The Effects of Bilingualism on Executive Functioning

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Abstract. Bilingualism has been an important topic for researchers in the last few decades considering educational and lifespan benefits. It has been shown that bilingualism can have special effects on individual executive functioning. However, specific effects on different domains of executive functioning as well as different age groups still need a general or systematic explanation. Therefore, this paper systematically reviews previous studies about how bilingual competence can have effect on individual executive functioning and provides suggestions for future research, focusing on bilingual evaluations and classifications. Both advantages and disadvantages of bilingualism as well as current limitations of research in this field are discussed. It can be indicated that there cannot be a consensus regarding the general effects on individual executive functioning since both of the fields are complex, while a system of knowledge can be acquired. Differences in research results can be due to the ambiguity of bilingual evaluations, age control, demographic diversity, and variations in language use. Future research may focus on more detailed manipulations of language status and comparisons in order to complete a more systematic knowledge about this topic regarding its complexity.

Keywords: Bilingualism; executive functioning; language acquisition.

1. Introduction

International connections and communications have been becoming increasingly close in the last few decades. The numbers of bilinguals have been increasing accordingly. Considering the cross-cultural backgrounds, it is important for researchers to examine how bilingualism influences individual executive functioning for educational purposes and lifespan benefits. A substantial amount of research has been done to explore the topic on bilingualism and executive functioning. However, significant debates still exist regarding the relationships between the two. This paper systematically reviews research on how bilingualism influences executive functioning of individuals with a focus on evaluations of bilingualism as well as domains in executive functioning, and provides some suggestions on future research.

2. Key Concepts

2.1. Bilingualism

Bilingualism refers to the ability of individuals to use two languages at the same time. However, bilingualism is not easy to define in research practices. The categorizations and evaluations of bilingualism vary in different research [1]. In other words, researchers use different standards and measures to operationalize bilingual individuals. According to Elliott et al., important standards include proficient levels, frequencies, contexts, and activeness [1]. Proficient levels evaluate to what extent individuals master both languages. Frequencies evaluate both how often individuals use each language and how often they switch between two languages. Contexts measure in which environments individuals use each language, and whether they use both simultaneously in the single environment. The activeness examines whether individuals passively know both languages or actively speak the two. The complicated systems of evaluating bilingualism indicate problems in research. Different approaches can lead to different results even with the same samples, possibly due to the variations in measurement tools and the corresponding emphasis shown in the measurements.

In Chen & Yow's research, they measured bilingualism based on different frequencies of using dominant language to examine effects on older adults [2]. They showed a spectrum of language use frequencies, indicating that the complexity of bilingual evaluations has made relevant research difficult to reach a consensus.

2.2. Executive Functioning

Executive functioning refers to a series of cognitive processes that individuals perform to manage tasks in daily life. It contains plenty of domains, supported by different models. Generally, some key domains of common executive functioning include inhibition, updating or working memory, and shifting [3]. Inhibition indicates the ability to suppress inappropriate mental processes and avoid distractions, such as ignoring irrelevant stimuli and concentrating on relevant stimuli during problem-solving. Updating refers to the ability to manage information in working memory, especially revising information to respond to changing environments. Shifting emphasizes the ability to switch between different cognitive processes or different tasks [4]. Three-factor model examines the three domains simultaneously. In two-factor models, any two domains out of the three can be considered together. Besides that, according to Karr et al., different aspects of common executive functioning are emphasized in research on individuals with different ages [3]. Research on preschool individuals is likely not to emphasize the domain of shifting. However, adolescents and adults are examined on all of the three key domains, indicating the importance of considering individual cognitive development when examining executive functioning. Generally, the three-factor model is widely accepted by researchers to examine different aspects of common executive functioning.

3. Analysis

3.1. Advantages

A variety of research suggests that bilingualism is beneficial to the key domains of executive functioning. Ward & Awani examined the effect of language switching skills on nonlinguistic task switching abilities by replicating a previous study, while changing the mode from an in-person study to a fully online study [5]. The participants were young adults aged between 18-25 with a majority of university students. The sample size was 78 for replication purpose, while large enough to have statistical power. The nonverbal intelligence of the participants was measured using the questionnaire as a control variable to make sure of the similar general cognitive intelligence of them. A task-switching model was used to investigate the shifting domain of individual executive functioning that participants were asked to respond by colors or by shapes of the stimuli. Data were analyzed using significance testing as well as Bayesian approaches. Both analyses suggested bilinguals' advantage in reduced global switch costs due to better cognitive flexibility from switching between two languages as well as better attentional control. In addition, Bayesian approaches indicated reduced local switch costs in bilinguals, further emphasizing this advantage. This showed the importance of carefully evaluating different analyzing approaches as well. Possible limitations included the vague evaluating standards of bilingualism, which may have influenced the reliability and generalizability of the results. Contexts and proficient levels were described with self-rated scales, while frequencies of use of languages were not described. These measures were not controlled in the study, leaving space for biases due to participants' language use conditions. On the other hand, Gallo et al. examined the neuroplasticity and cognitive reserve related to bilingualism [6]. The participants were young adults at a university as well with their general intelligence measured through the questionnaire. As bilinguals, the participants' proficiency levels of the second language were measured through self-rated scales and translation tasks. Flanker task was completed by participants in order to examine the structural brain-behavior relationship between caudate nucleus, a structure for bilingual control and common executive functioning, and cognitive performances of the bilinguals. MRI scanning was conducted to each participant after completing all of the questionnaires and tasks to examine the caudate nucleus and obtain objective data. Results showed that bilingual experiences were

advantageous to Flanker performances. Besides that, bilingual experiences induced a neuroplastic trajectory in the caudate nucleus that it initially increased in volume for language switching control and later reduced back to the normal condition because of the stable cognitive enhancement. This enhancement of the caudate nucleus induced the cognitive reserve effect that the bilinguals automized the switching control and inhibiting process, indicating an overall increase in domain-general executive functioning. In addition, the evaluations of the first language of the participants were lacking, leading to possible bias.

Other studies examined general individual executive functioning as well. Elliott et al. examined the general executive functioning of older bilinguals and monolinguals with cognitive tasks as well as MRI scanning [1]. The bilingual participants were active bilinguals who frequently used both of the two languages in their daily lives. Results showed that bilinguals demonstrated a similar cognitive reserve that indicated reduced cognitive decline with brain atrophy, or reduced gray matter thickness [6]. This suggested that lifelong bilingual experiences might buffer against age-related cognitive decline. Possible limitation included bias from self-rated language skills reported by older adults with cognitive impairment. Massa et al. examined the general executive functioning of bilinguals and monolinguals with several domain-general executive tasks as well as language switch tasks with event-related potentials recorded [7]. Age effects were explored as well that both young and older bilinguals and monolinguals were recruited to be compared with their peers. Results showed that bilinguals performed better than monolinguals in language-related executive tasks such as Stroop test and verbal fluency task, indicating better inhibition and shifting functions, although there was no significant evidence that bilinguals experienced slowed decline in executive functioning compared with monolinguals. Possible limitations included bias from self-rated language dominance levels as well as the potential effects of the differences of participants in the degrees of dominance on study results.

It can be indicated from these studies that young adults at university level and older adults starting to experience cognitive decline are the main target participants in the studies. Some research would consider aging effects based on the differences in general executive functioning between the two age groups. Cognitive tasks conducted in the studies varied a lot, although the targets were generally the key domains of executive functioning, especially inhibition and shifting. Some research results were domain-specific, while others could be generalized to domain-general executive functioning, possibly due to the choices of different cognitive tasks conducted. Neuroimaging, such as MRI, could be a useful tool in cognitive research to obtain objective data on brain structure and function. The studies share the overall limitation from the perspective of evaluating and operationalizing bilingualism. Most studies used self-rated scales for language use evaluations, and different standards were used simultaneously. The complexity of the studies increased, and bias might arise from the use of different standards in a single study.

3.2. Disadvantages

Some research argues that bilingualism has no benefits on executive functioning in several domains and even disadvantageous effects. Nichols et al. conducted research on the general executive functioning of monolinguals as well as bilinguals [8]. More than 10,000 adults were recruited in this large-scale study to complete twelve cognitive tests examining different domains of executive functioning, including inhibition, updating, shifting, reasoning, and planning. These tests were assigned to three factors of memory, verbal, and reasoning. Besides participants' self-reported proficiency of language use, their demographic information, such as age, education level, socioeconomic status, and handedness, was collected using the questionnaire. Matched samples of monolinguals and bilinguals were assigned based on the demographic information collected to eliminate possible effects of confounding variables, while unmatched monolinguals and bilinguals were compared directly as well. Data were analyzed with significant tests, linear regression, as well as factor analysis. Results showed that no significant difference was found between bilingual and monolingual participants in general regarding the cognitive tests, except for only one test about

memory of digits, while the effect was trivial. There were no significant differences as well between the matched samples, further emphasizing the null hypothesis of the positive effects on executive functioning. In addition, considering the control and matched samples for different ages, there was still no significant evidence supporting the hypothesis that bilingualism could help reduce the age-related cognitive decline. Possible limitations included the assignments of the matched sample since the languages and evaluating standards of the bilinguals were not matched and controlled. The assignments reduced the reliability of the results as different languages mastered as well as degrees of language use conditions could have effects on participants' performances on cognitive tests. Besides that, Goldsmith et al. examined the effects of bilingualism on a specific domain of executive functioning which was attentional disengagement from the developmental perspective [9]. Participants included 492 middle-class elementary school children from Canada, China, and Lebanon with age ranged from 9 to 14. The demographic information, especially socioeconomic status, of the participants was collected using questionnaire. The evaluating standards of language use were detailed that bilingualism was operationalized based on both contexts and degrees of balance when using each of the language to categorize bilingual participants according to their self-reports. Participants completed a computer-based congruency task involving numerical digits to assess attentional control. Congruent trials showed larger digits with larger sizes, while incongruent trials showed larger digits with smaller sizes. Reaction times as well as accuracy of participants for the trials were recorded and analyzed. Digit span task was adopted as a measure of general cognitive and intellectual levels of the participants, with the results that monolingual participants had greater spans than bilinguals, indicating higher intellectual levels. Data of the congruency task were analyzed with a one-way analysis of variance for both the overall bilingual participants and specific subgroups based on degrees of balanced language use. The analysis indicated that monolinguals generally responded faster and more accurate than bilinguals, both very balanced and minimally balanced participants. Matched samples of demographic information were examined as well, indicating no significant effects on attentional disengagement of monolinguals and bilinguals. Possible limitations included the biases caused by the self-reported language use conditions of the participants. Self-reported language use among elementary school children might not accurately represent their actual language proficiency, suggesting the need for objective, standardized assessments in future studies. In addition, similar language status of bilinguals with different languages used might lead to different results.

Other research indicated no benefits and even disadvantages of bilingualism on executive functioning in general. Gard et al. examined the effects on general executive functioning of older adults, considering the cognitive impairment [10]. Participants were English monolinguals and French-English bilinguals aged 65 and older with controlled demographic information, selected to investigate potential cognitive differences in aging. They were required to self-report their perceived cognitive issues, and then complete several cognitive tasks about verbal and nonverbal executive functioning. Results showed that bilingualism had no significant effects on nonverbal cognitive task, while monolinguals performed significantly better than bilinguals on verbal cognitive task. Possible limitations included biases from ambiguous definitions of executive functioning since the domains of executive functioning was not specified in the study, and key aspects such as working memory were excluded from common executive functioning. Lukasik et al. examined the domain of working memory updating of bilinguals and monolinguals [11]. The US adult participants were recruited to self-report their demographic information for controlled confounding variables as well as their language status, including proficiency, contexts, ages of language acquisition, and frequencies of switching languages. Working memory updating was measured by both verbal and nonverbal visuospatial tasks. Results demonstrated that there were no significant differences between the two groups on either verbal or nonverbal tasks in general. There was only a slight advantage of bilingualism on one composite task score, while regression model analysis suggested that the advantage was not related to bilingualism, supporting the null hypothesis of bilingual advantage. Possible limitations included the lack of evaluation of participants' general cognitive abilities that might have effects on the results.

Generally these studies recruited a large number of participants with various ages, enhancing the generalizability of findings on executive functioning. The similar large scales of the studies showed in cognitive tasks as well that large sets of tasks measuring different key domains of executive functioning were assigned to participants in each study, except for the study focusing on elementary school children, possibly considering the limited cognitive load and concentration time of children. Languages used by the participants in each study were specified, although they were different across the studies. These studies all took demographic information, including gender, education levels, and socioeconomic status, as controlled variables to assign matched samples of monolinguals and bilinguals. This could make the results more reliable since these factors might have effects on executive functioning. However, common limitations appeared in the studies that the ambiguous operationalized definitions of both bilingualism and executive functioning reduced the reliability since the complexity of the studies increased.

4. Discussion and Suggestion

There have been significant debates about the effects of bilingualism on individuals' executive functioning without a consensus. However, the studies share the common issue related to the operationalized definitions of bilingualism. The issue highlights the importance of investigation based on detailed classification. Considering the broad evaluating principles and definitions of bilingualism, it is actually hard to generalize the findings to individuals with various language status. Instead of obtaining an overall conclusion, future research should obtain a knowledge system regarding the complexity of bilingualism. It should be paid attention that generally there are no significant differences in executive functioning of the two groups when the demographic information of the individuals is controlled, emphasizing the importance of these confounds besides simple bilingualism and executive functioning. The potential issues related to demographic information of individuals have been noticed in some studies that differences in demographic backgrounds possibly contribute to differences in executive functioning, regardless of language use. Different evaluating standards of bilingualism, including proficiency levels, contexts, frequencies, and activeness, should not only be considered as background information of the participants, but also be considered as a control variable that one evaluating standard is applied, while keeping other aspects constant. Future research could combine cross-sectional and longitudinal designs to explore how different bilingual evaluations influence executive functioning over time. Besides that, the languages studied vary. The importance of languages used by individuals is underevaluated by current studies. The potential effects of linguistic differences, such as alphabetic versus logographic systems, on executive functioning have not been examined by researchers. These effects may provide valuable insights into language-specific cognitive processing. Future research can focus on differences among languages used by bilinguals to examine specific effects.

5. Conclusion

In general, this paper focuses on the effects of bilingualism on executive functioning of individuals. Previous research has shared the common issue considering the classifications of bilingualism. Comparative analyses among different standards of bilingualism are still insufficient. In addition, previous research has mentioned the importance of controlling demographic variables of the participants to obtain reliable results. Furthermore, linguistic differences in languages used by bilingual individuals have not been examined by researchers, which may contribute to the differences in executive functioning. Comparative studies can be conducted later to examine the effects from the linguistic perspective and obtain a more systematic knowledge about this topic. In this case, educators as well as policymakers are able to take advantage of the knowledge and insights to enhance individuals' cognitive development, career adaptability, and overall well-being, improving the lifespan benefits.

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