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# Semi-incidental collocation learning from reading: effects of repeated exposure, prior vocabulary knowledge, congruency, and association strength

**Abstract:** This study examined the effect of repeated exposure on semi-incidental collocation learning, while also exploring the extent to which learner-related (prior vocabulary knowledge), and item-related factors (congruency, association strength) can modulate its effect. In an experiment using a Latin-square design, eighty-two learners of English at a university in Spain read a series of academic texts that included 18 collocations at different frequencies of exposure (1, 3, and 5). A control group did not undergo any treatment. Collocation gains were measured by a form recall and a form recognition posttest immediately after the treatment and two weeks later to explore the long-term effects of the treatment. Results from mixed-effects regression modelling showed a positive effect of repetition on learning gains, although not always statistically significant. Prior vocabulary knowledge interacted with repetition, suggesting that the facilitative effect of increased repetition decreases for L2 learners with a larger vocabulary. Congruency and association strength affected form recall only.

**Keywords:** collocations; semi-incidental learning; reading; repetition; EFL

# 1 Introduction

Learning vocabulary in a second/foreign language is a multifaceted endeavour that involves multiple types of knowledge (Nation 2022). Acquiring a language implies not only learning a vast number of words, but also the recurring patterns of collocations.

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Collocations can be broadly defined as sequences of words that tend to co-occur together in discourse (Schmitt 2010). Most collocations, however, are less frequent than single words in the input (Durrant and Schmitt 2010), which increases the amount of exposure L2 learners need to encounter and acquire a wide range of them. Research shows that textbooks offer L2 learners limited opportunities to learn collocations (Meunier 2012). Furthermore, in English as a Foreign Language (EFL) contexts, limits on teaching time puts pressure on teaching priorities, which do not always include teaching vocabulary, let alone collocations (Siyanova-Chanturia and Webb 2016). One short-cut to maximise exposure to collocations is to provide L2 learners with sufficient encounters repeatedly in a short space of time (Boers et al. 2014a, 2014b).

Repetition has been shown to play a key role in vocabulary development as a whole (Uchihara et al. 2019). Studies on the effect of repetition on the incidental learning of collocations have accrued in the past few years. Overall, the effectiveness of repetition for L2 collocation learning remains unclear, as findings have varied across studies (Dang et al. 2022; Durrant and Schmitt 2010; Pellicer-Sánchez 2017; Szudarski and Carter 2016; Vu and Peters 2023; Webb and Chang 2020; Webb et al. 2013). Crucially, the majority of these studies aimed to determine a threshold number of encounters beyond which repetition becomes beneficial. While it is important to address the role of repetition, the relationship between repetition and collocation knowledge seems to be more complex (Szudarski 2017). Few studies have examined the range of factors that are likely to interact with repetition, which can also influence how collocations are acquired and retained (e.g., Dang et al. 2022; Vu and Peters 2022). Some of these factors are the importance of the collocation for comprehension (particularly for reading) (Pulido 2007), as well as item-related factors such as congruency (or the availability of L1 equivalents) (e.g., Vu and Peters 2022), and learner characteristics such as language proficiency (e.g., Vilkaitė-Lozdienė 2017). Rather than focusing solely on the number of encounters needed to gain knowledge of collocations, this study was carried out to address the role of frequency of exposure in conjunction with other factors – congruency, association strength, and prior vocabulary knowledge – that may interact with it. The increasing number of studies which have investigated these learner- and item-related factors have yielded mixed results (e.g., Dang et al. 2022; Pellicer-Sanchéz 2017; Vilkaitė-Lozdienė 2017; Vu and Peters 2022; Webb and Chang 2022). Consequently, further research is necessary to better understand how these factors influence and interact with the role of repetition in L2 collocation learning. A second aim was to explore the role of contextual support and input density as variables that can modulate the effects of meaning-focused learning on incidental collocation learning. The degree of contextual support (e.g., informative/non-informative) can influence vocabulary learning. Research on single-word acquisition suggests that contextual support has a positive impact,

particularly on gaining knowledge of word meanings (Teng 2016; Webb 2008) but also on learning word forms (Teng 2019). These studies demonstrate how context enhances word learning, leading us to suggest that similar principles could be relevant for collocation learning, which warrants further investigation. The results have clear pedagogical implications for teachers and learners in identifying variables that affect collocation learning. The findings also have theoretical implications, suggesting that frequency alone may not fully explain collocation learning, highlighting the need to consider other factors like contextual support. These pedagogical and theoretical implications will be addressed in detail in the Discussion.

## 1.1 (Semi-)incidental collocation learning

Collocations are defined in this study as the co-occurrence of two words that form particular syntactic patterns (e.g., adjective-noun) with a high statistical strength-of-association which are also valued along semantic dimensions such as congruency (Nesselhauf 2003). This hybrid definition of collocations provides a thorough identification of collocations by combining aspects from both the form- and meaning-based traditions (Szudarski 2023). While the meaning-based or phraseological tradition categorises collocations according to semantic criteria such as compositionality, or whether the meaning of a collocation can be inferred from the meaning of its component words (e.g., Cowie 1998), the form-based tradition includes corpus driven-methods that employ statistical measures to identify words that commonly occur together (e.g., Sinclair 2004).

Collocations have long been of interest in L2 learning research (Szudarski 2023): while learning and competently using collocations is important for conferring native-like proficiency and accurate language use in general (González-Fernández and Schmitt 2015), it is often implausible to teach collocations through explicit instruction, due in part to the vast number of collocations in a language. As such, there has been an increasing interest in studying collocation learning through incidental means (e.g., Dang et al. 2022; Pellicer-Sánchez 2017; Vilkaitė-Lozdienė 2017; Vu and Peters 2022; Webb and Chang 2020). In the vocabulary literature, incidental learning is described as learning that occurs unintentionally or while engaged in other activities, such as reading a novel (Schmidt 1994). The difficulty in assessing the degree to which L2 learners become aware of the object of the study is a challenge, especially considering that most learning implies some level of conscious attention (Nation 2022). Rather than using narrow definitions of incidental and intentional learning, we prefer to describe the learning conditions in this study as semi-incidental, a term coined by Pellicer-Sánchez and Boers (2019). While our intervention did not employ deliberate enhancement techniques (i.e., bolding), collocations were embedded in a

systematic manner (e.g., the first sentence always included a target item), so it is possible that participants noticed the collocations in the input.

Several studies on incidental collocation acquisition indicate that collocations can be learnt through reading (-while-listening) to fictional stories and academic texts (e.g., Dang et al. 2022; Pellicer-Sánchez 2017; Szudarski and Carter 2016; Toomer and Elgort 2019; Tuzcu 2023; Vilkaitė-Lozdienė 2017; Vu and Peters 2022, 2023; Vu et al. 2023), viewing academic lectures (Dang et al. 2022), and TV (Puimège and Peters 2019). However, learning tends to be modest (Webb and Nation 2017). The relatively low learning gains, however, should not diminish the importance of incidental learning for overall development of collocational knowledge across different knowledge aspects. Small, gradual gains can lead to large ones if L2 learners do large quantities of reading and/or routinely engage in L2 learning activities as part of their own idiosyncratic learning journeys. This particularly applies to L2 learners at English-medium universities, who commonly engage in extensive reading for their studies, with special attention on academic input (Coxhead 2020).

## 1.2 Repetition and collocation learning

Repetition is a central factor in vocabulary acquisition: in general, the more repetitions with a word, the more likely it would be to be learnt (Uchihara et al. 2019). According to Zipf's law, however, L2 learners are unlikely to come across the same collocations repeatedly (Boers et al. 2014a, 2014b), and the learning gaps between encounters would diminish the repetition effect (Nation 2022). Given the infrequent occurrence of collocations compared to single words, collocation learning can be enhanced substantially by materials intentionally designed to include collocations at higher rates of recurrence than in naturally occurring language (Macis 2018). Repeated exposure with collocations during reading is beneficial because learners acquire the knowledge of the form and meaning whilst improving the fluency with which the collocation is processed in context (Pellicer-Sánchez 2020).

Several studies have examined the effect of repetition on the incidental learning of collocations. Some indicate that repetition can significantly contribute to the incidental learning of collocations through reading (-while-listening) fiction (e.g., Webb et al. 2013; Webb and Chang 2020), and academic texts (e.g., Sonbul and Schmitt 2013). Webb et al. (2013) was one of the first studies that examined the effect of repetition on incidental collocation learning. In this study, four groups of L1-Taiwanese university students simultaneously read and listened to a modified graded reader, in which 18 collocations appeared 1, 5, 10, or 15 times. Posttest results showed a better receptive knowledge of a collocation the more often it was repeated. Similarly, Webb and Chang (2020) examined the relationship between repetition and

incidental collocation learning from different modalities of input (reading-only, listening-only, and reading-while-listening). The results revealed positive correlations between repetition and collocation learning. However, they were only statistically significant in the reading-while-listening condition. Using a sentence-level task, Durrant and Schmitt's (2010) reading study found that repetition resulted in higher levels of collocational knowledge compared to a condition with only a single exposure. In this study, a cued recall task was used, where participants were instructed to remember made-up low frequency adjective-noun collocations that had been introduced during the training session.

Additional studies did not manipulate the number of repetitions as they were addressing other aspects of incidental learning, but used materials where collocations were repeated a fixed number of times. In a study that measured both immediate gains and long-term retention, Sonbul and Schmitt (2013) compared the effects of incidental, semi-incidental (using bolding), and decontextualised input on collocation learning among advanced ESL speakers. Participants read short passages featuring medical collocations, each repeated three times. Findings revealed learning across all conditions, with the semi-incidental condition showing greater immediate gains compared to the incidental condition. However, long-term retention was significantly better in the incidental treatment, where collocations were embedded in rich, meaningful contexts.

Other studies have brought the significant effect of repetition into question. Szudarski and Carter (2016) examined the effect of repetition and repetition plus input enhancement on collocation acquisition among Polish EFL learners. Participants read six short stories which contained 6 and 12 encounters with 20 collocations. Results showed that, while 12 repetitions significantly improved form recall knowledge, there was no significant improvement in form recognition. Notably, the collocations featured delexical verbs in verb-noun combinations (e.g., "take a step"), which pose a particular challenge for L2 learners (Altenberg and Granger 2001). While Pellicer-Sánchez (2017) found that adjective-pseudo word collocations can be picked up incidentally from reading short stories, no statistically significant advantage in learning outcomes was found for 8 compared to 4 repetitions. More recently, Vu and Peters (2022) reported that repetition was not a predictor of collocation learning from reading a grader reader. As the authors suggest, the absence of a frequency effect in this study could be attributed to the narrow range in the frequencies of the items (1–4) and the extended treatment period (11 weeks), which may have diluted the impact of repetition. In a later study (Vu and Peters 2023), repetition did not show a significant effect in three reading modes: reading-while-listening, reading with textual input enhancement, and reading-while-listening plus textual input enhancement. Meanwhile, Dang et al. (2022) did not find a significant effect of repetition either, although this study focused on academic lectures as L2 input.

While much research has focused on the frequency of collocations, input density, or how densely collocations are packed within a text, has been often overlooked. According to the input hypothesis (Krashen 1985) and the noticing hypothesis (Schmidt 1990), the more frequently learners encounter linguistic features and the more they notice these features, the more likely they are to learn and retain them. Thus, input density might significantly influence learners' ability to notice, process, and remember collocations. Szudarski and Carter (2016) explored this idea, which they referred to as input flood. They embedded collocations into six fictional stories, each collocation appearing either 6 or 12 times. The findings indicated gains in form recognition with 6 encounters and in form recall with 12 encounters. However, their study used longer texts (600 running words) and focused on less frequent collocations, such as those with delexical verbs. In this study, we used short texts with closely spaced target collocations. By arranging collocations in a clustered manner, we make it easier for learners to notice and focus on them. Despite its potential importance, no studies have yet explored how such input density affects the (semi-)incidental learning of collocations, leaving a gap in our understanding of effective vocabulary teaching strategies.

Taken together, prior research indicates that repetition alone does not exclusively drive collocation learning. Salient features such as text genre (fiction vs academic), the collocation's properties (e.g., collocation type), and several learner- and item-related variables (e.g., language proficiency, the availability of a L1 equivalent), may dilute and/or interact with the effect of repetition (Pellicer-Sánchez and Boers 2019).

## 1.3 Additional factors affecting the incidental learning of collocations

Research has indicated that collocation learning could be affected by various factors related to the collocations (e.g., congruency) and the learners themselves (e.g., prior vocabulary knowledge) (Boers 2020). Congruency has received substantial research attention given its impact on collocation errors (Laufer and Waldman 2011). It refers to the probability of L1-L2 collocational equivalence. Collocations that have L1-L2 lexical similarities are categorised as congruent whereas collocations that contain lexical items that are different in the two languages are labelled as incongruent (Nesselhauf 2003). For example, the English collocation "fast food" is congruent with its Spanish counterpart *comida rápida*. On the other hand, the English collocation "soft drink" has no literal equivalent in Spanish (i.e., *refresco*).

Congruency affects the difficulty learners may experience in learning collocations; that is, the learning burden of congruent collocations is lighter relative to that of incongruent ones (Wolter 2020). Both Vu and Peters (2022) and Vu and Peters (2023) found that congruency predicted collocation recall, suggesting that L2 learners find incongruent collocations more difficult to understand and recall due to the lack of L1 equivalents.

Another relevant factor that might affect collocation learning is association strength. Association strength refers to the strength of co-occurrence of two or more words, which is often assessed by corpus-based statistical measures like mutual information (MI) or t-scores. While previous research predominantly used MI or t-score, the rationale for their selection remains unclear. A more recent alternative, the log Dice, is considered more suitable for language learning research (Granger 2019). Unlike other measures, the log Dice does not rely on random occurrence and allows for comparisons across different language corpora while assessing collocation strength and exclusivity (Gablasova et al. 2017). It has a theoretically fixed maximum value of 14 but typically falls below 10 (Rychlý 2008). The impact of association strength on collocation learning has yielded mixed results. While Vu and Peters (2022) and Dang et al. (2022) found no significant effect, Puimège and Peters (2019) observed a significant relationship between association strength and learning. These disparities may stem from variations in the type of L2 exposure (reading, reading-while-listening, viewing).

Prior vocabulary knowledge has been shown to have a strong, positive effect on collocation learning from reading (Vilkaitė-Lozdienė 2017; Vu and Peters 2022, 2023; Vu et al. 2023). This might be explained by the fact that L2 learners who have larger vocabularies have better reading skills (Schmitt et al. 2004), allowing them to pay attention to new words while engaged in a reading task. However, recent studies suggest that the complexity of the stimuli may outweigh the impact of vocabulary knowledge. Using academic lectures as L2 input, Dang et al. (2022) did not find a positive effect of prior vocabulary knowledge. This highlights the importance of considering the complexity of both the type of input and the properties of the stimuli when developing effective pedagogical strategies.

## 1.4 Aims and research questions

There are some research gaps that the current study aims to fill. First, an important aspect of the design that differs from other relevant collocations studies is the role of input density and the fact that all repetitions were presented close to each other. Our semi-incidental learning conditions also include rich contextual cues for the collocations. Second, while a few studies have investigated how various factors influence

L2 learners' collocation learning, their findings have been inconsistent. In light of the previously mentioned gaps, the present study aims to answer the following research questions:

1. To what extent does the degree of frequency of exposure affect the degree to which collocations are learnt and retained in semi-incidental learning conditions?
2. What is the relationship between repeated exposure and other learner- (prior vocabulary knowledge) and item-related factors (congruency, association strength) in predicting the learning of collocations through reading?

# 2 Materials and methods

## 2.1 Participants

One hundred L1-Spanish learners of English were recruited from a Spanish University. Among them, eighty-two (47 female, 35 male) were randomly assigned to an experimental group, while eighteen (11 female, 7 male) were placed in a no-treatment control group. All participants were university students pursuing English-taught degrees in English Teacher Education or English Studies and were between the ages of 19 and 25 ($M$ = 19.88, SD = 3.46). Their English proficiency level was at least upper-intermediate or B2 level in the Common European Framework of Reference (CEFR), as determined by an external official certificate they provided before being admitted to university. All participants had formally studied English for at least ten years. They all had experience reading academic texts in English as part of their degree. To minimise the possibility of participants having exposure to the target items of the study, the topics of the stimulus materials were intentionally unrelated to their academic background.

To evaluate the participants' prior vocabulary knowledge, we administered the revised version of the Vocabulary Levels Test (VLT) (Schmitt et al. 2001). The 3,000, 5,000, and 10,000 frequency levels were chosen for this study: the 2K level would have been too easy while the academic band was deemed uninformative due to its inclusion of several English-Spanish cognates (e.g., "vehicle" (*vehículo*)) that our participants were likely familiar with (see Chen et al. 2012). The 10K level was included because several Latin root words in the 3K and 5K levels might have been familiar to L1-Spanish natives, possibly skewing the results. The VLT total score was computed adding up the scores from the three individual sections (max = 30), and thus it was scored out of 90 (30 words x 3 levels) (see Table 1). There was no statistically significant difference between the control group and the experimental group in terms of prior vocabulary knowledge ($t$(98) = 0.53, $p$ = 0.71).

**Table 1:** Means (M), standard deviations (SD), and confidence intervals (CI) of the VLT 3K level, 5K level, 10K level, and total score for the treatment and control groups.

|  | 3,000 M (SD) [95 % CI] | 5,000 M (SD) [95 % CI] | 10,000 M (SD) [95 % CI] | Total M (SD) [95 % CI] |
|---|---|---|---|---|
| Treatment (*n* = 82) | 26.54 (3.35) [24.89, 29.03] | 26.03 (3.69) [25.11, 28.83] | 20.73 (4.89) [19.71, 21.70] | 83.71 (13.07) [80.34, 88.63] |
| Control (*n* = 18) | 27.38 (4.01) [23.81, 27.73] | 25.88 (3.36) [24.61, 28.45] | 21.55 (4.41) [20.41, 22.49] | 84.25 (11.56) [79.62, 87.89] |

## 2.2 Target items

A total of 30 target items were initially chosen for the pilot phase, which were extracted from a range of sources, such as collocation dictionaries (e.g., the Oxford Learners' Dictionary) and language corpora (e.g., Corpus of Contemporary American English (COCA)). Collocations that were found to be relatively well known in the piloting phase (e.g., "blood clot") were removed. Eighteen target collocations were finally selected for this study. Raw corpus frequencies were obtained from the COCA using Davies's (2008) interface. The log Dice score was used to decide if a word pair was a strong collocation. The significance cut-off threshold was set at 5 or higher, given that log Dice is usually less than 10 (see Rychlý 2008). The scores ranged between 5.6 and 12.4, indicating a medium-high collocational strength. Most individual components within the target collocations were among the 5,000 most frequent word families in English. Exceptions included the adjective "cerebral" and the noun "marrow" from the 7,000 most frequent word families, along with the nouns "lice" and "palsy," which belonged to the 9,000 and 10,000 most frequent word families, respectively. Nesselhauf's (2003) operationalisation of congruency was used to determine the congruency status of the collocations. During the pilot phase, five experienced Spanish-English translators rated each item for the degree of overlap in form-meaning connections between L1 and L2. Half of the collocations were congruent and half incongruent. Table 2 summarises the properties of the target items.

## 2.3 Reading materials

Twenty-four short texts (18 containing each of the 18 target items) were extracted from a range of sources: language corpora such as the COCA, medical resources

**Table 2:** Target collocations and their properties.

|     | Collocation | Congruency | Association strength (log Dice score) | COCA frequency |
| --- | --- | --- | --- | --- |
| 1. | gum disease | congruent | 7 | 248 |
| 2. | bone marrow | congruent | 11.3 | 2317 |
| 3. | head lice | congruent | 6.1 | 181 |
| 4. | cerebral palsy | congruent | 12.4 | 903 |
| 5. | kidney failure | congruent | 8 | 652 |
| 6. | yeast infection | congruent | 6.1 | 233 |
| 7. | wasp sting | congruent | 9.4 | 14 |
| 8. | rib cage | congruent | 11.08 | 806 |
| 9. | acute pain | congruent | 7.7 | 167 |
| 10. | hot flushes | incongruent | 7.9 | 74 |
| 11. | bedside manner | incongruent | 6.6 | 292 |
| 12. | hay fever | incongruent | 10.8 | 252 |
| 13. | cold sore | incongruent | 6.6 | 105 |
| 14. | heat rash | incongruent | 5.9 | 42 |
| 15. | stem cells | incongruent | 8.2 | 3917 |
| 16. | chief complaint | incongruent | 5.6 | 76 |
| 17. | stretch marks | incongruent | 9.6 | 334 |
| 18. | stomach cramps | incongruent | 9 | 145 |

(*Collins dictionary [of] medicine*, Youngson 2004), as well as Internet medical resources such as the NHS England website.

Each text achieved lexical coverage of at least 96 % with the most common 4,000 words from the British National Corpus (BNC), determined by Vocabprofile with Lextutor (Cobb n.d.). This included off-list words, which were identified as Spanish-English cognates by five experienced Spanish-English translators during piloting (e.g., "cure" (*cura*), "tolerance" (*tolerancia*), "pollen" (*polen*). Although a 98 % coverage could have been more suitable for optimal understanding of the texts (Laufer and Ravenhorst-Kalovski 2010), achieving this proved unfeasible without omitting medical terms essential for content comprehension and textual coherence. A 96 % lexical coverage is generally adequate for inferring the meaning of words from context while reading (Liu and Nation 1985). Additionally, based on the piloting, it was estimated that the participants were expected to understand approximately 4–5,000 English words receptively. Details on the lexical coverage of each text are provided in the Supplementary Materials.

A modified version of Webb's (2008) context specification scale was used to rate the level of contextual support of the texts. Five English native speakers with English teaching backgrounds were asked to read the passages and rate the level of contextual support on a scale from 1 (contextually unsupportive) to 3 (contextually

supportive). Only passages with a rating of 3 were included in the study. Passages that were initially rated below 3 were minimally modified and rerated to ensure they met the required level of contextual support. All passages can be described as pedagogical in Beck et al.'s (1983) terms: they all included context cues about the target collocation's meaning. To check for the adequacy of contextual cues, we consulted WordNet (Princeton University 2010) and Sketch Engine (SketchEngine n.d.). This process ensured that the terms identified as contextual cues were relevant and informative of the core meaning of the items. For instance, the bolded terms in the following example were identified as cues of "hot flushes":

> Example:
>
> **Menopause** can cause symptoms like anxiety, mood swings, changes in **hormone levels**, and **irregular periods**, with hot flushes being the **hallmark symptom**. Often referred to as "the change of life", **menopause** is a natural **biological process**. Hot flushes, or sudden sensations of intense **body heat**, are typically **experienced by** most **women** for 6 months to 2 years, although they can last much longer. In the UK, up to 75 percent of **women** report experiencing hot flushes, which can occur at any time, both during the day and night, significantly impacting **daily life** and **sleep quality**.

The study included three frequency conditions: 1, 3, and 5. The rationale for including these three levels aligns with previous research and study objectives. Durrant and Schmitt (2010) found that a single encounter can establish an initial memory trace that may be reinforced with subsequent exposures. The 3-repetition level was selected following Sonbul and Schmitt's (2013) finding that three exposures to low-frequency collocations led to significant gains using contextualised learning conditions (i.e., enriched and enhanced). Given the characteristics of our study design – input density, repetition distribution–, it was interesting to examine whether 3 repetitions would also result in significant gains in semi-incidental learning conditions. The 5-repetition group was included because previous studies have shown that 5 encounters can lead to incidental collocation learning (Webb et al. 2013). Frequency was manipulated within subjects, and counterbalanced across lists, such that each participant encountered each collocation in one of the three frequency conditions, and saw equal numbers of items per condition.

Because encountering the same collocations repeatedly in natural contexts is generally rare (Boers and Lindstromberg 2009), the repetitions in this study were seeded into short texts (range 85–105 running words). This design allowed us to control for delays between subsequent exposures which may affect learning and to facilitate noticing of new items. The changes made to the texts were minimal to ensure they remained as authentic as possible. Two native speakers of English reviewed the texts to ensure that they were cohesive and sounded natural after the

adjustments. The frequency conditions were organised as follows: the first encounter with the collocation was always included in the first sentence, irrespective of the condition. For the 1-repetition condition, this was the only occurrence of the item. In the 3-repetition condition, subsequent encounters were placed in the middle of the paragraph (second encounter) and at the end (usually in the final sentence). Wherever possible, the 5-repetition condition consisted of 5 sentences where participants encountered the collocation once in each sentence. Examples of the different conditions can be found in the Supplementary Materials file.

## 2.4 Measures and procedure

This study employed a pretest-posttest-delayed posttest, within-subject Latin-square design.

The Latin-square arrangement was used to systematically counterbalance the assignment of materials and conditions across participants, thereby reducing potential order effects, item-specific biases, and condition-item confounds (Rogers and Révész 2020). Participants took part in three sessions, separated by two weeks each. All study components were distributed online via SoSci Survey, a web-based experiment presentation interface (Leiner 2019). Participants were monitored by the teacher in a computer-based environment.

In the first session, participants signed the consent forms and completed the pretests, which included a slightly modified version of the Language Experience and Proficiency Questionnaire (LEAP-Q) (Marian et al. 2007), the revised version of the VLT, and two pretests on the target items. The pretests consisted of a form recall and a form recognition task. The form recall pretest measured productive knowledge of the form-meaning link using a translation format in which the L1 meanings cued the responses. Participants were provided with the first letter of each component word of the collocations to avoid elicitation of other word pairs and were asked to provide the L2 collocation.

Example of form recall test

*sarpullido*:

h_____ r_____ (answer: "heat rash")

The second pretest assessed form recognition through a multiple-choice format. Participants selected the correct form of target items from five options, including three distractors and an "I'm not sure" option to prevent blind guessing. L2 learner corpora, including the *Universidad Autónoma de Madrid Corpus de Interlenguas*

*Escritas* (O'Donnell 2008), was used to find appropriate fillers for the test. The pretests included 16 distractors intended to draw participants' attention away from the target items. The distractors were semantically related to the target items, but were considered significantly easier by the teachers.

> Example of form recognition test
>
> heat _____:
>
> a) spot
>
> b) fever
>
> c) mark
>
> d) rash
>
> e) I don't know

In the second session, participants completed the treatment, where they read the 24 passages. Texts were displayed one at a time (one passage per screen) in Arial size 18. Participants were unable to return to previously read screens and were instructed to read each passage once. Following the reading, an immediate test was administered. To evaluate overall understanding of the texts and assess whether participants had paid attention to the readings, they had to answer a multiple-choice question where they had to select the topics they encountered from a list of 10 items, with only 5 being correct. This question aimed to identify participants who may have skipped passages, as identifying the correct topics was relatively easy. Participants also had to answer two questions to rate their overall comprehension and perceived difficulty of the passages on a 5-point scale (e.g., from "I struggled to understand the texts" to "I had no trouble understanding the texts"). Finally, participants completed the form recall and form recognition tests, which were identical to the ones administered at pretest but with re-randomised items.

In the last session, the delayed posttest, the same form recall and form recognition tests were administered with the items re-randomised. The distractors were kept in the posttests to minimise testing effects. At the end of this session, participants filled out a retrospective questionnaire to gather qualitative data on their overall engagement with academic texts, their perception of learning, and vocabulary learning strategies.

The experiment was piloted with 12 EFL learners who had comparable language levels and backgrounds as the actual study participants. The pilot participants were given the passages to read and were then asked to complete the posttests. They reported good comprehension of the texts and no issues completing the tasks.

## 2.5 Scoring and analyses

Results of the no-treatment control group ($n$ = 1,296 observations) showed near-zero variance, indicating minimal collocation gains in both immediate and delayed post-tests compared to the pretest. As zero-variance predictors should be excluded from a model (Kuhn and Johnson 2013), only data from treatment group data was analysed. Responses in the form recall tests that contained minor spelling mistakes were scored as correct as long as the response was comprehensible (e.g., "accute pain").

## 2.6 Model fitting

Statistical analyses were carried out with the R statistical platform (version 4.1.1, R Core Team 2021). Unaggregated data were fitted to logistic mixed-effects regression models (Baayen et al. 2008). Model assumptions were checked through residuals using the DHARMA package (version 0.4.6, Hartig 2020). Marginal $R^2$ and conditional $R^2$ were computed with performance package (version 0.11.0, Lüdecke et al. 2021). Pairwise comparisons among the three repetition groups were conducted using the emmeans package (version 1.10.1, Lenth 2020). The models were fitted with binomial distributions since the outcome was binary (learnt or not). The final dataset from the experimental group included 2,771 observations from 82 participants to 18 items. 181 observations were excluded from the analyses because they were correct responses in the pretest.

   Two models were fit for the two outcome measures (form recall, form recognition). Outcome scores from both immediate and delayed testing times were included in each model with "Testing time" as a fixed factor (main effect). Model fitting started from a core model including fixed effects of all the potential explanatory variables: Frequency of exposure, Testing time, learner variables (Prior vocabulary knowledge), item-related factors (Congruency, Corpus frequency, Association strength), two-way interactions with Frequency of exposure, where the interaction would have been interpretable. The reference (intercept) level for Frequency was the 1-repetition condition, and for Testing time, the Immediate post-test. For the item-related variables, Congruent was the reference level for Congruency, and Corpus frequency and Association strength were centred. Learners' vocabulary scores from the VLT were centred around the grand mean to reduce collinearity in the models. We followed a step-by-step backwards model selection procedure using model comparison (likelihood ratio test) to remove non-significant predictors (Plonsky and Ghanbar 2018). The maximal random effects structure was used that was supported by the data (Barr et al. 2013).

# 3 Results

Before exploring the research questions, the learners' postreading comprehension of the texts was examined. The results revealed that participants had no trouble understanding the texts, with approximately 80 % reporting comprehension of the main ideas and details. All participants correctly identified the text topics, demonstrating attentiveness, so no participant was excluded from the dataset.

Mean scores for form recall and form recognition increased from the pretest to the immediate posttest and from the pretest to the delayed posttest. The descriptive statistics is reported in Table 3 for form recall and in Table 4 for form recognition. Form recall gains were lower relative to form recognition, which indicates that active recall of a collocation's form is more effortful than passive recognition.

The generalised linear mixed-effects regression model for form recall (Table 5, $R^2$ marginal = 0.35, $R^2$ conditional = 0.41) revealed that Frequency was a significant predictor of form recall. The results also revealed significant effects of Prior vocabulary knowledge, Congruency, Association strength (as measured by logDice score), and Testing time. Congruent items were more likely to be picked up than incongruent collocations, and larger vocabulary scores increased the probability of recalling the collocations' forms. As expected, Testing time had a negative effect on learning, i.e., on average, learners performed worse on the delayed posttest compared to the immediate posttest. The model also revealed a significant negative interaction between Prior vocabulary knowledge and Frequency, which suggests that the effect of Frequency decreases for L2 learners with higher vocabularies.

**Table 3:** Form recall Ms, SDs and CIs for pretest to immediate posttest and pretest to delayed posttest by condition (1, 3, 5 repetitions).

|  | Pretest-immediate | | Pretest-delayed | |
| --- | --- | --- | --- | --- |
|  | M (SD) [95 % CI] | | M (SD) [95 % CI] | |
|  | **Mean score** | **Proportional score** | **Mean score** | **Proportional score** |
| 1 repetition | 1.78 (0.65) | 9.89 (3.61) | 1.63 (1.45) | 9.06 (8.06) |
|  | [1.23, 2.41] | [6.83, 13.39] | [1.19, 2.35] | [6.61, 13.06] |
| 3 repetitions | 3.71 (0.89) | 20.61 (4.94) | 3.52 (1.38) | 19.56 (7.67) |
|  | [2.16, 4.13] | [17.39, 21.16] | [2.86, 4.07] | [15.89, 22.61] |
| 5 repetitions | 4.89 (1.37) | 27.17 (7.61) | 4.49 (1.67) | 24.94 (9.28) |
|  | [3.13, 5.46] | [14.22, 30.33] | [3.39, 6.03] | [18.83, 33.50] |

Proportional scores represent performance expressed as a percentage of the maximum possible score (18), calculated as (mean score/18) × 100.

**Table 4:** Form recognition Ms, SDs and CIs for pretest to immediate posttest and pretest to delayed posttest by condition (1, 3, 5 repetitions).

|  | Pretest-immediate | | Pretest-delayed | |
|---|---|---|---|---|
|  | M (SD) [95 % CI] | | M (SD) [95 % CI] | |
|  | Mean score | Proportional score | Mean score | Proportional score |
| 1 repetition | 5.44 (1.29) | 30.22 (7.17) | 5.19 (2.46) | 28.83 (13.67) |
|  | [3.86, 6.39] | [21.22, 39.22] | [4.31, 6.51] | [19.96, 37.70] |
| 3 repetitions | 8.04 (1.83) | 44.67 (10.17) | 7.77 (3.08) | 43.17 (17.11) |
|  | [5.57, 10.23] | [34.92, 54.42] | [6.64, 9.03] | [33.46, 52.88] |
| 5 repetitions | 8.36 (2.05) | 46.44 (11.39) | 8.12 (2.71) | 45.11 (15.06) |
|  | [7.34, 11.45] | [36.67, 56.21] | [6.35, 10.82] | [35.35, 54.87] |

Proportional scores were calculated as in Table 3.

Pairwise comparisons (Table 6) showed that form recall gains were significantly higher for items repeated 3 and 5 times relative to the 1-repetition condition ($p < 0.001$). However, there was no statistically significant difference between form recall gains for collocations repeated 3 times and 5 times ($p = 0.220$).

The generalised linear mixed-effects model for form recognition (Table 7, $R^2$ marginal = 0.41, $R^2$ conditional = 0.52) showed that Frequency and Prior vocabulary knowledge were significant predictors of learning. Testing time had a significant negative effect, indicating that there is a decrease in the probability of a correct form recognition answer as testing moves from immediate to delayed. The effect of Congruency did not reach statistical significance ($p = 0.055$).

Pairwise comparisons (Table 8) between the three frequency learning conditions further revealed significant differences in form recognition gains. Overall, the results showed that increased repetition of collocations led to higher form recognition gains, with 5 repetitions showing the highest gains, followed by 3, and then the 1-repettition condition.

# 4 Discussion

## 4.1 The effect of frequency of exposure

In answer to the first research question, our frequency manipulation indicated a positive relationship between repetition and various aspects of L2 collocational competence, though this relationship was not always statistically significant. Increased repetition led to significantly higher gains in form recognition.

**Table 5:** Mixed-effects logistic regression model for form recall of target collocations.

|  | Estimate | SE | z | p |
|---|---|---|---|---|
| Intercept | −2.930 | 0.437 | −6.695 | <0.001 |
| Frequency | 0.195 | 0.029 | 6.535 | <0.001 |
| Prior vocabulary | 0.094 | 0.024 | 3.799 | <0.001 |
| Congruency | 0.503 | 0.262 | 1.916 | 0.013 |
| Association strength | 0.105 | 0.046 | 2.285 | 0.022 |
| Frequency x Prior vocabulary | −0.002 | 0.004 | −0.724 | 0.017 |
| Testing time | −0.246 | 0.094 | −2.606 | 0.009 |
| **Random effects** | **Variance** | **SD** | | |
| Participant (Intercept) | 0.308 | 0.551 | | |
| Item (Intercept) | 0.302 | 0.550 | | |

**Table 6:** Pairwise comparisons for form recall with Tukey correction $p < 0.05$.

| Contrast | Estimate | SE | z | p |
|---|---|---|---|---|
| 1–3 | −0.084 | 0.020 | −4.218 | <0.001 |
| 1–5 | −0.118 | −0.118 | −5.986 | <0.001 |
| 3–5 | −0.033 | −0.033 | −1.660 | 0.220 |

**Table 7:** Mixed-effects logistic regression model for form recognition of target collocations.

|  | Estimate | SE | z | p |
|---|---|---|---|---|
| Intercept | 0.364 | 0.213 | 1.709 | 0.087 |
| Frequency | 0.269 | 0.028 | 9.383 | <0.001 |
| Prior vocabulary | 0.066 | 0.010 | 6.413 | <0.001 |
| Congruency | 0.597 | 0.241 | 2.472 | 0.055 |
| Testing time | −0.285 | 0.091 | −3.113 | 0.002 |
| **Random effects** | **Variance** | **SD** | | |
| Participant (Intercept) | 0.424 | 0.651 | | |
| Item (Intercept) | 0.271 | 0.520 | | |

**Table 8:** Pairwise comparisons for form recognition with Tukey correction $p < 0.05$.

| Contrast | Estimate | SE | z | p |
|---|---|---|---|---|
| 1–3 | −0.073 | 0.026 | −2.729 | 0.017 |
| 1–5 | −0.161 | 0.026 | −6.115 | <0.001 |
| 3–5 | −0.088 | 0.027 | −3.255 | 0.003 |

Interestingly, however, no significant differences were found between 3 and 5 repetitions at the level of form recall. This finding suggests that more encounters with collocations do not necessarily lead to larger gains at all levels of collocational knowledge, which is in line with Szudarski and Carter (2016), Pellicer-Sánchez (2017), Vu and Peters (2022, 2023), and Dang et al. (2022). This pattern was also observed in the multisite study by Peters et al. (2023), who replicated Webb et al.'s (2013) study and reported smaller learning gains despite a positive effect of repetition. Together, these findings contrast with earlier work reporting strong linear relationships between repetition and collocation learning (e.g., Sonbul and Schmitt 2013; Webb et al. 2013; Webb and Chang 2020) and point to a more constrained role for frequency in L2 collocation acquisition. Overall, our study contributes to the body of research showing that repetition can facilitate collocation learning through reading, but that its effects are not uniform across knowledge dimensions (e.g., Webb et al. 2013; Webb and Chang 2020). These findings further suggest that frequency effects may be contingent on contextual and instructional factors, such as embedding collocations in pedagogical texts that reduce the vocabulary load of a text and facilitate L2 learners' noticing (Sonbul and Schmitt 2013). Specifically, embedding collocations within short, densely packed texts may enhance their visibility and learning potential, especially when they include unfamiliar components. This approach contrasts with earlier studies that relied on less dense materials, such as graded readers (e.g., Webb and Chang 2020; Vu and Peters 2022, 2023), fictional stories (e.g., Pellicer-Sánchez 2017; Szudarski and Carter 2016) and academic lectures (Dang et al. 2022), and may help explain some of the observed effects and differences across studies.

The type of collocations targeted in this study contained medical terms (e.g., "rash" in "heat rash", "palsy" in "cerebral palsy"), which may not have been known by participants in their L1. This is in line with Sonbul and Schmitt's (2013) study, where they included 10 predominantly unknown medical collocations, although arguably more technical than those in this study (e.g., "cloud baby"). However, one might assume that L2 learners can map the collocation to their L1 counterparts, particularly if they had prior knowledge of the individual collocations' components (e.g., "heat", "cerebral", in the previous examples). We hypothesise that the

availability of meaningful cues in the immediate context may have led to successful initial form-meaning connections (Webb and Nation 2017). Future studies could investigate the role of contextual support for L2 collocational development by incorporating contexts that vary in supportiveness.

One well-documented issue in L2 collocational development concerns the potential fuzziness of collocations' boundaries (Wray 2002). Martinez and Murphy (2011) found that L2 learners often assign incorrect meanings to formulaic sequences, typically because they pay attention to the meanings of the individual words within the sequence (e.g., Vu and Peters 2022). A focus on word-level comprehension can hinder L2 learners' ability to recognise collocations as cohesive units (Pellicer-Sánchez 2020). Our research design addressed this by presenting repetitions closely together within short passages. Such repetition density might have enhanced the salience of the collocations as meaningful chunks, enabling L2 learners to notice them more easily. We posit that this experimental design holds particular significance at the initial stages of collocation acquisition, where reinforcement through subsequent exposure to collocations in varied contexts is crucial (Durrant and Schmitt 2010). This is an important aspect of the design which differs from other relevant collocation research which has manipulated repetition (e.g., Pellicer-Sánchez 2017; Sonbul and Schmitt 2013; Toomer and Elgort 2019).

It is also important to consider the extent of durable (delayed) learning. Learning gains showed a slight decrease in the delayed posttests compared to the immediate ones, but differences were very small. This result was unexpected given the two-week interval between testing sessions, and could imply that participants acquired the target items not solely from reading but from the immediate posttests. Previous studies using delayed posttests have also observed testing effects (Webb and Chang 2020).

## 4.2 Form recall versus form recognition gains

Mean scores for the three repetition conditions increased from pretest to immediate posttest but decreased from immediate to delayed testing for both measures (see Tables 3 and 4). Learning gains were significantly smaller for form recall compared to form recognition. This is a common factor among L2 collocation studies, whereby repetition results in greater gains in the development of receptive knowledge with relatively low gains in productive knowledge (e.g., Toomer and Elgort 2019). The proportional scores registered in this study ranged from approximately 10 % to 50 % gains, depending on the outcome measure. It should be noted, however, that our target collocations contained nouns likely to be known by the participants, which could have had a facilitative effect on the collocation gains (Webb et al. 2013). Additionally, the characteristics of the participants (L1-Spanish) might have also

facilitated the acquisition of the medical-related terms, given the utility of Latinate vocabulary (e.g., "cells") for learning low-frequency English words (Chen et al. 2012). The scores obtained in the form recognition posttests should be interpreted with caution, as there is a possibility of overestimation. The test involved selecting the correct answer from multiple choices, a format that has been debated in previous studies due to its susceptibility to guessing, which can lead to score overestimation (see Gyllstad et al. 2015; Dang et al. 2022). Despite discouraging blind guessing, it remains uncertain if participants strictly followed these instructions. There is also a possibility of an order effect, where cues from the preceding form recall test influenced choices in the form recognition test, although this seems less likely. However, the chance that participants recalled cues from the prior test cannot be entirely discounted.

Learning gains are not directly comparable to those in other studies due to fundamental treatment differences. Studies on incidental acquisition of collocations used longer reading materials (e.g., Toomer and Elgort 2019), looked at other types of collocations (e.g., infrequent collocations in Szudarski and Carter 2016), or used different types of input (e.g., bimodal input in Webb et al. 2013).

## 4.3 The effect of learner- and item-related variables

In response to our second research question about the relationship between repetition and other item- and learner-related variables, our results indicate that prior vocabulary knowledge modulated the effect of repetition. This finding is noteworthy, as it provides evidence that the effect of repetition may be conditioned by L2 learners' existing lexical resources rather than operating uniformly across proficiency levels. The observed negative interaction between prior vocabulary knowledge and repetition suggests a stronger relationship between recall knowledge and repetition among L2 learners with smaller vocabularies. Analysed further, this interaction reveals that collocation (and overall vocabulary) knowledge is incremental in nature, such that L2 learners with lower prior vocabulary knowledge benefit most from repeated exposure. There may also be an assumption that L2 learners with larger vocabularies are more likely to have partial knowledge of some target items due to their broader lexical repertoire. Overall, the finding that L2 learners with higher prior vocabulary knowledge learnt more aligns with previous studies (Vilkaitė-Lozdienė 2017; Vu and Peters 2022, 2023; Vu et al. 2023) and provides additional evidence that lexical knowledge is a strong predictor of semi-incidental collocation learning.

Regarding item-related factors, this study found that congruency significantly predicted form recall, but its effect on form recognition was only marginal, suggesting that incongruent collocations pose a challenge in short-term retrieval rather than in

recognition. This result is consistent with Peters (2016), who found that congruency only played a role in the intentional form recall of collocations but not in their recognition. More recent incidental collocation learning studies have corroborated these results (Vu and Peters 2022, 2023). Incongruent collocations are typically less likely to be recalled due to L1-L2 mismatches (Peters 2016). This finding may also relate to deceptive compatibility, wherein L2 learners rely on patterns from the L1 to supply word combinations in the L2 (Laufer and Waldman 2011). In certain cases, collocations might appear relatively congruent with the L1, but closer inspection reveals their lack of literal equivalents in the L2. For instance, in our data, the item "cerebral palsy" prompted recall of the infelicitous collocation "cerebral paralysis" because its Spanish equivalent is "*parálisis cerebral*". Previous research has noted the influence of the L1 on collocational acquisition, as well as the enhanced recall of congruent collocations (e.g., Vu and Peters 2022, 2023; Wolter and Gyllstad 2011).

Association strength emerged as a significant predictor for form recall. This suggests that collocations with higher log Dice scores are more salient, influencing their learnability. For instance, in our data, "bone marrow" (11.3) may have been more noticeable than other items whose association score was lower (e.g., "heat rash", 5.9). This could be due to "bone marrow" being unlikely to appear in non-medical contexts, and "marrow" unlikely to co-occur with other lexical items. Previous research suggests that different association measures can predict learners' knowledge of collocations (Nguyen and Webb 2017). However, the effect of association strength has been inconsistent. For instance, while Puimège and Peters (2019) found an effect of MI scores on the incidental uptake of collocations from audiovisual input, Vu and Peters (2022) found no relationship between MI scores and form recall of collocations from reading. These mixed results likely stem from differences in the type of collocations being explored (e.g., lexical vs grammatical) or the mode of input (reading vs viewing). Future studies could provide a wider range of association strengths, which may yield varying results, adding depth to the findings.

Taken together, the findings of the present study indicate that L2 collocational knowledge develops gradually, and is shaped by the interaction between repetition, treatment characteristics, and learner- and item-related variables. While repetition facilitated learning, particularly at the level of form recognition, its effect was not uniform across knowledge dimensions, supporting recent accounts that view frequency as a necessary but insufficient condition for collocation learning. A key contribution of this study is that repetition is particularly beneficial for lower-proficiency learners, while item-level factors such as congruency and association strength also influence collocation learnability. These findings point to the need for more fine-grained approaches that integrate frequency with learner- and item-level variables in research on L2 collocation learning.

# 5 Limitations and suggestions for future research

This study assessed collocational knowledge at the levels of form recognition and form recall levels only. Future studies should address other aspects of collocational knowledge (e.g., meaning recall) and with other types of items (e.g., grammatical collocations). The tests used in this study may not have been sensitive enough to reveal the vocabulary knowledge that participants may have accumulated. An examination of the individual responses in the form recall posttests showed that participants gained partial knowledge of the item's form. Future research could include a variety of productive and receptive tests to assess the breadth of knowledge gained. Participants might have had partial knowledge of the target items, which may have influenced the amount of knowledge gained. Another limitation is that learners' reading comprehension was not formally assessed due to time constraints imposed by classroom scheduling. A full assessment of reading comprehension could have clarified the findings and ruled out alternative explanations, like a trade-off between understanding and repetition.

The role of context in collocation learning should be further explored to identify conditions that best support the noticing and retention of collocations. This could be particularly relevant when considering collocations with figurative meanings, which are often more challenging for L2 learners to grasp (Macis 2018). Future studies could consider manipulating context informativity by using vignettes in different conditions (via script orders) and then systematically either adding or removing contextual clues. This approach could reveal how specific contexts foster the development of strong semantic associations, thereby enhancing the likelihood of lexical retention (Ferreira and Ellis 2016).

# 6 Conclusions

This study examined the role of repeated exposure in semi-incidental collocation learning and how repetition interacts with various collocation- and learner-related factors. Results showed that exposure to short pedagogical texts seeded with collocations led to measurable learning gains, with prior vocabulary knowledge, congruency, and association strength emerging as significant predictors. Taken together, the findings highlight the need to consider frequency effects in L2 collocation learning in combination with other sources of variation.

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