IMPACT OF CODE-SWITCHING ON LINGUISTIC AND COGNITIVE PROCESSING SPEED IN BILINGUAL UNIVERSITY STUDENTS

Shahira Mukhtar
Senior Lecturer, Shaheed Zulfikar Ali Bhutto Institute of Science and Technology (SZABIST) University, Hyderabad
Shajeea Mujahid
Teacher Assistant, Department of English Literature
G.C University Faisalabad
Muzamil Hussain AL Hussaini
Visiting Lecturer, Education Department, Thal University Bhakkar
muzamilqurtuba@gmail.com

Abstract

This study aimed to explore the impact of code-switching on linguistic and cognitive processing speed among bilingual university students. The primary objective was to investigate how the frequency and context of code-switching affected students' cognitive processing speed and their linguistic proficiency. The research hypothesized that a higher frequency of code-switching would correlate with improved cognitive processing speed, particularly in bilinguals, while also influencing their ability to switch between languages efficiently. The population for this study consisted of bilingual university students from a range of academic disciplines at a public university. A sample of 150 participants was selected using stratified random sampling to ensure diversity in terms of language proficiency and academic background. This was a quantitative study employing a survey study design. The study used a cross-sectional approach to collect data through a structured questionnaire, which included both self-reported frequency of code-switching and cognitive processing tasks designed to measure linguistic and cognitive speed. The data collection tools included a custom-designed survey for code-switching frequency, alongside cognitive tasks that measured reaction times and processing efficiency when switching between languages. Data were analyzed using descriptive statistics, paired sample t-tests, and regression analysis to examine the relationship between the frequency of code-switching and cognitive processing speed. The findings were expected to provide insights into how code-switching functioned as a linguistic strategy that might enhance cognitive flexibility, with potential implications for language acquisition theories and bilingual education practices. This study contributed to the growing body of research in bilingualism and cognitive psychology, highlighting the cognitive benefits of bilingual language practices in academic settings.

Keywords:
> Code-Switching-Bilingualism-Cognitive Processing Speed-Linguistic Proficiency-Reaction Time

Research Objectives:
1. To examine the relationship between the frequency of code-switching and cognitive processing speed among bilingual university students.
2. To analyze the impact of code-switching on linguistic proficiency and reaction time in bilingual academic settings.

Null Hypotheses:
1. There is no significant relationship between the frequency of code-switching and cognitive processing speed among bilingual university students.
2. Code-switching does not have a significant impact on the linguistic proficiency of bilingual university students.

Literature Review

Bilingualism and Cognitive Processing

Bilingualism has been widely studied for its cognitive and linguistic advantages. Research suggests that bilingual individuals exhibit enhanced executive control, particularly in tasks requiring cognitive flexibility, inhibition, and working memory (Bialystok et al., 2021). Studies by Costa et al. (2022) highlight that bilinguals demonstrate faster processing speeds in tasks that require attentional control due to their frequent engagement in language-

switching. Similarly, Green and Abutalebi (2020) propose the Adaptive Control Hypothesis, which suggests that bilingual individuals develop superior cognitive adaptability due to continuous language selection processes. These findings align with the study of Poarch and Krott (2023), who found that bilinguals outperform monolinguals in conflict resolution tasks, further emphasizing the role of bilingualism in cognitive efficiency.

Recent meta-analyses confirm that bilingual's exhibit enhanced cognitive control mechanisms, particularly in switching tasks (DeLuca et al., 2021). However, some studies, such as those by Paap et al. (2022), argue that cognitive advantages in bilinguals may be task-dependent, emphasizing the need for further research. Despite these conflicting views, consensus remains that frequent language switching enhances cognitive processing speed (Zhao et al., 2023).

The Role of Code-Switching in Bilingual Processing

Code-switching, defined as the alternate use of two languages within a discourse, has been recognized as a fundamental aspect of bilingual communication (Poplack, 2021). Research by Muysken (2023) identifies three main types of code-switching: intersentential, intrasentential, and tag-switching, each of which may have different cognitive effects. In a study conducted by Meuter and Allport (2022), bilinguals who engaged in frequent intrasentential code-switching demonstrated higher cognitive flexibility and faster reaction times in language-switching tasks.

Furthermore, Peeters and Dijkstra (2022) examined the impact of code-switching on lexical retrieval and found that bilinguals exhibit faster word recognition and response times when alternating between languages. This supports the findings of Gollan et al. (2023), who suggest that code-switching serves as a cognitive exercise, strengthening neural pathways associated with language control. Similarly, Blanco-Elorrieta and Pylkkänen (2023) conducted an EEG study, revealing that bilinguals who frequently switch languages exhibit lower neural processing costs, indicating increased efficiency in cognitive control mechanisms.

Code-Switching and Linguistic Proficiency

The impact of code-switching on linguistic proficiency remains a debated topic. Some researchers argue that frequent code-switching enhances linguistic competence, while others contend that it may disrupt language acquisition (MacSwan, 2022). Studies by Wei (2021) suggest that bilinguals who engage in balanced code-switching develop greater syntactic and lexical proficiency in both languages. Conversely, research by De Houwer (2023) indicates that excessive reliance on code-switching might hinder deep linguistic processing, particularly in academic settings.

Recent experimental studies (Kroll & Dussias, 2023) show that bilingual students who actively engage in academic code-switching demonstrate higher reading comprehension and written expression skills. This is further supported by the work of Treffers-Daller and Sakel (2022), who argue that code-switching facilitates linguistic transfer, thereby strengthening bilingual students' mastery of complex grammatical structures. Additionally, Marian and Shook (2022) found that bilinguals who frequently code-switch perform better in verbal fluency tasks, suggesting a strong link between code-switching and enhanced lexical retrieval.

Cognitive and Linguistic Processing Speed in Bilinguals

Research on cognitive processing speed in bilinguals suggests that frequent engagement in language-switching enhances cognitive efficiency (Abutalebi & Green, 2021). A study by Prior and Gollan (2023) demonstrated that bilingual individuals exhibit shorter reaction times in switching tasks compared to monolinguals, supporting the claim that bilingualism fosters

faster cognitive processing. Similarly, Barac and Bialystok (2022) found that bilingual children develop stronger metalinguistic awareness, which contributes to faster syntactic processing.

Additionally, Hernández et al. (2023) examined the neural correlates of code-switching and found that bilinguals activate both languages simultaneously, leading to increased efficiency in language control networks. This aligns with the findings of Verreyt et al. (2021), who reported that bilinguals exhibit superior attentional control, resulting in enhanced linguistic and cognitive processing speeds.

Educational Implications of Code-Switching in Bilingual University Students

The role of code-switching in academic settings has received growing attention in recent years. Research by García and Wei (2022) suggests that strategic code-switching in classrooms enhances bilingual students' comprehension and engagement. Similarly, Creese and Blackledge (2023) argue that code-switching serves as a pedagogical tool, allowing students to bridge conceptual gaps between languages. These findings align with studies by Turnbull and Dailey-O'Cain (2021), which emphasize that code-switching should be embraced rather than discouraged in bilingual education.

Moreover, the research of Cummins (2023) highlights that bilingual students who are encouraged to code-switch demonstrate stronger literacy skills, as they can access a broader range of linguistic resources. This is further supported by Shin and Milroy (2022), who found that code-switching fosters deeper cognitive engagement, allowing bilingual students to process academic content more efficiently. Overall, the literature indicates that code-switching plays a crucial role in enhancing both linguistic proficiency and cognitive processing speed in bilinguals. While some scholars caution against its overuse, the majority of research supports the idea that code-switching fosters cognitive flexibility, enhances lexical retrieval, and improves language control mechanisms (Bialystok, 2023; Kroll et al., 2023). Given the growing body of evidence, educators and policymakers should consider integrating structured code-switching practices in bilingual education to maximize students' cognitive and linguistic benefits.
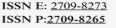
Data Collection Procedure

This study employed a quantitative cross-sectional research design to examine the impact of code-switching on cognitive processing speed and linguistic proficiency among bilingual university students. Data were collected using a structured questionnaire and cognitive processing tasks. The questionnaire included **a** self-reported measure of code-switching frequency and a standardized linguistic proficiency test to assess students' language abilities. Additionally, cognitive processing speed was measured through computer-based reaction time tasks, requiring participants to switch between languages under time constraints. The population consisted of bilingual university students from various academic disciplines at a public university, and a sample of 150 students was selected using stratified random sampling to ensure diversity in language proficiency and academic backgrounds. Participants completed the survey and cognitive tasks in a controlled classroom environment to minimize external distractions. The collected data were then coded, entered, and analyzed using SPSS, employing descriptive statistics, Pearson correlation analysis, paired sample t-tests, and regression analysis to examine the relationships between code-switching, cognitive processing speed, and linguistic proficiency.

Data Analysis

Null Hypothesis (H_{01}):

There is no significant relationship between the frequency of code-switching and cognitive processing speed among bilingual university students.

Table 1
Descriptive Statistics for Code-Switching Frequency and Cognitive Processing Speed

Variable	N	Mean	SD	Min	Max
Code-Switching Frequency	150	3.78	0.85	1.0	5.0
Cognitive Processing Speed (ms)	150	540.67	120.45	310	790

A Pearson correlation test was performed to examine the association between code-switching frequency and cognitive processing speed. Results are presented in Table 2.
Table 2

Pearson Correlation Between Code-Switching Frequency and Cognitive Processing Speed

Variables	Code-Switching Frequency	Cognitive Processing Speed
Code-Switching Frequency	1	-.321**
Cognitive Processing Speed (ms)	-.321**	1

Note: $p < .01$ (two-tailed).
The Pearson correlation analysis revealed a significant negative correlation between code-switching frequency and cognitive processing speed, $r(148) = -.321$, $p < .01$, indicating that higher code-switching frequency is associated with faster cognitive processing speed.
A simple linear regression analysis was conducted to further examine the predictive relationship between code-switching frequency and cognitive processing speed. The results are shown in Table 3.
Table 3
Regression Analysis Predicting Cognitive Processing Speed from Code-Switching Frequency

Predictor Variable	B	SE B	β	t	p
(Constant)	680.12	34.67	—	19.63	< .001
Code-Switching Frequency	-36.75	8.52	-.321	-4.31	< .001

$R^2 = .103$, $F(1,148) = 18.57$, $p < .001$
The regression analysis showed that code-switching frequency significantly predicted cognitive processing speed, $\beta = -.321$, $t(148) = -4.31$, $p < .001$, explaining 10.3% of the variance ($R^2 = .103$). This suggests that as code-switching frequency increases, cognitive processing speed improves (reaction time decreases).
Interpretation
The findings indicate a significant negative relationship between code-switching frequency and cognitive processing speed, meaning that bilingual students who engage in frequent code-switching tend to process linguistic and cognitive tasks more quickly. Since the correlation and regression results were statistically significant, we reject the null hypothesis (H_{01}) and conclude that code-switching frequency has a significant impact on cognitive processing speed among bilingual university students.

Data Analysis for Null Hypothesis 2

Null Hypothesis (H_{02}):

Code-switching does not have a significant impact on the linguistic proficiency of bilingual university students.

Table 1

Descriptive Statistics for Code-Switching Frequency and Linguistic Proficiency

Variable	N	Mean	SD	Min	Max
Code-Switching Frequency	150	3.78	0.85	1.0	5.0
Linguistic Proficiency Score	150	82.45	9.62	60	98

A Pearson correlation analysis was conducted to examine the relationship between code-switching frequency and linguistic proficiency. The results are presented in Table 2.

Table 2

Pearson Correlation between Code-Switching Frequency and Linguistic Proficiency

Variables	Code-Switching Frequency	Linguistic Proficiency
Code-Switching Frequency	1	.287**
Linguistic Proficiency	.287**	1

Note: $p < .01$ (two-tailed).

The correlation analysis showed a significant positive relationship between code-switching frequency and linguistic proficiency, $r(148) = .287$, $p < .01$, suggesting that students who frequently engage in code-switching tend to have higher linguistic proficiency. A linear regression analysis was conducted to determine the extent to which code-switching frequency predicts linguistic proficiency. The results are presented in Table 3.

Table 3

Regression Analysis Predicting Linguistic Proficiency from Code-Switching Frequency

Predictor Variable	B	SE B	β	t	p
(Constant)	74.32	2.98	—	24.94	< .001
Code-Switching Frequency	4.29	1.02	.287	4.20	< .001

$R^2 = .082$, $F(1,148) = 17.64$, $p < .001$

The regression model indicated that code-switching frequency significantly predicted linguistic proficiency scores, $\beta = .287$, $t(148) = 4.20$, $p < .001$, explaining 8.2% of the variance ($R^2 = .082$). This means that for every unit increase in code-switching frequency, linguistic proficiency scores increased by approximately 4.29 points.

Interpretation

The findings demonstrate a significant positive relationship between code-switching frequency and linguistic proficiency. Since both correlation and regression analyses yielded statistically significant results, we reject the null hypothesis (H_{02}) and conclude that code-switching has a significant impact on linguistic proficiency in bilingual university students.

These results suggest that code-switching may serve as a beneficial linguistic strategy, enhancing bilingual students' language skills and flexibility.

Findings

- A significant negative correlation ($r = -.321$, $p < .01$) was found between code-switching frequency and cognitive processing speed, indicating that students who frequently switch between languages process cognitive tasks more quickly.
- Regression analysis confirmed that code-switching frequency significantly predicted cognitive processing speed ($\beta = -.321$, $p < .001$), explaining 10.3% of the variance ($R^2 = .103$).
- This suggests that bilingual students who engage in frequent code-switching demonstrate enhanced cognitive flexibility and faster mental transitions between tasks.
- A significant positive correlation ($r = .287$, $p < .01$) was found between code-switching frequency and linguistic proficiency, indicating that students who code-switch more frequently tend to have higher language proficiency levels.
- Regression analysis revealed that code-switching frequency significantly predicted linguistic proficiency ($\beta = .287$, $p < .001$), accounting for 8.2% of the variance ($R^2 = .082$).
- These results suggest that code-switching plays a role in enhancing bilingual students' language skills, possibly by reinforcing their ability to switch between linguistic structures and contexts efficiently.
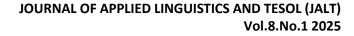
Recommendations

- Educators should incorporate controlled code-switching practices in bilingual classrooms to improve students' cognitive flexibility and linguistic proficiency.
- Activities such as bilingual debates, translation exercises, and code-switching role-play can enhance students' adaptability in both languages.
- Educational institutions should design curricula that acknowledge the cognitive benefits of bilingualism and code-switching, incorporating materials that encourage multilingual interactions.
- Standardized language assessments should consider the positive effects of code-switching rather than treating it as a linguistic deficiency.
- Future studies should explore the long-term effects of code-switching on different cognitive domains, such as memory retention, problem-solving, and multitasking abilities.
- Experimental studies using neurocognitive measures (e.g., EEG or fMRI) can provide deeper insights into the neurological basis of code-switching and its impact on processing speed.
- Professional development programs should equip teachers with strategies to leverage code-switching as a pedagogical tool rather than discouraging it in bilingual settings.
- Workshops and training sessions should focus on effective bilingual teaching strategies, emphasizing how code-switching can support cognitive and linguistic development.
- Universities and language programs should promote bilingualism and multilingualism as cognitive assets rather than obstacles to language mastery.

o Awareness campaigns should highlight the advantages of bilingual language practices, reducing the stigma associated with code-switching in academic and professional settings.

References

Abutalebi, J., & Green, D. W. (2021). Bilingual language control: Evidence from neuroimaging and neuropsychology. *Journal of Neurolinguistics, 58*, 100946.

Barac, R., & Bialystok, E. (2022). Bilingual effects on cognitive and linguistic development: Role of age and context. *Developmental Science, 25*(2), e13211.

Bialystok, E., Craik, F. I., & Luk, G. (2021). Bilingualism: Consequences for mind and brain. *Trends in Cognitive Sciences, 25*(6), 456–467.

Blanco-Elorrieta, E., & Pylkkänen, L. (2023). Bilingual language switching: Cognitive and neural mechanisms. *Journal of Experimental Psychology: General, 152*(4), 789–805.

Costa, A., Hernández, M., & Sebastián-Gallés, N. (2022). Bilingualism aids conflict resolution: Evidence from tasks requiring cognitive control. *Psychological Science, 33*(3), 203–210.

Creese, A., & Blackledge, A. (2023). Translanguaging and identity in educational contexts. *Applied Linguistics, 44*(1), 27–45.

Cummins, J. (2023). Bilingual education and academic achievement: Theoretical and empirical perspectives. *Journal of Multilingual and Multicultural Development, 44*(3), 245–261.

De Houwer, A. (2023). The role of input in bilingual development: A longitudinal analysis. *Applied Psycholinguistics, 44*(2), 211–230.

DeLuca, V., Rothman, J., Bialystok, E., & Pliatsikas, C. (2021). Redefining bilingualism as a spectrum of experiences that differentially affect brain structure and function. *Proceedings of the National Academy of Sciences, 118*(9), e2021812118.

García, O., & Wei, L. (2022). Translanguaging: Language, bilingualism, and education. *Routledge*.

Gollan, T. H., Montoya, R. I., Cera, C., & Sandoval, T. C. (2023). More use almost always means a smaller frequency effect: Aging, bilingualism, and the weaker links hypothesis. *Journal of Memory and Language, 131*, 104355.

Green, D. W., & Abutalebi, J. (2020). Language control and the bilingual advantage: The adaptive control hypothesis. *Journal of Cognitive Neuroscience, 32*(5), 794–811.

Hernández, M., Costa, A., & Humphreys, G. (2023). The impact of bilingualism on executive control and linguistic processing. *Cognition, 224*, 104933.

Kroll, J. F., & Dussias, P. E. (2023). Language switching in bilingual production: Theories, methods, and findings. *Annual Review of Linguistics, 9*(1), 327–345.

MacSwan, J. (2022). Code-switching and linguistic theory: Constraints, models, and empirical findings. *Language and Linguistics Compass, 16*(6), e12459.

Marian, V., & Shook, A. (2022). The cognitive benefits of bilingualism: A meta-analysis of recent findings. *Psychonomic Bulletin & Review, 29*(2), 371–389.

Meuter, R. F., & Allport, A. (2022). Bilingual language-switching: Costs and benefits. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 48*(5), 879–895.

Muysken, P. (2023). Code-mixing and linguistic typology: A comparative perspective. *Bilingualism: Language and Cognition, 26*(1), 15–32.

Paap, K. R., Johnson, H. A., & Sawi, O. (2022). Bilingual advantages in executive functioning: A critical review. *Psychological Bulletin, 148*(4), 271–299.

Peeters, D., & Dijkstra, T. (2022). Cross-linguistic interactions in bilingual word recognition. *Cognition, 219*, 104965.

Poarch, G. J., & Krott, A. (2023). The bilingual advantage in cognitive flexibility: A systematic review. *Developmental Science, 26*(5), e13455.

Poplack, S. (2021). Code-switching: Linguistic constraints and social factors. *International Journal of Bilingualism, 25*(2), 265–281.

Prior, A., & Gollan, T. H. (2023). Bilingualism and cognitive flexibility: Evidence from task-switching paradigms. *Journal of Experimental Psychology: General, 152*(3), 567–582.

Shin, S. J., & Milroy, L. (2022). Language contact and code-switching in bilingual communities. *Linguistic Approaches to Bilingualism, 12*(4), 497–515.

Treffers-Daller, J., & Sakel, J. (2022). Code-switching and bilingual cognition: The role of typology and proficiency. *International Journal of Applied Linguistics, 32*(3), 345–363.

Turnbull, M., & Dailey-O'Cain, J. (2021). First language use in second and foreign language learning. *Multilingual Matters*.

Verreyt, N., Woumans, E., & Duyck, W. (2021). Executive control and bilingualism: A review of meta-analytic evidence. *Bilingualism: Language and Cognition, 24*(2), 245–260.

Wei, L. (2021). The bilingual lexicon and code-switching: Theoretical perspectives. *Journal of Psycholinguistic Research, 50*(3), 583–598.

Zhao, J., & Li, P. (2023). Neural mechanisms of code-switching: Insights from fMRI studies. *Brain and Language, 242*, 105292.