OPEN ACCESS

Language Education & Assessment

ISSN 2209-3591

https://www.castledown.com/journals/lea/

Language Education & Assessment, 9, 103828 (2026)

https://doi.org/10.29140/lea.2026.103828

Executive Working Memory, Phonological Short-Term Memory, and Vocabulary Size as Predictors of Immediate and Delayed Recall of Low-Frequency Words Among EFL Learners

OUMAIMA BELGAMRA[a]

AMINE AMZIL[b]

[a]*Faculty of Educational Sciences, Mohammed V University, Rabat, Morocco*
belgamraoumaima0@gmail.com

[b]*Faculty of Educational Sciences, Mohammed V University, Rabat, Morocco*
amine.amzil@fse.um5.ac.ma

Abstract

Despite extensive research on vocabulary acquisition and memory processes in foreign language learning, limited attention has been given to how cognitive factors differentially influence distinct stages of early lexical retention. The present study examined whether vocabulary size, phonological short-term memory, and executive working memory predict immediate and delayed recall of unfamiliar words among 57 undergraduate EFL learners. Participants completed a Vocabulary Size Test and digit span tasks (forward and backward), as well as immediate and 30-minute delayed recall tasks involving low-frequency adjectives. Multiple regression analyses revealed a clear stage-specific pattern: none of the cognitive variables significantly predicted immediate recall, suggesting that early accessibility may reflect, at least in part, transient activation. In contrast, delayed recall was significantly predicted by vocabulary size and executive working memory, as indexed by backward digit span, whereas phonological short-term memory did not account for unique variance. These findings indicate that early lexical stabilization is associated with both the structural richness of prior lexical knowledge and the capacity to regulate attention and manage interference. The results highlight the importance of distinguishing between short-term accessibility and early representational stabilization when examining individual variables in foreign vocabulary learning.

Keywords: vocabulary acquisition, executive working memory, phonological short-term memory, vocabulary size, immediate recall, delayed recall

Data Availability Statement: *All relevant data are within this paper.*

Introduction

Despite extensive research on vocabulary acquisition, reading comprehension, and fluency development, limited attention has been given to the cognitive mechanisms that govern the retention of newly learned vocabulary over time. In particular, the influence of individual variables such as vocabulary size, phonological short-term memory, and executive working memory on the immediate and delayed recall of unfamiliar words remains insufficiently explored. Therefore, investigating how these cognitive variables affect both the initial encoding and subsequent consolidation of lexical items offers critical insights into the dynamic processes underlying second and foreign language learning. In this regard, this paper seeks to fill this gap by investigating the effect of phonological short-term memory, executive working memory, and vocabulary size, on both immediate and delayed recall of unfamiliar words.

Individual Variables and Lexical Retention

Understanding why some learners retain newly encountered vocabulary more successfully than others remains a central question in second and foreign language acquisition. Variability in language learning outcomes has often been attributed to a range of learner-related variables. Among these, vocabulary knowledge, working memory capacity, and phonological short-term memory have been identified as particularly relevant to lexical learning processes. Vocabulary knowledge reflects the breadth of lexical representations available to learners (Webb & Nation, 2017), while working memory capacity supports the manipulation and integration of information during processing (Baddeley, 1996; Harrington & Sawyer, 1992; Sunderman & Kroll, 2009). Phonological short-term memory, in turn, facilitates the temporary storage of phonological forms during initial encoding (Gathercole & Baddeley, 1993; Service, 1992).

Recent handbook-level and synthetic accounts have similarly emphasized the central role of working memory and executive attention in second and foreign language learning and lexical processing (Li, 2022; Wen, 2019). Extending these recent syntheses, Schwieter and Wen (2022) provide a more integrated understanding of working memory by synthesizing theoretical and empirical research across cognitive psychology and the language sciences, illustrating how working memory contributes to diverse aspects of language acquisition, processing, and use. This integrated perspective provides a valuable theoretical basis for examining how different cognitive mechanisms contribute to individual differences in vocabulary learning. In addition, recent scholarship on individual differences in language acquisition has further emphasized that cognitive capacities such as working memory and attentional control play a central role in explaining variability in lexical learning outcomes across learners (Wen et al., 2023). Together, these findings underscore the importance of cognitive resources in shaping language learning success.

Vocabulary knowledge and executive working memory have received sustained attention due to their close relationship with language processing and learning (Allal-Sumoto et al., 2023; Karakoç & Köse, 2017; Şen & Kuleli, 2015). A robust vocabulary supports comprehension and production across modalities, while executive working memory has been linked to attentional allocation, information integration, and the management of competing representations during complex language tasks (Just & Carpenter, 1992; Kane & Engle, 2003).

In this regard, a crucial theoretical distinction concerns immediate versus delayed recall. Classic memory models distinguish between temporary activation within short-term storage systems and more stable long-term representations (Atkinson & Shiffrin, 1968; Baddeley, 2000). Immediate recall may rely heavily on residual activation within short-term or working memory systems, whereas recall following a delay may depend more strongly on the relative stability of the encoded representation and the extent to which it has begun to integrate into existing lexical networks. Therefore, distinguishing between these stages allows for a more precise investigation of the cognitive processes underlying early lexical learning. Taken together, these variables are expected to differentially support the encoding and retention of new lexical items, providing a basis for examining their combined influence on immediate and delayed recall.

The Complementary Systems Account of Lexical Learning

A prominent theoretical framework for understanding early lexical retention is provided by the Complementary Systems Account of word learning. Building on the complementary learning systems framework originally proposed by McClelland, McNaughton, and O'Reilly (1995), Davis and Gaskell (2009) extended this account specifically to lexical acquisition. Within this framework, vocabulary learning is understood to rely on the interaction of two partially distinct learning systems. The first system supports rapid encoding of new information through the formation of temporary memory traces. These representations are established quickly but remain fragile and only weakly connected to existing lexical knowledge. The second system supports gradual integration, through which newly encoded items become embedded within distributed semantic and phonological networks in the neocortex.

In the early stages of learning, newly encountered words are represented as initial, context-dependent representations that allow for short-term retrieval but remain highly susceptible to interference (Baddeley, 2000). Because these representations are not yet fully integrated, they may be accessed immediately after exposure but can deteriorate when competing cognitive activity intervenes. This integration involves the establishment of systematic connections between the novel lexical item and pre-existing representations, including semantic neighbors and phonologically related forms (Davis & Gaskell, 2009; Gaskell & Dumay, 2003). As integration progresses, retrieval becomes less dependent on contextual support and more reliant on stable network connectivity (Davis & Gaskell, 2009).

Although much of the empirical literature on lexical consolidation has examined changes occurring across extended intervals, including sleep-dependent reorganization (Dumay & Gaskell, 2007), the Complementary Learning Systems framework also implies that differences in integration strength may already emerge over shorter retention periods (Davis & Gaskell, 2009; McClelland et al., 1995). Even within relatively brief delays, retrieval may reflect the relative stability of the encoded representation and the extent to which it has begun to form connections within the mental lexicon. From this perspective, delayed recall may provide a more sensitive index of early lexical integration and resistance to interference (Davis & Gaskell, 2009; Henderson et al., 2013). Consequently, individual variables that influence encoding precision, elaborative processing, or interference control may differentially affect delayed recall.

In the context of the present study, recall following a 30-minute retention interval may provide a more sensitive behavioral indicator of early representational stabilization, reflecting the extent to which newly encoded lexical items have begun to establish connections within existing semantic and phonological networks. Although this interval is relatively brief and does not reflect long-term retention, it can capture early stages of lexical consolidation and representational stabilization (Davis & Gaskell, 2009; McClelland et al., 1995; Nation, 2013). From this perspective, individual variables that support elaborative encoding and resistance to interference would be expected to exert a stronger influence on delayed recall than on immediate recall. In this regard, this framework highlights the importance of both initial encoding and subsequent integration processes in determining the stability of newly learned lexical representations, thereby providing a theoretical basis for examining variation in immediate and delayed recall. This distinction can also be conceptualized as reflecting differences between online (immediate) and offline (delayed) measures of lexical processing, with delayed recall indexing early stages of lexical integration rather than initial encoding.

Executive Working Memory as a Mechanism of Early Integration

Working memory is commonly defined as a limited-capacity system responsible for the temporary maintenance and manipulation of information (Baddeley, 2000; Bayliss et al., 2005). In Baddeley's (2007) revised model, working memory comprises a central executive system and three subsidiary components: the phonological loop, the visuospatial sketchpad, and the episodic buffer (Baddeley, 2007; Grabe & Stoller, 2011). For lexical learning, two components are particularly relevant: the phonological loop, which supports the short-term retention of unfamiliar phonological sequences, and the episodic buffer, which integrates information across subsystems and links working memory representations with long-term memory (Baddeley, 2000).

During novel word learning, learners must connect an unfamiliar phonological form to a semantic representation (Baddeley et al., 1998). The episodic buffer has been proposed to support such cross-domain binding by integrating phonological, semantic, and contextual information into a unified episodic representation (Baddeley, 2000). In this sense, successful early lexical encoding may depend not only on temporary maintenance of the phonological form but also on the effective binding of form and meaning within working memory.

Beyond storage and binding, executive working memory has also been conceptualized as reflecting executive attentional control and the regulation of interference (Engle, 2002). The central executive governs the allocation of attention, the coordination of processing, and the inhibition of competing representations. During vocabulary learning, executive working memory may facilitate sustained attention during encoding, promote semantic elaboration, and protect fragile lexical traces from interference during a retention interval. According to depth-of-processing theory (Craik & Lockhart, 1972), elaborative semantic processing enhances the durability of memory representations. Learners with greater executive resources may therefore be better able to engage in meaningful elaboration, linking novel lexical items to prior knowledge and related concepts.

Within the broader framework of early lexical stabilization, executive working memory may thus contribute through three interrelated mechanisms: (1) maintaining unfamiliar phonological forms via the phonological loop, (2) binding form and meaning through the episodic buffer, and (3) regulating interference and supporting elaborative processing through executive control. These mechanisms increase the likelihood that an initially fragile representation will survive competing cognitive activity and begin to establish connections within existing lexical networks. Accordingly, executive working memory would be expected to exert a stronger influence on delayed recall, which reflects early representational stabilization, than on immediate recall, which may rely more heavily on transient activation within short-term storage systems (Baddeley, 2000; Kane & Engle, 2003). Within this framework, executive working memory is expected to support both the initial encoding of lexical items and their early stabilization, making it a key cognitive mechanism underlying successful vocabulary learning and retention.

Vocabulary Size and Lexical Network Density

Vocabulary knowledge is widely recognized as a central component of language proficiency. As Wilkins (1972) famously noted, "Without grammar, very little can be conveyed; without vocabulary, nothing can be conveyed" (p. 111). Empirical research has consistently demonstrated strong associations between vocabulary size and overall language proficiency (Albrechtsen et al., 2008; Alderson, 2005;

Laufer & Goldstein, 2004), highlighting the foundational role of lexical knowledge in comprehension and production. Following from this lexical or vocabulary knowledge is multifaceted, encompassing breadth, depth, and both receptive and productive dimensions (Schmitt, 2010). In this regard, the present study focuses specifically on receptive vocabulary size, as indexed by a standardized vocabulary size test.

Beyond its contribution to general proficiency, vocabulary size may play a mechanistic role in the learning of novel lexical items. The mental lexicon has been conceptualized as a network of interconnected semantic and phonological representations (Aitchison, 2012). Learners with larger vocabularies are generally assumed to possess richer and more densely interconnected lexical networks, providing multiple associative pathways between lexical items (Aitchison, 2012; Nation, 2013). From this network perspective, acquiring a new word involves establishing connections between the novel representation and existing lexical nodes. A denser lexical network may therefore provide more anchoring points for integration, facilitating embedding and subsequent retrieval.

Empirical evidence further supports the role of prior vocabulary knowledge in novel word learning. For example, Peters and Webb (2018) found that learners with larger vocabulary sizes demonstrated greater gains in the acquisition of new lexical items, consistent with the Matthew effect (Stanovich, 1986). Such findings suggest that prior lexical knowledge can scaffold further vocabulary growth by providing structural support for integration. Neurocognitive research has similarly shown associations between vocabulary size and structural adaptations in regions implicated in phonological and semantic processing (Lee et al., 2007), further underscoring the relationship between lexical knowledge and network organization.

Within the Complementary Systems framework, vocabulary size may therefore influence early lexical stabilization by determining the structural richness of the learner's lexical network. While vocabulary size may not substantially enhance immediate recall when retrieval can rely on residual activation, it may play a more pronounced role in delayed recall, when successful retrieval depends on the strength of integration within the lexical system. Learners with larger vocabularies may be better positioned to embed newly encoded words within existing networks, thereby increasing representational stability across a retention interval. Accordingly, vocabulary size is expected to facilitate the integration and stabilization of newly learned lexical items, particularly in delayed recall conditions where successful retrieval depends on the strength of lexical network connections.

Current Study

Although previous research has acknowledged the contribution of cognitive factors to vocabulary learning, limited attention has been given to how these capacities operate across distinct stages of early lexical acquisition. In particular, few studies have examined vocabulary size, phonological short-term memory, and executive working memory simultaneously within a single design while directly comparing immediate and delayed recall. As a result, it remains unclear whether these cognitive resources exert comparable effects during initial encoding and early representational stabilization, or whether their influence varies as newly learned words begin to consolidate.

Grounded in the Complementary Systems Account of lexical learning (Davis & Gaskell, 2009), the present study conceptualizes immediate recall as reflecting residual activation within temporary memory systems, whereas delayed recall is viewed as indexing early stabilization and resistance to interference. From this perspective, cognitive capacities that support elaborative processing, cross-domain binding, and interference regulation should become increasingly important as fragile lexical traces begin to integrate into existing networks.

Within this framework, vocabulary size is expected to facilitate integration by providing a richer and more densely connected lexical network, thereby offering multiple anchoring points for newly encoded representations (Aitchison, 2012). Executive working memory, indexed in this study by backward digit span performance, is conceptualized as supporting sustained attention, elaborative encoding, and resistance to interference (Engle, 2002). In contrast, phonological short-term memory, indexed by forward digit span, primarily reflects temporary storage capacity and may be less directly involved in representational stabilization.

Accordingly, the present study investigates whether vocabulary size, phonological short-term memory, and executive working memory differentially predict immediate and delayed recall of unfamiliar words among EFL learners. By examining these variables simultaneously across two retention intervals, the study aims to clarify their relative contributions to early lexical encoding and early integration.

To address this aim, the following research questions were formulated:

1. To what extent does vocabulary size predict immediate and delayed recall of unfamiliar words?
2. To what extent does phonological short-term memory capacity predict immediate and delayed recall of unfamiliar words?
3. To what extent does executive working memory, as indexed by backward digit span, predict immediate and delayed recall of unfamiliar words?

Based on the theoretical framework outlined above, the following hypotheses were derived:

H1. Immediate recall will not be significantly predicted by vocabulary size, phonological short-term memory, or executive working memory, as retrieval at this stage primarily reflects residual activation within temporary memory systems rather than stabilized lexical representations.

H2. Executive working memory, as indexed by backward digit span, will significantly predict delayed recall performance, reflecting its role in elaborative encoding and resistance to interference during early lexical stabilization.

H3. Vocabulary size will significantly predict delayed recall performance, reflecting the contribution of lexical network density to the integration of newly learned words.

H4. Phonological short-term memory, as indexed by forward digit span, will not significantly predict delayed recall performance, as simple maintenance capacity alone is insufficient for representational stabilization across a retention interval.

Methodology

Research Design

This study employed a quantitative cross-sectional design to examine the extent to which individual differences in vocabulary size, phonological short-term memory, and executive working memory predict the recall of unfamiliar lexical items. Vocabulary size and memory measures were assessed using standardized instruments: the Vocabulary Size Test and the Digit Span Test (forward and backward). Forward digit span was used as an index of phonological short-term memory, whereas backward digit span was used as an index of executive working memory. Word recall performance served as the dependent variable and was measured through immediate and 30-minute delayed recall tasks involving low-frequency adjectives. Multiple regression analyses were conducted to evaluate the unique contributions of vocabulary size, phonological short-term memory, and executive working memory to recall performance at each retention interval. This design enabled the examination of whether cognitive factors differentially predict early accessibility versus early representational stabilization of newly learned words.

Participants

The participants in this study were undergraduate students enrolled in the department of English studies. To maintain group homogeneity and reduce variability related to academic level, only first-year students were recruited; third-year and master's students were excluded. The final sample consisted of 57 students aged between 18 and 22 years. This age range reflects variability in educational trajectories (e.g., gap years or delayed enrollment) while remaining typical for first-year university cohorts. As the study was conducted in Morocco, the participants were native speakers of Arabic, with French commonly used as a second language in their educational background. All participants were enrolled in an English as a Foreign Language (EFL) program and had an intermediate level of English proficiency (approximately B1–B2 according to the CEFR). This linguistic background also informed the exclusion of cognates with French in the Word Recall Task.

Instruments

The Vocabulary Size Test

The Vocabulary Size Test used in this study is a standardized instrument developed by Paul Nation and David Beglar (2007) to estimate learners' receptive vocabulary knowledge. The test consists of 140 multiple-choice items, with 10 items sampled from each 1,000-word frequency band, covering up to the 14,000 most frequent word families based on the British National Corpus. The frequency bands are hierarchically organized, progressing from high-frequency to lower-frequency vocabulary, thereby allowing for a systematic estimation of vocabulary size across proficiency levels.

The test is designed to be discrete and context-independent, requiring participants to identify the correct meaning of a target word from closely related alternatives. This format minimizes the possibility of guessing based on partial knowledge and ensures that successful performance reflects precise lexical understanding rather than general familiarity.

For example, participants were presented with a target word and asked to select the correct meaning from four options. An example item from the fifth frequency band is: *"COMPOST: We need some compost."* a) strong support, b) help to feel better, c) hard stuff made of stones and sand stuck together, d) rotted plant material.

The present study employs the monolingual version validated by Beglar (2010), whose findings support the reliability and validity of the instrument. Vocabulary size estimates are derived by multiplying the raw score by 100 (e.g., a score of 45 corresponds to an estimated vocabulary size of 4,500-word families).

Digit Span Test

The Digit Span Test is a widely used measure of short-term memory and working memory capacity (Dehn, 2008). It comprises two versions: forward and backward digit span which assess partially distinct cognitive processes. In the forward digit span task, participants are required to recall sequences of digits in the same order in which they are presented, thereby primarily assessing phonological short-term memory. Sequences typically begin with two digits and increase in length following successful recall, continuing until the participant can no longer reproduce them accurately.

In contrast, the backward digit span task requires participants to recall the digits in reverse order, placing greater demands on executive processes such as manipulation, attentional control, and the regulation of interference. As a result of these additional cognitive demands, performance on the backward digit span task is typically lower than on the forward version.

In the present study, both versions were administered using standardized materials from the TestMyBrain platform. Digit sequences were presented visually, and participants were required to reproduce them either in the same order (forward span) or in reverse order (backward span). For example, a sequence such as “3–8–2” would be recalled as “3–8–2” in the forward condition and “2–8–3” in the backward condition. Scores were determined based on the maximum span correctly recalled.

Importantly, digit span tasks particularly the backward version, are commonly interpreted as indices of executive working memory rather than comprehensive measures of the entire multicomponent working memory system. While forward digit span primarily reflects phonological storage capacity, backward digit span is thought to capture executive control processes, including attentional allocation and the regulation of interference (Engle, 2002). However, these tasks do not directly assess all components of working memory, such as the episodic buffer or complex integration processes, and therefore provide a partial rather than exhaustive measure of working memory functioning. This limitation should be considered when interpreting the relationship between working memory capacity and lexical retention.

The Word Recall Task

The target words used in the Word Recall Task were selected based on several criteria to ensure consistency and minimize potential sources of bias. Emotional words (e.g., *dead*, *sick*) were excluded to avoid possible emotional interference. All target items were low-frequency two-syllable adjectives drawn from the BNC/COCA Word Frequency Lists (2012), ranging from the 10th to the 21st frequency bands in order to ensure unfamiliarity. To minimize phonological variability and cognitive load, all selected words consisted of two syllables, as longer words require greater rehearsal demands in short-term memory (Baddeley et al., 1975). In addition, cognates with French were excluded to prevent the activation of pre-existing lexical associations in participants’ long-term memory.

Each target word was presented together with a short, simplified definition describing its meaning (e.g., *paltry*: “very small or meagre”; *stolid*: “calm and not showing emotion or excitement”). The definitions were intentionally brief and composed primarily of high-frequency vocabulary in order to minimize processing difficulty unrelated to the target items. Most of the lexical items used within the definitions were drawn from the first frequency band, with only a small number taken from the second and third bands. A complete list of the target words and their corresponding definitions is provided in Appendix A.

During the task, participants studied each word–definition pair carefully. Immediate recall was assessed directly after exposure, whereas delayed recall was assessed following a 30-minute interval. In both conditions, participants completed a free-recall task in which they were required to retrieve the target words from memory. Responses were scored for accuracy, with each correctly recalled item receiving one point in both the immediate and delayed recall conditions.

Data Collection

The study was conducted in small groups of eight participants at a time. Participants were seated at a distance from one another to prevent collaboration, discussion, or rehearsal during the tasks. All lexical items were presented visually on a data show screen in a very quiet and controlled classroom environment to ensure optimal concentration and minimize external distractions.

The study began with a word familiarity pretest administered four days prior to the main recall task in order to ensure that the target adjectives were unfamiliar to participants. Immediately afterward, they completed the Vocabulary Size Test; this additional task was included to separate the familiarity check from the later learning session and to reduce immediate carryover or rehearsal of the target items within that initial session. Although this interval reduced immediate rehearsal effects, the possibility of residual testing or priming effects cannot be entirely excluded and should be considered when interpreting the findings.

Four days later, participants completed the learning and recall session. During encoding, each word–definition pair was presented visually for 5 seconds. The timing of showing the stimuli was based on previous experimental vocabulary learning research which used similar fixed presentation durations in intentional learning tasks, demonstrating that such exposure supports sufficient initial encoding without allowing prolonged rehearsal (Nakata, 2011). This duration was considered sufficient to allow initial semantic processing while maintaining experimental control, minimizing overlearning, and preserving sensitivity to individual differences in encoding efficiency. The controlled visual presentation ensured equal exposure time for all participants and standardized the encoding conditions.

After this phase, participants were briefly engaged in casual conversation with the researcher, including questions about everyday topics such as dinner or campus life, to further reduce potential recency effects. Participants were then given 40 seconds to write down as many of the target words as possible on a provided sheet, in any order they preferred, completing the immediate recall task.

Participants were informed that additional tasks would follow; however, they were not explicitly told that a second recall test would be administered. To prevent rehearsal and ensure that the delayed recall reflected retention rather than short-term rehearsal, they were asked to complete a 30-minute metacognitive awareness questionnaire as a distractor activity. This task required reflection on their learning strategies and study habits, effectively occupying cognitive resources between the two recall assessments and preventing intentional rehearsal of the target items. After this 30-minute interval, participants were given another 40 seconds to complete the delayed recall task under the same conditions as the immediate recall.

On a separate day, participants completed the Digit Span Test, administered in a quiet, controlled environment to minimize distractions and ensure accurate measurement. The testing schedule was made flexible to accommodate participants' academic commitments and personal well-being, including avoiding fatigue or illness. This approach extended the data collection period over eight days but was preferred over online testing to maintain consistency, control environmental variables, and optimize the reliability of the cognitive measures.

At the end of the study, all participants were sincerely thanked for their time, effort, and commitment, and the purpose and procedures of the study were briefly reviewed to reinforce transparency and ethical practice.

Data Analysis

All statistical analyses were conducted using IBM SPSS Statistics (Version 26). Descriptive statistics were calculated for all study variables, followed by Pearson product–moment correlations to examine associations among immediate recall, delayed recall, vocabulary size, digit forward span (phonological short-term memory), and digit backward span (executive working memory). To determine the unique contribution of each cognitive variable, two separate multiple regression analyses were performed. However, prior to conducting the regression analyses, the assumptions of multiple regression were examined for both the immediate recall and delayed recall models. Multicollinearity among predictors was assessed using tolerance and variance inflation factor (VIF) statistics, and no problematic collinearity was observed (Tolerance = .746–.870; VIF = 1.149–1.340). Diagnostic checks also indicated no violations of normality, linearity, or homoscedasticity. Immediate recall was entered as the dependent variable in the first model and delayed recall in the second, with vocabulary size, digit forward span, and digit backward span entered simultaneously as predictors. This analytic strategy allowed for the evaluation of differential predictive patterns across retention intervals while controlling for shared variance among predictors. Statistical significance was evaluated at the .05 level.

Results

This section presents the descriptive and inferential analyses examining the relationships between vocabulary size, phonological short-term memory, executive working memory, and recall performance across the two retention intervals.

Table 1 presents the descriptive statistics for the study variables. Participants obtained a mean score of 5.68 (SD = 1.67) on the immediate recall task. Performance on the delayed recall task was slightly lower, with a mean of 5.22 (SD = 1.65). The mean vocabulary size score was 5963.16 (SD = 1923.59). For the memory measures, the mean digit forward span was 4.98 (SD = 1.02), while the mean digit backward span was 4.28 (SD = 1.17).

Table 1. Descriptive statistics of participants' scores of the digit forward span, digit backward span, vocabulary size test, immediate recall, and delayed recall task

	Minimum	Maximum	Mean	Standard Deviation
Digit forward span	4.00	9.00	4.98	1.02
Digit backward span	3.00	8.00	4.28	1.17
Vocabulary size test	2200	9800	5963.16	1923.59
Immediate recall	2.00	9.00	5.68	1.67
Delayed recall	1.00	9.00	5.22	1.65

To examine the relationships among the study variables, Pearson product–moment correlations were conducted. As presented in Table 2 and based on Cohen's (1988) guidelines, immediate and delayed recall were strongly and positively related ($r = .67$, $p < .01$). While immediate recall did not show significant associations with vocabulary size or either digit span measure, delayed recall demonstrated moderate positive correlations with vocabulary size ($r = .38$, $p < .01$) and digit backward span ($r = .42$, $p < .01$). No significant relationship was observed between delayed recall and digit forward span. In addition, vocabulary size was positively associated with digit backward span ($r = .36$, $p < .01$), and a significant correlation emerged between digit forward and digit backward span ($r = .39$, $p < .01$).

To further examine the predictive relationships among these variables, multiple regression analyses were conducted.

Table 2. Pearson correlations among immediate recall, delayed recall, vocabulary size, and digit span measures

	Immediate Recall	Delayed Recall	Vocabulary Size	Digit Forward Span	Digit Span Backward
Immediate recall	1	.67**	.18	.17	.24
Delayed recall	.67**	1	.38**	.13	.42**
Vocabulary size	.18	.38**	1	.12	.36**
Digit forward span	.17	.13	.12	1	.39**
Digit backward Span	.24	.42**	.36**	.39**	1

To further evaluate the unique predictive contributions of these variables, two multiple regression analyses were conducted. The first regression analysis aimed at examining whether vocabulary size, digit forward span, and digit backward span predicted performance on the immediate recall task (Table 3). The overall model accounted for 12% of the variance in immediate recall scores ($R^2 = .12$, Adjusted $R^2 = .07$). However, none of the predictors reached statistical significance. Vocabulary size ($\beta = .15$, $p = .277$) and digit forward span ($\beta = .02$, $p = .876$) did not significantly predict immediate recall performance. Digit backward span showed a positive but non-significant association ($\beta = .26$, $p = .093$). Overall, the results indicate that the examined cognitive variables did not significantly explain variability in immediate recall performance.

Table 3. Multiple regression predicting immediate recall from vocabulary size and digit span measures

Predictor	B	SE	β	t	P
Constant	3.34	1.21	—	2.76	.008
Vocabulary size	0.13	0.12	.15	1.10	.277
Digit forward span	0.04	0.23	.02	0.16	.876
Digit backward span	0.30	0.17	.26	1.71	.093

Note: $R^2 = .12$, Adjusted $R^2 = .07$.

Another regression model was conducted to examine whether vocabulary size, digit forward span, and digit backward span predicted delayed recall performance (Table 4). The overall model was statistically significant, $F(3, 53) = 5.59$, $p = .002$, accounting for 24% of the variance in delayed recall scores ($R^2 = .24$, Adjusted $R^2 = .20$). Vocabulary size emerged as a significant positive predictor ($\beta = .26$, $p = .046$), as did digit backward span ($\beta = .34$, $p = .017$). In contrast, digit forward span did not significantly predict delayed recall performance ($\beta = -.03$, $p = .818$). These findings indicate that both vocabulary size and executive working memory uniquely contributed to variability in delayed recall.

When compared to the immediate recall model, which was not statistically significant and did not yield significant predictors, the delayed recall model demonstrated a clearer pattern of cognitive contributions. Whereas none of the examined variables significantly predicted immediate recall, both vocabulary size and digit backward span emerged as significant predictors of delayed recall. This contrast suggests that the influence of cognitive and lexical factors was more pronounced in the delayed recall condition than in the immediate recall condition.

Table 4. Multiple regression predicting delayed recall from vocabulary size and digit span measures

Predictor	B	SE	β	t	p
Constant	2.28	1.12	—	2.04	.047
Vocabulary size	0.23	0.11	.26	2.05	.046
Digit forward span	–0.05	0.21	–.03	–0.23	.818
Digit backward span	0.40	0.16	.34	2.46	.017

Note: $R^2 = .24$, Adjusted $R^2 = .20$, $F(3, 53) = 5.59$, $p = .002$.

Discussion

Overview of the Findings

The present study set out to examine whether individual differences in vocabulary size, phonological short-term memory, and executive working memory were associated with the immediate and delayed recall of unfamiliar lexical items among EFL learners. The findings revealed a clear distinction between the two recall conditions. While none of the examined variables significantly predicted immediate recall performance, the model predicting delayed recall was statistically significant and accounted for a meaningful proportion of variance (24%).

In this latter condition, both vocabulary size and executive working memory as indexed by backward digit span emerged as significant predictors, each contributing uniquely to performance. This pattern suggests that the cognitive demands underlying immediate accessibility differ from those involved in maintaining lexical representations across a retention interval. In what follows, the findings are interpreted in relation to the theoretical perspectives outlined in the introduction.

Immediate Recall: Transient Accessibility After Encoding

The absence of significant predictors for immediate recall indicates that this condition may primarily reflect short-term accessibility rather than stabilized lexical knowledge. Immediate recall occurred directly after the encoding phase, at a point where recently presented lexical items were likely still active within short-term storage systems. Classic memory models (Atkinson & Shiffrin, 1968) describe such accessibility as the result of temporary activation rather than durable representation. Similarly, within the Complementary Systems Account (Davis & Gaskell, 2009), newly learned words are initially supported by rapidly formed episodic traces that permit short-term retrieval prior to integration into distributed cortical networks.

Under such circumstances, retrieval may not require extensive elaboration, interference regulation, or integration within the broader mental lexicon. This may help explain why vocabulary size did not significantly predict immediate recall. Although learners with larger vocabularies possess richer lexical networks (Aitchison, 2012), the benefits of network density may not yet be necessary when items remain recently activated.

A similar interpretation applies to executive working memory. Backward digit span, which reflects executive manipulation and attentional regulation (Engle, 2002), did not significantly predict immediate recall. Because immediate retrieval likely relied on temporarily accessible traces rather than on interference resistance or organized elaboration, the contribution of executive working memory may have been minimal at this stage.

Finally, phonological short-term memory, as measured by forward digit span, did not significantly predict immediate recall. Although phonological maintenance is theoretically relevant during initial encoding (Baddeley, 2000), the use of familiar digit stimuli and the possibility of chunking strategies may have limited the sensitivity of this measure. Moreover, when recall follows immediately after presentation, performance may depend less on stable storage capacity and more on general short-term activation. Taken together, these findings suggest that immediate recall in the present study primarily reflected transient accessibility rather than the strength of stabilized lexical representations.

Delayed Recall: Retention Across a Temporal Interval

In contrast to immediate recall, delayed recall was significantly predicted by both vocabulary size and executive working memory. This condition required participants to retrieve lexical items following a 30-minute retention interval, during which intervening cognitive activity likely reduced reliance on transient short-term activation. Within the complementary learning systems framework originally proposed by McClelland et al. (1995) and extended to lexical acquisition by Davis and Gaskell (2009), delayed recall may therefore provide a more sensitive behavioral indicator of early representational stabilization rather than mere residual activation within temporary memory systems.

Executive Working Memory and Retention

Executive working memory, as indexed by backward digit span, emerged as a significant predictor of delayed recall. It is important to clarify that backward digit span does not constitute a comprehensive measure of working memory capacity. Rather, simple span tasks capture a relatively circumscribed aspect of executive functioning, particularly the ability to manipulate information while maintaining attentional regulation (Conway et al., 2005). Accordingly, the present findings should be interpreted as reflecting the involvement of executive control processes specifically, rather than global working memory capacity.

From a theoretical perspective, the association between executive working memory and delayed recall can be situated within models that emphasize coordinated binding and interference regulation during learning. Within Baddeley's multicomponent framework, the episodic buffer has been proposed to support the integration of information across subsystems and its linkage to long-term memory (Baddeley, 2000). Although backward digit span does not directly measure episodic buffer functioning, stronger executive working memory may facilitate the coordination of phonological and semantic information during encoding, allowing form–meaning associations to be represented in a more coherent and retrievable manner.

In addition, executive working memory has been conceptualized as closely tied to elaborative processing. Depth-of-processing theory posits that semantic elaboration enhances the durability of memory representations (Craik & Lockhart, 1972). Individuals with greater executive resources may be more capable of sustaining attention, activating related lexical knowledge, and engaging in structured encoding, thereby strengthening the initial representation of newly learned words.

Executive working memory may also play a role beyond the encoding phase. Because delayed recall requires retrieval following intervening cognitive activity, the regulation of interference becomes particularly relevant. Engle (2002) characterizes working memory capacity as reflecting executive attention and the ability to maintain task-relevant representations in the face of distraction. In this sense, stronger executive working memory may contribute to the preservation of fragile lexical traces across the retention interval, increasing the likelihood of successful retrieval.

Importantly, these interpretations remain correlational rather than causal. The findings indicate that individual differences in executive working memory are associated with greater stability of newly encoded lexical items over time. However, they do not imply that executive working memory alone determines lexical retention, nor do they exclude the contribution of additional cognitive and contextual factors.

Vocabulary Size and Lexical Integration

Vocabulary size also emerged as a significant predictor of delayed recall, contributing unique variance beyond executive working memory. This pattern indicates that prior lexical knowledge plays a role in the stabilization of newly learned words that cannot be reduced to executive attentional processes alone.

As discussed in the literature review, the mental lexicon has been conceptualized as a structured network of interconnected semantic and phonological representations (Aitchison, 2012). Within such a network, new lexical items are not stored in isolation but must establish links with pre-existing representations. Learners with larger vocabularies likely possess more elaborated and densely interconnected lexical systems, thereby increasing the probability that newly encoded words can anchor to related forms or meanings. From the perspective of the Complementary Systems Account (Davis & Gaskell, 2009; McClelland et al., 1995), early lexical stabilization involves the gradual embedding of novel representations within distributed cortical networks. A richer lexical system may therefore provide a structural substrate that facilitates this embedding process, enhancing representational durability over time.

Although vocabulary size was moderately correlated with executive working memory, both predictors remained significant in the regression model, indicating partial independence. This suggests that vocabulary size contributes to delayed retention not merely through attentional regulation but through properties inherent to the organization of the lexical system itself. In other words, executive working memory may influence how information is processed during encoding and retention, whereas vocabulary size may influence where and how effectively new representations can be integrated within existing knowledge structures.

The observed pattern is also consistent with the Matthew effect in language learning (Stanovich, 1986), whereby learners with greater prior knowledge accrue cumulative advantages over time. Such advantages may not be immediately observable when recall depends primarily on transient activation shortly after exposure. However, when retrieval requires stability across a retention interval, the structural richness of prior knowledge becomes more consequential.

Taken together, the findings reinforce a distinction between short-term accessibility and early representational stabilization. Immediate recall appears to reflect temporary accessibility following encoding and was relatively insensitive to stable individual differences. Delayed recall, in contrast, was more strongly associated with executive working memory and vocabulary size, suggesting that both attentional regulation and lexical network structure contribute to the maintenance of newly encoded words across time.

By situating these findings within established theoretical frameworks including classic memory models (Atkinson & Shiffrin, 1968), the complementary learning systems account (Davis & Gaskell, 2009; McClelland et al., 1995), Baddeley's multicomponent model (Baddeley, 2000), depth-of-processing theory (Craik & Lockhart, 1972), and lexical network perspectives (Aitchison, 2012), the present study moves beyond descriptive association and offers a theoretically grounded explanation for why vocabulary size and executive working memory were more predictive of delayed recall than immediate recall.

Pedagogical Implications

The present findings suggest that not all stages of vocabulary learning are equally sensitive to stable individual differences. While immediate recall appeared relatively independent of executive working memory and vocabulary size, delayed recall was significantly associated with both executive working memory and prior lexical knowledge. This distinction has implications for instructional design and assessment practices.

First, the results indicate that durable vocabulary learning may depend partly on learners' capacity to regulate attention and manage interference during encoding and retention. Although formal cognitive testing is not typically feasible in classroom settings, instructional approaches that reduce cognitive load and support structured encoding may benefit learners with weaker executive working memory. For example, guided elaboration, explicit form–meaning mapping, and structured review sessions may help stabilize newly introduced lexical items.

Second, the significant contribution of vocabulary size to delayed retention underscores the importance of systematically expanding learners' lexical repertoires. A richer vocabulary appears to provide structural advantages for integrating new words into existing knowledge networks. Pedagogically, this finding reinforces the value of prioritizing high-frequency and mid-frequency vocabulary, promoting cumulative exposure, and ensuring repeated encounters with lexical items across contexts.

Third, the contrast between immediate and delayed recall highlights the importance of incorporating delayed assessments into instructional practice. Sole reliance on immediate post-tests may overestimate learning by capturing transient accessibility rather than stabilized knowledge. Integrating spaced retrieval, distributed practice, and delayed evaluation may provide a more accurate indication of durable vocabulary acquisition.

Limitations and Future Research Directions

Despite the valuable insights generated by the present study, several limitations should be acknowledged when interpreting the findings. First, executive working memory was operationalized using the backward digit span task, which captures a specific aspect of executive functioning, namely, manipulation, attentional regulation, and interference control rather than the full multicomponent construct of working memory capacity (Conway et al., 2005). The findings should therefore be interpreted as reflecting executive control processes more specifically, rather than overall working memory functioning. Future research would benefit from incorporating complex span tasks, such as reading span or operation span measures, to provide a more comprehensive assessment of working memory capacity.

In addition, phonological short-term memory was assessed using the forward digit span task, which relies on highly familiar numerical stimuli. Because digits are overlearned, performance may partially reflect long-term memory support in addition to phonological storage capacity. Future studies may therefore benefit from incorporating nonword repetition or pseudoword-based tasks, as these require learners to form, temporarily maintain, and reproduce novel phonological representations rather than rely on highly familiar numerical stimuli. Consequently, they may provide a more sensitive measure of the phonological storage processes that directly support the acquisition of unfamiliar vocabulary.

Another limitation concerns the temporal structure of the experimental design. Although the four-day interval between the familiarity pretest and the main recall session was intended to reduce immediate carryover effects, the possibility of residual testing or priming effects cannot be entirely excluded. Similarly, while the 30-minute interval between the immediate and delayed recall conditions was sufficient to reduce short-term rehearsal, it represents a relatively brief retention period and may still reflect residual activation or short-term memory influences rather than longer-term lexical consolidation. Consequently, the findings should be interpreted as reflecting early representational stabilization rather than long-term consolidation in the neurobiological sense. Future research employing longer retention intervals and delayed posttests administered across multiple days may provide a clearer distinction between short-term stabilization and longer-term retention processes.

Finally, the sample consisted exclusively of undergraduate EFL learners within a specific educational context, which may limit the generalizability of the findings. Replication across different age groups, proficiency levels, and linguistic backgrounds would help clarify the developmental and contextual variability in the cognitive mechanisms underlying vocabulary acquisition and lexical retention.

Conclusion

The present study examined whether vocabulary size, phonological short-term memory, and executive working memory predict immediate and delayed recall of unfamiliar lexical items among EFL learners. The findings revealed a clear distinction between stages of recall. Immediate recall was not significantly associated with the examined cognitive variables, suggesting that early accessibility may rely primarily on transient activation following encoding. In contrast, delayed recall was significantly predicted by both vocabulary size and executive working memory, indicating that early lexical stabilization is linked to attentional regulation and the structural richness of existing lexical knowledge.

Executive working memory, operationalized through backward digit span, reflects a specific aspect of executive functioning rather than global working memory capacity. The results therefore suggest that both the organization of prior lexical knowledge and the ability to regulate attention contribute to the maintenance of newly encoded words across a retention interval. Overall, the findings underscore the importance of distinguishing between short-term accessibility and early stabilization when examining individual differences in vocabulary learning.

Acknowledgement

This work was carried out with the support of the Centre National de la Recherche Scientifique et Technique (CNRST) as part of the ‘PhD-Associate Scholarship – PASS’ program. We are also sincerely grateful to the anonymous reviewers for their insightful and constructive comments, which contributed to improving the manuscript.

References

Aitchison, J. (2012). Words in the mind: An introduction to the mental lexicon (4th ed.). Wiley-Blackwell.

Albrechtsen, D., Haastrup, K., & Henriksen, B. (2008). *Vocabulary and writing in a first and second language: Processes and development*. Springer. https://doi.org/10.1057/9780230593404

Alderson, J. C. (2005). *Diagnosing foreign language proficiency: The interface between learning and assessment*. A&C Black. https://doi.org/10.5040/9781474212151

Allal-Sumoto, T. K., Miyoshi, K., & Mizuhara, H. (2023). The effect of productive vocabulary knowledge on second language comprehension. *Frontiers in Psychology, 14*, 1049885. https://doi.org/10.3389/fpsyg.2023.1049885

Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. W. Spence & J. T. Spence (Eds.), *Psychology of learning and motivation* (Vol. 2, pp. 89–195). Academic Press. https://doi.org/10.1016/S0079-7421(08)60422-3

Baddeley, A. (1996). The fractionation of working memory. *Proceedings of the National Academy of Sciences, 93*(24), 13468–13472. https://doi.org/10.1073/pnas.93.24.13468

Baddeley, A. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences, 4*(11), 417–423. https://doi.org/10.1016/S1364-6613(00)01538-2

Baddeley, A. (2003). Working memory and language: An overview. *Journal of Communication Disorders, 36*(3), 189–208. https://doi.org/10.1016/S0021-9924(03)00019-4

Baddeley, A. D. (2007). *Working memory, thought, and action*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198528012.001.0001

Baddeley, A. D., Gathercole, S. E., & Papagno, C. (1998). The phonological loop as a language learning device. *Psychological Review, 105*(1), 158–173. https://doi.org/10.1037/0033-295X.105.1.158

Baddeley, A. D., Thomson, N., & Buchanan, M. (1975). Word length and the structure of short-term memory. *Journal of Verbal Learning and Verbal Behavior, 14*(6), 575–589. https://doi.org/10.1016/S0022-5371(75)80045-4

Bayliss, D. M., Jarrold, C., Baddeley, A. D., Gunn, D. M., & Leigh, E. (2005). Mapping the developmental constraints on working memory span performance. *Developmental Psychology, 41*(4), 579–597. https://doi.org/10.1037/0012-1649.41.4.579

Beglar, D. (2010). A Rasch-based validation of the Vocabulary Size Test. *Language Testing, 27*(1), 101–118. https://doi.org/10.1177/0265532209340194

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203771587

Conway, A. R., Kane, M. J., Bunting, M. F., Hambrick, D. Z., Wilhelm, O., & Engle, R. W. (2005). Working memory span tasks: A methodological review and user's guide. *Psychonomic Bulletin & Review, 12*(5), 769–786. https://doi.org/10.3758/BF03196772

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, *11*(6), 671–684. https://doi.org/10.1016/S0022-5371(72)80001-X

Davis, M. H., & Gaskell, M. G. (2009). A complementary systems account of word learning: Neural and behavioural evidence. *Philosophical Transactions of the Royal Society B: Biological Sciences, 364*(1536), 3773–3800. https://doi.org/10.1098/rstb.2009.0111

Dehn, M. J. (2008). *Working memory and academic learning: Assessment and intervention*. John Wiley & Sons.

Dumay, N., & Gaskell, M. G. (2007). Sleep-associated changes in the mental representation of spoken words. *Psychological Science, 18*(1), 35–39. https://doi.org/10.1111/j.1467-9280.2007.01845.x

Engle, R. W. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science, 11*(1), 19–23. https://doi.org/10.1111/1467-8721.00160

Gaskell, M. G., & Dumay, N. (2003). Lexical competition and the acquisition of novel words. *Cognition, 89*(2), 105–132. https://doi.org/10.1016/S0010-0277(03)00070-2

Gathercole, S. E., & Baddeley, A. D. (1993). Phonological working memory: A critical building block for reading development and vocabulary acquisition. *European Journal of Psychology of Education, 8*(3), 259–272. https://doi.org/10.1007/BF03174081

Grabe, W., & Stoller, F. L. (2011). *Teaching and researching reading* (2nd ed.). Routledge. https://doi.org/10.4324/9781315833743

Harrington, M., & Sawyer, M. (1992). L2 working memory capacity and L2 reading skill. *Studies in Second Language Acquisition, 14*(1), 25–38. https://doi.org/10.1017/S0272263100010457

Henderson, L. M., Weighall, A. R., Brown, H., & Gaskell, M. G. (2013). Online lexical competition during spoken word recognition and word learning in children and adults. *Journal of Experimental Child Psychology, 114*(2), 166–189. https://doi.org/10.1111/cdev.12067

Just, M. A., & Carpenter, P. A. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review, 99*(1), 122–149. https://doi.org/10.1037/0033-295X.99.1.122

Kane, M. J., & Engle, R. W. (2003). Working-memory capacity and the control of attention: The contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology: General, 132*(1), 47–70. https://doi.org/10.1037/0096-3445.132.1.47

Karakoç, D., & Köse, G. D. (2017). The impact of vocabulary knowledge on reading, writing and proficiency scores of EFL learners. *Journal of Language and Linguistic Studies, 13*(1), 352–378.

Laufer, B., & Goldstein, Z. (2004). Testing vocabulary knowledge: Size, strength, and computer adaptiveness. *Language Learning, 54*(3), 399–436. https://doi.org/10.1111/j.0023-8333.2004.00260.x

Lee, H., Devlin, J. T., Shakeshaft, C., Stewart, L. H., Brennan, A., Glensman, J., ... Price, C. J. (2007). Anatomical traces of vocabulary acquisition in the adolescent brain. *Journal of Neuroscience, 27*(5), 1184–1189. https://doi.org/10.1523/JNEUROSCI.4442-06.2007

Li, S. (2022). Working memory and second language learning: A critical and synthetic review. In A. Godfroid & H. Hopp (Eds.), *The Routledge handbook of second language acquisition and psycholinguistics* (pp. 348–360). Routledge. https://doi.org/10.4324/9781003018872-32

McClelland, J. L., McNaughton, B. L., & O'Reilly, R. C. (1995). Why there are complementary learning systems in the hippocampus and neocortex: Insights from the successes and failures of connectionist models of learning and memory. *Psychological Review, 102*(3), 419–457. https://doi.org/10.1037/0033-295X.102.3.419

Nakata, T. (2011). Computer-assisted second language vocabulary learning in a paired-associate paradigm: A critical investigation of flashcard software. *Computer Assisted Language Learning, 24*(1), 17–38. https://doi.org/10.1080/09588221.2010.520675

Nation, I. S. P. (2013). *Learning vocabulary in another language* (2nd ed.). Cambridge University Press. https://doi.org/10.1017/CBO9781139858656

Nation, P., & Beglar, D. (2007). *A vocabulary size test*. Victoria University of Wellington. https://doi.org/10.26686/wgtn.12552197.v1

Peters, E., & Webb, S. (2018). Incidental vocabulary acquisition through viewing L2 television and factors that affect learning. *Studies in Second Language Acquisition, 40*(3), 551–577. https://doi.org/10.1017/S0272263117000407

Schmitt, N. (2010). *Researching vocabulary: A vocabulary research manual*. Springer. https://doi.org/10.1057/9780230293977

Schwieter, J. W., & Wen, Z. E. (Eds.). (2022). The Cambridge handbook of working memory and language. Cambridge University Press.

Şen, Y., & Kuleli, M. (2015). The effect of vocabulary size and vocabulary depth on reading in EFL context. *Procedia – Social and Behavioral Sciences, 199*, 555–562. https://doi.org/10.1016/j.sbspro.2015.07.546

Service, E. (1992). Phonology, working memory, and foreign-language learning. *The Quarterly Journal of Experimental Psychology A: Human Experimental Psychology, 45A*(1), 21–50. https://doi.org/10.1080/14640749208401314

Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly, 21*(4), 360–407. https://doi.org/10.1598/RRQ.21.4.1

Sunderman, G., & Kroll, J. F. (2009). When study-abroad experience fails to deliver: The internal resources threshold effect. *Applied Psycholinguistics, 30*(1), 79–99. https://doi.org/10.1017/S0142716408090048

Webb, S., & Nation, P. (2017). *How vocabulary is learned*. Oxford University Press. https://doi.org/10.25170/ijelt.v12i1.1458

Wen, Z. (2019). *Working memory and second language learning: Towards an integrated approach*. Multilingual Matters. https://doi.org/ 10.21832/9781783095735

Wen, Z., Sparks, R. L., Biedroń, A., & Teng, M. F. (2023). Cognitive individual differences in second language acquisition: Theories, assessment and pedagogy. De Gruyter. https://doi.org/10.1515/9781614514749

Wilkins, D. A. (1972). *Linguistics in language teaching*. Edward Arnold.

Appendix A

1. **Paltry**
   (of an amount) very small or meagre.

2. **Puckish**
   someone who plays tricks on people or teases them

3. **Hoary**
   (of a person) very old and with white or grey hair

4. **Jejune**
   (of ideas or writings) dry and uninteresting

5. **Stolid**
   (of a person) calm and not showing emotion or excitement

6. **Tetchy**
   easily made angry, unhappy, or upset

7. **Callow**
   (of a young person) inexperienced and immature.

8. **Inane**
   extremely silly or with no real meaning or importance

9. **Tawdry**
   looking bright and attractive but in fact of low quality

The website from which the frequency lists were taken:
https://www.lextutor.ca/