Inhibitory Control and Academic Performance in Arabic-Speaking Primary School Students

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ABSTRACT

This Quasi-Experimental Study Examined the Relationship Between Inhibitory Control, Assessed Via Stroop Test (Speed And Accuracy), And Academic Performance in Arabic Language, Mathematics, And Grade Point Average (Gpa) Among 60 Primary School Students. A Correlational Design Was Employed To Determine Whether Stroop Test Performance Predicted Academic Outcomes. Descriptive Statistics And Spearman's Rank Correlations Revealed A Significant Medium Negative Correlation Between Inhibitory Control Speed (Time To Complete Interference Task) And Mathematics Performance (R = -0.32, P = .012), Indicating That Faster Inhibition Was Associated With Higher Mathematics Scores. No Significant Correlations Were Found Between Speed And Arabic Language Or Gpa, Nor Between Accuracy (Uncorrected Errors) And Any Academic Outcome. These Findings Partially Support The Hypothesis That Inhibitory Control Is Linked To Academic Performance In Subjects With High Executive Function Demands, Such As Mathematics, But Suggest Limited Effects On Arabic Language And Overall Gpa. Finally, This Work Discussed Implications Of Educational Interventions Targeting Executive Functions.

Keywords: Aacademic Performance, Arabic language, Inhibitory Control, GPA, Mathematics,

INTRODUCTION

Academic performance, defined as the level of knowledge demonstrated compared to educational standards (Rodríguez-Hernández et al., 2020), is shaped by multiple factors, including socio-economic status (Lengua et al., 2007), self-regulation (Valiente et al., 2009), and executive functions (Miyake et al., 2000). Inhibitory control, a core executive function, enables individuals to suppress automatic responses in favor of goal-directed behaviors (Diamond, 2013; Miyake et al., 2000). This cognitive process is critical in educational settings, supporting selective attention, distraction management, and problem-solving (Blair & Razza, 2007). Numerous studies have linked inhibitory control to children's academic achievement, but its role in specific linguistic and cultural contexts, such as Arabic-speaking primary school students, requires further exploration (Bialystok, 2005; Kaddouri et al., 2025).

Arabic poses unique cognitive challenges due to its diglossic nature, as students navigate between Modern Standard Arabic (MSA) and spoken dialects (Saiegh-Haddad, 2003). This linguistic divide necessitates inhibitory control to suppress interference from colloquial dialects during reading, writing, and vocabulary acquisition (Tibi & Kirby, 2018). Additionally, the Arabic writing system, with its visually similar letters distinguished by diacritic signs, demands robust visual inhibitory control to avoid errors (Abu-Rabia & Taha, 2006). In mathematics, inhibitory control facilitates problem-solving by filtering irrelevant stimuli (Bull & Lee, 2014), while for overall academic performance (GPA), it supports self-regulation and socio-emotional competence (Valiente et al., 2009). However, empirical findings remain mixed, particularly in Arabic-speaking contexts, where developmental and environmental factors like socio-economic status and bilingualism may

influence outcomes (Lengua et al., 2007; Bialystok, 2005).

The Stroop test, a standard measure of inhibitory control, assesses interference suppression by requiring participants to focus on word color rather than on semantic meaning (Stroop, 1935). Blair and Razza (2007) and St Clair-Thompson and Gathercole (2006) demonstrated that Stroop performance is associated with academic outcomes in children, but its application to Arabic and its differential effects across subjects remain unclear. For instance, Bouayad and El-Mir (2022) found that students with reading comprehension difficulties in Arabic exhibit weak inhibitory control, suggesting its necessity for focusing on relevant textual information and integrating it effectively. Es-salmi (2024) reported a significant negative correlation between inhibitory control test performance (e.g., Stroop and Go/No-Go) and errors in mathematical problem-solving among Moroccan pupils, where effective inhibition prevents interference from convergent information (e.g., 8×9 vs. 8×7), enhancing mathematical accuracy.

Other studies have further elucidated the role of inhibitory control in academic achievement. Best et al. (2011) found that better executive function performance, including inhibitory control and attention, was associated with higher achievement in reading and mathematics among children aged 5 to 17, emphasizing the importance of early support for these skills. Bialystok (2005) highlighted how bilingualism enhances inhibitory control, enabling bilingual children to ignore distractions and improve cognitive and academic performance in tasks requiring deep concentration. Similarly, Blair and Razza (2007) argued that inhibitory control and stress regulation in kindergarten predict early mathematics and reading abilities, underscoring the need for preschool interventions. Duckworth et al. (2019) noted that self-control, a facet of executive control, consistently predicts academic achievement, with students who delay gratification achieving higher grades. Espy et al. (2004) found that inhibitory control and other executive functions explain individual differences in emerging mathematical skills in preschoolers, advocating for early training.

In contrast, Pascual et al. (2019) suggested that the relationship between executive functions and academic performance weakens with age due to brain maturation, though inhibitory control retains a modest effect in high-demand cognitive domains. Poropat (2009) confirmed through a meta-analysis that conscientiousness, linked to inhibitory control, is a stronger predictor of academic success than intelligence. Neurally, Botvinick et al. (2004) demonstrated that the anterior cingulate cortex (ACC) plays a key role in conflict monitoring and cognitive control, supporting the role of inhibitory control in complex cognitive tasks essential for effective learning. Dvorak (2024) found that Stroop test errors, rather than response time, negatively correlate with college students' GPA, suggesting errors may be a sensitive indicator of inhibitory control. In reading, Arrington et al. (2014) noted that inhibitory control difficulties hinder word processing due to inattention, while Butterfuss and Kendeou (2018) established that effective inhibitory control facilitates inference generation and integration during comprehension of complex texts. Altemeier et al. (2008) demonstrated that inhibition aids reading skill development through attention control, particularly in dyslexia. Finally, Kaddouri et al. (2025) found that working memory, integrated with inhibitory control, strongly predicts performance in Arabic, mathematics, and GPA, suggesting complementary roles for executive functions.

This study explores the correlation between inhibitory control (speed and accuracy) and academic performance in Arabic, mathematics, and GPA among primary school students. Two hypotheses were tested: (1) students with high Stroop test performance (faster times, fewer errors) will achieve higher academic performance, and (2) inhibitory control will show stronger associations in subjects with high executive function demands, such as mathematics.

METHOD

Participants

The sample comprised 60 primary school students (30 males, 30 females; *M* age = 11.5 years, *SD* = 1.2, range = 10–13) from a single institution. Participants were evenly distributed across fifth (n = 30) and sixth (n = 30) grades. Inclusion required written consent from participants and guardians, with students having learning disabilities or cognitive impairments excluded. Ethical approvals were obtained from relevant educational

authorities.

Data Collection and Analysis

Inhibitory control was assessed using a computerized Stroop test, measuring speed (time to complete the interference task in seconds) and accuracy (number of uncorrected errors). The test presented congruent and incongruent trials, with participants identifying the word's color via keypress. Academic performance data (Arabic language, mathematics, GPA) were retrieved from first-semester school records, scored on a 10-point scale.

Descriptive statistics (means, standard deviations, ranges) were calculated. The Shapiro-Wilk test confirmed non-normal data distribution, necessitating non-parametric analyses. Spearman's rank correlation coefficients examined relationships between inhibitory control (speed, accuracy) and academic performance (Arabic language, mathematics, GPA). Significance was set at $p < .05$, with analyses conducted in SPSS (Version 26). Assumptions of independence and linearity were verified.

RESULTS

Descriptive statistics for academic performance and inhibitory control are presented in Table 1 below. Arabic language scores averaged 7.28 (*SD* = 1.16, range = 4.25–9.59), indicating consistent performance. Mathematics scores showed greater variability (*M* = 6.45, *SD* = 1.54, range = 3.25–9.50). GPA averaged 6.91 (*SD* = 0.93, range = 4.58–8.72). Stroop speed averaged 210.55 seconds (*SD* = 56.17, range = 130–356), and accuracy (uncorrected errors) had a mean of 3.40 (*SD* = 3.49, range = 0–16).

Table 1 Descriptive Statistics for Academic Performance and Inhibitory Control Measures

Variable	*M*	*SD*	Range
Arabic Language	7.28	1.16	4.25–9.59
Mathematics	6.45	1.54	3.25–9.50
Grade Point Average (GPA)	6.91	0.93	4.58–8.72
Stroop Speed (seconds)	210.55	56.17	130–356
Stroop Accuracy (uncorrected errors)	3.40	3.49	0–16

Spearman's correlations, necessitated by non-normal data, are shown in Table 2 below.

Table 2 Spearman's Correlations Between Inhibitory Control Components and Academic Performance

Variable	GPA (*r*)	GPA (*p*)	Maths (*r*)	Maths (*p*)	Arabic Language (*r*)	Arabic Language (*p*)
Speed (Time)	-0.07	.586	-0.32	.012	-0.05	.713
Accuracy (Uncorrected Errors)	0.05	.731	-0.09	.492	0.01	.927

Note: *N* = 60. Speed is time (seconds) to complete the Stroop task; negative correlations indicate shorter times associate with higher scores.

Stroop speed showed no significant correlation with GPA ($r = -0.07$, $p = .586$) or Arabic language ($r = -0.05$, $p = .713$). A medium negative correlation, per Cohen (1988), was found with mathematics ($r = -0.32$, $p = .012$).

Accuracy showed no significant correlations with GPA (r = 0.05, p = .731), mathematics (r = -0.09, p = .492), or Arabic language (r = 0.01, p = .927).

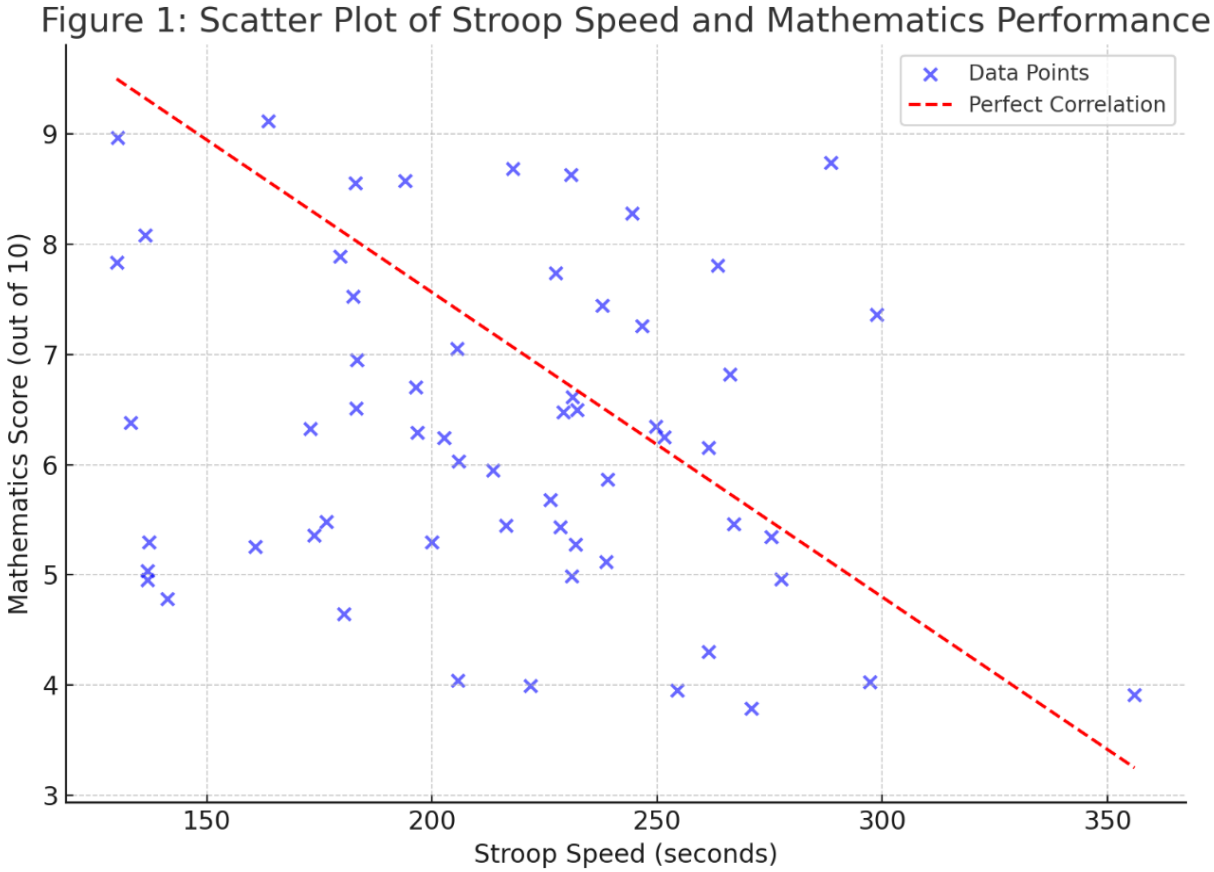

Figure 1 Illustration of scatter plot of Stroop speed versus mathematics scores, with the diagonal line indicating perfect correlation and data point spread reflecting correlation strength.

The first hypothesis, expecting higher Stroop performance to predict better academic outcomes, was partially supported for speed in mathematics (r = -0.32, p = .012) but not for GPA, Arabic language, or accuracy. The second hypothesis, anticipating stronger correlations in high-demand subjects like mathematics, was supported for speed but not accuracy.

DISCUSSION

The present study investigated the relationship between inhibitory control, as measured by the Stroop test (speed and accuracy), and academic performance in Arabic language, mathematics, and grade point average (GPA) among 60 primary school students. The findings revealed a significant medium negative correlation between inhibitory control speed and mathematics performance (r = -0.32, p = .012), indicating that faster inhibition is associated with higher mathematics scores. However, no significant correlations were found between speed and Arabic language (r = -0.05, p = .713) or GPA (r = -0.07, p = .586), nor between accuracy (uncorrected errors) and any academic outcome. These results partially support the first hypothesis - that higher Stroop test performance predicts better academic outcomes - and strongly support the second hypothesis, which posits stronger associations in subjects with high executive function demands, such as mathematics. The following discussion interprets these findings in light of theoretical frameworks and prior research, while addressing implications, limitations, and futures directions.

Interpretation of Findings

The significant correlation between inhibitory control speed and mathematics performance aligns with prior research highlighting the role of executive functions in mathematical achievement (Best et al., 2011; Es-salmi, 2024). Mathematics requires rapid inhibition of irrelevant stimuli, such as suppressing incorrect operations

(e.g., confusing 8×9 with 8×7), which demands efficient cognitive control (Bull & Lee, 2014; Es-salmi, 2024). The medium effect size (r = -0.32) suggests a meaningful relationship, consistent with Blair and Razza (2007), who found that inhibitory control in early education predicts mathematical skills by supporting focus and problem-solving. This finding supports the second hypothesis, as mathematics' high executive function demands—requiring logical reasoning and attention control—make it particularly sensitive to inhibitory control speed.

In contrast, the lack of a significant correlation between inhibitory control speed and Arabic language performance is consistent with the linguistic and memory-based nature of Arabic learning. The diglossic structure of Arabic, requiring students to navigate between Modern Standard Arabic (MSA) and spoken dialects, imposes cognitive demands (Saiegh-Haddad, 2003). However, these demands may rely more on working memory and linguistic processing than on rapid inhibitory control, as suggested by Kaddouri et al. (2025). For instance, reading comprehension and vocabulary acquisition in Arabic involve integrating semantic information, which may be less dependent on suppressing automatic responses compared to mathematics (Bouayad & El-Mir, 2022). This finding aligns with the second hypothesis, as Arabic language's lower executive function demands result in weaker associations with inhibitory control speed.

The absence of a significant correlation between inhibitory control speed and GPA is notable, given prior evidence linking executive functions to overall academic achievement (Duckworth et al., 2019; Kaddouri et al., 2025). GPA, as an aggregate measure, is influenced by multiple factors, including motivation, socio-economic status, and self-regulation, which may dilute the specific effect of inhibitory control (Poropat, 2009). This result suggests that while inhibitory control speed is critical for specific domains like mathematics, its impact on broader academic performance is less pronounced, possibly due to the mediating role of other cognitive and non-cognitive factors (Lengua et al., 2007).

The lack of significant correlations between inhibitory control accuracy (uncorrected errors) and any academic outcome is unexpected, particularly in light of Dvorak (2024), who found that Stroop test errors negatively correlated with GPA in college students. This discrepancy may be attributed to developmental differences, as primary school students' inhibitory control is still maturing, potentially making speed a more sensitive indicator than accuracy (Pascual et al., 2019). Additionally, the variability in accuracy (SD = 3.49, range 0–16) suggests that some students made significantly more errors, which may reflect inconsistent attention rather than stable inhibitory control deficits, reducing its predictive power. This finding underscores the need to differentiate between speed and accuracy when assessing inhibitory control's academic impact.

Theoretical Implications

These findings support Miyake et al.'s (2000) model of executive functions, which posits inhibitory control as a distinct yet interrelated process critical for goal-directed behaviors. The significant role of inhibitory control speed in mathematics reinforces the importance of interference inhibition in tasks requiring cognitive flexibility and attention control (Diamond, 2013). The lack of association with Arabic language performance aligns with theoretical frameworks of diglossic language acquisition, which emphasize working memory over inhibitory control for managing linguistic distance between MSA and dialects (Saiegh-Haddad, 2003). The null findings for GPA suggest that self-regulation theory, which links inhibitory control to broader academic success via behavioral and emotional regulation, may be less applicable in primary school contexts where other factors dominate (Valiente et al., 2009).

The results also highlight the developmental complexity of inhibitory control. As Espy et al. (2004) noted, inhibitory control significantly influences emergent academic skills in early childhood, but its effect may weaken with age due to brain maturation (Pascual et al., 2019). The stronger association with mathematics in this study suggests that inhibitory control remains critical in cognitively demanding domains during middle childhood, supporting targeted interventions in primary education.

Practical Implications

The significant correlation between inhibitory control speed and mathematics performance has practical

implications for educational interventions. Training programs targeting executive functions, such as those improving inhibitory control through cognitive tasks (e.g., Stroop-like exercises), could enhance mathematical achievement (Best et al., 2011). Schools could integrate such activities into curricula, particularly for students struggling with mathematics, to bolster their ability to suppress irrelevant stimuli and focus on problem-solving.

The lack of association with Arabic language performance suggests that interventions for Arabic learning should prioritize linguistic and memory-based strategies, such as explicit instruction in MSA vocabulary and grammar, rather than inhibitory control training (Tibi & Kirby, 2018). However, given the diglossic challenges, supplementary exercises to strengthen visual inhibitory control (e.g., distinguishing similar Arabic letters) may still benefit orthographic accuracy (Abu-Rabia & Taha, 2006).

The null findings for GPA indicate that improving overall academic performance requires a multifaceted approach, addressing motivation, socio-economic status, and self-regulation alongside cognitive skills (Lengua et al., 2007). Educators and policymakers should consider holistic interventions that combine cognitive training with socio-emotional support to maximize academic outcomes.

CONCLUSION

This study provides evidence that inhibitory control speed is a significant predictor of mathematics performance among primary school students, supporting its role in subjects with high executive function demands. However, its limited impact on Arabic language and GPA highlights the domain-specific nature of inhibitory control and the influence of other cognitive and environmental factors. These findings contribute to the growing literature on executive functions in Arabic-speaking educational contexts, emphasizing the need for targeted interventions to enhance mathematical achievement and further research to elucidate inhibitory control's role in diverse academic domains.

Limitations

Several limitations should be noted. First, the sample size (n = 60) is relatively small, which limits generalizability to broader Arabic-speaking populations. Second, the study relied on a single measure of inhibitory control (Stroop test), which may not capture the full spectrum of inhibitory processes (e.g., response inhibition measured by Go/No-Go tasks). Third, the exclusion of students with learning disabilities ensured sample homogeneity but may have overlooked how inhibitory control impacts diverse learners. Fourth, environmental factors such as socio-economic status and bilingualism, which influence inhibitory control and academic performance, were not controlled for, potentially confounding results (Bialystok, 2005; Lengua et al., 2007). Finally, the cross-sectional design precludes causal inferences, as longitudinal data would better clarify the developmental trajectory of inhibitory control's impact.

Future Directions

Future research should address these limitations by:

1. **Expanding Sample Size and Diversity**: larger, more diverse samples must be included across Arabic-speaking countries to enhance generalizability and account for variations in educational curricula and socio-economic status.

2. **Using Multiple Measures** of inhibitory control (e.g., Go/No-Go, Flanker) to provide a comprehensive assessment of inhibitory processes.

3. **Including Diverse Learners** because inhibitory control affects students with learning disabilities or bilingual backgrounds, given the cognitive advantages of bilingualism (Bialystok, 2005).

4. **Controlling Confounding Variables** such us socio-economic status, parenting practices, and motivation in order to isolate inhibitory control's unique contribution.

5. **Adopting Longitudinal Designs** that allow the exploration of how inhibitory control's impact on academic performance evolves over time, particularly as cognitive maturation progresses (Pascual et al., 2019).

6. **Testing Interventions** in order to evaluate the efficacy of inhibitory control training programs on mathematics and Arabic performance, building on findings from Best et al. (2011).

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