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Can bilingualism delay age-related cognitive decline?

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Can bilingualism delay age-related cognitive decline?

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Abstract
Getting older is associated with a decline in cognitive abilities. In recent years the search for factors that can protect us against cognitive aging has grown. One of those factors is proposed to be bilingualism. In previous studies, bilingualism has been shown to lead to cognitive advantages, such as enhanced executive functions. However, those previous findings are controversial, as it has been argued that they might as well be explained by several confounding factors, such as immigration status, cultural differences and socio-economic status. This paper proposes a study with the aim to question bilingualism as a potential factor to delay age-related cognitive decline. The proposed study will compare the performance of middle-aged and older monolingual and bilingual adults on the Simon task, a task measuring non-verbal inhibitory control, and the trail-making task, a task measuring switching. Importantly, the participant groups will be carefully matched in order to eliminate possible confounding factors. The results are expected to show that the performance of the monolinguals and bilinguals will decline to the same extent between the two age groups. These expected results will suggest that bilingualism might not be a protective factor against age-related cognitive decline.

1. Theoretical background

1.1 Aging and cognitive decline

Getting older comes with a decline in cognitive abilities. Salthouse (2009) showed that this decline is already visible in the performance of people in their 20s and 30s on different tasks measuring cognitive functioning. He also discusses that after the age of 60, the magnitude of the age-related cognitive decline accelerates, resulting in a decline twice to four times greater than before the age of 60. Examples of cognitive abilities that decline with age are processing speed (Salthouse, 2009; Schaie, 1996) and episodic memory (i.e. memories of events experienced in the past) (Salthouse, 2003, 2009). The greatest impairments with age were found to be those associated with executive functions (Basak, Boot, Voss, & Kramer, 2008; Braver & Barck, 2002). Executive functions are higher order cognitive processes that regulate behaviour and other cognitive processes, such as attention and visual perception (see Diamond, 2013 for a review). They mostly depend on structures in the prefrontal cortex (review in Stuss, 2011). In the literature there is no consensus about the organization of the executive function system. Nevertheless, most studies are based on the organization proposed in the Unity and Diversity model by Miyake, Friedman, Emerson, Witzki, & Howerter (2000). According to this model there are three separable executive functions: 1) switch-

ing, the ability to switch between different tasks and mental sets, 2) updating, the ability to monitor representations in working memory and update them with new information, and 3) inhibition, the ability to suppress a dominant response. Age-associated impairments have been found in inhibitory control (Darowski, Helder, Zacks, Hasher, & Hambrick, 2008; Zanto, Henningan, Östberg, Clapp, & Gazzaley, 2010), task switching (Cepeda, Kramer, & Gonzalez de Sather, 2001; Kray, 2006) and working memory (Bopp & Verhaeghen, 2005; Fiore, Borella, Mammarella, & De Beni, 2012; Fournet et al., 2012). Furthermore, brain imaging data has demonstrated abnormal activation in the prefrontal cortex in older adults during a task demanding cognitive control (Braver & Barck, 2002).

With increasing numbers of older people across the world, the interest in the search for factors that can protect against cognitive aging has grown. This search is important, since the age-related decline of cognitive abilities has effects on daily life activities such as driving, making decisions, remembering what groceries to buy, and understanding (complex) instructions (e.g. Blazer, Yaffe, & Karlawish, 2015). Furthermore, Vaughan and Giovanello (2010) showed that measures of executive functioning predicted so-called 'instrumental activities of daily living' (e.g. financial management, cooking, household chores) in older adults, meaning that a decrease in executive functioning will also affect daily life activities. Previous studies have found that cognitive training in reasoning, processing speed, working memory and attentional control (e.g. by means of video game training) have lasting positive effects on cognitive abilities in older people and also transfer to other non-trained domains (Basak et al., 2008; Brehmer, Westerberg, & Bäckman, 2012; Rebok et al., 2014). Furthermore, lifestyle factors such as physical and social activities have been shown to prevent age-related cognitive decline (Buchman et al., 2012; James, Wilson, Barnes, & Bennett, 2011; Bherer, Erickson, & Liu-Ambrose, 2013). The current proposed research will focus on a different, and more controversial, factor that is suggested to delay the decline of executive functions, namely bilingualism.

1.2 Bilingualism as a protector against cognitive decline

In the current study, the term *bilingualism* will be used to refer to those who grew up with two languages from birth or early childhood. Previous studies suggest that bilinguals have enhanced executive functions compared to monolinguals. That is, enhanced inhibition, switching and updating abilities have been found in bilinguals throughout the whole lifespan using a wide variety of tasks (recent review in Bialystok, 2017). Traditionally, this bilingual advantage has been explained by the Inhibitory Control model proposed by Green (1998). The theory is based on the consistent finding that in bilinguals both languages are constantly active during language production, even in contexts where only one language is required (review in Kroll, Dussias, Bic, & Perrotti, 2015). Because of the joint activation of both languages, there is a constant competition between simultaneously activated lemmas from both languages to be selected. This suggests that bilinguals must have some sort of control system to prevent intrusion from the non-target language. Green (1998) proposed in his model that bilinguals are constantly inhibiting lemmas from the non-target language in order to solve the competition. This would lead to a continuous training and therefore improvement of inhibitory control. Recently, however, new findings have challenged the prevailing theory and doubts have been raised if inhibition

really is the underlying mechanism of the bilingual advantage. Instead, it has been proposed that the bilingual advantage might be explained by the bilinguals' use of executive attention, which is the ability to monitor attention. That is, bilinguals would shift their attention away from the non-target language to the target language, rather than actively inhibit the non-target language (Bialystok, 2017).

The enhanced executive functions found in bilinguals make bilingualism interesting as a possible factor to delay cognitive decline in aging, since effects of this decline have been found to be the greatest in executive control processes. Previous studies that have looked into the effects of bilingualism on aging, suggest that bilingualism can delay the onset of dementia by 4 to 5 years (Bialystok, Craik, & Freedman, 2007; Craik, Bialystok, & Freedman, 2010) and can also delay the decline in executive control (Bialystok, Craik, Klein, & Viswanathan, 2004; Bialystok, Craik, & Luk, 2008; Bialystok, Poarch, Luo & Craik, 2014; Gold, Kim, Johnson, Kryscio, & Smith, 2013). These results suggest that bilingualism is one of the factors that contributes to cognitive reserve, which is a compensatory mechanism enabling individuals to function normally despite neural damage or impairment to the brain. Bialystok et al. (2004) were the first to study the effects of bilingualism on executive functions in older populations. They let monolingual and bilingual middle-aged (mean age 43 years old) and older adults (mean age 71 years old) participate in a Simon task, which measures inhibitory control. In this task participants are presented with blue and red squares that are associated with a left or right button press. Stimuli appear on the left or right sight of the screen, thus leading to incongruent trials (e.g. left button, right side of the screen) and congruent trials (e.g. left button, left side of the screen). In the incongruent trials participants need to inhibit their reaction triggered by the side of the screen and only focus on the color of the square. The difference in reaction time between the congruent and incongruent trials is called the Simon effect. One thing the researchers looked at was the increase in the Simon effect between the two age groups. They found that this increase was greater for the monolinguals than for the bilinguals, which suggests that the age-related processing decline was more severe for the monolinguals than for the bilinguals. The studies conducted by Bialystok et al. in 2008 and 2014 found similar results on tasks assessing inhibition and working memory, and Gold et al. (2013) found evidence for delayed age-related declines in bilinguals by using a switching task.

1.3 Confounding variables

In the past years researchers have questioned the existence of a bilingual advantage more and more (e.g. De Bruin, Bak, & Della Sala, 2015; Paap & Greenberg, 2013 ; Paap, Johnosn, & Sawi, 2015). According to those researchers, there are methodological problems within this field of research which make the results hard to interpret. One of those problems is the possibility of confounding variables such as immigration status, cultural differences, socio-economic status (SES) and IQ (Bak, 2016). When not controlled for, those factors might cause the tested monolinguals and bilinguals to not only differ in how many languages they speak but also in other respects. Furthermore, they can cause differences within the group of bilinguals, making them a heterogenous group. Importantly, those factors can have an influence on the performance on tasks that are used to test executive control. For example, the studies by Bialystok, Craik and Freedman (2007, 2010) have been criticized

because the participants were not matched in terms of immigration status (Fuller-Thomson & Kuh, 2014). In Craik et al. (2010), 79% of the bilinguals were immigrants, compared to 32% of the monolinguals (De Bruin et al., 2015). Fuller-Thomson and Kuh (2014) argue that the difference found in age of onset of dementia might have been due to what is known as the *healthy migrant effect* – the tendency of migrants to be healthier and to have "better morbidity and mortality outcomes than non-immigrants" (p. 129). It might be possible that healthy people are more likely to immigrate and thus to become bilingual. In line with this argumentation, several studies have found that immigrants show increased cognitive control and a delay in cognitive decline when compared to non-immigrants, independently of bilingualism. Similarly, Bialystok et al. (2008) used participants with and without a migration background. The study by Bialystok et al. (2004) can also be criticized, because they compared monolingual speakers of English living in Canada with bilingual speakers of English and Tamil or Cantonese living in India or China. In this study, differences in culture and lifestyle between the monolinguals and bilinguals could have been confounding factors. The importance of controlling for cultural factors has been shown by Carlson and Choi (2009). In their study, Korean-English bilinguals performed better than American monolinguals on executive control tasks. However, this bilingual advantage was not found when the same sample of bilinguals was compared with Korean monolinguals. This suggests that the found differences between the bilingual group and the American monolinguals were not due to bilingualism, but due to cultural differences. The same could have been the case for the study by Bialystok et al. (2004). The importance of controlling for possible confounding variables has been highlighted even more by a study by De Bruin et al. (2015). They compared the performance of carefully matched monolingual and bilingual older adults on two tasks measuring executive control. The participants were matched for immigration status, lifestyle, SES, education, IQ and gender. On both tasks they did not find an effect of bilingualism. This suggests that earlier findings that did show a bilingual advantage might have been caused by one or more confounding factors, and not by the bilingualism of the participants.

2. The proposed study

The literature review showed that there is still uncertainty about whether bilingualism leads to enhanced executive functions and whether it could delay age-related cognitive decline. That is, previous studies suggesting that it does (e.g. Bialystok et al., 2004, 2008, 2014), did not control for possible confounding factors such as migration status and cultural differences which could have had an effect on the outcome of the studies. The present proposed study will try to answer the research question to what extent bilingualism is able to slow down the process of age-related decline in executive functions. This is an important question to answer, since diminished executive functions have been shown to be related to problems in daily functioning in older people (Vaughan & Giovanello, 2010). The present study will replicate the studies previously conducted by Bialystok and colleagues (2004, 2008, 2014). Importantly, it will differ from those previous studies by carefully matching participant groups and by taking care of potential confounding factors. Furthermore, whereas these previous studies focussed on the executive function of inhibition, the current study will expand these studies by also including a task assessing switching.

Given the inconsistent findings reported in studies on the bilingual advantage in older bilinguals and the lack of well-controlled designs in previous studies, the research question in the present study proposal will be explorative and no specific hypothesis will be formulated. That is, the study will function to find out whether previous reported delays of age-related cognitive decline can be replicated when using a well-controlled design, or whether those previous findings could possibly be explained by confounding factors.

3. Methods

3.1 Participants

There will be four groups of participants: monolingual and bilingual adults between 30 and 50 years old and older adults between 60 and 80 years old. The participants will all be non-immigrant, native speakers of English living in the UK. Following Bialystok et al. (2004, 2008, 2014), the bilingual participants will have acquired their second language from birth or during early childhood (i.e. before the age of 5). Ideally, bilingual participants should use both their languages on a daily basis. The monolinguals will not have functional command of any other language. The participants will all have normal or corrected-to-normal vision.

All participants will first fill out a questionnaire which will collect information about the age of acquisition of the languages they speak, patterns of language use, language proficiency, medical history and activities that are suggested to be cognitively enriching, such as playing computer games or musical instruments and engaging in physical activity (Valian, 2015). They will also complete two non-verbal components of the Wechsler Abbreviates Scale of Intelligence (WASI-II, Wechsler, 2011) as a measure of IQ. Finally, they will be screened for symptoms of dementia/mild cognitive impairment using the Addenbrooke's Cognitive Examination-III (ACE-III, Hsieh, Schubert, Hoon, Mioshi & Hodges, 2013). Based on the results of the questionnaire and the tests, the monolinguals and bilinguals in each age group will be matched on: gender, age, SES, lifestyle, IQ and ACE-III score. Within the bilingual groups, the participants will be matched on the age of acquisition of their second language and language proficiency.

3.2 Task and procedure

3.2.1. Simon task

The Simon task (Simon, 1990) will be used to assess inhibitory control. The participants will be given a button box with a red button on the left side and a blue button on the right side. On a computer, they will see a blue or a red square on the left or on the right side of the screen and they will have to press the button corresponding to the right colour. There will be two kinds of trials: congruent and incongruent trials. In the congruent trials, the side of the screen matches with the button that needs to be pressed (e.g. red square presented on the left side of the screen). In the incongruent trials, there is a mismatch between the side of the screen and the button that needs to be pressed (e.g. red square presented on the right side of the screen). So, in the incongruent trials, the participants need to inhibit their reaction triggered by the side of the screen and only focus on the colour of the square. Half of the trials will be congruent and half will be incongruent. The two trial types will be presented quasi randomly. The participants will be instructed to respond as

quickly and as accurately as possible. From the data, the Simon effect can be calculated, which is the proportional increase in reaction time between the congruent and incongruent trials. It is calculated using the formula (incongruent – congruent)/congruent. Using this formula rather than only subtracting the reaction time in the congruent trails from the reaction time in the incongruent trials corrects for potential baseline differences.

3.2.2. Trail making task

The trail making task will be used to assess switching (Armitage, 1946). The task consists of two parts. The first part is a neutral condition to assess baseline speed. During this part, participants will receive a sheet of paper with circles containing the numbers 1 to 25 randomly arranged over the sheet. Their task will be to connect the numbers in ascending order as quickly as possible. During the second part, participants will be presented with a sheet of paper containing the numbers 1 to 12 and the letters A to L. Those will have to be connected by alternating between letters and numbers in ascending order (e.g. 1-A-2-B etc.). Again, they will have to do this as quickly and as accurately as possible. This part of the test measures switching between mental sets of letters and numbers. Any mistakes will have to be corrected immediately or will be pointed out by the experiment leader if the participants do not notice their mistake themselves. Correcting of mistakes will add to the time of completion of the task.

For both parts, the time it takes the participants to complete them will be measured in seconds, which will be used to measure the switching cost. This is the proportional increase in time of completion between the neutral and the switching part. The formula to calculate the switching cost is (switching – neutral)/neutral.

4. Possible results

Because this is a study proposal written for a course, no real results can be presented. Instead, an expectation of what the results will look like will be described. First of all, it is expected that in both the Simon task and the trail making task, all participants will be significantly slower in the trials that demand the use of executive functions compared to the trials that do not. That is, in the Simon task it will take time to resolve conflict by inhibiting a response triggered by interfering stimuli and during the trail making task it will take time to switch between mental sets of numbers and letters.

Second, it is expected that this extra time needed to resolve conflict and to switch between mental sets will be comparable between monolinguals and bilinguals in both age groups. Thus, no significant differences are expected in the Simon effect and the switching cost between monolinguals and bilinguals.

Finally, it is expected that the Simon effect and the switching cost between the two age groups will significantly increase for both the monolinguals and the bilinguals, since both groups will suffer from some age-related cognitive decline. Furthermore, since the Simon effect and the switching cost are not expected to significantly differ between the monolinguals and bilinguals in each age group, the results are also predicted to show that the Simon effect and the switching cost will increase to the same extent between the two age groups for the monolinguals and bilinguals.

5. Discussion

In this paper, a study has been proposed that puts bilingualism as a potential factor to delay age-related cognitive decline in executive functions to the test. Recent studies have suggested that the bilingual advantage found in previous experiments might have been caused by confounding variables and not by the effect of bilingualism per se (e.g. De Bruin et al., 2015). Based on this, the current study proposal aims to replicate previous studies by Bialystok et al. (2004, 2008, 2014), which found that in bilinguals the age-related decline of executive functions was delayed compared to monolinguals. This will be done by matching the monolingual and bilingual participants on different possible confounding variables. Middle-aged and older monolingual and bilingual adults will perform in a Simon task and trail making task, used to tap into the executive functions inhibition and switching. The results are predicted to show that in both age groups there will be no significant difference in performance between the monolinguals and bilinguals, meaning that no cognitive advantage is predicted to be found for the bilinguals. Therefore, the results are expected to show that the age-related cognitive decline between monolinguals and bilinguals will be the same.

First of all, these results will suggest that bilingualism does not lead to a slowing of age-related cognitive decline in executive functioning. This is in contrast with previous studies reporting a delay in decline of executive functions in bilinguals compared to monolinguals (Bialystok et al., 2004, 2008, 2014; Gold et al., 2013), and suggests that the positive results in these studies might be explained by confounding variables. However, it is important to note that these results will not exclude any other possible effect bilingualism could have on cognitive aging. For example, studies have shown that bilingualism might delay the onset of dementia by 4 to 5 years (Bialystok et al., 2007; Craik et al., 2010). These studies have been criticized before on not controlling for immigration status. However, Alladi et al. (2013) found the same delaying effect of bilingualism on dementia after controlling for immigration status and other potential confounding factors. Furthermore, Bak, Nissan, Allerhand and Daery (2014) showed in their longitudinal study that bilingual participants of 72 years old had better general intelligence, memory, speed of information processing, reasoning, reading skills and verbal fluency than would be expected based on their childhood intelligence scores. This was a very well conducted study, as the participants were controlled for all important factors. Those results suggest that bilingualism might still be a potential factor to delay decline in other cognitive domains than executive control. A suggestion for future research is therefore to extent this line of research and to compare decline in cognitive domains such as memory and processing speed between carefully matched monolinguals and bilinguals.

Second, this study will add to the ongoing discussion about the bilingual advantage. That is, since it is expected that in both age groups the bilinguals will not outperform the monolinguals, it will contradict previous studies that have suggested that bilinguals have a cognitive advantage compared to monolinguals. On the other hand, it will be in line with studies that did not find evidence for an advantage (for recent overviews of the discussion on the bilingual advantage see Bialystok, 2017 and Antoniou, 2019). Whereas some authors that found null results have concluded that the bilingual advantage does not ex-

ist at all (e.g. Duñabeitia et al., 2014; Paap & Greenberg, 2013; Paap et al., 2015), others have argued that this conclusion is too radical. According to Bialystok (2017) "studies that have failed to find differences between monolingual and bilingual groups have instead found no differences, that is, null results, but are interpreted as negative results. However, absence of evidence is not evidence of absence." (p. 253). A recent proposed alternative interpretation of the null results is that the underlying mechanism of the possible bilingual advantage might not be inhibition, but executive attention (Bialystok, 2017). Executive attention is the ability to monitor attention. According to this view, bilinguals do not inhibit one of their languages during speech, but rather focus their attention to the target language. The predicted failure of the current study to find a bilingual advantage on the Simon task (a task measuring inhibition) might support this view. If executive attention is the mechanism that is trained in bilinguals by focusing attention to the target language, they should outperform monolinguals on tasks assessing executive attention. In a recent study, Grundy, Chun-Fat-Yim, Friesen, Mak and Bialystok (2017) tested this in monolingual and bilingual young adults by measuring their attentional disengagement abilities. Disengagement of attention is the ability to shift attention away from previous information that is no longer relevant and to focus attention on current relevant information. They found evidence for enhanced disengagement abilities in the bilinguals compared to the monolinguals. If it is executive attention that is enhanced in bilinguals rather than inhibition, it would be interesting to see whether the results found by Grundy et al. (2017) could be replicated in bilingual older adults and if bilingualism can slow the decline in attentional abilities with age.

To conclude, the results of this study proposal are predicted to suggest two things: 1) that bilingual middle-aged and older adults do not show enhanced inhibition and switching abilities compared to carefully matched monolinguals, and 2) that bilingualism does not slow age-related decline in executive functions. Despite these null results, it is important to note that they should not be taken as evidence that the bilingual advantage does not exist at all or that bilingualism cannot contribute to slowing of age-related cognitive declines in any other way. Therefore, suggestions have been made for future studies to focus on the effects of bilingualism on other cognitive abilities, such as memory, processing speed and executive attention. ■

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