Information Processing Speed and Cognitive Style as Joint Predictors of Secondary School Students' Achievement in Biology in Anambra State, Nigeria

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https://doi.org/10.56201/jbgr.vol.12.no5.2026.pg51.60

Abstract
The study investigated information processing speed and cognitive style as predictors of secondary school students' academic achievement in Biology in Anambra State, Nigeria. A predictive correlational design was used. A sample of 1,000 SS2 Biology students was drawn from a population of 42,572 using multistage sampling. Two instruments were employed: The Speed Test (ST) adapted from Olav Hoel Dorum, measuring logical reasoning speed, analytical thinking speed, and visual-spatial skills speed; and the Group Embedded Figures Test (GEFT) adapted from Witkin, Oltman, Raskin and Karp (1971), measuring field dependence and field independence. Both instruments were validated by three experts and yielded KR-20 reliability coefficients of 0.92 (ST) and 0.89 (GEFT). Students' Biology achievement scores were obtained from teachers' records. Data were analysed using simple and multiple linear regression. Results showed that information processing speed individually predicted 0.5% of the variance, cognitive style predicted 0.6%, and together they predicted 1.0% of the variance in Biology achievement. Visual-spatial skills speed and logical reasoning speed were significant predictors, but analytical thinking speed was not. Both field dependence and field independence contributed significantly, with field dependence having a slightly larger effect. The joint predictive model was significant, and the regression equation was derived. It was concluded that while information processing speed and cognitive style are significant predictors, their combined effect remains modest, and visual-spatial processing is more relevant to Biology than analytical thinking speed. Recommendations included that Biology teachers should prioritise visual-spatial training and design instruction that accommodates both field-dependent and field-independent learners.

Keywords: *Information processing speed, cognitive style, academic achievement, Biology, field dependence, Nigeria*

Introduction
Academic achievement in Biology depends not only on content knowledge but also on cognitive efficiency and individual differences in how students process and organise information. Information processing speed refers to the rate at which an individual perceives, analyses, and responds to information, affecting memory encoding, retrieval, and problem-solving (Erdodi & Lichtenstein, 2021). Cognitive style, defined as an individual's consistent and preferred way of processing information and thinking, influences how students approach learning tasks (Egbo & Okoli, 2024). In Biology, which requires students to interpret diagrams, understand hierarchical systems, and integrate knowledge across levels, both processing speed and cognitive style may play significant roles. For instance, a student

with fast visual-spatial processing can quickly interpret a diagram of the circulatory system, while a field-independent learner may excel at isolating details such as cellular structures, and a field-dependent learner may better grasp ecosystem interconnections.

Information processing speed is often assessed using timed tests of logical reasoning, analytical thinking, and visual-spatial skills (Lee, 2023). In Nigerian secondary schools, where examination time constraints are strict, students with faster processing speeds may have an advantage, but the magnitude of this advantage is unclear. Cognitive style, particularly the field dependence-independence continuum (Witkin et al., 1971), has been linked to academic performance. Field-independent individuals, who can disembed details from complex backgrounds, are often thought to excel in science, but field-dependent individuals, who rely on contextual cues, may perform well in subjects like Biology that emphasise relationships among systems. Understanding which dimensions of processing speed and which cognitive styles predict Biology achievement is essential for tailoring instruction. Empirical reviews on information processing speed and academic achievement have yielded mixed findings. Rindermann and Neubauer (2004) found that processing speed influenced school performance indirectly through higher mental abilities, rather than directly. Dodonova and Dodonov (2012) reported that processing speed and intelligence each accounted for about 18% of the variance in school achievement in Russian students. Lee (2023) found that cognitive processing speed directly and indirectly affected math fluency in children with ADHD. Abdulkadir, Yahaya, Shehu, Yahaya and Akanbi (2023) reported a significant influence of academic processing speed on pre-service physics teachers' performance in Ilorin, Nigeria. Regarding cognitive style, Alalouch (2021) found that no single cognitive style was exclusively associated with better performance, but students with a stronger preference for a style performed better. Ifelunni, Ezema, Ugwu, Eze and Ncheke (2022) found a significant correlation between field-dependent cognitive style and primary school pupils' achievement in Mathematics in South-East Nigeria. Egbo and Okoli (2024) reported that cognitive style significantly predicted secondary school students' achievement in Computer studies in Onitsha Education Zone, accounting for 0.4% of the variance. Sharma and Kharbanda (2024) found no relationship between cognitive style and academic achievement in India. No previous study has jointly examined information processing speed and cognitive style as predictors of Biology achievement in Anambra State, making the present investigation novel and timely.

Purpose of the Study

The purpose of the study was to determine information processing speed and cognitive style as predictors of secondary school students' academic achievement in Biology in Anambra State. Specifically, the study sought to determine:

1. The predictive value of information processing speed on students' academic achievement in Biology.
2. The predictive value of cognitive style on students' academic achievement in Biology.
3. The joint predictive value of information processing speed and cognitive style on students' academic achievement in Biology.
4. The relative contributions of the dimensions of information processing speed (logical reasoning speed, analytical thinking speed, visual-spatial skills speed) and cognitive style (field dependence, field independence) to the prediction.

Research Questions

1. What is the predictive value of information processing speed on secondary school students' academic achievement in Biology?

2. What is the predictive value of cognitive style on secondary school students' academic achievement in Biology?
3. What is the joint predictive value of information processing speed and cognitive style on secondary school students' academic achievement in Biology?
4. What are the relative contributions of the dimensions of information processing speed and cognitive style to the prediction of academic achievement in Biology?
5.

Hypotheses

The following null hypotheses were tested at 0.05 level of significance:
1. Information processing speed is not a significant predictor of students' academic achievement in Biology.
2. Cognitive style is not a significant predictor of students' academic achievement in Biology.
3. Information processing speed and cognitive style jointly are not significant predictors of students' academic achievement in Biology.
4. The relative contributions of the dimensions of information processing speed and cognitive style to the prediction are not significant.

Method

The study adopted a predictive correlational research design, which is appropriate for determining the extent to which one or more predictor variables explain variance in a dependent variable without experimental manipulation (Nworgu, 2015). The study was conducted in Anambra State, Nigeria, a region with a high concentration of public secondary schools and a diverse student population, making it suitable for investigating cognitive predictors of academic achievement. The population comprised all 42,572 Senior Secondary Two (SS2) students offering Biology in public secondary schools in Anambra State during the 2025/2026 academic session (source: Planning, Research and Statistics Department, Post Primary Schools Services Commission, Awka, 2024). SS2 students were selected because they have reached an advanced stage of cognitive development, are deeply engaged with the Biology curriculum, and have three-term achievement scores readily available in school records. A multistage sampling procedure was used to obtain a sample of 1,000 students. First, five education zones (Aguata, Onitsha, Nnewi, Awka and Ogidi) were randomly selected from the six zones in the state. Second, within each selected zone, five public secondary schools were selected using simple random sampling, yielding 25 schools. Third, within each school, the first 40 students offering Biology whose three-term achievement scores for the 2024/2025 academic session were available in teachers' folders were purposively selected, resulting in 1,000 participants (458 males, 542 females). This procedure ensured geographical representation and access to complete academic records. Two instruments were used for data collection. The first was the Speed Test (ST), adapted from Olav Hoel Dorum, a 30-item timed test designed to measure information processing speed across three dimensions: logical reasoning speed (ability to identify patterns and relationships), analytical thinking speed (capacity to deconstruct complex problems), and visual-spatial skills speed (proficiency in understanding and manipulating visual information). The test has a time limit of eight minutes (an average of 15 seconds per item), and scoring is based on the number of correct responses, with a maximum score of 30. Higher scores indicate faster processing speed. The second instrument was the Group Embedded Figures Test (GEFT), adapted from Witkin, Oltman, Raskin and Karp (1971), a 25-item perceptual test that assesses cognitive style by requiring respondents to locate a simple figure within a larger complex figure. Scores range from 0 to 25; higher scores indicate greater field independence, while lower scores indicate field dependence. Both instruments were validated by three experts – two from the Department of Science Education and one from the Department of Educational Foundations (Measurement and Evaluation Unit) at Nnamdi Azikiwe University, Awka – who assessed item clarity, appropriateness, and content validity. The reliability of the Speed Test was established using the Kuder-Richardson Formula 20 (KR-20), which yielded a coefficient of 0.92, indicating excellent internal consistency. The reliability of the GEFT was also determined using KR-20, yielding a coefficient of 0.89. Students' academic achievement in Biology was obtained from teachers' record folders; the average score from three terms (first, second, and third terms) of the 2024/2025 academic session was computed for each student. Ten research assistants, who were colleagues of the researcher and worked closely with Biology teachers in the sampled schools, were trained on the study procedures. They obtained permission from school heads, collected students' Biology scores, and administered the Speed Test and GEFT to the 1,000 students under standardised, timed conditions, collecting all materials immediately after each test. Data were analysed using simple linear regression (to determine the individual predictive value of information processing speed and cognitive style) and multiple linear regression (to determine their joint predictive value and the relative contributions of their dimensions). All null hypotheses were tested at the 0.05 significance level, and hypotheses were rejected when the p-value was ≤ 0.05.

Results

Research Question 1: What is the predictive value of information processing speed on secondary school students' academic achievement scores in Biology?

Table 1: Prediction of Students' Achievement score in Biology by Information processing speed (IPS)

Model	R	R^2	Adjusted R^2	Unstandardized coefficients (B)	Std. Error
Constant IPS	.068[a]	.005	.004	71.830 .090	14.866

a. Predictors: (Constant), Information processing speed

Table 1 shows that there is a low positive relationship (R = .068) between information processing speed and achievement in Biology. The R-Square value of 0.005 indicates that 0.5percent of the variance in Biology achievement scores is predicted by information processing speed. The unstandardized coefficient *B* of .090 shows that a unit rise in information processing speed increases academic achievement score in Biology by 9.0%.

Research Question 2: What is the relative contribution of the dimensions of information processing speed (logical reasoning speed, analytical thinking speed, visual-spatial skills speed) to prediction of secondary school students' academic achievement in Biology?

Table 2: Contributions of the Dimensions of Information processing speed in the Prediction of Achievement scores in Biology

Model		Unstandardized Coefficients		Standardized Coefficients	t	Pvalue
		B	Std. Error	*β*		
	(Constant)	70.044	1.327		52.789	.000
1	Logical Reasoning Speed	.136	.061	.071	2.233	.026
	Analytical Thinking Speed	.378	.234	.098	1.617	.106
	Visual-Spatial Skills	.547	.236	.141	2.319	.021

a. Dependent Variable: Biology Achievement score

Table 2 shows that achievement in Biology increases by 13.6% whenever a students' logical reasoning speed increases by one unit whereas achievement increases by 37.8% for every unit increase in analytical thinking speed, with achievement increasing by 54.7% where visual-spatial skills increases by one unit. The order of relative contribution to achievement score in Biology from the highest to lowest by each dimension of information processing speed therefore is; visual-spatial skills, analytical thinking speed and followed by logical reasoning speed.

Research Question 3: What is the predictive value of cognitive style on secondary school students' academic achievement scores in Biology?

Table 3: Prediction of Students' Achievement score in Biology by Cognitive style (ST)

Model	R	R^2	Adjusted R^2	Unstandardized coefficients (B)	Std. Error
Constant Cognitive style	.074[a]	.006	.005	65.170 .177	14.860

a. Predictors: (Constant), Cognitive style

Table 3 shows that there is a low positive relationship (R = 0.074) between cognitive style and achievement in Biology. the R-Square value of 0.006 indicates that 0.6percent of the variance in Biology achievement scores is predicted by cognitive style. The unstandardized coefficient *B* of .177 shows that a unit rise in cognitive style increases academic achievement score in Biology by 17.7%.

Research Question 4: What are the relative contribution of the dimensions of cognitive style (field dependent and field independent) to prediction of secondary school students' academic achievement in Biology?

Table 4: Contributions of the Dimensions of Cognitive style in the Prediction of Achievement scores in Biology

Model		Unstandardized Coefficients		Standardized Coefficients	t	Pvalue
		B	Std. Error	*β*		
	(Constant)	71.720	2.512		28.545	.000
1	Field Dependence	.479	.196	.077	2.447	.015
	Field Independence	.217	.090	.076	2.422	.016

a. Dependent Variable: Biology Achievement score

Table 4 shows that achievement in Biology increases by 47.9% whenever a students' field dependence increases by one unit, and by 21.7% for every unit increase in field indepence. The order of relative contribution to achievement score in Biology from the highest to lowest by each dimension of cognitive style therefore is; field dependence followed by field independence.

Research Question 4: What is the joint predictive value of information processing speed and cognitive style secondary school students' academic achievement in Biology?

Table 5: Joint Prediction of Students' Achievement score in Biology by Information processing speed and Cognitive style

Model	R	R^2	Adjusted R^2	Unstandardized coefficients (B)	Std. Error
Constant Information processing speed Cognitive style	.101[a]	.010	.008	67.660 .091 .179	14.832

a. Predictors: (Constant), Information processing speed, Cognitive style

Table 5 shows that there is a low positive relationship (R = 0.101) among information processing speed, cognitive style and achievement in Biology. The R-Square value of .010 which indicates that 1.0percent of the variance in Biology achievement scores is co-predicted by information processing speed and cognitive style. The unstandardized coefficient *B* of .091 and .179 respectively shows that, a unit rise in information processing speed and cognitive style together, results in increment in achievement score by 9.1% due to information processing speed and by 17.9% due to cognitive style.

Hypothesis 1: Information processing speed is not a significant predictor of students' academic achievement scores in Biology.

Table 6: Significance of Prediction of Achievement score in Biology by Students' Information processing speed

Model		Sum of Squares	df	Mean Square	F	Pvalue
	Regression	1030.701	1	1030.701	4.664	.031[b]
1	Residual	220566.738	998	221.009		
	Total	221597.439	999			

a. Dependent Variable: Achievement score
b. Predictors: (Constant), Information processing speed

Table 6 shows that information processing speed is a significant predictor of achievement scores in Biology, F (1, 998) = 4.664, p < 0.05. The null hypothesis was therefore rejected meaning that information processing speed is a significant predictor of achievement scores in Biology. Since information processing speed is a significant predictor of achievement scores in Biology, the regression model (Y= a + bX) for the prediction of achievement score in Biology as derived from Table 1, where constant = 71.830 and b value = .090 is:

Achievement = 71.830 + 0.090(IPS)

Where, Achievement = Achievement score in Biology and IPS = Information processing speed.

Hypothesis 3: The relative contributions of the dimensions of information processing speed (logical reasoning speed, analytical thinking speed, visual-spatial skills speed) to prediction of students' academic achievement in Biology is not significant.

Table 7: Significance of Prediction of Achievement score in Biology by the Dimensions of Information processing speed

Model		Sum of Squares	df	Mean Square	F	Pvalue
	Regression	2268.096	3	756.032	3.433	.017[b]
1	Residual	219329.343	996	220.210		
	Total	221597.439	999			

a. Dependent Variable: Achievement
b. Predictors: (Constant), Visual-Spatial Skills, Logical Reasoning Speed, Analytical Thinking Speed

Table 7 shows that the dimensions of information processing speed jointly predicted the students' achievement scores in Biology significantly, F (3, 996) = 3.433, p < 0.05. However, data contained in Table 2 shows the significance of the contributions of the individual dimensions of information processing speed to the prediction of achievement scores in Biology.

Table 2 shows that logical reasoning is a significant predictor of achievement scores in Biology, t(3, 996) = 2.233, p < 0.05 and visual-spatial skills is a significant predictor of achievement scores in Biology, t(3, 996) = 2.319, p < 0.05. The only non-significant contributor to the achievement score of students in Biology in is analytical thinking. However, since the joint prediction of all the dimensions of information processing speed in the prediction of achievement score in Biology is significant, the regression model ($Y= a + bX_1 + cX_2 + dX_3$) for the prediction of achievement score in Biology as can be derived from Table 2 is:

Achievement = 70.044 + .136(LRS) + .378(ATS) + .547(VPS)

Where, Achievement = Achievement score in Biology and LRS = Logical reasoning speed, ATS = Analytical thinking skills, and VSS= Visual=Spatial skills

Hypothesis 3: Cognitive style is not a significant predictor of students' academic achievement scores in Biology.

Table 8: Significance of Prediction of Achievement score in Biology by Students' Cognitive style

Model		Sum of Squares	df	Mean Square	F	Pvalue
	Regression	1223.243	1	1223.243	5.540	.019[b]
1	Residual	220374.196	998	220.816		
	Total	221597.439	999			

a. Dependent Variable: Achievement score
b. Predictors: (Constant), Cognitive style

Table 8 shows that cognitive style is a significant predictor of achievement scores in Biology, $F(1, 998) = 5.540$, $p < 0.05$. The null hypothesis was therefore rejected meaning that cognitive style is a significant predictor of achievement scores in Biology. Since cognitive style is a significant predictor of achievement scores in Biology, the regression model ($Y= a + bX$) for the prediction of achievement score in Biology as derived from Table 3, where constant = 65.170 and b value = 0.177 is:

Achievement = 65.170 + 0.177(COS)

Where, Achievement = Achievement score in Biology and COS = Cognitive style.

Hypothesis 4: The relative contributions of the dimensions of information processing speed (logical reasoning speed, analytical thinking speed, visual-spatial skills speed) to prediction of students' academic achievement in Biology is not significant.

Table 9: Significance of Prediction of Achievement score in Biology by the Dimensions of Cognitive style

Model		Sum of Squares	df	Mean Square	F	Pvalue
	Regression	2701.061	2	1350.530	6.151	.002[b]
1	Residual	218896.378	997	219.555		
	Total	221597.439	999			

a. Dependent Variable: Achievement
b. Predictors: (Constant), Field Independence, Field Dependence

Table 9 shows that the dimensions of cognitive style jointly predicted the students' achievement scores in Biology significantly, $F(2, 997) = 6.151$, $p < 0.05$. However, data contained in Table 4 shows the significance of the contributions of the individual dimensions of cognitive style to the prediction of achievement scores in Biology.

Table 4 shows that field dependence is a significant predictor of achievement scores in Biology, $t(2, 997) = 2.447$, $p < 0.05$and field independence is also a significant predictor of achievement scores in Biology, $t(2. 997) = 2.422$, $p < 0.05$. Thus, the significant contributor to the achievement score of students in Biology in order of significance is field dependence followed by field independence However, since the joint prediction of all the dimensions of cognitive style in the prediction of achievement score in Biology is significant, the regression model ($Y= a + bX_1 + cX_2$) for the prediction of achievement score in Biology as can be derived from Table 4 is:

Achievement = 71.720 + .479(FID) + .217(FIID)
Where, Achievement = Achievement score in Biology and FID = Field Dependence, FIID = Field independence

Hypothesis 5: Information processing speed and cognitive style jointly, is not a significant predictor of students' academic achievement in Biology.
Table 10: Significance of Joint Prediction of Achievement score in Biology by Students' Cognitive style and Information processing speed

Model		Sum of Squares	df	Mean Square	F	Pvalue
1	Regression	2272.482	2	1136.241	5.165	.006[b]
	Residual	219324.957	997	219.985		
	Total	221597.439	999			

a. Dependent Variable: Achievement
b. Predictors: (Constant), Cognitive Style, Information Processing Speed

Table 10 shows that information processing speed and cognitive style significantly co-predicted achievement scores in Biology $F(2, 997) = 5.165$, $p < 0.05$. The null hypothesis was therefore rejected meaning that that cognitive style and information processing speed do significantly co-predict achievement scores of in Biology.
Since information processing speed and cognitive style do significantly co-predict achievement scores of students in Biology, the regression model ($Y = a + bX_1 + cX_2$) for the prediction of achievement score in Biology as derived from Table 5, where constant = 67.660, b value = 0.091 and c value = 0.179 as:
Achievement = 67.660 + 0.091(IPS) + 0.179(COS)
Where, Achievement = Achievement score in Biology, IPS = Information processing speed and COS = Cognitive style.

Discussion

The finding that information processing speed individually predicted only 0.5% of the variance in Biology achievement, and cognitive style 0.6%, indicates that these cognitive factors have a modest direct effect. This aligns with Rindermann and Neubauer (2004), who found that processing speed influenced school performance indirectly rather than directly, and with Egbo and Okoli (2024), who reported that cognitive style accounted for 0.4% of the variance in Computer studies achievement. However, the present results differ from Dodonova and Dodonov (2012), who found that processing speed and intelligence together explained 28% of the variance. The discrepancy likely arises because Dodonova and Dodonov aggregated achievement across multiple subjects, whereas the present study focused on a single subject (Biology) where content-specific knowledge may override general cognitive speed. The finding that visual-spatial skills speed was a significant predictor while analytical thinking speed was not is particularly revealing. Biology is a highly visual subject, relying on diagrams of cell structures, anatomical systems, ecological pyramids, and genetic crosses. Students who can quickly interpret, manipulate, and recall visual information have a distinct advantage. Analytical thinking speed, which involves step-by-step logical deduction, is more relevant to mathematics or physics than to Biology. This finding extends the work of Lee (2023), who found that cognitive processing speed affected math fluency, and Abdulkadir et al. (2023), who reported processing speed influenced physics performance, by showing that in Biology, visual-spatial speed is the key dimension. The significant contribution of logical reasoning speed, though smaller, suggests that some aspects of Biology (e.g., Punnett squares, data interpretation) do benefit from rapid logical processing.

Regarding cognitive style, both field dependence and field independence positively predicted achievement, but field dependence had a slightly larger coefficient (B = 0.479 vs. 0.217). This challenges the common assumption that field-independent learners are inherently better at science. In Biology, which emphasises interconnected systems (ecosystems, food webs, organ systems), field-dependent learners who perceive information in context and attend to relationships may be particularly well-suited. This finding is consistent with Ifelunni et al. (2022), who found a significant correlation between field-dependent cognitive style and mathematics achievement, and with Alalouch (2021), who reported that no single style was exclusively associated with better performance. The non-significant interaction between the two styles (as seen from the joint model) suggests that Biology accommodates both analytic and holistic thinkers, provided instruction is varied. The joint prediction model (1.0% variance explained) was only slightly higher than the sum of the individual models, indicating that information processing speed and cognitive style share some overlapping variance but each contributes uniquely. The regression equation (Achievement = 67.660 + 0.091*IPS + 0.179*CS) provides a quantitative tool for future researchers. Overall, the findings imply that while cognitive speed and style matter, they are far less influential than instructional quality, prior knowledge, and study habits. The non-significance of analytical thinking speed suggests that Biology teachers need not emphasise timed analytical drills; instead, they should focus on visual-spatial training and varied instructional formats that cater to both field-dependent and field-independent learners.

Conclusion

The study concluded that information processing speed and cognitive style are significant but weak predictors of secondary school students' academic achievement in Biology in Anambra State. Visual-spatial skills speed is a more relevant dimension of processing speed than analytical thinking speed, and field dependence predicts achievement slightly more strongly than field independence. The joint predictive model explains only 1.0% of the variance, indicating that other factors are substantially more important.

Recommendations

1. Biology teachers should prioritise visual-spatial training activities, such as diagram annotation, mental rotation exercises, and model building, to strengthen the processing dimension most predictive of achievement.
2. Teacher training programmes should emphasise varied instructional formats – including collaborative, context-rich activities for field-dependent learners and independent, detail-focused tasks for field-independent learners – within the same lesson.
3. Curriculum developers should consider that analytical thinking speed is not a significant predictor for Biology; timed analytical drills should be de-emphasised in favour of visual and relational reasoning tasks.
4. Further research should examine the interaction between cognitive style and specific Biology content domains (e.g., ecology vs. molecular biology) to refine instructional recommendations.

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