need for Experimental Designs

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Bilingualism can be classified as the situation where individuals acquire a second language (Diebold, 1961) and regularly use their two languages in daily life for communication purposes (Grosjean & Miller, 1994). A number of facets such as second language proficiency in writing, speaking, reading, and listening, second language use of frequency and context (e.g., at home, work, or school), frequency of switching between languages and code-switching are determinants of bilingualism (MacKey, 2001). In addition, age of second language acquisition allows individuals to be further categorised as sequential early or late bilingual. Individuals who acquire their second language after the acquisition of their first language yet before the age of six are termed as sequential early bilingual and those after the age of six as sequential late bilingual (Tao et al., 2015). However, when individuals are exposed to two languages from birth, they are considered to be simultaneous bilinguals and both languages are deemed to be the person's first language (McLaughlin,1984, as cited in Liddicoat, 1991).

Cognitive skills in particular executive functions (i.e., inhibition, monitoring and swicthing) (Miyake et al., 2000) are related to the effective performance of daily activities such as managing one's medication and finances (Bell-McGinty et al., 2002; Cahn-Weiner et al., 2007), rendering it of vital importance to investigate ways to maintain and enhance such skills. Studies conducted to this effect reveal that everyday experiences, environmental simulations, and cognitive training (e.g., sports, music, & video games) ameliorate an individual's latent cognitive potential (for review see Green & Bavelier, 2008; Willis & Schaie, 2009). In this sense, bilingualism, which requires the coordination of two languages by inhibiting one language to speak in the other and switching between the two languages is considered to be an effective form of cognitive training to enhance executive functions (Bialystok, 2011).

The bilingual advantage hypothesis has received considerable support from correlational and neuroimaging studies (Abutalebi et al., 2014; Bialystok et al., 2006; Bialystok & Viswanathan, 2009; Schroeder & Marian, 2012; Schweizer et al., 2012). Bilinguals have been found to outperform monolinguals on a range of cognitive tasks (Antoniou, 2019) that mainly tap processes of executive functions (i.e., inhibition of dominant responses, shifting between mental sets, and the monitoring and updating of information in working memory (Miyake et al., 2000). On the other hand, other studies, do not find a bilingual advantage in cognition (Brito et al., 2016; Kaushanskaya et al., 2011; Luo et al., 2013**;** Nichols et al., 2020; Papageorgiou, et al., 2018) and attribute such effects to publication bias, in which significant compared to non-significant findings are published to a greater degree (de Bruin et al., 2014), to underpowered designs due to small sample sizes (Paap et al., 2015; Paap, et al., 2016) and a lack of control of confounding variables such as socio-economic status, ethnicity, and linguistic factors between the groups (Gathercole et al., 2016; Morton & Harper, 2007; Paap & Greenberg, 2013). It has further been indicated that uncovering the effects of second language use is more difficult in younger adults who are at their peak cognitively (Vinerte & Sabourin, 2015), especially when less demanding cognitive tasks are used as outcome measures (Ibrahim et al., 2013; Qu et al., 2015).

Overall, while some studies find a relationship between bilingualism and cognition others do not, thus the existence of a bilingual advantage remains a controversial topic. One cognitive skill expected to improve via bilingualism is task switching abilities as the mechanisms of dual language coordination that is inhibition, monitoring and switching overlap with those of task switching (Abutalebi & Green, 2008; Costa et al., 2009). The possibility of improved cognitive skills and a delay in the onset of dementia render it important to carry out further studies in relation to the cognitive effects of bilingualism. Therefore, an objective of the current paper is to provide an overview of past studies that have ex-

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amined the cognitive effects of bilingualism and suggest directions for future research regarding bilingualism and task switching. The following section will expand on task switching abilities.

Measurement of Task Switching Abilities

Execution of a given task requires the activation of a task set, that is, the representation of the relevant task stimuli and response (S-R) mappings (Kiesel et al., 2010). Task switching abilities thus require the effective allocation of attention to the task at hand, activation of the relevant rule, and appropriate response selection amongst other options (Abutalebi & Green, 2008; Monsell, 2003; Rubin & Meiran, 2005). Therefore, task switching skills require effective processes of switching, monitoring and inhibition (Abutalebi & Green, 2008). To assess task switching ability, individuals respond to perceptual stimuli using the same rule on repetition trials (i.e., non-switch trials) and alternate between rules on mixed task blocks (i.e., includes both switch and non-switch trials), in which two types of cost: switch and mixing, are calculated. A larger cost is indicative of lower performance, that is, increased response times and error rates (Rubin & Meiran, 2005).

Bilingualism, Language Switching and Task Switching Abilities

Considering that cognitive control, task switching and language switching abilities utilize similar brain regions, that is, left inferior frontal gyrus and caudate nucleus (Hosoda et al., 2012), precuneus, posterior cingulum, fusiform gyrus, pre-supplementary motor region, calcarine fissure (de Baene et al., 2015), and insular and basal ganglia (Weissberger et al., 2015), it is expected that individuals who engage in language switching will have improved task switching abilities (Paap et al., 2017). However, the exact nature of the effect of bilingualism on task switching abilities is unclear.

Correlational Research

Correlational studies have revealed mixed findings with regard to the positive effects of bilingualism on task switching abilities. Some studies (Christoffels et al., 2015; Marzecova et al., 2013; Prior & Gollan, 2011; Prior & Macwhinney, 2010; Tao et al., 2015; Woumans et al., 2019; Yang et al., 2018; Zunini et al., 2019) show that use of two languages foster such skills while others (Chung-Fat-Lim et al., 2018; Hernández et al., 2013; Jaekel et al., 2018; Mor et al., 2014; Moradzadeh et al., 2014; Nicoladis et al., 2018; Paap & Greenberg, 2013; Paap et al., 2017; Paap & Sawi, 2014; Rodriguez-Pujada et al., 2013; Shulley & Shake, 2016; Sörman et al., 2019; von Bastian et al., 2015) find no effect.

Language Switching Training

Considering that executive functions aid in the acquisition of a second language (Kapa & Colombo, 2014), an issue that arises with correlational research is that the direction of the relationship between language use and task switching abilities is unclear. One question that therefore requires clarification is whether individuals have better executive functions because they had acquired a second language or whether people who have better executive functions learn a second language? To this end, some studies (Dong & Liu, 2016; Kang et al., 2017; Liu et al., 2019; Prior & Gollan, 2013; Timmer et al., 2018; Wu et al., 2018) have examined the effect of language switching training on task switching abilities, which show of mixed findings. Some studies (Kang et al., 2013; Liu et al., 2019; Trimmer et al., 2018) find that language switching training improves task switching abilities while others (Prior & Gollan, 2013; Wu et al., 2018) show of no significant effect.

Language Learning

To unravel whether bilingualism can lead to cognitive gains, there is a need for longitudinal studies. To fulfil this gap, Ramos et al. (2017) has examined whether language learning via a course can enhance task switching abilities in older adults. Findings of this study showed older adults enrolled in a language course did not have improved task switching abilities compared to those who did not enrol in a language course, indicating that language learning does not enhance skills of task switching.

Discussion

Overall, findings of past studies reveal that effect of bilingualism on task switching abilities fluctuate. In discerning the effects of language use on task switching abilities, frequency of language use and switching between languages has been extensively examined. It is recommended that the form of language switching such as switching between languages in written communication is also assessed. This is because findings of studies with toddlers have shown improved task engagement and disengagement abilities following only auditory exposure to two languages (D'Souza et al., 2020; Kovacs & Mehler, 2009). Such findings suggest that the mechanisms of dual language coordination go beyond verbal language use. In light of current findings, it is possible to say that future research is needed to determine the circumstances of bilingual advantages (if any exist). To further this line of research there is therefore a need for cause-effect studies. The following section will expand on the need for such studies and suggest possible methodological improvements.

Future Directions: Experimental Designs

Overall, the majority of the studies that have examined bilingualism and task switching abilities reveal of a beneficial effect. However, some of the issues present in the current studies include the lack of: pre-tests (Prior & Gollan, 2013), control groups (Kang et al., 2013 Liu et al., 2019; Wu et al., 2018) and random assignment of participants to the experimental and control groups (Ramos et al., 2017). One alternative way to shed light onto the matter and clarify the effect of bilingualism on cognition is the use of experimental designs. This methodology requires for a group of participants equal on a number of demographic variables to be randomly allocated to the experimental and control group once assessed for their task switching abilities. Participants in the experimental group will be required to start learning the second language in question then after for which task switching abilities would be assessed for both groups a second time.

The lack of pre-tests is an important limitation as it limits the ability to determine the extent of change in task switching abilities following language acquisition. It is also possible that prior to language acquisition the experiment groups' executive functions were improved and that any difference observed between the groups do not reflect language use. On the other hand, without pre-tests it is not possible to say that language acquisition has had no effect on cognition as it may be that there is a trend towards an improvement yet cannot be observed due to factors such as limited training. It is therefore important to have measurements of people's cognitive abilities before and after language acquisition.

Some studies (Kang et al., 2013, Liu et al., 2019; Wu et al., 2018) have included a pre-test and post-test design in the measurement of task switching abilities, yet, their sample only consisted of bilingual participants. In such an instance, the lack of a control group (i.e., monolingual individuals) is a limiting factor. Inclusion of control groups will enable the assessment of whether any reduction in switching or mixing costs are attributable to language use. Otherwise, it is possible that any activity other than language use may lead to an improvement in task switching abilities. In their study, Liu et al. (2019) included a control group that did not require language switching training, yet, further research in this regard are needed.

The lack of random assignment to groups is also a limitation. Considering that executive functions are related to reading ability (Butterfuss & Kendeou, 2018) and language learning ability (Kapa & Colombo, 2014), individuals already enrolled in a language learning program is problematic. Any difference or the lack of difference between groups may be attributable to individual differences. One way to overcome this is to randomly assign monolingual individuals to the experimental and control group in which language acquisition for the experimental group will begin herein after.

The use of passive control groups (Ramos et al., 2017) is also inadequate. Studies that examine cognitive training such as the effects of video game training on cognition state the importance of eliminating placebo effects (Boot et al.., 2011; 2013). For this reason, there is a need for active control groups in which participants engage in an alternative activity (e.g., reading a book) for the same extent of time that the experimental group is involved in learning a second language. If the active control group and the experimental group show improvement in comparison to the passive control group, we could postulate that the improvement is a result of any kind of activity rather than language use. However, if the improvement is seen in only the experimental group then it is possible to conclude that language learning drove the group differences.

Other issues that need to be resolved is participants expectation based on their group allocation. For example, the fact that participants will be aware that they are assigned to the language learning group may lead to expectation for how language learning may influence their cognitive performance. Such expectations can increase or decrease participants motivation which can influence their task performance (Kahneman, 1973). For this reason, it is possible that improvement is related to participants expectation than to the actual learning of a second language per se. (Boot et al., 2013). To overcome this limitation, it is important to assess via a post-experiment questionnaire participants expectation regarding language learning, their level of motivation, and knowledge regarding the link between language learning and task switching and ensure that groups are equated on these aspects (Boot et al., 2011; 2013).

Conclusion

The bilingual advantage hypothesis is a current topic of debate for which there are several fundamental questions that still need to be addressed. Some questions include the need to determine how bilingualism influences executive functions and to decide on the direction of the effect. In other words, it is important to discern whether people with improved executive functions learn a second language or whether learning a second language leads to an improvement in executive functions. To address such questions and those alike there is a need for studies that are of longitudinal experimental design that include language learning programs.

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