Sentence Processing in Indonesian-English Bilingual Children with and without Language Impairment

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ABSTRACT

Reading comprehension is shaped by syntactic complexity, working memory, and linguistic proficiency, especially in bilingual students with language disorders. This study examines how bilingualism and SLI influence sentence processing in syntactically similar languages, focusing on the effects of language features, impairment status, and syntactic complexity on comprehension accuracy, reading speed (RS), recall speed (RcS), and fixation duration (FD). Forty-four balanced bilingual elementary students (22 SLI, 22 typically developing) completed silent, self-paced sentence reading tasks in Indonesian and English. Comprehension accuracy, reading speed, recall speed, and fixation duration were analyzed via ANCOVA and MANOVA, controlling for sentence length, number of syllables, number of modifiers, and the number of propositions. Results showed that SLI status significantly impaired all reading performance indicators, regardless of language. Language type had no effect on accuracy or reading speed, but did affect recall speed, especially in English, reflecting working memory load. Syntactic complexity—particularly the number of modifiers and propositions—negatively impacted comprehension accuracy and recall, disproportionately affecting SLI students. Fixation duration patterns revealed that SLI students allocated more visual attention in English. The Group effect outweighed Language and Group × Language interaction, suggesting that broad cognitive-linguistic deficits contribute more to comprehension difficulties than language-specific features. Instructional strategies should target content chunking and memory scaffolds across both languages.

Keywords: bilingualism; inclusive education; reading comprehension; SLI; syntactic complexity

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INTRODUCTION

Reading comprehension is a complex cognitive process involving parallel mechanisms for decoding, integrating, and retrieving textual information. While these processes occur automatically in typically developing children (Layes et al., 2021), they pose significant challenges for students with Specific Language Impairment (SLI) (Bishop, 2006), whose difficulties range from decoding to sentence-level comprehension. These challenges stem from deficits in verbal working memory, which impair simultaneous storage and processing of linguistic information, especially in longer or syntactically complex sentences (Montgomery et al., 2016).

Bilingualism adds further complexity, requiring learners to manage two linguistic systems, which may increase the load on working memory and can hinder performance for some learners (Yang, 2017) When one language has a more complex orthography or syntax, reading deficiencies may be amplified (Lallier et al., 2014). Bilingual children with SLI face distinct challenges in processing syntactically complex sentences (Zebib et al., 2019), and slower processing speed may hinder comprehension (Jacobson et al., 2011).

Despite extensive research on bilingualism and working memory, how Indonesian-English bilingual children with SLI process language remains underexplored—particularly in balanced bilingual contexts where both languages are used at home and school in daily communication. While students with SLI may decode fluently in both languages, their comprehension difficulties reveal that surface-level fluency does not reflect deeper processing challenges. Indonesian and English differ orthographically, with Indonesian being transparent and English opaque. Although prior studies have examined working memory and executive functions in reading comprehension (Hung, 2021; Meisinger et al., 2021; Nouwens et al., 2017, 2021), few have controlled for syntactic complexity across languages to analyze comprehension accuracy, reading speed, recall speed, and fixation duration.

This study employs self-paced silent reading with computerized eye tracking to capture real-time reading processes, offering novel insights into bilingual sentence processing, working memory deficits, and syntactic complexity effects in children with SLI. In light of the Regulation of the Minister of Education, Culture, Research, and Technology No. 12 of 2024, which makes English instruction optional in Indonesian primary schools until 2027/2028, participants were recruited from a bilingual private school using both Cambridge and Merdeka curricula to ensure consistent dual-language exposure and balanced proficiency. This design supports controlled measurement of timing variables and minimizes confounds.

This study explores how bilingual SLI students process sentences in languages that share syntactic similarities and investigates whether language characteristics, impairment status, and syntactic complexity influence reading performance. Specifically, it examines how bilingualism and SLI interact to affect comprehension accuracy, reading speed (RS), recall speed (RcS), and fixation duration (FD). To isolate the effects of SLI from bilingual proficiency, students with matched fluency in Indonesian and English were selected based on school-based scores, given the absence of standardized fluency tests for Indonesian. It is hypothesized that syntactic complexity impairs performance across all measures (Siu & Ho, 2020), bilingualism exerts a smaller effect than impairment as the participants are fluent in both languages (Espi-Sanchis & Cockcroft, 2022), and SLI students show overall weaker outcomes in both languages (Kızılaslan & Tunagür, 2021; Penke & Wimmer, 2024).

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Many children with reading impairments can decode accurately but fail to comprehend even simple sentences—a gap often overlooked in bilingual educational settings. The goal is to support bilingual children with SLI through targeted educational interventions that address deeper comprehension challenges beyond surface-level fluency.

THEORETICAL FRAMEWORK

Reading comprehension involves lower-level decoding and higher-level integration (Kintsch & Rawson, 2005). Bilinguals navigate these processes differently based on each language's orthographic transparency and syntactic complexity.

LANGUAGE ORTHOGRAPHY AND READING PERFORMANCE

Phonological processing plays a key role in bilingual reading. Skilled readers access words directly (Frost, 2005), but orthographic depth shapes this process—transparent orthographies rely on phonology, while opaque ones require grapheme-phoneme conversion. Thus, Indonesian-English bilinguals may adopt different strategies across languages.

The nature of a language's orthography plays a crucial role in reading performance. Like their typically developing peers (Kaani et al., 2022), bilingual dyslexic children read more accurately and quickly in transparent orthographies (e.g., Spanish, Hindi, Indonesian) than in opaque ones (e.g., French, English), due to more consistent grapheme–phoneme mappings (Lallier et al., 2014). Although both Spanish and Indonesian are considered transparent, Indonesian offers more consistent grapheme–phoneme mapping—aside from the <e> = /e/ vs. /ə/ alternation (Alwi et al., 1998). In contrast, Spanish includes context-dependent correspondences (e.g., <c>/<qu>, <g>/<gu>) and orthographic redundancies like <b>/<v>, reducing one-to-one consistency (Kattán-Ibarra & Pountain, 2003). This higher transparency helps minimize lower-level decoding variability in our study, so group differences are more likely to reflect sentence-level processing demands.

For bilingual and reading-impaired populations, these findings highlight the impact of orthographic complexity on reading comprehension. Bilingual readers with balanced proficiency show stronger working memory, aiding word processing and recall (Espi-Sanchis & Cockcroft, 2022). Working memory supports comprehension by maintaining key propositions, integrating across clauses, and enabling inferences—functions that, when limited, impair processing and coherence (Nasrullah, 2025). In contrast, students with dyslexia struggle with phonological recoding and working memory, resulting in slower RS (Caravolas, 2005). Beyond cognitive factors, orthographic transparency also shapes bilingual reading outcomes. Fluency gaps between transparent and opaque orthographies are often minimal, pointing to cross-linguistic skill transfer (Kaani et al., 2022). Skills from one language can support reading development in another, enabling faster fluency without relearning foundational strategies (Durgunoğlu, 2002).

SENTENCE LENGTH AND READING PERFORMANCE

Sentence length, measured by syllables or words, affects RS and recall—especially in deep orthographies. In German, poor readers relied on phonological recoding for longer, complex words, slowing their reading, while skilled readers used direct recognition strategies (Müller et al., 2020). A similar pattern was observed in Finnish, where syllable length impacted RS mainly in

poor readers. Meanwhile, syllable length influences recall, with readers who have stronger working memory less affected during recall tasks. In contrast, less-skilled readers fixated longer on polysyllabic words, slowing recall due to reliance on phonological decoding (Kuperman & Van Dyke, 2011). Sentence length, measured in terms of word length can influence reading accuracy, speed, and recall. In opaque orthographies, longer words require greater cognitive processing, leading to slower RS (Müller et al., 2020). This effect is particularly strong in deep orthographies with unpredictable phoneme-grapheme mappings.

SYNTACTIC COMPLEXITY AND READING PERFORMANCE

Syntactic complexity plays an important role in reading comprehension. It refers to the structural intricacy of a sentence, determined by factors such as the number of clauses, sentence length, the use of subordinate clauses, and embedded syntactic elements (Grela et al., 2023). It includes elements such as the length of production units, amount of subordination, coordination, and degree of phrasal elaboration (Lu & Ai, 2015). It is measured by how varied and sophisticated the production units or grammatical structures are (Liu & Afzaal, 2021). The ability to parse sentence structures and integrate textual information efficiently varies across languages, particularly in bilingual individuals who must manage different syntactic rules. Research suggests that syntactic competence is a strong predictor of comprehension ability across both first and second languages (Siu & Ho, 2020). Because Indonesian and English differ in sentence structure, bilingual readers may rely on distinct strategies when constructing meaning from text (Kirana, 2022). Both languages use S–V–O clauses; the key controlled contrast is noun-phrase modification—Indonesian typically N–Adj vs. English Adj–N—allowing us to test complexity effects in closely matched grammatical contexts. Comprehension also extends beyond individual word meanings, requiring readers to integrate propositions across sentences to establish semantic coherence (Kintsch & Rawson, 2005).

WORKING MEMORY AND READING PERFORMANCE

Working memory capacity is equally significant, as it determines a reader's ability to maintain and integrate textual information (Kintsch & Rawson, 2005). Readers with limited working memory struggle to retain relevant content, directly affecting comprehension accuracy. Processing information during reading efficiently depends on three primary factors: processing speed, available space for processing, and the energy required to sustain processing operations (see Grela et al., 2023). As the capacity in working memory is limited, efficient readers allocate cognitive resources effectively, whereas poor readers experience greater constraints in recalling and processing information (Kızılaslan & Tunagür, 2021).

Individuals with SLI often show verbal short-term memory deficits, impairing their ability to retain and integrate linguistic information, which hinders syntactic processing and sentence comprehension. Research has shown that SLI individuals often struggle with wh-questions, passives, and long-distance dependencies due to working memory overload, which impairs syntactic parsing (Penke & Wimmer, 2024). Their difficulties are not solely syntax-related but are also attributed to working memory constraints, limiting their ability to process complex linguistic input effectively (Islami et al., 2024).

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Daneman and Carpenter (1980) established a strong correlation between working memory and reading comprehension, particularly in relation to reading span—the amount of information retained while reading. Dyslexic readers, in particular, tend to have a shorter reading span, making them difficult to construct coherent mental representations of text (Farmer et al., 2017; Kimel et al., 2020). They often focus on forming a basic text base rather than engaging in higher-level comprehension processes such as inference-making and constructing situation models (Kintsch & Rawson, 2005).

READING SPEED AND RECALL SPEED

Another critical factor influencing reading comprehension is RS, which reflects efficiency in word recognition, lexical access, and syntactic parsing. Faster RS allow readers to allocate more cognitive resources to inferencing and semantic integration, thereby improving comprehension accuracy (Rayner et al., 2016). Conversely, slower RS are often linked to decoding difficulties, particularly among SLI individuals, who struggle with working memory limitations and inefficient linguistic processing, thus weakens comprehension (Van Dyke et al., 2014). One of the factors that contribute to RS is fixation - the time during which a reader's eyes remain directed to particular area of text (Kintsch & Rawson, 2005). It indicates the cognitive processes during reading especially when meaningful information is extracted from the text during fixation (Rayner et al., 2016).

RcS reflects a reader's ability to retain and retrieve propositional content, with faster RcS indicating more efficient processing—crucial for integrating complex syntactic structures. (Rayner et al., 2016). Studies on bilingual readers have shown that recall strategies differ between typically developing individuals and those with SLI (Christopher et al., 2012; Parshina et al., 2022; Van Dyke et al., 2014). While bilinguals often exhibit cross-linguistic transfer in recall strategies, dual-language activation can sometimes slow processing compared to monolingual counterparts (Parshina et al., 2022). Furthermore, SLI conditions impair working memory and linguistic integration, affecting both reading and RcS (Van Dyke et al., 2014).

METHOD

PARTICIPANTS

Forty-four Indonesian-English bilingual students (Grades 2–4) from an inclusive elementary school participated, equally split into SLI (n = 22) and non-SLI (n = 22) groups. SLI status was confirmed via school referrals, clinical records, and language screening; non-SLI peers were matched by grade and bilingual exposure. Ribeiro, et.al (2016) found that accuracy and reading fluency predict reading comprehension in Grade 2, but these factors become less significant by Grade 4. Since children with SLI often show delayed development in comprehension and related skills, Grades 2–4 were selected as the target group. At this stage, most Indonesian children have achieved fluent decoding and sufficient vocabulary exposure, allowing us to examine reading processes beyond basic literacy.

To ensure consistent dual-language exposure and controlled conditions for measuring reading and RcS, all participants were drawn from an inclusive private school in Surabaya that implements both the Cambridge International Curriculum and the Merdeka Curriculum where Indonesian and English are used for instruction and daily communication. According to both

curricula, students in Grade 3–4 are expected to reach A2 proficiency on the CEFR scale. Although the exact reference scientific article is unavailable, this equivalence was confirmed through curriculum comparison. Selecting students from these environments ensured balanced proficiency and minimized confounds related to language dominance. Purposive sampling ensured that participants met the following criteria: (a) formal diagnosis of SLI (for the SLI group), (b) balanced fluency in Indonesian and English based on school standardized assessments, and (c) completion of a vocabulary pretest confirming knowledge of all lexical items in the reading comprehension tasks. Balanced fluency was assessed through regular school-based evaluations in Indonesian and English, covering spelling, retelling, comprehension, and speaking. These followed teacher guidelines, including the Cambridge Checkpoint for English. Although no national fluency test exists for Indonesian language, assessments used consistent rubrics reviewed by bilingual educators to ensure cross-language comparability. Only students with similar performance across both languages were included; those with notable discrepancies were excluded to maintain a balanced bilingual sample. All participants completed the reading test administered by the researchers. Ethical approval for this study was granted by the Health Research Ethics Committee of the Faculty of Public Health, Universitas Airlangga (Approval No: 149/EA/KEPK/2024), and participation was limited to children whose parents provided informed consent, in accordance with ethical guidelines for research involving vulnerable populations.

INSTRUMENTS

Two sets of reading comprehension tests were developed—one in Indonesian and one in English—each consisting of 17 sentences matched for syntactic, morphological, and phonological complexity, aligned with second-grade curriculum standards. To control for the influence of vocabulary knowledge on reading comprehension (Babayiğit, 2014), all keywords were drawn from participants' school materials. Vocabulary was selected using AntConc (Anthony, 2022) from Indonesian Language Class textbooks and English Language Class textbooks. To ensure that vocabulary selection was aligned with participants' proficiency, all keywords were cross-checked against the CEFR-aligned Cambridge wordlists for Pre A1 Starters, A1 Movers, and A2 Flyers. This confirmed that selected words fell within the expected A2 proficiency range for Grade 3–4 students, consistent with both the Merdeka and the Cambridge curricula. Words met strict criteria to reduce cognitive load: maximum three syllables, frequent textbook occurrence (≥2), no derivational affixes (Carlisle, 2000), and no diphthongs or consonant clusters (Kintsch & Rawson, 2005). Only content words—nouns, verbs, adjectives, and adverbs—were used, as they carry core referential meaning (Alwi et al., 1998; Katamba, 2005). The selected words were then constructed into sentences given that sentence reading fluency has been shown to be a stronger predictor of reading comprehension than word reading fluency (Kirschmann et al., 2021)

The sentences were constructed with identical syntactic patterns across languages: S+V+O, S+Adj+V, S+V+Adverbials, S+V+O+Adverbials, and S+V+O+Adj+Adverbials. Adjectives were placed near subjects and/or objects, and adverbials which are limited to time and place (Haenggi et al., 1995; Zwaan & Radvansky, 1998) appeared either at the beginning or end of the sentence. These structures reflect typical subject–predicate formats without complex clauses, appropriate for the participants' developmental stage (Simard et al., 2014). Variations in modifier placement were included to probe working memory demands during sentence processing (Kirana, 2022), while maintaining cross-language equivalence in linguistic complexity. Participants answered 73

multiple-choice questions across both sessions, scored dichotomously (1 = correct; 0 = incorrect), with accuracy expressed as a percentage.

PROCEDURE

Participants completed two sessions—Indonesian first, then English one week later—to minimize learning effects. Due to school scheduling, language order was not counterbalanced, though procedures and timing were consistent. We acknowledge this confound and recommend full counterbalancing in future studies. Each sentence contained 3–6 propositions to ensure syntactic consistency across languages. Participants silently read each sentence on screen via the Arrasyi-Kid system, then answered comprehension questions targeting specific propositions. For example, in the sentence *Ayah membaca koran* (*Father reads a newspaper*), the questions included *Siapa yang membaca?* (*Who was reading?*), targeting the subject; *Apa yang ayah lakukan?* (*What did Father do?*), targeting the verb; and *Apa yang ayah baca?* (*What did Father read?*), targeting the object. The comprehension questions were delivered via pre-recorded audio, and participants responded using a joystick.

Data collection focused on three key measures: reading accuracy, RS, RcS, and FD. RS and RcS served as indirect working memory indicators, reflecting attentional focus and memory activation per the embedded-process model (Cowan et al., 2021). Since readers with similar proficiency vary in processing speed (Stine-Morrow et al., 2008), timing measures like self-paced reading or eye-tracking, supported by statistical modelling, help estimate text processing duration (Miller, 2015). Reading accuracy was assessed by categorizing responses as either correct or incorrect based on whether they precisely matched the information provided in the sentence. RS was measured using the first forward-sweep of eye movement —the continuous sequence from the first fixation to the last fixation—, ensuring that only the initial reading process was considered without including regressions – the backward eye movement to read previous word. Regression was excluded to ensure equal measurement since, according to Kintsch and Rawson (2005), novice readers rely on first-pass processing, and including regressions would confound group comparisons. RcS was recorded as the time taken from the moment the pre-recorded question ended until the participant pressed the button on the joystick to submit their response.

APPARATUS

Data was collected using Arrasyi-Kid (Kirana et al., 2023), an in-house eye-tracking system comprising a fixation/saccade camera, closed-back headphones (audio questions), joystick (timed responses), and a 24″ computer screen for presenting stimuli and answers. Sentences were shown silently in Montserrat 52 font, one at a time, with adjustable display options: black text on a light background or white text on a dark background.

Eye movements were measured binocularly with the Arrasyi-Kid system which compare gaze coordinates to detected words with a similarity threshold of ≥ .75 to confirm word recognition as well as fixation duration. Five-point-calibration initializes every reading session. The eye-tracker cameras and headphones were adjustable to fit varying head sizes and shapes in children. The recalibration warning will be triggered if the comparison threshold is below .75. Reading time for each sentence was defined by the first forward eye sweep. The system has been field-tested with approximately 400 students in three East Java cities to assess reliability and validity. The software supports a controlled pause–resume function triggered by the experimenter upon

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participant request and recalibration warning; during pauses, stimulus presentation, timing, and gaze logging are suspended and then resume seamlessly at the same trial, ensuring data integrity while mitigating fatigue.

DATA ANALYSIS

This study employed a combination of Multivariate Analysis of Covariance (MANCOVA), and Univariate Analysis of Covariance (ANCOVA) to comprehensively examine how group membership (SLI vs. Non-SLI) and language (Indonesian vs. English) influenced reading comprehension processes in bilingual students. The analysis focused on four dependent variables: accuracy, RS, RcS, and fixation duration (FD). The use of MANCOVA follows prior research on language development and impairment (e.g. Boerma et al., 2016), which employed multivariate analysis to examine group differences across multiple comprehension-related outcomes while controlling for relevant covariates. Similarly, our study analyzes reading performance across several dependent variables while adjusting for syntactic complexity.

Before conducting MANCOVA, Box's M Test was performed to check the assumption of homogeneity of covariance matrices across groups. Results indicated a significant violation of this assumption, Box's M = 1632.595, $p < .001$. Given this violation, Pillai's Trace was selected as the primary multivariate test statistic, as it is considered the most robust to heterogeneity when sample sizes are large (Todorov et al., 2020).

Univariate ANCOVA was run for each dependent variable, with syllable length, sentence length, modifier count, and proposition number as covariates. Levene's Test indicated significant variance violations across groups ($p < .001$), but parametric tests remain robust with large, balanced samples (Azwar, 2015). Given the dataset (N = 1,496) and equal group sizes, ANCOVA was appropriate. To strengthen inference, bootstrapping with 200 resamples was applied, reducing reliance on normality assumptions (Hesterberg, 2011).

RESULTS

The analysis included 44 Indonesian-English bilingual elementary students—22 with SLI and 22 typically developing—who completed reading comprehension tasks in both languages, yielding 1,496 trials (748 per group). Table 1 provides the descriptive statistics for the key dependent variables (Accuracy, RS, RcS, and FD) for each group and language.

TABLE 1. Descriptive Statistics for Dependent Variables

Variable	Group	Language	M	SD
Accuracy (%)	SLI	Indonesian	0.6619	0.2950
	SLI	English	0.6403	0.3088
	Non-SLI	Indonesian	0.8392	0.2231
	Non-SLI	English	0.8120	0.2417
RS	SLI	Indonesian	12.43	14.23
	SLI	English	12.65	16.01
	Non-SLI	Indonesian	7.95	5.49
	Non-SLI	English	8.65	6.38
RcS (ms)	SLI	Indonesian	6159.99	5818.02
	SLI	English	8505.57	9372.15
	Non-SLI	Indonesian	4269.00	2764.42

FD (ms)	Non-SLI	English	5449.59	3298.89
	SLI	Indonesian	468.84	190.37
	SLI	English	518.03	256.46
	Non-SLI	Indonesian	404.29	124.33
	Non-SLI	English	380.62	121.38

Overall, SLI students showed lower reading performances in all measure than the Non-SLI. SLI students consistently showed lower reading comprehension accuracy than their non-SLI peers. RS was slower for SLI students. Meanwhile, SLI students also took longer RcS. FD revealed further processing challenges. SLI students fixated longer in both languages than the Non-SLI. The SLI students spend longer time for RS, RcS and FD when they were reading sentences in English. Similar trend was seen in Non-SLI, except for FD where they fixated longer when reading sentences in Indonesian language

TABLE 1. The correlation between the covariates with the dependent variables (Accuracy, RS, RcS, FD)

		Syllable Length	**Sentence Length**	**Modifier Count**	**Constituent Count**	**Accuracy**	**RS**	**RcS**	**FD**
Syllable	*r*	1	.538**	.567**	.822**	-.035	.069**	-.049	-.031
Length	*p*		.000	.000	.000	.172	.008	.060	.238
Sentence	*r*		1	.433**	.789**	-.065*	.088**	.039	-.018
Length	*p*			.000	.000	.012	.001	.135	.496
Modifier	*r*			1	.634**	-.068**	.073**	-.040	-.005
Count	*p*				.000	.008	.005	.126	.840
Constituent	*r*				1	-.031	.094**	-.008	-.021
Count	*p*					.232	.000	.758	.418
Accuracy	*r*					1	-.143**	-.286**	-.056*
	p						.000	.000	.032
RS	*r*						1	.196**	.108**
	p							.000	.000
RcS	*r*							1	.013
	p								.602
FD	*r*								1
	p								

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Several significant correlations were observed among linguistic and cognitive variables. Syllable length showed a weak positive correlation with reading speed ($r = .069$, $p < .05$). Sentence length was weakly correlated with accuracy ($r = –.065$, $p < .05$) and reading speed ($r = .088$, $p < .05$). Modifier count correlated weakly with accuracy ($r = –.068$, $p < .05$) and reading speed ($r = .073$, $p < .05$). Number of propositions showed a weak positive correlation with RS ($r = .094$, $p < .05$). Accuracy was negatively correlated with RS ($r = –.143$, $p < .01$), RcS ($r = –.286$, $p < .01$), and FD ($r = –.056$, $p < .05$). RS was positively correlated with RcS ($r = .196$, $p < .01$) and fixation ($r = .108$, $p < .05$). RcS showed a weak positive correlation FD ($r = .013$, $p < .05$).

TABLE 3. Multivariate Effects

Effect	Pillai's Trace	F	df (hyp)	df (error)	p	ηp²
Group	.184	83.454	4	1485	<.001	.184
Language	.019	7.070	4	1485	<.001	.019
Group x Language	.014	5.209	4	1485	<.001	.014
Syllable length	.003	1.258	4	1485	.285	.003
Sentence length	.006	2.420	4	1485	.047	.006
Modifier count	.011	4.036	4	1485	.003	.011
Number of Proposition	.007	2.796	4	1485	0.25	.011

Accuracy, RS, RcS, and FD were the four dependent variables that were subjected to the combined effects of Group (SLI vs. Non-SLI), Language (Indonesian vs. English), and their interaction in the MANCOVA study. To account for differences in syntactic complexity, factors such as syllable length, sentence length, number of modifiers, and number of propositions were also included.

The analysis revealed a significant main effect of Group, with SLI students demonstrated consistently lower scores than NON-SLI across all measures, accounting for 18.4% of the variance. Language also showed a small but significant effect, explaining 1.9% of the variance, while the interaction between Group and Language was statistically significant but minimal, contributing only 1.4%—indicating that language type had little influence on the performance gap between groups.

Additionally, the analysis assessed how syntactic complexity variables affected reading performance. There was a significant effect of sentence length (p =.047), suggesting that participants had more difficulty understanding longer sentences. The combined dependent variables also showed minor but significant effects from modifier count (p =.003) and number of proposition (p =.025), confirming that poorer reading performance was generally a result of increased syntactic complexity. However, the combined dependent variables were not substantially affected by syllable length (p =.285), suggesting that the number of syllables in a sentence was not a crucial component of students' performance.

RESULTS OF BETWEEN-SUBJECTS EFFECTS

Levene's Test of Equality of Error Variances was used to determine whether the error variances of the dependent variables were equal across groups before performing the Univariate Analysis of Covariance (ANCOVA) for each dependent variable. The findings showed that for every dependent variable, the homogeneity of variance assumption was broken: F (3,1492) = 30.33, p <.001 for accuracy; F (3,1492) = 37.51, p <.001 for RS; F (3,1492) = 41.53, p <.001 for RcS; and F (3,1492) = 43.37, p <.001 for FD. The ANCOVA's F-test is thought to be resilient to violations of homogeneity when the sample size is large enough (Azwar, 2015), therefore even if the violation of homogeneity could raise worries, this risk is reduced in this study because of its large sample size (N = 1496).

TABLE 2. Results of Between-Subjects Effects Analysis for Accuracy, RS, RcS, and FD

Dependent Variable	Effect	*F*	*df*	*p*	ηp²
Accuracy	All variables	25.635	7	.000	.108
	intercept	572.193	1	.000	.0.43
	Group	158.27	1	.000	.096
	Language	1.163	1	.281	.001
	Group x Language	0.041	1	.840	.000
	Syllable Length	3.321	1	.069	.002
	Sentence length	5.132	1	.024	.003
	Modifier count	6.996	1	.008	.005
	Number of Proposition	9.268	1	.002	.006
RS	All variables	9.539	7	.000	.043
	intercept	21.033	1	.000	.014
	Group	51.24	1	.000	.033
	Language	0.000	1	.985	.000
	Group x Language	0.158	1	.691	.000
	Syllable Length	.106	1	.745	.000
	Sentence length	.487	1	.486	.000
	Modifier count	.642	1	.423	.000
	Number of Proposition	.888	1	.346	.001
RcS	All variables	15.513	7	.000	.068
	intercept	81.757	1	.000	.052
	Group	65.38	1	.000	.042
	Language	24.77	1	.000	.016
	Group x Language	3.63	1	.057	.002
	Syllable Length	2.316	1	.128	.002
	Sentence length	1.164	1	.281	.001
	Modifier count	4.533	1	.033	.003
	Number of Proposition	.008	1	.928	.000
FD	All variables	19.139	7	.000	.083
	intercept	483.472	1	.000	.245
	Group	115.22	1	.000	.072
	Language	1.77	1	.183	.001
	Group x Language	14.998	1	.000	.010
	Syllable Length	.001	1	.981	.000
	Sentence length	1.007	1	.316	.001
	Modifier count	.053	1	.818	.000
	Number of Proposition	.041	1	.840	.000

The ANCOVA results revealed several significant effects of group status, language type, and syntactic complexity variables on reading comprehension performance across four key dependent measures: accuracy, RS, RcS, and FD. For accuracy, the model significantly explained 10.8% of the variance, (p = .001). The intercept and unmeasured variables accounted for an additional 27.8% of the variance p = .001), indicating a strong baseline effect. Among the covariates, sentence length (p = .024), modifier count (p = .008), and number of proposition (p = .002) were significant predictors. Group status (SLI vs. Non SLI) had a substantial effect, explaining 9.6% of the variance (p = .000). For RS, the overall model was significant (p = .000), explaining 4.3% of the variance. Unmeasured factors contributed 1.4% (p = .000), while group status remained a significant factor (p = .000), accounting for 3.3% of the variation. In terms of RcS, the model explained 6.8% of the variance (p = .000), with the intercept accounting for 5.2% (p = .000). Modifier count (p = .033), group status (p = .000), and language type (p = .000) were all significant predictors. For FD, the model explained 8.3% of the variance (p = .000), with a substantial effect from unmeasured factors

(p = .000). Group status again showed a strong influence (p = .000), and a significant interaction between group and language was observed (p = .000).

TABLE 3. Predicted Means from ANCOVA Equation for Accuracy, RS, RcS, and FD
(Adjusted Means and 95% Confidence Intervals)

Variable	Group	Language	Adjusted Mean	Standard Error	95% CI
Accuracy (%)	SLI	Indonesian	66.2	.016	(63, 69)
	SLI	English	64.1	.016	(61, 67)
	Non-SLI	Indonesian	83.9	.016	(81, 87)
	Non-SLI	English	81.2	.016	(78, 84)
RS (s)	SLI	Indonesian	12.67	.698	(11.30, 14.04)
	SLI	English	12.41	.698	(11.05, 13.78)
	Non-SLI	Indonesian	8.19	.698	(6.82, 9.56)
	Non-SLI	English	8.41	.698	(7.04, 9.77)
RcS (ms)	SLI	Indonesian	5829.27	359.89	(5123.33, 6535.21)
	SLI	English	8836.29	359.89	(8130.35, 9542.24)
	Non-SLI	Indonesian	3938.28	359.89	(3232.33, 4644.22)
	Non-SLI	English	5780.31	359.89	(5074.36, 6486.25)
FD (ms)	SLI	Indonesian	465.25	11.07	(443.54, 486.96)
	SLI	English	521.62	11.07	(499.92, 543.33)
	Non-SLI	Indonesian	400.70	11.07	(378.99, 422.41)
	Non-SLI	English	384.21	11.07	(362.50, 405.92)

Table 5 presents the adjusted means for all dependent variables across groups and languages after controlling for syntactic complexity covariates. When computing projected performance, the covariates were set at their mean values (syllable length = 10.18, sentence length = 5.71, modifier count = 0.94, and number of propositions = 4.18). The total score of accuracy for stimuli in both languages is 100%.

Following ANCOVA's first coefficient estimate, residuals were subjected to Kolmogorov-Smirnov test with Lilliefors adjustment to find that residuals were not normally distributed (p <.001 for all dependent variables). Bootstrapping with 200 resamples was used to solve this violation and generate bias-corrected confidence ranges for every parameter estimate.

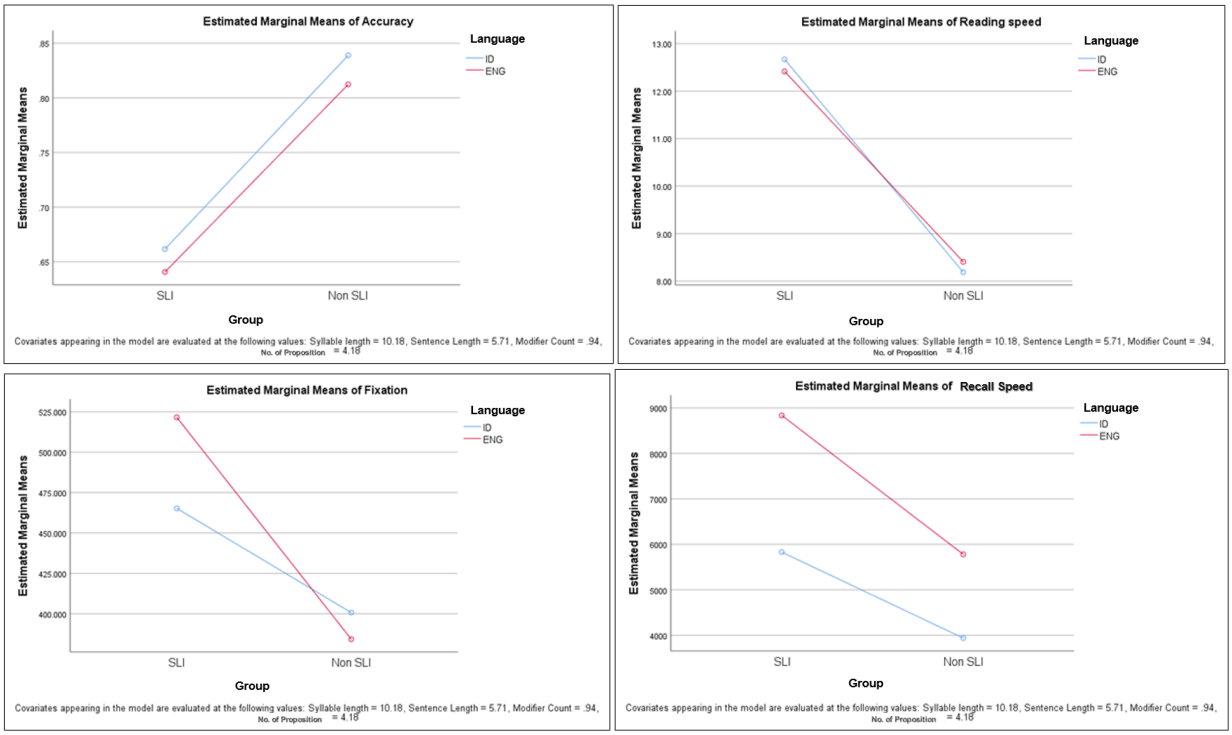

FIGURE 1. Estimated measures of Accuracy, Reading Speed, Response Speed and Fixation of SLI and NON-SLI participants

Figure 1 illustrates a more detailed analysis examining predicted performance for each group within each language. It confirms that SLI students consistently scored lower in both languages compared to Non-SLI group. For accuracy, SLI group scored 66.2% in Indonesian and 64.1% in English. Meanwhile, Non-SLI students achieved higher scores, 83.9% in Indonesian and 81.2 % in English. A similar trend emerged for RS. SLI students took 12.67 seconds per sentence in Indonesian and 12.42 seconds per sentence in English. The Non-SLI group read faster at 8.19 seconds in Indonesian and 8.41 seconds in English.

For RcS, Non-SLI group showed better performance as they took faster time to recall the information from the stimuli in both languages. SLI group needed 5829.27 ms to recall answers in Indonesian stimuli, but required 8836.29 ms in English. Non-SLI students required 3938.28 ms in Indonesian and 5780.31 ms in English, following a similar language pattern. This indicated that RcS was slower in English for both groups.

Lastly, SLI group showed longer FD than NON-SLI group in both languages demonstrating more efficient visual processing across both languages. SLI group fixated for an average of 465.25 ms in Indonesian and 521.62 ms in English, reflecting longer FD when processing English sentences. In contrast, Non-SLI group fixated for 400.70 ms in Indonesian and 384.21 ms in English.

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DISCUSSION

The influence of syntactic complexity on reading comprehension performance among Indonesian-English bilingual elementary students with and without SLI was explored in this work. Affecting reading accuracy, speed, memory, and fixation time across both languages, results from MANCOVA and ANCOVA analyses revealed that SLI status was the strongest predictor of lower reading comprehension ability. Syntactic complexity, especially that is indexed by the number of propositions, modifiers, and sentence length, significantly affected performance, particularly among SLI students. This suggests that higher content density increases cognitive demands during reading. Language and Group × Language interaction had smaller effect than Group; this suggests that broad cognitive-linguistic processing deficiencies gives more contribution to reading comprehension problems than language-specific causes.

Despite the manipulation of sentence-level syntactic complexity—such as sentence length, syllable length, number of modifiers, and number of propositions—no significant effects were found on RS in either group. However, SLI students consistently read more slowly than their typically developing peers. As supported by Johann et.al (2020), the consistently slower reading speed observed in SLI students, despite matched syntactic conditions and efficient decoding stage, suggests underlying cognitive processing limitations .

Although previous research has shown that opaque orthographies such as English and French increase cognitive processing demands—particularly with longer words—leading to slower RS (Müller et al., 2020), our findings do not align with this pattern. In the current study, no significant difference in sentence-level RS was observed between Indonesian and English in either the SLI or the Non-SLI group. This lack of difference may be attributed to the participants' balanced fluency and vocabulary knowledge in both languages, which likely mitigated orthographic complexity effects typically observed in less proficient bilinguals. Interestingly, while RS remained stable across languages, SLI students exhibited significantly longer FDs when reading English compared to Indonesian, a pattern not observed in Non-SLI group. This suggests that the additional cognitive load imposed by English's opaque orthography did not affect overall timing but did manifest in localized processing difficulties—reflected in more prolonged fixations—specifically among SLI students. These findings highlight that, for bilingual children with SLI, orthographic complexity may disrupt lower-level visual-linguistic integration without necessarily slowing overall RS, pointing to subtle inefficiencies that are not captured by timing measures alone.

Comprehension involves the construction of propositional meaning and the integration of these propositions into a coherent mental representation (Kintsch & Kintsch, 2005). SLI group appear to find the integration phase, where efficient use of working memory is needed (Grela et al., 2023), more taxing in English. This is reflected in their accuracy score, which was lower in English, albeit not significantly so. This discrepancy between effort (as seen in fixation) and outcome (as reflected in accuracy), despite similar sentence-level reading times, indicates inefficiencies in sentence integration and resource allocation during reading typical to poor comprehenders (Kuperman & Van Dyke, 2011). It appears that SLI students may compensate for processing difficulty by maintaining overall reading pace while over-focusing on certain segments, ultimately leading to reduced comprehension accuracy. In contrast to the SLI group, Non-SLI students showed no significant differences between Indonesian and English in FD, RS, or accuracy. This consistency corroborates with Kaani et al. (2022), and suggests balanced processing strategies across both orthographies. Their equal fluency in both languages is likely to support efficient and

flexible reading, regardless of orthographic transparency. This emphasizes that working memory limitations are central to reading difficulties in both monolingual and bilingual SLI students.

The consistently lower accuracy in the SLI group, especially as sentence length, number of modifiers, and number of constituents increase, suggests that their comprehension difficulties stem not from fluency or vocabulary deficits as both groups are fluent in both languages. When readers are fluent in both languages and are familiar with the vocabularies used in the text, phonological processing is not the limiting factor (Mekheimer, 2024). Instead, syntactic load—the number of constituents (propositions) and modifiers taxed the participants' working memory and integration capacity (Smail et al., 2024). Though this pattern is shown in both groups, the SLI group is affected more severely. It appears that SLI students can process only a subset of propositions during a single read-through (Perfetti & and Stafura, 2014), with peripheral elements such as modifiers being more likely to be omitted due to limited processing resources (Andreu et al., 2016). This can happen as SLI students have a lower ceiling for how much information they can hold and integrate, particularly under time constraints (Taboada Barber et al., 2022) while Non-SLI students can manage more propositions and maintain accuracy better under increased load (Stanford & Delage, 2020). This explains why accuracy decreases as the number of modifiers increases. These effects appear across both languages, confirming that limited working memory is closely linked to reduced accuracy when reading syntactically dense texts among bilinguals with reading difficulties (Kieffer et al., 2021).

The present study found that language type and the number of modifiers significantly influenced RcS, defined as the time taken by students to answer comprehension questions, regardless of accuracy. These findings consistently show that syntactic and linguistic complexity increase processing demands across groups and languages. SLI students had slower RcS in both languages, with significantly longer response times in English—averaging over three seconds more than in Indonesian. This suggests that despite balanced bilingual fluency, English's greater orthographic opacity and syntactic demands may impose additional cognitive load on SLI students, who are already known to have limitations in working memory capacity. Similarly, typically developing (Non-SLI) students also showed a significant delay in RcS when processing English texts compared to Indonesian, although the time difference was smaller than in the SLI group. This consistent pattern across both groups reinforces the notion that language transparency and syntactic structure influence the ease with which bilingual children retrieve and organize information to answer comprehension questions. This suggests that even in balanced bilinguals, information retrieval may differ depending on the linguistic structure, and SLI students are more vulnerable to such variation due to impaired processing efficiency (Espi-Sanchis & Cockcroft, 2022; Monnier et al., 2022).

Importantly, the study revealed a significant negative correlation between RcS and comprehension accuracy. In both SLI and Non-SLI groups, students who took longer to respond tended to answer less accurately, regardless of the language. This relationship supports the interpretation that RcS is not merely a reflection of deeper cognitive engagement, but rather a marker of working memory limitations or processing difficulty (Borella & de Ribaupierre, 2014). The consistent pattern across Indonesian and English suggests that longer recall times signal greater cognitive effort or retrieval difficulty, which compromises comprehension performance.

This study suggests that reading comprehension problems are linked to the requirement to hold and process several content units simultaneously in working memory, rather than to morphosyntactic parsing difficulties. These finding is aligned with Srisang and Everatt (2021), who demonstrated that reading comprehension is predicted not merely by vocabulary exposure but

by structural processing (e.g., grammar) and higher-order inference skills, depending on learners' proficiency levels. These findings underscore the need for targeted reading interventions for bilingual SLI students, focusing on content structure and working memory support rather than general language exposure. Strategies like chunking, visual scaffolding, and pre-reading previews can ease cognitive load during reading. Teachers should guide students in segmenting materials and breaking down complex phrases. Crucially, these interventions must be delivered in both languages to strengthen cross-linguistic comprehension skills.

CONCLUSION

This study explored how Indonesian-English bilingual elementary students, with and without SLI, comprehend sentences with varying syntactic complexity. SLI status consistently predicted poor performance across reading measures—accuracy, speed, recall, and fixation—regardless of language. Sentence length had the strongest negative impact, followed by element and modifier count, indicating that higher content density hinders processing. Syllable length had no significant effect, suggesting phonological demands are not the main challenge. MANCOVA showed a strong group effect, with SLI vs. non-SLI differences explaining much of the variance, while language and group × language interaction effects were statistically significant but small. This suggests that the observed comprehension differences are primarily driven by language impairment rather than by bilingual status or language-specific factors. In other words, both groups responded similarly across Indonesian and English, challenging assumptions that bilingual SLI students would be disproportionately impaired in their non-dominant language.

The study's use of school-based fluency measures, single-clause stimuli, and forward-only eye-tracking limits syntactic and processing insights, while its focus on balanced bilinguals may constrain generalizability. Future research should examine regressive eye movements, multi-clause structures, and counterbalanced designs to clarify SLI comprehension repair, and compare bilingual profiles while incorporating function words and morphosyntactic complexity to assess grammatical strain. Finally, investigating the effectiveness of interventions such as content chunking and working memory strategies may offer targeted support to enhance comprehension for bilingual children with SLI.

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