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The Impact of Language Exposure, Phonological Memory, and Cross-Linguistic Similarities in ESL Vocabulary Acquisition: A Multi-Group Analysis Using PLS-SEM

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ABSTRACT

Vocabulary acquisition is essential for second language (L2) learning and is influenced by various linguistic, cognitive, and contextual factors. This research investigates the combined and individual effects of language exposure, phonological memory, and cross-linguistic similarities on English vocabulary acquisition among international learners of English as a Second Language (ESL). A quantitative, cross-sectional research design was employed, involving 184 international ESL learners enrolled at a language center in Kuala Lumpur. Data were collected using a structured questionnaire, vocabulary tests, and were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) via SmartPLS (Version 4.0). Additionally, multi-group analysis (MGA) was conducted to assess potential variations across demographic groups. Results demonstrated that language exposure, phonological memory, and cross-linguistic influences significantly enhance vocabulary size and depth. Among these variables, language exposure emerged as the most influential predictor, followed by phonological memory. Cross-linguistic similarities also played a facilitative role by reducing cognitive load and enhancing word recall. Together, these factors explained a substantial proportion of the variance in vocabulary acquisition outcomes, suggesting an interdependent relationship among them. This study underscores the importance of tailoring ESL instruction to address learners' linguistic backgrounds, cognitive capacities, and exposure contexts. By integrating these elements into curriculum design, educators and policymakers can implement more personalized and effective vocabulary acquisition strategies. The findings contribute to theoretical advancements in second language acquisition (SLA), particularly in understanding how individual differences and linguistic transfer mechanisms influence learning, while also offering practical guidance for improving ESL pedagogy in diverse learning environments.

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1. Introduction

Vocabulary acquisition is widely acknowledged as a fundamental aspect of second language acquisition (SLA), crucial in comprehension and effective communication. As an essential element of second language (L2) mastery, vocabulary proficiency significantly impacts overall language competence and fluency [1,2]. However, despite its importance, acquiring vocabulary remains a complex and demanding process, particularly for learners in English as a Foreign Language (EFL) and English as a Second Language (ESL) environments. In these contexts, limited vocabulary knowledge frequently impedes academic progress and restricts learners' ability to engage in meaningful interactions [3–5].

For international learners of English, vocabulary acquisition is further complicated by linguistic, cognitive, and contextual barriers. Structural differences between learners' first language and their second language, i.e., English, including disparities in phonology, syntax, and morphology, present significant hurdles in acquiring vocabulary [6–8]. Cross-linguistic similarities, such as cognates and shared linguistic features, can either facilitate or hinder the learning process depending on their nature and extent [9,10]. Furthermore, cultural attitudes toward English, shaped by historical and societal contexts, add layers of complexity to vocabulary acquisition [11–13].

Language exposure has emerged as a critical determinant of vocabulary acquisition. Studies show that the frequency, quality, and diversity of exposure significantly enhance both vocabulary breadth (the number of words known) and depth (understanding nuances and relationships between words) [14–17]. Phonological memory—the ability to retain and process sound patterns—further supports vocabulary acquisition by enabling learners to internalize unfamiliar lexical items and integrate them into long-term memory [18,19].

These dimensions of vocabulary acquisition interact dynamically. Greater exposure to high-quality language input enhances both recognition and retention of lexical items. Phonological memory aids in processing these inputs, while cross-linguistic similarities reduce cognitive load and improve learning efficiency [7]. Together, these factors underscore the importance of adopting holistic and context-sensitive approaches to vocabulary instruction.

Despite the progress in understanding these variables, much-existing research has taken a fragmented approach, often examining language exposure, phonological memory, and cross-linguistic similarities in isolation. This study seeks to bridge these gaps by investigating their combined and interactive effects on vocabulary acquisition among International ESL learners. Using a robust methodological framework, this research examines the influence of these variables on both vocabulary breadth and depth, offering new insights into SLA theory and practice. The primary aims of this research are to:

- Investigate the impact of language exposure on ESL vocabulary acquisition.
- Examine the role of phonological memory in vocabulary learning.
- Explore how cross-linguistic similarities affect vocabulary acquisition.

Assess the moderating effects of age on these relationships.

A key element of learning a second language, especially for those learning English as a second language (ESL), is expanding one's vocabulary. A number of linguistic and cognitive elements influence how well ESL students pick up new words. This study investigates the effects of three main factors on vocabulary acquisition: phonological memory, cross-linguistic similarities, and positive language exposure. It also looks at how these correlations could change depending on the age range of ESL students. To look more closely at these relationships, the following theories are put forth. The following hypotheses are proposed to investigate these relationships in greater detail:

H1. *Positive language exposure significantly impacts ESL vocabulary acquisition.*

H2. *Phonological memory positively affects ESL vocabulary acquisition.*

H3. *Cross-linguistic similarities positively*

affect ESL vocabulary acquisition.

H4a. *ESL learners' age group moderates the influence of language exposure on ESL vocabulary acquisition.*

H4b. *ESL learners' age group moderates the influence of phonological memory on ESL vocabulary acquisition.*

H4c. *ESL learners' age group moderates the influence of cross-linguistic similarities on ESL vocabulary acquisition.*

1.1. Conceptual Framework for ESL Vocabulary Acquisition

The acquisition of vocabulary in English as a Second Language (ESL) is influenced by several key factors, including language exposure, phonological memory, and cross-linguistic similarities [9,14,19]. Language exposure plays a critical role in enhancing vocabulary acquisition, as frequent and meaningful encounters with English through reading, listening, and interaction provide repeated exposure to lexical items, thereby facilitating retention and understanding [15,17]. Phonological memory, which refers to the ability to store and recall sound patterns, further supports the integration of unfamiliar words into long-term memory, enabling deeper processing and retention of new vocabulary [18,19]. Furthermore, cross-linguistic similarities, which stem from the linguistic relationships between a learner's first language (L1) and second language (L2), can either support or hinder the learning process, depending on the nature of these connections [9,10]. These linguistic influences, along with other factors, contribute to two key dimensions of vocabulary acquisition: breadth, which denotes the number of words a learner knows, and depth, which encompasses word meanings, associations, and contextual applications [20,21].

As shown in **Figure 1**, The conceptual framework illustrates the dynamic interplay of three key variables. Each of the three key variables plays a separate but interrelated role in the framework, contributing to how learners understand, remember, and use new English vocabulary.

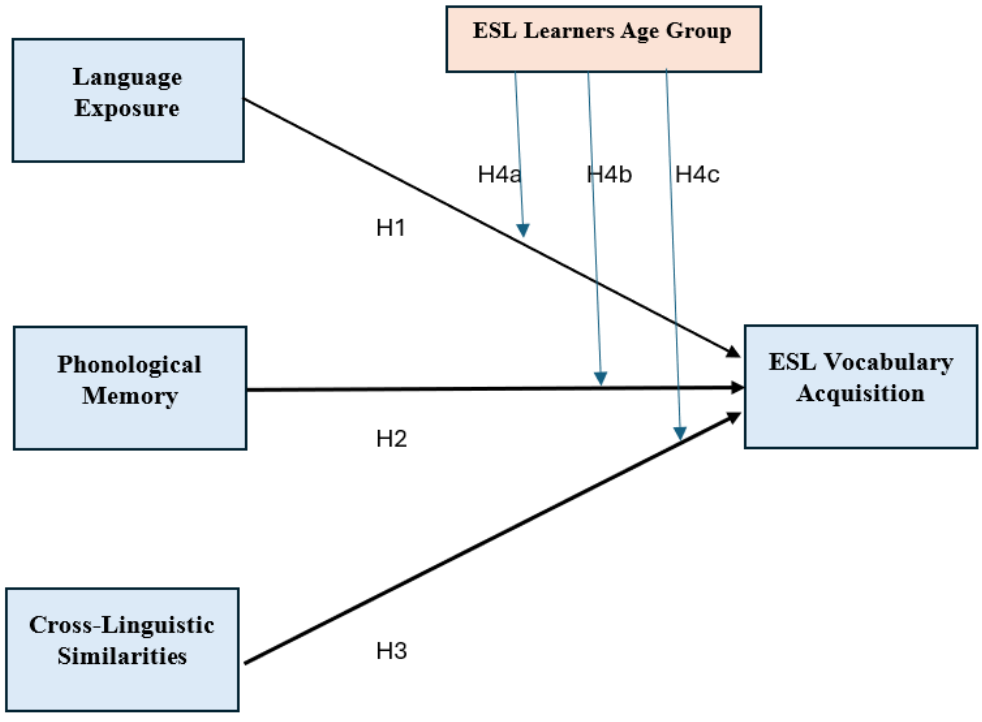

Figure 1. ESL Vocabulary Acquisition Conceptual Framework.

Language exposure refers to the frequency and quality of learners' contact with English in different contexts, such as classroom learning, social interactions, and media consumption. In this framework, this variable likely acts as an exogenous factor directly or indirectly influencing vocabulary acquisition. Learners who are exposed to English more frequently and in richer contexts are expected to benefit from increased opportunities to encounter, practice, and understand new words, which enhances their vocabulary development.

Phonological memory, another key component of the framework, represents the learner's ability to retain and process phonological information in short-term memory. This cognitive skill is essential for encoding unfamiliar word sounds, making it an important factor in vocabulary acquisition. Within this model, phonological memory may represent a mediating variable linking language exposure and vocabulary acquisition. Learners with stronger phonological memory tend to be more adept at memorizing and retrieving new vocabulary, which may explain why some individuals perform better than others despite similar levels of exposure.

Cross-linguistic similarities refer to the extent to which the learner's native language (L1) resembles English in certain characteristics, such as similarities in phonology, orthography or semantics. This variable potentially influences the relationship between language exposure and vocabulary acquisition. For example, learners whose native language contains related words or structural similarities to English (such as Spanish-English pairs) may experience positive vocabulary transfer, which facilitates the learning of new vocabulary. On the other hand, significant linguistic differences (as is the case for learners who speak both Chinese and English) can hinder learning, requiring extra effort and support. Recognizing these similarities or differences is critical to adapting ESL instruction to learners' backgrounds.

This framework focuses on English as a Second Language (ESL) vocabulary acquisition, the outcome variable that reflects a learner's ability to understand, remember, and use English words in both receptive (listening and reading) and productive (speaking and writing) skills. This dependent variable is influenced by the cumulative and interactive effects of language exposure, phonological memory, and similarities across languages, indicating that vocabulary learning is a multifaceted process influenced by both external conditions and internal learner characteristics.

2. Review of Literature and Hypotheses

2.1. Vocabulary Acquisition (The Dependent Variable)

Research on second language (L2) vocabulary acquisition emphasizes two critical dimensions: vocabulary breadth (VB) and vocabulary depth (VD). These dimensions are distinct yet interdependent, collectively providing a comprehensive framework for understanding L2 lexical knowledge [20,22].

The literature review cites a number of previous studies on the relationship between vocabulary learning, phonological memory and language exposure. However, our knowledge of how these elements interact in the context of English as a second language (ESL) learning, especially for learners abroad, remains incomplete. The present study seeks to fill this gap by providing a comprehensive overview of these factors.

Vocabulary Breadth (VB) pertains to the sheer number of words a learner knows, regardless of their depth of understanding. VB is often classified into four subcategories: active recall (retrieving a word's form), passive recall (recalling its meaning), active recognition (identifying its form), and passive recognition (recognizing its meaning) [21–23]. These nuanced classifications underscore the multifaceted processes involved in acquiring and utilizing vocabulary, highlighting the cognitive complexity inherent in L2 learning.

Vocabulary Depth (VD), in contrast, addresses the qualitative aspects of lexical knowledge, including understanding nuanced meanings, word associations, and the interconnected structure of the mental lexicon [24]. VD is frequently assessed through tasks that measure semantic and collocational relationships, with tools such as Read's Word Associates Format (WAF) and the Word Association Test [25]. Further measures, such as tests of collocational knowledge and word part comprehension [26–28], illustrate the intricacies and richness of VD, offering deeper insights into learners' lexical proficiency.

Empirical evidence highlights significant deficiencies in both VB and VD among Saudi English majors, emphasizing the critical need for targeted instructional interventions [7]. The persistence of these gaps underscores a broader trend observed in EFL contexts, where structural and pedagogical constraints impede effective vocabulary acquisition. L2 vocabulary acquisition is a complex process shaped by various learning strategies and contextual influences. Engaging in activities such as reading, listening, and interacting with multimedia content plays a crucial role in vocabulary development for EFL learners [29]. Teng found that reading while listening was more effective than reading alone in enhancing EFL learners' recognition of word forms and grammatical comprehension [30]. These findings highlight the significance of both exposure frequency and the depth of cognitive engagement in vocabulary acquisition.

2.2. Independent Variables

2.2.1. Language Exposure and ESL Vocabulary Acquisition

Hypothesis 1 (H1). *Positive language exposure significantly impacts ESL vocabulary acquisition.*

Language exposure is a fundamental determinant of vocabulary acquisition, with both its quantity and quality often outweighing the importance of the starting age of instruction [17,31,32]. Research emphasizes that sustained engagement with English—through classroom instruction, multimedia resources, or authentic social interactions—substantially enhances lexical gains [33]. For instance, meaning-focused reading has been shown to significantly bolster vocabulary breadth (VB), particularly among adult ESL learners, by promoting comprehension and retention [34]. In Content and Language Integrated Learning (CLIL) contexts, structured exposure to high-frequency vocabulary facilitates learners' understanding of functional and everyday language [35].

Although studies reveal that exposure alone is insufficient for optimal vocabulary acquisition. Language exposure is a fundamental determinant of vocabulary acquisition, with both its quantity and quality often outweighing the importance of the starting age of instruction [17,31,32]. Research emphasizes that sustained engagement with English—through classroom instruction, multimedia resources, or authentic social interactions—substantially enhances lexical gains [33]. For instance, meaning-focused reading has been shown to significantly bolster vocabulary breadth (VB), particularly among adult ESL learners, by promoting comprehension and retention [34]. In Content and Language Integrated Learning (CLIL) contexts, structured exposure to high-frequency vocabulary facilitates learners' understanding of functional and everyday language [35].

Despite these advances, individual differences, such as developmental language disorders, demand personalized instructional strategies to maximize the benefits of language exposure [36]. These insights align with theoretical frameworks like Krashen's Input Hypothesis and Ellis's interactionist theory [15], which highlight the importance of comprehensible, high-quality input for effective vocabulary development. Consequently, pedagogical approaches that balance structured and incidental exposure are essential to optimize learning outcomes.

2.2.2. Phonological Memory and ESL Vocabulary Acquisition

Hypothesis 2 (H2). *Phonological memory positively affects ESL vocabulary acquisition.*

Phonological memory (PM), the ability to temporarily store and manipulate sound patterns, is a critical cognitive mechanism underpinning vocabulary acquisition [18,19,37,38]. Empirical studies consistently link higher PM capacity to greater vocabulary breadth and overall language proficiency [39]. In ESL contexts, PM has been shown to facilitate the acquisition, retention, and processing of new lexical items [40,41].

PM training has demonstrated varied impacts depending on the type of vocabulary knowledge assessed. For instance, while PM training enhances productive vocabulary development in beginner learners, its influence on receptive vocabulary appears limited [40]. Furthermore, automatized phonological vocabulary knowledge, as assessed through tasks like lexicosemantic judgment, better predicts real-life listening comprehension than recognition or recall alone, reflecting the significance of automatization in language acquisition [42].

Among bilingual children, PM supports both vocabulary and grammar development across languages, with cross-linguistic effects modulated by age and linguistic factors [43]. Early literacy acquisition in English Language Learners (ELLs) also depends heavily on PM, distinguishing their learning patterns from those of monolingual peers [44]. Finally, retrieval-based techniques, such as low-stakes quizzes and flashcards, enhance long-term retention, underscoring the need for learner-specific implementation [45].

2.2.3. Cross-Linguistic Similarities and ESL Vocabulary Acquisition

Hypothesis 3 (H3). *Cross-linguistic similarities positively affect ESL vocabulary acquisition.*

Cross-linguistic similarities, such as cognates, shared syntactic structures, and semantic parallels, provide cognitive scaffolds for second language (L2) vocabulary learning [9,10]. These similarities reduce cognitive load, aiding learners in acquiring and retaining new vocabulary [46,47].

While cross-linguistic similarities enhance vocabulary acquisition, they also present challenges. False cognates and incongruent collocations can hinder learning, particularly in typologically distant language pairs, necessitating balanced instructional strategies [48–50]. Similarly, semantic clustering may impede vocabulary retention, suggesting that interlingual differences require tailored pedagogical approaches [51,52]. In multilingual contexts, cognate awareness and language co-activation are pivotal for vocabulary acquisition, especially in third-language (L3) learning [53].

Despite these complexities, the facilitative role of cross-linguistic similarities is evident in early bilingual and simultaneous bilingual learners, where typological closeness positively impacts vocabulary size and accuracy [54]. Addressing these dynamics through explicit instruction and awareness of interlingual transfer can optimize vocabulary outcomes in diverse learning environments.

2.2.4. Moderation Role of ESL Learners' Age Group

Hypothesis 4a (H4a). *ESL learners' age group moderates the influence of language exposure on ESL vocabulary acquisition.*

Hypothesis 4b (H4b). *ESL learners' age group moderates the influence of phonological memory on ESL vocabulary acquisition.*

Hypothesis 4c (H4c). *ESL learners' age group moderates the influence of cross-linguistic similarities on ESL vocabulary acquisition.*

Age significantly influences L2 vocabulary acquisition, with neural plasticity in younger learners favoring phonological and lexical development, while older learners excel in syntactic and semantic aspects due to cognitive maturity [55]. Age also moderates the effects of language exposure, PM, and cross-linguistic similarities, with younger learners benefiting more from interactive and multimodal activities and older learners leveraging advanced strategies like spaced repetition [56].

Age significantly influences L2 vocabulary acquisition, with neural plasticity in younger learners favoring phonological and lexical development, while older learners excel in syntactic and semantic aspects due to cognitive maturity [55]. Age also moderates the effects of language exposure, PM, and cross-linguistic similarities, with younger learners benefiting more from interactive and multimodal activities and older learners leveraging advanced strategies like spaced repetition [56]. Moreover, age-related differences in vocabulary acquisition emphasize the need for instructional approaches that are tailored to learners' developmental and cognitive profiles.

3. Methodology

3.1. Research Design and Instruments

This study adopted a cross-sectional research design with a quantitative approach to explore the relationships between language exposure, phonological memory, cross-linguistic similarities, and ESL vocabulary acquisition among international learners. This design facilitated systematic data collection and analysis, providing a snapshot of interrelated factors within the conceptual framework. While effective for identifying correlations, the design's limitations in establishing causality are acknowledged.

Data collection involved two main instruments: a structured questionnaire and a vocabulary test. The ques-

tionnaire was designed to evaluate language exposure, phonological memory (PM), and cross-linguistic similarities, while the vocabulary test measured both the breadth and depth of vocabulary knowledge.

Language exposure was measured using a 10-item scale that captured the quality and quantity of participants' interaction with English in formal (e.g., classroom instruction) and informal (e.g., multimedia use, social interaction) contexts. Drawing on Krashen's Input Hypothesis and Ellis's interactionist theory [14,15], the scale emphasized comprehensible and meaningful input as pivotal for second language acquisition. Phonological memory was assessed using a 9-item instrument adapted from Baddeley and Gathercole and Baddeley [18,19], focusing on participants' ability to recall and process sound patterns, a key skill in vocabulary retention and integration. Cross-linguistic similarities were measured through an 11-item scale that explored participants' use of linguistic parallels, such as cognates and typological overlaps, informed by Odlin's [9] and Ringbom's findings on linguistic transfer [10]. While these instruments effectively operationalized theoretical constructs, the reliance on self-reported data may introduce subjective biases.

The vocabulary test assessed both the breadth and depth of lexical knowledge using established measurement tools. Breadth was evaluated through the Vocabulary Size Test (VST), adapted from Nation and Beglar [57], which examined the first 3,000 most frequently used word families and demonstrated a reliability alpha of .84. Depth was measured using a modified version of Read's Word Association Test (WAT) [24], which assessed collocational and semantic relationships with a reliability alpha of 0.80. While these instruments provided a comprehensive assessment of lexical knowledge, their emphasis on specific dimensions may not fully capture the contextual and pragmatic aspects of vocabulary use.

To ensure validity, all instruments underwent expert review to confirm cultural and linguistic appropriateness for international learners. Responses were recorded on a five-point Likert scale to capture nuanced perceptions. This methodological rigor enhanced the study's reliability, but the limitations of cross-sectional data and subjective measures suggest the need for complementary longitudinal and qualitative approaches in future research.

3.2. Survey Respondents

The study was carried out at the Centre for Languages and Pre-University Academic Development (CELPAD) at the International Islamic University Malaysia (IIUM) in Gombak, Selangor. CELPAD provides English language courses as part of its foundational programs, serving students from a wide range of linguistic and cultural backgrounds. The research sample consisted of 184 International ESL learners enrolled in CELPAD's English courses. The research sample consisted of 184 international ESL learners enrolled in English courses at the Centre for Languages and Pre-University Academic Development (CELPAD) at the International Islamic University Malaysia (IIUM). The participants came from diverse linguistic backgrounds, with Arabic (40.8%) being the most common first language, followed by Malay (24.5%), Chinese (20.7%), and Hindi (14.1%). The sample included 87 male (47.3%) and 95 female (52.7%) students, ensuring a balanced gender representation.

In terms of academic levels, the participants were distributed across three levels: Level 4 (35.3%), Level 5 (32.6%), and Level 6 (32.1%). Additionally, the study considered age as a moderating variable, dividing the sample into two subgroups: 120 students (65.2%) were below 25 years old, while 64 students (34.8%) were 25 years or older. The distribution of students across different first languages, academic levels, gender, and age groups reflects the diversity of the student body at CELPAD, making the sample representative of international ESL learners at the institution (See **Table 1**).

Table 1. Students' First Language, Gender, Level, and Age Group.

Variable	Category	N	Percentage (%)
First Language	Arabic	75	40.8
	Malay	45	24.5
	Chinese	38	20.7
	Hindi	26	14.1

Table 1. *Cont.*

Variable	Category	N	Percentage (%)
Gender	Male	87	47.3
	Female	95	52.7
Academic Level	Level 4	65	35.3
	Level 5	60	32.6
	Level 6	59	32.1
Age Group	<25 years	120	65.2
	>25 years	64	34.8
Total Participants		184	100

The sampling technique employed was simple random sampling. A comprehensive list of international learners enrolled at CELPAD was obtained, and participants were randomly selected using their matriculation numbers, ensuring equal probability of selection for all eligible students. This sampling approach ensured representativeness within the target population. A sample size of 184 participants was deemed sufficient for achieving the research objectives and conducting statistical analyses, including structural equation modeling (SEM), as recommended by Kline [58].

3.3. Data Analysis

The study employed advanced statistical techniques to validate the conceptual framework. Descriptive statistics were analyzed using SPSS 29, while Variance-Based SEM was conducted using SmartPLS 4.0 [59,60]. Following the approach outlined by Hair et al. [61], the analysis was carried out in two stages: first, a measurement model assessment to establish reliability, validity, and construct properties, and second, a structural model evaluation to examine the hypothesized relationships between affective factors and ESL vocabulary acquisition. This rigorous two-step process ensured a robust validation of the models, providing reliable insights into the impact of affective factors on vocabulary learning.

4. Results

4.1. Assessment of Outer Model

Before analyzing the hypothesized structural model, the psychometric properties of the measurement model were thoroughly assessed (**Figure 2**). The model included four key constructs: language exposure, phonological memory, cross-linguistic similarities, and ESL vocabulary acquisition. Convergent validity was evaluated using factor loadings and Average Variance Extracted (AVE), with acceptable thresholds set at >0.60 and >0.50, respectively [61]. Construct reliability was determined through Composite Reliability (CR), maintaining a minimum threshold of >0.70, as recommended by Hair et al. (2022). These assessments ensured the measurement model's validity and robustness.

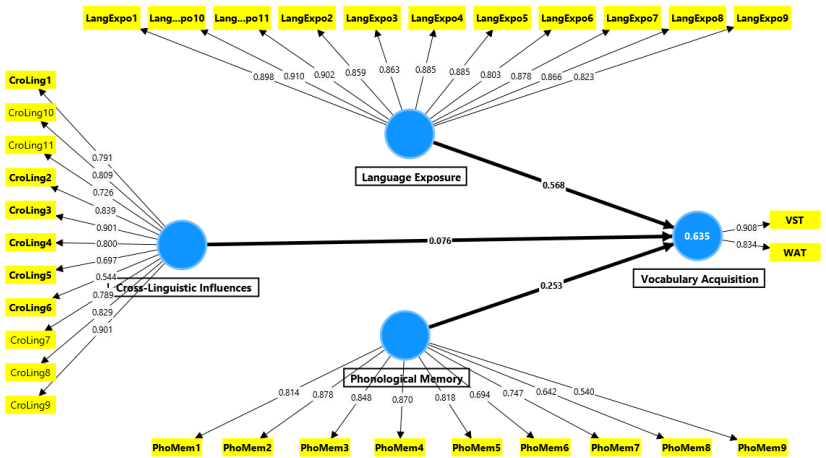

Figure 2. Outer Model Assessment.

4.1.1. Assessment of Constructs' Reliability and Convergent Validity

All constructs exhibited AVE values exceeding the 0.50 threshold and CR values surpassing 0.70 (see **Table 2**). After removing problematic items, all retained factor loadings exceeded 0.50, confirming satisfactory convergent validity and reliability [60,61]. Hair et al. suggest that a factor loading should ideally be above 0.70, with 0.50 as the minimum acceptable threshold [61]. In this study, the factor loading for almost all the items are above 0.70, with few items within the acceptable threshold of 0.5. These results validate the measurement model as a robust foundation for structural model analysis.

Table 2. Constructs' Reliability and Convergent Validity Metrics.

Construct	Item	Factor Loadings	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
Cross-Linguistic Similarities	CroLing1	0.791	0.938	0.95	0.624
	CroLing10	0.809			
	CroLing11	0.726			
	CroLing2	0.839			
	CroLing3	0.901			
	CroLing4	0.8			
	CroLing5	0.697			
	CroLing6	0.544			
	CroLing7	0.789			
	CroLing8	0.829			
	CroLing9	0.901			
Language Exposure	LangExpo1	0.898	0.968	0.969	0.758
	LangExpo10	0.91			
	LangExpo11	0.902			
	LangExpo2	0.859			
	LangExpo3	0.863			
	LangExpo4	0.885			
	LangExpo5	0.885			
	LangExpo6	0.803			
	LangExpo7	0.878			
	LangExpo8	0.866			
	LangExpo9	0.823			
Phonological Memory	PhoMem1	0.814	0.91	0.919	0.592
	PhoMem2	0.878			
	PhoMem3	0.848			
	PhoMem4	0.87			
	PhoMem5	0.818			
	PhoMem6	0.694			
	PhoMem7	0.747			
	PhoMem8	0.642			
	PhoMem9	0.540			
Vocabulary Acquisition	VST	0.908	0.715	0.723	0.759
	WAT	0.834			

4.1.2. Assessment of Discriminant Validity

Discriminant validity, a critical measure for confirming the conceptual distinctiveness of constructs, was assessed using three methods:

I. Fornell-Larcker Criterion

According to the Fornell-Larcker criterion, the square root of the AVE for each construct must be greater than its correlations with other constructs. As shown in **Table 3**, all constructs satisfied this requirement, confirming adequate discriminant validity [61,62].

Table 3. Discriminant validity: Fornell-Larcker Criterion.

Construct	*1*	*2*	*3*	*4*
Cross-Linguistic Similarities	*0.790*			
Language Exposure	*0.580*	*0.871*		
Phonological Memory	*0.292*	*0.631*	*0.769*	
Vocabulary Acquisition	*0.479*	*0.772*	*0.634*	*0.871*

Note: In bold are the square root of average variance extracted (AVE) and below them are the squares of correlation of the constructs.

II. Heterotrait-Monotrait Ratio (HTMT)

To address potential limitations of the Fornell-Larcker criterion, the Heterotrait-Monotrait (HTMT) ratio was utilized as an additional measure of discriminant validity. All HTMT values remained below the threshold of 1.0, indicating no issues with discriminant validity [59,60,63]. A summary of these results is presented in **Table 4**.

III. Cross-Loadings

Finally, cross-loadings were analyzed to verify that each indicator demonstrated a stronger loading on its intended construct compared to other constructs. The results, presented in **Table 5**, confirm the discriminant validity of the measurement model, as all indicators satisfied this criterion [61]. Collectively, these evaluations provide robust evidence of the measurement model's discriminant validity, underscoring its appropriateness for subsequent structural analysis.

Table 4. Discriminant validity: HTMT.

Construct	*1*	*2*	*3*	*4*
Cross-Linguistic Similarities				
Language Exposure	0.596			
Phonological Memory	0.301	0.661		
Vocabulary Acquisition	0.558	0.927	0.794	

Table 5. Discriminant Validity: Cross-Loadings Criterion.

Items	**Cross-Linguistic Similarities**	**Language Exposure**	**Phonological Memory**	**Vocabulary Acquisition**
CroLing1	***0.791***	0.475	0.208	0.375
CroLing10	***0.809***	0.430	0.174	0.351
CroLing11	***0.726***	0.418	0.266	0.330
CroLing2	***0.839***	0.532	0.319	0.473
CroLing3	***0.901***	0.553	0.265	0.453
CroLing4	***0.800***	0.475	0.204	0.385
CroLing5	***0.697***	0.453	0.301	0.375
CroLing6	***0.544***	0.189	0.087	0.126

Table 5. *Cont*.

Items	Cross-Linguistic Similarities	Language Exposure	Phonological Memory	Vocabulary Acquisition
CroLing7	***0.789***	0.413	0.156	0.334
CroLing8	***0.829***	0.455	0.259	0.401
CroLing9	***0.901***	0.504	0.215	0.413
LangExpo1	0.471	***0.898***	0.602	0.683
LangExpo10	0.564	***0.910***	0.543	0.670
LangExpo11	0.483	***0.902***	0.588	0.712
LangExpo2	0.491	***0.859***	0.519	0.665
LangExpo3	0.493	***0.863***	0.530	0.643
LangExpo4	0.486	***0.885***	0.608	0.728
LangExpo5	0.475	***0.885***	0.609	0.716
LangExpo6	0.506	***0.803***	0.478	0.636
LangExpo7	0.583	***0.878***	0.518	0.660
LangExpo8	0.492	***0.866***	0.545	0.658
LangExpo9	0.523	***0.823***	0.487	0.606
PhoMem1	0.133	0.427	***0.814***	0.442
PhoMem2	0.215	0.533	***0.878***	0.516
PhoMem3	0.171	0.490	***0.848***	0.483
PhoMem4	0.216	0.547	***0.870***	0.549
PhoMem5	0.274	0.565	***0.818***	0.528
PhoMem6	0.307	0.507	***0.694***	0.490
PhoMem7	0.331	0.570	***0.747***	0.554
PhoMem8	0.207	0.381	***0.642***	0.434
PhoMem9	0.113	0.249	***0.540***	0.326
VST	0.513	0.766	0.579	***0.908***
WAT	0.298	0.558	0.524	***0.834***

4.2. Results Based on Research Questions

4.2.1. Research Question 1: How Does Language Exposure Impact ESL Vocabulary Acquisition?

The results indicate that language exposure was identified as the strongest predictor of vocabulary acquisition, demonstrating a significant positive effect ($\beta = 0.568$, T-Value = 11.755, $p < 0.001$). This underscores the crucial role of consistent and meaningful language interaction in vocabulary development.

4.2.2. Research Question 2: What Is the Role of Phonological Memory in Vocabulary Learning?

Phonological memory exhibited a significant positive influence on vocabulary acquisition ($\beta = 0.253$, T-Value = 5.907, $p < 0.001$), highlighting the importance of memory processes in language learning.

4.2.3. Research Question 3: How Do Cross-Linguistic Similarities Affect Vocabulary Acquisition?

Although cross-linguistic similarities had a smaller effect, they still showed a statistically significant positive impact on vocabulary acquisition ($\beta = 0.076$, T-Value = 2.013, $p = 0.044$). This indicates that linguistic interactions between languages can support vocabulary growth in ESL learners.

4.2.4. Research Question 4: How Does Age Moderate the Effects of Language Eposure, Phonological Memory, and Cross-Linguistic Similarities on Vocabulary Acquisition?

The moderating role of age revealed that younger learners benefit more from phonological memory and

cross-linguistic similarities than older learners, while language exposure showed a consistent impact across age groups.

4.3. Estimation of the Hypothesized Structural Model

The subsequent phase of the variance-based structural equation modeling (SEM) analysis focused on assessing the hypothesized structural model (inner model) to examine the proposed relationships within the study's framework. After confirming the psychometric properties of the measurement model—particularly its construct reliability and validity—the analysis advanced to this critical stage. Hypothesis testing was conducted using the bootstrapping procedure in SmartPLS version 4, following the guidelines of Hair et al. [61]. The bootstrapping analysis employed 1,000 resamples to produce robust estimates for the hypothesized relationships, as depicted in **Figure 3**.

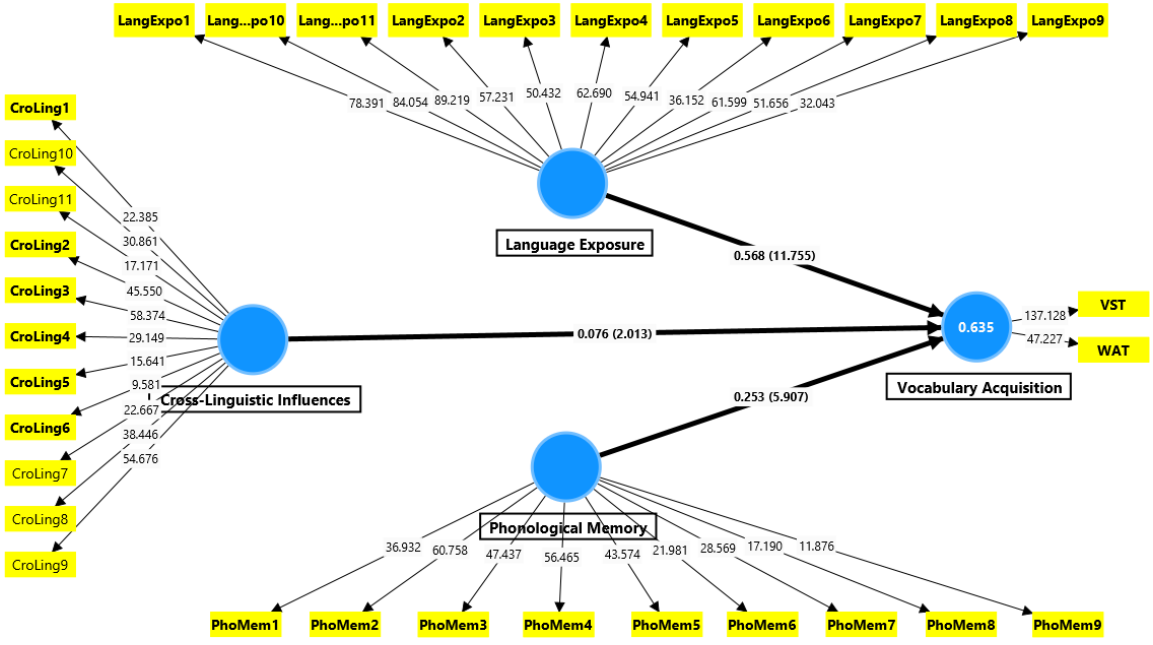

Figure 3. Graphical Representation of Inner Model After the Bootstrapping Procedure.

4.4. Hypotheses Testing

The structural model results summarized in **Table 6** reveal significant relationships among language exposure, phonological memory, cross-linguistic similarities, and ESL vocabulary acquisition. Each hypothesis was evaluated using standardized beta coefficients (β), critical ratios (T-Values), and *p*-values [61].

Table 6. Direct Hypotheses of the Study.

Hypo	Structural Path	Beta	T-Value	*P*-Value	Decision
H1	Language Exposure → Vocabulary Acquisition	0.568	11.755	0.000	supported
H2	Phonological Memory → Vocabulary Acquisition	0.253	5.907	0.000	supported
H3	Cross-Linguistic similarities → Vocabulary Acquisition	0.076	2.013	0.044	supported

Language exposure was identified as the strongest predictor of vocabulary acquisition, demonstrating a significant positive effect (β = 0.568, T-Value = 11.755, $p < 0.001$), underscoring the crucial role of consistent and meaningful language interaction in vocabulary development. Additionally, phonological memory exhibited a significant positive influence on vocabulary acquisition (β = 0.253, T-Value = 5.907, $p < 0.001$), highlighting the importance of memory processes in language learning. Although cross-linguistic similarities had a smaller effect, they still showed a statistically significant positive impact on vocabulary acquisition (β = 0.076, T-Value = 2.013, $p = 0.044$), indicating that linguistic interactions between languages can support vocabulary growth in ESL learners. These findings emphasize the significance of both language exposure and cognitive resources in vocabulary learning while offering valuable insights into the role of cross-linguistic influences.

4.5. Coefficient of Determination and Effect Size

The coefficient of determination (R^2) for Vocabulary Acquisition is 0.640, indicating that 64% of its variance is explained by Language Exposure, Phonological Memory, and Cross-Linguistic similarities, demonstrating strong predictive power [61]. Among the predictors, Language Exposure had the largest effect size ($f^2 = 0.213$), showing a substantial contribution to vocabulary acquisition. Phonological Memory followed with a medium effect size ($f^2 = 0.176$), underlining the significance of cognitive memory processes in learning new vocabulary. Cross-Linguistic similarities had a smaller, though notable, effect size ($f^2 = 0.116$), reflecting the influence of language interplay on vocabulary acquisition (see **Table 7**).

Table 7. Coefficient of Determination (R^2) and Effect's Size (F^2).

Hypo	Structural Path	F^2	R^2
H1	Language Exposure → Vocabulary Acquisition	0.213	
H2	Phonological Memory → Vocabulary Acquisition	0.176	0.635
H3	Cross-Linguistic similarities → Vocabulary Acquisition	0.116	

4.6. Multigroup Analysis (MGA) Across Age Groups

Since the moderator, the students' age group, was a categorical variable, its moderating effect was assessed through group comparisons using multigroup analysis (MGA) [61]. To examine the research model across two age sub-samples (<25 years and >25 years), a multigroup PLS analysis was performed by comparing the differences in the coefficients of the corresponding structural paths for each sub-sample (see **Table 7**).

First, regarding the relationship between Language Exposure and Vocabulary Acquisition, the analysis revealed no significant differences between the two age groups (Path coefficient for <25 years = 0.541; Path coefficient for >25 years = 0.653). Invariance was supported, suggesting that this relationship is consistent across age groups.

Second, for the relationship between Phonological Memory and Vocabulary Acquisition, the analysis showed that the path coefficient for the <25 years group was significantly stronger than for the >25 years group (Path coefficient for <25 years = 0.276; Path coefficient for >25 years = 0.191; p-value difference = −0.046). This supports the hypothesis that age moderates the influence of Phonological Memory on Vocabulary Acquisition.

Finally, for the relationship between Cross-Linguistic similarities and Vocabulary Acquisition, the analysis revealed a significant difference between the two age groups (Path coefficient for <25 years = 0.102; Path coefficient for >25 years = 0.003; p-value difference = −0.964). This indicates that Cross-Linguistic similarities significantly predict Vocabulary Acquisition for the <25 years group but not for the >25 years group, supporting a moderating effect of age. The results of SmartPLS analyses for the <25 years sub-sample and >25 years sub-sample are summarized in **Table 8**.

Table 8. MGA for Vocabulary Acquisition Predictors Across Age Groups.

Path	(<25 Years Old)		(>25 Years Old)		*P*-Value Difference	Invariant
	Path Coefficient	*p*-Value	Path Coefficient	*p*-Value		
Language Exposure → Vocabulary Acquisition	0.541	0.000	0.653	0.000	0.000	Yes
Phonological Memory → Vocabulary Acquisition	0.276	0.000	0.191	0.046	−0.046	Yes
Cross-Linguistic similarities → Vocabulary Acquisition	0.102	0.015	0.003	0.979	−0.964	No

5. Discussion

The findings of this study underline the multifaceted influences of language exposure, phonological memory, and cross-linguistic similarities on ESL vocabulary acquisition. Language exposure emerged as the strongest predictor, reinforcing the foundational importance of frequent, meaningful, and high-quality language interactions in facilitating vocabulary breadth and depth [17,35]. The strong impact of language exposure aligns with Krashen's Input Hypothesis [14], highlighting the necessity of comprehensible input for effective second language acquisition. This result emphasizes the need for learners to engage in varied and interactive contexts, such as multimedia resources and social interactions, to enhance lexical knowledge.

Phonological memory, a key cognitive resource, demonstrated a significant influence on vocabulary acquisition, underscoring its role in the encoding, storage, and retrieval of lexical items [18,19]. The results corroborate existing research suggesting that learners with higher phonological memory capacity perform better in retaining and processing new vocabulary [39,64]. These findings suggest that incorporating memory-based strategies, such as repetition and sound-based activities, can enhance learners' lexical retention.

Cross-linguistic similarities, although contributing less strongly, still played a significant role in reducing cognitive load and facilitating the acquisition of new vocabulary, particularly for learners whose L1 shares structural and lexical overlaps with English [9,46]. However, the smaller effect size may reflect the typological differences between Arabic and English, which pose unique challenges for international learners. Negative transfer or interference might also limit the benefits of cross-linguistic similarities, emphasizing the need for targeted instruction to mitigate such barriers.

The moderating role of age revealed that younger learners benefit more from phonological memory and cross-linguistic similarities than older learners, while language exposure showed a consistent impact across age groups. This finding aligns with findings by Baker et al. [65], which suggest that younger learners' neural plasticity may enhance their capacity to process phonological and cross-linguistic cues. For older learners, pedagogical strategies should leverage their advanced cognitive skills and metalinguistic awareness to maximize vocabulary acquisition.

6. Implications

The study has significant implications for both theory and practice. Theoretically, it extends our understanding of how cognitive, linguistic, and contextual factors interact in vocabulary acquisition, enriching models such as Krashen's Input Hypothesis and Baddeley's working memory framework. Practically, the findings emphasize the need for holistic instructional approaches that integrate diverse language exposure opportunities, memory-enhancing strategies, and awareness of cross-linguistic similarities. Educators should design tasks that combine structured and incidental exposure, scaffolded memory activities, and explicit instruction on managing L1–L2 differences.

For younger learners, interactive and engaging tasks, such as gamified vocabulary exercises and phonological training, should be prioritized. For older learners, instruction should focus on deep processing strategies, such as

contextual analysis and semantic mapping, to exploit their cognitive and metalinguistic strengths.

7. Limitations

While this study provides valuable insights, it is not without its limitations. The sample consisted solely of international ESL learners in Malaysia, which may restrict the applicability of the findings to broader cultural and linguistic contexts. To enhance the generalizability of the results, future research should examine more diverse learner populations. Moreover, the study employed a cross-sectional design, which limits the ability to track changes in affective factors and vocabulary acquisition over time. A longitudinal approach would offer a more comprehensive understanding of how these relationships develop throughout different stages of language learning. Another potential limitation is the reliance on self-reported data, which may be subject to biases such as social desirability or inaccurate self-perception. Supplementing quantitative data with qualitative methods, such as interviews or focus groups, could provide richer and more in-depth perspectives. Lastly, the study focused exclusively on vocabulary acquisition without considering its interaction with other language skills, such as speaking, listening, and writing. Future research should adopt a more integrative approach to examine how affective factors influence overall linguistic competence.

8. Recommendations

To address the limitations identified in this study, future research should aim for broader participant samples beyond international ESL learners in Malaysia to enhance the applicability of the findings across diverse linguistic and cultural settings. Employing a longitudinal research design would allow for an examination of how vocabulary acquisition and affective factors evolve over time, offering a more dynamic perspective on language learning. Additionally, since self-reported measures may introduce biases, incorporating qualitative methodologies, such as observational studies and interviews, would provide more nuanced insights into learners' experiences. Furthermore, as this study concentrated solely on vocabulary acquisition, future investigations should explore its connections with other language skills, including speaking and writing, to develop a more comprehensive understanding of language learning processes.

From a pedagogical perspective, language instructors should integrate culturally relevant learning materials and foster interactive classroom environments that align with students' linguistic backgrounds. The incorporation of digital learning tools, such as mobile-assisted language learning (MALL), can further enhance incidental and autonomous vocabulary acquisition [8,66]. For younger learners, phonological training and multimedia-based instruction may support vocabulary retention, while advanced learners could benefit from explicit instruction in cross-linguistic strategies and complex vocabulary exercises.

At the policy level, curriculum developers should consider incorporating both structured learning approaches and opportunities for incidental vocabulary acquisition to create a balanced instructional framework. Future research should further investigate the interplay between motivation, learning strategies, and affective factors using mixed-methods approaches to gain a more holistic understanding of vocabulary development across different educational settings.

9. Conclusions

This study underscores the critical roles of language exposure, phonological memory, and cross-linguistic similarities in enhancing vocabulary acquisition among international ESL learners. While language exposure emerged as the most influential factor, the contributions of phonological memory and cross-linguistic similarities reveal the importance of cognitive and linguistic dimensions in vocabulary learning. By addressing individual learner differences and contextual factors, this research provides valuable insights for educators, curriculum designers, and policymakers seeking to optimize ESL instruction. Future studies should build on these findings to explore more comprehensive models of vocabulary acquisition and their application in diverse linguistic and cultural settings.

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Conflicts of Interest

The author declares that there is no conflict of interest whatsoever.

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