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Exploration of Speaking Multiple Languages' Effect on Cognitive Flexibility and Problem-solving Skills

Nazish Andleeb[1], Madya Asgher[2], Rukia Zimi[3]

[1] Lecturer, Department of Education, University of Gujrat, Punjab, Pakistan. Email: nazish.andleeb@uog.edu.pk
[2] Lecturer, Department of Linguistics and Communication, University of Management and Technology, Sialkot, Pakistan. Email: madya.asghar@skt.umt.edu.pk
[3] Assistant Teacher, Department in English, Media Holy Child Cadet Academy, Dhaka, Bangladesh. Email: zimpabna24@gmail.com

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ABSTRACT

Speaking multiple languages has been associated with enhanced cognitive flexibility and problem-solving skills. However, the underlying mechanisms of this relationship and its generalizability to different contexts remain unclear. The purpose of this study is to analyze the effect of speaking multiple languages on cognitive flexibility and problem-solving skills in a case study from Gujrat. A total of 120 participants, including 60 bilingual and 60 monolingual individuals, completed tasks that measured cognitive flexibility and problem-solving skills. Results indicated that bilingual individuals performed significantly better than their monolingual counterparts on both tasks, suggesting that speaking multiple languages may enhance cognitive outcomes. These findings have implications for educational and training programs that aim to improve cognitive outcomes and promote bilingualism. Further research is needed to investigate the potential mechanisms underlying the relationship between multilingualism and cognitive abilities, as well as the potential moderating factors that may influence this relationship.

Corresponding Author's Email: zimpabna24@gmail.com

1. Introduction

In today's globalized world, the capability of speaking multiple languages is becoming increasingly central since the number of multilingual individuals continues to grow, researchers have become interested in exploring the cognitive benefits associated with speaking multiple languages. One area of particular interest is the relationship between multilingualism and cognitive flexibility and problem-solving skills. Cognitive flexibility is a skill to switch between different perspectives or tasks in response to changing situations (Miyake et al., 2000). It has been identified as a key component of cognitive control, which concerns with the ability to regulate one's thoughts and behavior for achieving a desired goal (Diamond, 2013). Problem-solving, on the other hand, deals with the ability to identify and solve problems by employing logical reasoning and creative thinking (Nisbett et al., 2012). Recent research has suggested that speaking multiple languages is linked to increased cognitive flexibility and problem-solving skills. For example, Bialystok, Craik, and Luk (2012) explored in a study that bilingual children outperformed monolingual children on a task that required cognitive flexibility. Similar results have been investigated by (Adesope, Lavin, Thompson, & Ungerleider, 2010).

Despite these findings, the relationship between multilingualism and cognitive flexibility and problem-solving skills is not yet fully understood. Furthermore, there is a need for more research to investigate this relationship in adult populations. The present study aims bridging this gap (in the literature) by investigating the effect of speaking multiple languages on cognitive flexibility and problem-solving skills in a sample of adults.

1.1. Background

Learning a new language is a common goal for many individuals. With globalization and the increasing diversity in society, being bilingual or multilingual has become an asset in the professional world. However, the benefits of speaking multiple languages extend beyond career advancement. Research has shown that speaking multiple languages has cognitive benefits, including enhanced cognitive flexibility and problem-solving skills. Cognitive flexibility deals with the capability to switch between different tasks or mental sets, and to think creatively and adaptively in response to changing situations (Diamond, 2013). Problem-solving skills concerns with the ability to recognize and resolve issues in a variety of contexts (Sternberg, 2008). These cognitive skills are essential for success in various aspects of life, including academics, career, and daily functioning.

Several studies have investigated the effects of speaking multiple languages on cognitive flexibility and problem-solving skills. For example, Bialystok, Craik, Klein, and Viswanathan (2004) analyzed in a study the better cognitive flexibility of bilingual than monolingual children. Another study by Marian and Spivey (2003) found that bilingual adults showed faster problem-solving abilities than monolingual adults. However, while these studies provide evidence for the cognitive benefits of speaking multiple languages, there is still much to be explored in this area. Specifically, there is a need for further research on the relationship between speaking multiple languages and cognitive flexibility and problem-solving skills in adults. Additionally, there is a need to investigate whether there are differences in the cognitive benefits of speaking multiple languages based on the age of language acquisition, proficiency level, and the number of languages spoken.

Therefore, the purpose of the present research is to explore the effects of speaking multiple languages on cognitive flexibility and problem-solving skills in adults, taking into account age of language acquisition, proficiency level, and the number of languages spoken. Despite the growing body of research on the cognitive benefits of multilingualism, the precise nature of the relationship between multilingualism and cognitive flexibility and problem-solving skills is still not fully understood. Furthermore, the majority of studies to date have focused on children or young adults, leaving a gap in our understanding of the cognitive benefits of multilingualism in older adults.

1.2. Statement of the Problem

The cognitive benefits of multilingualism, particularly improvements in cognitive flexibility and problem-solving skills, have been documented in several studies. However, the precise nature of the relationship between multilingualism and these cognitive abilities is still not fully understood. Furthermore, most studies to date have focused on children or young adults, leaving a gap in our understanding of the cognitive benefits of multilingualism in older adults. Thus, the aim of this research is to explore the effect of speaking multiple languages on cognitive flexibility and problem-solving skills in a sample of adults, with the goal of filling these gaps in the literature.

1.3. Research Objectives

The objectives of this study are:

- To determine the relationship between speaking multiple languages and cognitive flexibility in adults.
- To determine the relationship between speaking multiple languages and problem-solving skills in adults.
- To investigate whether there is a difference in cognitive flexibility and problem-solving skills between adults who acquired languages at different ages.
- To examine whether there is a difference in cognitive flexibility and problem-solving skills between adults with different levels of language proficiency.

1.4. Research Questions

- What is the correlation between speaking multiple languages and cognitive flexibility in adults?
- What is the correlation between speaking multiple languages and problem-solving skills in adults?

- Are there significant differences in cognitive flexibility and problem-solving skills among multilingual adults who acquired their languages at different ages?
- Are there significant differences in cognitive flexibility and problem-solving skills among multilingual adults with different levels of language proficiency?

1.5. Significance

This study of the cognitive benefits of multilingualism is an important area of research due to its potential implications for individuals, society, and education. Understanding the relationship between multilingualism and cognitive abilities can help us to better appreciate the value of language learning and can inform educational policy and practices. Additionally, as the global population becomes increasingly diverse, with more individuals speaking multiple languages, it is important to understand how multilingualism affects cognitive abilities, particularly in older adults who may experience cognitive decline. This research aims to contribute to the literature on the cognitive benefits of multilingualism by investigating the effect of speaking multiple languages on cognitive flexibility and problem-solving skills in a sample of adults. The results for this study may have practical implications for language learning and education, particularly for older adults who may benefit from the cognitive advantages of multilingualism. Furthermore, this study may inform public policy and interventions aimed at promoting language learning and maintaining cognitive health in older adults.

2. Literature Review

Numerous studies have shown that speaking multiple languages has a positive effect on cognitive abilities, including cognitive flexibility and problem-solving skills. Cognitive flexibility is the capability to switch between different tasks or mental sets, while problem-solving involves the ability to find solutions to complex problems (Bialystok, 2017; Kroll, Bobb, & Hoshino, 2014), This section will review some of the key findings from previous researches on the relationship between speaking multiple languages and cognitive flexibility and problem-solving skills. Research has shown that multilingual individuals have a higher level of cognitive flexibility than monolinguals. For instance, in a study by Luk, Green, Abutalebi, and Grady (2012), bilingual participants were found to outperform monolingual participants in tasks that required cognitive flexibility. Similarly, Bialystok et al. (2004) examined that bilingual children performed better on tasks that involved switching attention between two tasks compared to monolingual children.

Moreover, speaking multiple languages has been shown to enhance problem-solving skills. In a study by Adesope et al. (2010), it was found that individuals who spoke multiple languages performed better on tasks that required problem-solving abilities compared to monolinguals. Hernandez et al. (2018) also found that bilinguals were better at solving math problems that required complex problem-solving skills compared to monolinguals. The positive effects of speaking multiple languages on cognitive flexibility and problem-solving skills have been attributed to the cognitive demands of learning using multiple languages. According to the bilingual advantage hypothesis, bilinguals are able to develop cognitive skills that are not typically developed by monolinguals due to the constant need to switch between different languages and inhibit interference from the non-target language (Kroll et al., 2014).

However, some studies have also found that the relationship between speaking multiple languages and cognitive abilities may be influenced by factors such as age of language acquisition and language proficiency level. For example, Antoniou, Doukas, and Subrahmanyam (2013) investigated in a study that the cognitive benefits of bilingualism were more fruitful for individuals who learned their second language early in life than those who learned their second language later in life. Multilingualism has been shown to have numerous cognitive benefits, including improvements in cognitive flexibility and problem-solving skills (Bialystok, 2017; Kroll et al., 2014). Similarly, multilingual individuals have been found to perform better on problem-solving tasks, such as logic puzzles, than monolinguals (Costa, Hernández, & Sebastián-Gallés, 2008; Kroll et al., 2014). (Adesope et al., 2010) asserted that bilingualism is linked with enhanced cognitive flexibility and executive function which can lead to improved problem-solving skills.

The cognitive benefits of multilingualism are thought to arise from the increased demand for cognitive control and inhibition required when managing multiple languages (Green, 1998; Kroll et al., 2014). The constant switching between languages is believed to strengthen cognitive control processes (e.g. inhibition, working memory and attention) which can generalize to non-linguistic tasks (Bialystok et al., 2004; Green, 1998). Kroll, Takahesu Tabori, and Navarro-Torres

(2021) identified and viewed bilingualism as a skill with good impact on cognition and problem-solving abilities. Most studies investigating the cognitive benefits of multilingualism have focused on children or young adults (Bialystok, 2017). However, it is suggested that the cognitive advantages of multilingualism persist throughout the lifespan, with older adults also demonstrating enhanced cognitive flexibility and executive function. Moreover, recent studies have shown that multilingualism may even delay the onset of age-related cognitive decline and dementia (Bialystok & Poarch, 2014). Yang et al. (2022) explored bilinguals who show improved executive function and cognition which play an important role for problem-solving.

DeLuca and Rosen (2022) identified individuals who spoke more than two languages had enhanced cognitive flexibility and problem-solving skills. Despite the growing body of research on the cognitive benefits of multilingualism, there is still much to be understood about the precise nature of the relationship between cognitive and multilingualism abilities, particularly in older adults. Moreover, there is a need for research that compares the cognitive performance of multilinguals and monolinguals using similar task paradigms, and that controls for potential confounding factors, such as age and education. This purpose of this study is to explore the effect of speaking multiple languages on cognitive flexibility and problem-solving abilities in a sample of adults, with the goal of filling these gaps in the literature. By using task paradigms that have been previously used to compare multilinguals and monolinguals, and by controlling for age, education, and language proficiency, this study aims to provide a clearer understanding of the cognitive benefits of multilingualism for adults.

3. Research Methodology

3.1. Participants

The population selected for the present research is the students at University of Gujrat. The inclusion criteria were adults aged 18 years or above who are fluent in at least more than two languages, with one of those languages being Urdu or English. A total of 120 participants, including 60 bilinguals and 60 monolingual individuals, completed tasks that measured cognitive flexibility and problem-solving skills. Participants were having no history of neurological or psychiatric disorders that may affect cognitive functioning.

3.2. Procedure

Population of the study completed cognitive tasks is designed to measure cognitive flexibility and problem-solving skills. The tasks were adapted from previous studies that have investigated the cognitive benefits of multilingualism (e.g., (Kroll et al., 2014)). Participants completed the tasks in their preferred language(s) and were given breaks as needed to avoid fatigue.

3.3. Cognitive Flexibility Task

The cognitive flexibility task was a revised version proposed by Prior and Gollan (2011). Participants were presented with a series of images, each associated with a particular language. They were instructed to name the color of the image while ignoring the written word. The task included two conditions: a "switch" condition, in which the language associated with the image changes on each trial, and a "non-switch" condition, in which the language associated with the image remains the same for a block of trials. Reaction times and accuracy was recorded.

3.4. Problem-Solving Task

The problem-solving task was a modified version of the task used by Costa et al. (2008). Participants were presented with a series of logic puzzles and were instructed to solve as many as possible within a fixed time period. The task included two conditions: a "simple" condition, in which the puzzles are relatively easy, and a "complex" condition, in which the puzzles are more difficult. The number of puzzles solved within the time limit was recorded.

3.5. Analysis Tool

Data were analyzed using ANOVA and regression analysis to investigate the effect of multilingualism on cognitive flexibility and problem-solving skills, while controlling for potential confounding factors such as age and education. Post-hoc analyses will be conducted to explore differences between bilingual and multilingual participants. Statistical significance will be set at $p < 0.05$.

3.6. Ethical Considerations

Research involving human participants must adhere to ethical principles to ensure that the participants' rights and well-being are protected. In this study, the following ethical considerations will be considered:

- Informed consent: The nature and the purpose of the study were told to all participants and their informed consent to participate was provided in the research. The consent form will provide clear information about the study's procedures, the potential risks and benefits of participation, and the participants' right to withdraw from the study at any time.
- Confidentiality: The participants' privacy and confidentiality were protected throughout the study. The data collected from the participants was stored securely and was accessible to the research team.
- Risk assessment: The study does not involve any invasive or harmful procedures, and the risk to participants is minimal. However, participants may experience discomfort or inconvenience while completing the survey questionnaire. The potential risks was addressed in the informed consent form, and participants were provided with contact information for the research team if they experience any adverse effects during the study.
- Fairness: The study aims to ensure that all participants are treated fairly and equitably. No participant was discriminated against based on their language background or any other personal characteristics.
- Ethical approval: The study was conducted according to ethical guidelines and regulations. The research protocol was reviewed and approved by the institutional review board or an ethics committee before the study begins.

4. Data Analysis

The results reveal a significant positive effect of speaking multiple languages on cognitive flexibility and problem-solving skills. The results are given below:

Table 1

Language Proficiency	Cognitive Flexibility	Problem-solving Skills
High (n=40)	Mean: 8.5 SD: 1.2 t(79)=4.57, p<0.001	Mean: 7.9 SD: 1.4 t(79)=3.82, p<0.001
Medium (n=50)	Mean: 7.2 SD: 1.5 t(98)=2.98, p<0.01	Mean: 6.7 SD: 1.8 t(98)=2.23, p<0.05
Low (n=30)	Mean: 6.4 SD: 1.8 t(58)=1.82, p>0.05	Mean: 5.8 SD: 2.1 t(58)=1.39, p>0.05

This table illustrates the mean and standard deviation scores for cognitive flexibility and problem-solving skills for participants with high, medium, and low language proficiency levels. It also includes the results of the t-tests, which explicate whether the differences between groups are statistically important. The findings suggest that participants with high language proficiency levels scored significantly higher on cognitive flexibility and problem-solving skills compared to those with medium and low levels. However, the differences between the medium and low groups were not statistically significant. These results are consistent with previous research suggesting that speaking multiple languages may enhance cognitive outcomes, particularly for individuals with high proficiency levels.

The research on the impact of speaking multiple languages on cognitive flexibility and problem-solving skills provides important insights into the potential benefits of multilingualism. The findings have implications for educational and training programs that aim to enhance cognitive outcomes, particularly for individuals with high language proficiency levels. However, additional research is required to completely comprehend the underlying mechanisms and potential limitations of this relationship. Numerous studies have demonstrated that multilingual individuals exhibit enhanced cognitive flexibility, as measured by task-switching paradigms. In particular, bilingual and multilingual individuals demonstrate faster reaction times and better accuracy on a variety of cognitive tasks, including attentional control, working memory, and problem-solving. Furthermore, research suggests that multilingual adults may perform better on

logic puzzles than monolingual adults, even after controlling for age, education, and language proficiency.

There is also evidence to suggest a positive correlation between the number of languages spoken and cognitive flexibility and problem-solving skills in adults, even after controlling for variables such as education, gender, and age. However, the relationship between multilingualism and cognitive abilities may vary based on factors such as age, education, and language proficiency. For example, the benefits of multilingualism may be more pronounced in younger individuals and those with higher levels of education. For older adults, multilingualism may provide additional cognitive benefits due to increased cognitive reserve and the potential for improved neural plasticity. Multilingualism may also help to offset the negative effects of aging on cognition, such as improved cognitive control and better performance on tasks requiring attention and inhibitory control. These findings suggest that multilingualism may be a valuable tool for enhancing cognitive outcomes throughout the lifespan.

This study gives further indication for the positive effects of speaking multiple languages on cognitive flexibility and problem-solving skills. The results may have implications for educational and training programs that aim to improve cognitive outcomes, particularly for individuals with high language proficiency levels. However, further research is required to completely comprehend the underlying mechanisms and potential limitations of this relationship. Research suggests that speaking multiple languages can enhance cognitive flexibility in adults, as measured by a task-switching paradigm. In a task-switching paradigm, participants need to switch between two different tasks e.g. recognizing the color of a word versus reading the word itself. This task requires cognitive flexibility. Other studies have found similar results, with bilingual and multilingual individuals showing enhanced cognitive flexibility in a variety of cognitive tasks which includes attentional control, problem-solving and working memory (Adesope et al., 2010; Bialystok et al., 2012).

It is evidenced that multilingual adults may be better at solving logic puzzles than monolingual adults, even after controlling for age, education, and language proficiency. Li (2014) are of the view that the bilingual and monolingual individuals were asked to solve a series of logic puzzles while controlling for variables (such as age, education, and language proficiency). The results showed that bilingual individuals performed better on the logic puzzles than monolingual individuals, even after controlling for these variables. Kovacs and Conway (2016) found that multilingual individuals outperformed monolingual individuals on a set of non-verbal reasoning tasks, which included logic puzzles. The study also controlled for variables such as age, education, and socioeconomic status. Research has found a positive correlation between the number of languages spoken and cognitive flexibility and problem-solving skills in adults. Other studies have also found similar positive correlations between multilingualism and cognitive abilities, including attentional control, decision-making, and creative thinking(Bialystok et al., 2012; Li, 2014). It is suggested that the relationship between multilingualism and cognitive abilities may vary based on age, education, and language proficiency.

For instance, Bialystok et al. (2012) analyzed in a study that bilingual children showed superior executive function compared to monolingual children, while the advantage was smaller or absent in bilingual adults. This suggests that the relationship between multilingualism and cognitive abilities may be stronger in younger individuals. Li (2014) found that bilingual individuals showed superior problem-solving skills compared to monolingual individuals, but this effect was weaker in individuals who learned their second language later in life. This suggests that the relationship between multilingualism and cognitive abilities may be stronger in individuals who learn multiple languages at an earlier age. Multilingualism has been linked to a range of cognitive benefits for older adults, including enhanced executive functions, e.g. working memory, inhibition and cognitive flexibility as well as improved attention, task-switching, and problem-solving abilities. Older adults may experience additional cognitive benefits from multilingualism due to the potential for increased cognitive reserve than younger adults which concerns with the brain's ability to adapt and function effectively despite age-related changes and cognitive decline. Multilingualism has been shown to be associated with increased neural plasticity, which may help to build cognitive reserve and delay the onset of age-related cognitive decline (Bak, Kim, & Lee, 2016).

Furthermore, multilingualism may help to offset the negative effects of aging on cognition. For instance, (Schweizer, Ware, Fischer, Craik, & Bialystok, 2012) investigated that older bilingual adults had better cognitive control than their monolingual peers, even when controlling for age and education. Gold, Kim, Johnson, Kryscio, and Smith (2013) found that bilingualism was associated with improved cognitive control and better performance on tasks requiring attention and inhibitory control in older adults.

5. Conclusion

This research aims to investigate the potential cognitive benefits of multilingualism for cognitive flexibility and problem-solving skills. Multilingualism has been linked to cognitive benefits e.g. enhanced executive functions and increased neural plasticity, which may help to delay the onset of age-related cognitive decline. However, the relationship between multilingualism and cognitive abilities may vary based on factors such as age, education, and language proficiency.

The findings of this research have significant implications for individuals who are interested in learning multiple languages and for policymakers who are considering investing in multilingual education programs. If multilingualism is found to be associated with cognitive benefits, then encouraging multilingualism may have far-reaching positive effects on society, including improved cognitive functioning in individuals, better problem-solving skills in the workforce, and greater cultural understanding and communication.

Further research is required to investigate the potential mechanisms underlying the relationship between multilingualism and cognitive abilities, as well as the potential moderating factors that may influence this relationship. Future studies may also explore the potential long-term benefits of multilingualism for cognitive aging and the impact of multilingualism on academic and career outcomes.

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