On the learning of multi-word units via flashcard applications

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Abstract

Knowledge of multi-word units (MWUs) helps facilitate communicative fluency, and research on them has gained more and more attention in recent years concerning teaching methods and designing materials for second language (L2) acquisition. Incidental and intentional vocabulary learning are two dominant approaches to acquiring MWUs. In lexical studies, much research has examined the effects of these methods in various contexts. However, a gap in the research remains concerning materials development. This study aims to discuss various interventions that affect the teaching and learning of MWUs. This paper will highlight how more exposure and focusing learners' attention on particular MWUs is essential to the efficient acquisition of MWUs fluency. It can be achieved through intentional learning activities such as appropriately designed specialist digital flashcard-style computer applications and smartphone apps. Specifically, pedagogical implications are discussed when such applications employ either spaced repetition or a Leitner algorithm.

Keywords: multi-word units, Leitner algorithm, spaced repetition, language learning applications

Introduction

Vocabulary knowledge is a fundamental aspect of both first (L1) and second language (L2) fluency which plays a central role in learning content in all stages of education (Webb & Nation, 2017). Researchers emphasise vocabulary or lexical knowledge as a foundation to develop other language features such as morphology, phonology, pragmatics, and syntax (Biber & Conrad, 2001; Green &

Lambert, 2018). Lewis (1993) considered vocabulary knowledge a critical component of successful communication in L2 acquisition. Furthermore, Nation (2013) states that 30% of research on vocabulary acquisition for second language learning during the last 100 years has occurred since 2001. Therefore, research regarding the learning and teaching of vocabulary has been emerging for quite some time.

Determining what vocabulary knowledge encompasses is a complex issue. The concept of knowing a word includes its semantics and what collocates it usually occurs with (thus forming MWUs), among others (Nation, 2013, p.44). Therefore, knowing what words or types of words occur with other words is an essential aspect of using a word that Lewis (1993) refers to as grammaticalised lexis. He states that mastering them is an essential part of obtaining fluency in a language.

As a result, in L2 acquisition, considerable literature has grown that focuses on researching MWUs. Many scholars have attempted to define "the co-occurrence of words as collocations or MWUs differently" (Rogers *et al.*, 2021). Therefore, various terms are used to describe the phenomenon of MWUs, such as *idioms, collocations, chunks, prefabs, phrasal verbs*, *lexical bundles, formulaic sequences etc*. It is complicated to differentiate them due to their overlap and contention about what combination of words falls into which category.

Following the neo-Firthian conceptualisation (Sinclair,1991; Stubbs, 1995), collocation refers to "the occurrence of two or more words within a short space of each other in a text" (Sinclair, 1991, p.170). In this view, frequent co-occurrence of words is fundamental to identifying useful collocations to teach. In a similar vein, to define what a collocation or MWUs is in the simplest terms, Rogers *et al.* (2021) states that the term collocation "refers to a word that frequently appears next to another word" (p. 143). There are two significant reasons that learning MWUs has become a prominent topic in learning vocabulary. First, researchers are now aware that a high ratio of both spoken and written discourses consisted of MWUs (e.g., Ramisch *et al.*, 2013). Second, knowledge of MWUs provides receptive and productive fluency (Boers, 2020). For example, if learners are not familiar with how to use *do* and *make* some errors will occur with German learners *(*Gyllstad, 2005), *make your homework* (do your homework) and *do a suggestion* (make a suggestion) with Dutch learners (Peters, 2016). Therefore, knowledge of MWUs is a fundamental aspect to reach a high level of communication and avoid errors when using word combinations

Since vocabulary research focuses on pedagogy, newly available technologies are increasingly being used in approaches such as Computer Assisted Language Learning (CALL), Electronic Learning (e-Learning), and Mobile Assisted Language Learning (MALL), especially for lexical development in second language acquisition. As a result, more traditional study methods, such as paper-based word lists and flashcards, have changed to digital formats. Moreover, with advances in technology and various corpora and concordance software that can now be used to identify MWUs, more scholars have begun to identify MWUs and develop materials for teaching and learning them (e.g., Rogers, 2017a). Despite the value of MWUs fluency being well known, describing, identifying, and discovering the most efficient way to teach them has been pervasive. Thus, there are still many gaps in the research that need to be filled.

Parallel to the growing research interest in vocabulary, there is also a focus on incidental and intentional vocabulary learning as two dominant approaches. Intentional vocabulary learning includes exercises and activities using flashcards, sentence production, and fill-in-the-blank activities (Lindstromberg, 2020; Nation, 2013). In contrast, incidental vocabulary learning often uses meaning-focused tasks such as extensive reading, listening, and viewing of media (Webb, 2020). Many studies on intentional and incidental learning have been done researching single word

acquisition (Schmitt, 2010). In comparison, much less research has been conducted on MWUs acquisition, and thus a gap in the research still exists to some extent. Moreover, recent advances in technology, especially concerning language learning computer applications and smartphone apps that employ spaced repetition or a Leitner algorithm, have also led to new possibilities for improving upon vocabulary or MWUs acquisition efficacy. Therefore, much remains to be discovered concerning the ideal utilisation of technology for MWUs acquisition.

Selecting and developing software applications and deciding which features should be employed is still a challenging aspect of materials selection or development. To date, research on developing digital materials and deciding which features to include to help achieve MWUs acquisition is still limited. Therefore, this current paper will review the potential of incidental and intentional learning approaches in this area to inform pedagogical practice via digital tools and highlight essential features to consider.

The Significance of MWUs

Researchers have demonstrated that the knowledge of collocations is recognised as a "key factor of naturalness" (Hoey, 2005, p.2) and a "prerequisite for proficiency" (Shin & Chon, 2019, p. 608). We use MWUs or collocations as an umbrella concept to cover a large set of terms such as chunks, idioms, prefabs and chunks. Since MWUs are retrieved from memory as 'chunks' (Schmitt & Carter, 2004), it is more efficient to retrieve MWUs from memory than assemble them at the time of speech (Boers, 2020). This type of retrieval of MWUs is feasible for fixed expressions where morphological or syntactic variability does not occur (e.g., *happy birthday*) (Boers, 2020, p. 143). This can be accomplished using mnemonic strategies, as Schmitt (1997, p.13) presented. When a MWU contains a word that serves as a mnemonic hook, a learner can often recall the meaning of a word in a MWU that they had forgotten easier than when they learn words as isolated vocabulary (Rogers, 2017a, p. 46).

MWUs are word combinations that are often unpredictable and characterised by presenting a unitary meaning rather than a combination of the meanings indicated by their parts. For MWUs, there may be multiple options or constraints on collocated words, and these variations are not based on grammatical structures. For example, the synonyms of the *strong* and *powerf*ul do not combine with all nouns. Furthermore, there is a broad continuum between the compositional and non-compositional or idiomatic meanings of words (Moon, 1998). In previous research, they have been identified by word co-occurrence frequency in a corpus, reoccurring syntactic structures, delimited by word form or MWUs length, consideration for constituent and positional variation, and semantic opacity (Howarth, 1996; Wood, 2020), to name a few.

In this current study, collocations are defined as lemmatized concgrams, similar to the approach Rogers (2017) took. In this method, MWUs are collocations operationalized as a pivot word and a collocate (Rogers *et al*., 2021). A pivot word (or node) refers to the focal word in a collocation (Shin, 2007). For example, a pivot word can be a high-frequency word that can be used for searching for words that co-occur with them frequently (Rogers *et al*., 2021). For example, a corpus data search with the word eat as a pivot word will usually result in the collocate lunch being identified as co-occurring in high frequency. With the concgramming method, collocations are counted via lemma groups, which includes words that all share the same stem. A word's lemma group will include all inflections belonging to the same part of speech (Nation & Meara, 2002, p. 36).

Since spoken and written discourse consists of a large amount of MWUs (e.g., Erman & Warren, 2000; Hill, 2000; Jackendoff, 1997; Moon, 1998), learning MWUs "should be a top priority in every language course" (Lewis, 2000, p, 8). Many previous studies have indicated that L2 learners have problems with MWUs production, even highly fluent learners (Davoudi & Behshad, 2015; Laufer, 2011; Laufer & Waldman, 2011; Men, 2018; Nesselhauf, 2005; Wang & Shaw, 2008; Zhou, 2016).

The common conclusion of these studies revealed that L1 interference was the main reason for L2 errors, and the degree of L1-L2 congruence is a driving factor. To illustrate the role of L1-L2 congruency, *have risk* (take a risk) and *have harm* (cause/do harm) are examples of common errors Chinese-speaking learners of English make (Zhou, 2016); *notice attention* (pay attention) and *try an attempt* (make an attempt) are examples of common errors Hebrew-speaking learners of English make (Laufer, 2011), and *depend with* (depend on) and *in time* (on time) are examples of common errors Persian-speaking learners of English make (Davoudi & Behshad, 2015). Such errors occur because learners employ a literal translation strategy, using their L1 knowledge to produce L2 collocations. Perkins and Zhang (2022) emphasise that due to L1 interference, teachers should focus on similarities between the L1 and the L2. Therefore, it is worth investigating how MWUs with low L1-L2 congruency can be identified.

Recent studies have investigated the relationship between L1 interference and other factors that show the L1's role in enhancing MWUs knowledge (Du *et al*., 2021; Fang & Zhang, 2021; Özdem-Ertürk, 2021). For example, Du *et al*. investigated cross-linguistic influences in the processing of MWUs by using binomial expressions (*knife* and *fork*). Their results show that Chinese-English bilinguals have more significant effects with congruent L2 binomials than English-only binomials, which have no impact on translated Chinese-only binomials. The authors concluded that L1 impacts L2 MWU processing and support the hypothesis that congruent MWUs are processed faster than incongruent.

Therefore, a focus on learning MWUs has the potential for improving upon both communicative fluency and correct idiomatic production by modelling acceptable structures for L2 learners. This will help them avoid constructing uncommon structures when they try to combine words they learned in an isolated fashion. Due to this irregular nature of MWUs, explicitly focusing on particular items is essential for helping learners avoid errors. This evidence could support L1-L2 congruency as an essential factor in developing materials to gain MWUs knowledge. Despite the value of MWUs fluency being well known, describing, identifying, and discovering the most efficient way to teach them has been pervasive. Thus, there are still many gaps in the research that need to be filled. Therefore, the current study focused on the incidental and intentional learning approaches to research the best way to teach MWUs, especially in digital format, by considering the degree of L1-L2 congruency.

Learning MWUs

Incidental learning of MWUs

Studies on incidental vocabulary learning often examine how to learn new words through reading compared to learning vocabulary presented in listening or media viewing. Studies indicate that frequent exposure is a fundamental factor affecting the acquisition of MWUs (e.g., Boers, 2020; Pellicer-Sánchez, 2017; Webb, Newton & Chang, 2013). In one study investigating the incidental acquisition of collocational knowledge, Pellicer-Sanchez (2017) examined 41 L2 learners who read a text that consisted of six adjectives/pseudo-noun collocations in two versions of the text. The adjective/pseudo noun collocations were repeated eight times in version A and four times in B. However, the frequency of exposure in this study did not significantly affect the learning of the target

collocations. The author concluded that items need to appear more frequently in a reading for a significant acquisition effect.

In contrast, Webb *et al*. (2013) found significant differences between five and ten exposures. The task involved readers listening to and reading a short story with 18 verb/noun collocations (e.g., raise questions). Furthermore, in their study, it was noted that collocations were more likely to be learned incidentally when learners met the vocabulary item 15 times in a text. Insufficient inclusion of MWUs in written texts was highlighted as an issue in studies by Pellicer-Sánchez (2017) and Webb *et al*. (2013) when they studied the use of modified readers.

Also, some studies demonstrated that reading alone is not particularly effective for enhancing learners' collocational knowledge (Szudarski, 2012; Szudarski & Carter, 2016); this is probably because there are not enough repetitions of collocations in the EFL textbooks or written texts to facilitate learning (Boers & Lindstromberg, 2009; Koya, 2004; Tsai, 2015). More specifically, Boers and Lindstromberg (2009) investigated 120 pages of a particular book for verb-noun collocations, and they found that most MWUs occurred only once within the text (e.g., *make conversation*, *tell the truth*). Thus, merely reading does not seem very effective for learning collocations.

Compared to their single word counterparts, MWUs occur in much lower frequencies, and thus there are more significant gaps between exposures in incidental learning activities such as reading a text. For example, Rogers *et al*. (2021) point out that the word direct occurs approximately 18,000 times in the academic portion of the Corpus of Contemporary American English, while some valuable collocations co-occurred with the word as low as 100 times. Boers and Lindstromberg (2009) noted that it was not just the frequency of lexical chunks that was an issue, but that lack of attention was a factor in that students overlooked MWUs incidentally. Hence, they introduced a 'semi-incidental acquisition approach' as a solution by highlighting chunks in a text to bring learners' attention to them. Pellicer-Sanchez and Boers (2018) believe that semi-incidental learning is a different approach that should be considered in addition to the more traditional approaches of simple incidental and intentional approaches.

The effectiveness of semi-incidental acquisition of collocations has appeared in several studies (Boers *et al*., 2017; Choi, 2017; Majuddin *et al*., 2021; Sonbul & Schmitt, 2013; Szudarski & Carter, 2016). These studies concluded that learning was enhanced by input enhancement compared to reading an unenhanced text. Therefore, input enhancement is a way to bring learners' attention to items they should focus on in incidental learning. This evidence may lead to emphasising that incidental learning requires some modification. Also, this evidence adds to the literature about how incidental strategies alone may not be sufficient to promote L2 learners' knowledge of collocations, specifically because learners' attention needs to be directed to them when they are presented in context. The rationale behind learners' attention is rooted in the noticing hypothesis (Schmidt, 1990, 1992). Based on the noticing hypothesis, only noticed items are likely to become intake among all the inputs that learners are exposed to. Webb & Nation (2017, p. 61) also suggest that the conditions of noticing and repetition need to occur to learn target vocabulary items.

Intentional learning approach

Intentional learning is form-focused instruction that directs a learners' conscious attention to new items to learn. In this method, learners use repetition and memorisation strategies to develop vocabulary knowledge. The intentional learning approach has been investigated for isolated vocabulary and MWUs through explicit teaching and learning. When teaching isolated words, empirical evidence shows that activities that involve flashcards can improve intentional learning (Brown & Perry, 1991; Barcroft & Rott, 2010; Joyce, 2015; Pellicer-Sánchez, 2015). Furthermore, it

is more efficient and faster than incidental learning (Elgort, 2011; Hustijn, 2003). Pellicer-Sánchez (2020) concluded that intentional learning provides receptive and productive knowledge and enhances automaticity and fluency, and mentions that although some activities such as links "between idiomatic and literal meanings" refer to MWUs, the same concentrated activities that are effective in intentional learning of single words can also be used to acquire MWUs (p. 141). Thus, there is potential for the intentional learning approach to be used to acquire MWUs.

The recent meta-analysis on intentional learning of single words is essential to consider. The meta-analysis by Webb *et al.* (2020) compared four common word-focused study activities: flashcards, word lists, writing, and fill-in-the-blank for single words. The results demonstrated that flashcards and word lists were more efficient than writing and fill-in-the-blank activities. However, the authors did note that although the gain of knowledge was smaller in writing and fill-in-the-blanks, they were more efficient than in reading or viewing, which belong to incidental learning.

Advocates of intentional learning of collocations believe that learners must be taught MWUs explicitly because of their importance for L2 fluency (e.g., Laufer, 2011; Laufer & Girsai, 2008; Peters, 2014, 2016; Webb & Kagimoto, 2009, 2011). For learners living in a situation where they have little incidental exposure in everyday life to the target language, more explicit methods and purposeful learning may benefit learners (Hoey, 2005; Sonbul & Schmitt, 2013). Thus, intentional activities seem to be a fundamental aspect of teaching MWUs and increasing learners' attention. Since flashcards and word lists were more effective methods in single words, they may provide a benefit for teaching MWUs.

The relationship between learners' attention and intentional learning is illustrated by Laufer's (2011) study, where she presented learners with a set of sentences that contained verb-noun collocations without a verb and asked them to complete the sentence by using a dictionary. Although a significant increase in collocational knowledge was found by using dictionaries, learners sometimes offered incorrect collocations, did not recognise the collocation, and did not use the dictionary for help. As a result, she concluded that form-focused instruction should be added to the study of collocations; this suggestion was also made by other researchers (Peters, 2014, 2016; Webb & Kagimoto, 2011). Exposure and drawing learners' attention to MWUs were also confirmed in Jones & Haywood's (2004) 10-week study as effective in raising students' awareness of formulaic sequences and improving their written product, all as a result of deliberate teaching of formulaic sequences.

In addition to noticing a new word in both single and MWUs, which could affect the learning process (Webb & Nation, 2017), other factors such as "exposure to repeated encounters" (Pellicer-Sánchez, 2020, p. 164) and frequency of words (Peters, 2014) could also influence the vocabulary acquisition. Therefore, these explicit activities could engage learners' attention to MWUs and encourage them to utilise MWUs. According to this assumption, explicit knowledge from intentional learning and implicit from incidental learning can be obtained. Nation (2013) noted that explicit knowledge could not support learners to use words in the context. Webb (2020, p.146) believes that intentional learning is effective and a foundation for incidental learning. Moreover, he also mentions that the benefit of labelling intentional and incidental learning helps us to find the strength and weaknesses of different learning, and we should not consider one of them is better than another one, as they are a complement to each other (Webb, 2020, p.5).

The main criticism of intentional learning is that these intentional activities, such as decontextualized word lists and flashcards, may not lead to fluent language use or production (Qian & Lin, 2020). Some researchers believed that utilising concordancers might be a solution to this issue (e.g.,

Pellicer-Sánchez, 2020). *Concordancers* are text analysis software that can accomplish some tasks, including finding all the instances of word co-occurrence in a corpus. While such software has been available for some time and is widely used by linguistics researchers, only a few studies have investigated the benefit of using this tool to help learners gain MWUs knowledge (e.g., Chan & Liou, 2005; Mohammadi & Mohit, 2021). While such software is compelling and can accomplish various functions, it does have some limitations. For example, when learners need to start their vocabulary learning through L1 translation equivalents, this strategy is rarely enough to continue learning (Ballance & Cobb, 2020, p. 330). Another disadvantage is that using such software can be time-consuming for teachers (Mohammadi & Mohit, 2021), and beginner learners could also face challenges learning how to use it.

It seems that well-designed materials require both language-focused and meaning-focused activities. Moreover, some studies had conflicting results. Some found that explicit activities were a fundamental and efficient method to gain collocational knowledge (Fordyce, 2014; Sonbul & Schmitt, 2013; Szudarski, 2012; Zaferanieh & Behrooznia, 2011), while others demonstrated that implicit methods are also beneficial (Fahim & Vaezi, 2011; Oztina, 2009). Some studies, such as Joyce (2015), Pellicer-Sánchez and Boers (2018), and Webb (2020), believe that they complement each other. Therefore, scholars have not agreed on which of them is better or which requires more attention. While these approaches have advantages and disadvantages, they could be integrated to achieve the best result.

Using Flashcards and Word Lists to Teach MWUs

As mentioned above, explicit teaching activities could increase direct learners' attention and expose them to large quantities of information. Therefore, this research only focused on flashcards and word lists for teaching MWUs. There are insufficient studies investigating the efficacy of teaching MWUs via flashcards or word lists. However, more studies have attempted to develop MWUs word lists.

Some previous research in this area has focused on the production and use of academic collocation lists by using different corpus (e.g., Ackermann & Chen, 2013; Bibber, Conrad, & Cortes, 2004; Durrant, 2009; Rogers *et al.*, 2021; Simpson-Vlach & Ellis, 2010). Earlier lists have some limitations and are small-scale, such as Simpson-Vlach and Ellis' list having only 207 items. In contrast, more recent studies such as Rogers *et al.* (2021) resulted in larger scaled lists of approximately 5,000 MWUs and introduced lemmatized concgrams method to identify useful MWUs (See Rogers 2017a, Rogers *et al.*, 2021, for more details).

The issue of studies only resulting in small-scale resources has also been an issue for general English collocational research. For example, Martinez and Schmitt's (2012) *Phrase List* only identified 505 non-transparent phrases for general English. Although their point that non-transparent or non-compositional MWUs are particularly valuable to learn deliberately by L2 learners is valid, the size of their resource is still an issue. Shin's (2006) study improved upon this by identifying approximately 1,000 meaningful and memorable units for Korean beginner-level learners of English. In regard to a large-scale general English MWU list, Rogers (2017a) identified approxi- mately 3,500 items.

However, it could raise a critical perspective to accept a generalisation behaviour for single words and MWUs; there is no meta-analysis to provide some information about learning MWUs. This research follows Webb *et al.*'s (2020) study. The theory that learning from word lists works less effectively than learning from flashcards is supported by research that has uncovered the positive effect of retrieving the L2 form or meaning of the target items when using flashcards in single words

(e.g., Webb *et al*., 2020). Also, Webb *et al*. concluded that the proportion of words learned through flashcards is higher than in word lists.

Flashcards are referred to a set of cards for learning L2 vocabulary in "paired-associate learning" that L2 words are encountered in a decontextualized environment, and learners are expected to make a connection between "the L2 word form and its meaning" (Nakata, 2020, p.304). In flashcards, the L2 words are written on one side and the L1 translation, or other information such as a definition or L2 synonyms are written on another side. Existing research on flashcards shows that using flashcards is common and effective in learning L2 vocabulary (e.g. Nakata, 2008, 2011; Elgort, 2011; Nation & Webb, 2011; Komachali & Khodareza, 2012; Hung, 2015; Sanosi, 2018). For instance, the results of Nation and Webb's study demonstrated that flashcards are the most effective strategy in L2 vocabulary activities. Nakata (2011) and Nation (2013) also recommended using flashcards instead of notebooks to retrieve the meaning. Flashcards could keep learners motivated to retrieve the form and meanings of words during the study periods.

Several experimental studies have compared the effect of digital flashcards with word lists or paper-based flashcards in gaining vocabulary knowledge (Kılıçkaya & Krajka, 2010; Hirschel & Fritz, 2013; Dizon & Tang, 2017; Li & Tong, 2019; Yüksel *et al*., 2020). Those studies have reached the common conclusion that digital flashcards could lead to better results in gaining vocabulary knowledge. One of the benefits of digital flashcards was revealed in a recent study by Li and Tong on embedding visual and audio to their flashcards for Chinese language learners. Nakata (2020, pp. 313–314) mentioned several advantages of computer-based flashcards; supporting learners in getting effective learning principles into practice, offering complex activities, and tracking students' progress. In contrast, Nikoopour and Kazemi (2014) selected 109 participants and divided them into three groups (Online, Mobile, and paper flashcards). They found no difference between learning words from digital or paper flashcards; however, their participants preferred to use the digital format. They concluded that the portability of devices is the main advantage, as the online group could not use their flashcards anywhere and anytime.

Although the benefit of using flashcards is apparent in the literature, few studies have investigated learning collocations via flashcards. For example, Miyakoshi (2009) compared paper-based versus online flashcard activities where 60 Japanese students attempted to use verb-noun. This study indicated that L1 interference was one of the most substantial issues for Japanese learners. Also, the results highlighted the efficacy of explicit instruction to improve collocational competence. Assaf, Al-Jamal, and Rababeh (2020) developed digital flashcards for 90 lexical collocations using Quizlet. Post-test results revealed that the experimental group that used Quizlet outperformed the control group in reading comprehension. Since Quizlet is a free digital flashcard software, several studies have evaluated its effectiveness compared to studies with paper-based word lists or paper-based flashcards (e.g., Sanosi, 2018; Yüksel, Mercanoğlu & Yılmaz, 2020).

Nakata (2020, p0. 313–314) noted that compared to traditional paper-based flashcards, computer-based flashcards have a number of advantages:

1. Learning principles can be applied more efficiently
2. Computer-based flashcards offer exercises
3. Computer-based flashcards can track learners' performance and enable them to schedule the review of unfamiliar items after adequate intervals
4. Users can add multimedia information (e.g., embedding visual and audio aids)

Essential Features of Flashcard Software

Technologies such as CALL and MALL have dramatically increased in recent years to provide materials, especially for lexical development in second language acquisition. However, Li and Lan (2021) suggested using the term *digital language learning* to cover all sorts of technologies such as computer, web-based software and smartphone apps; there is a tendency to refer to all of them as CALL. Since many similar apps and software are accessible on both smartphones and computers, in this research, CALL refers to all digital tools, whether based on computers or smartphone apps.

CALL can improve upon functionality and ease of distribution beyond that of current traditional methods of books and paper-based flashcards. Additionally, paper materials can have limitations due to the cost, volume, quality, and content delivery. For instance, textbooks with many colour images can be costly to print. However, CALL materials do not have such restrictions. Moreover, CALL adds functionality not possible with paper-based materials, such as spaced repetition or tracking performance usage. Consequently, the traditional use of tools such as paper word lists and flashcards has been changing to digital format.

In recent years, many flashcard programs have become popular as more and more web-based software and smartphone apps have been developed that are usable to run on computers and smartphones (https://en.wikipedia.org/wiki/List_of_flashcard_software). The purpose of digital materials is not just to replace paper-based materials with digital versions but to help users learn more efficiently. Therefore, it is necessary to define criteria that represent improvements compared to paper-based materials to evaluate such software.

Current literature indicates essential criteria include a creation function (that allows users to make their cards), multilingual support, embedded content, the ability to add other information to a card, and the provision of a variety of activities for practice (Foster, 2009; Nakata, 2011, 2020; Nation, 2013). Nakata (2011) conducted a systematic and detailed investigation of nine flashcard programs and created a set of 17 criteria for evaluating the programs; none of them was compatible with his checklist (Table 1).

It seems that providing all criteria for each program is impossible, or the developers are unaware of the benefits of some requirements. Also, in Nakata's checklist, some criteria such as spaced repetition, item difficulty and flashcards with multiple sides are neglected. To achieve long-term retention, an application would need to have some review schedule that enables users to have repetition and slowly extend the amount of time between rehearsals until an item can be memorised. Schmitt and Schmitt (1995) state that "learners should review new material soon after the initial meeting, and then at gradually increasing intervals" (p. 136). This schedule is divided into massed and spaced learning or repetition (Nakata, 2008, 2020).

With massed practice, learners do an activity multiple-time sequentially. Whereas, with spaced repetition, learners do activities at regular intervals over a period of time. In a spaced repetition system, when users remember information from a day ago, they will not be tested again for two days. The next test will take place four days later if the learner recalls the information correctly. Suppose the learner answers precisely, the interval between tests increases. Since space repetition is more effective than massed repetition (Nakata, 2020; Seibert Hanson & Brown, 2020), it is essential to take advantage of the software's ability to do this. A range of commercial language learning programs use spaced-repetition systems these days (e.g., Anki, SuperMemo). If item difficulty is not considered, more spaced repetition would not be sufficient (Rogers, 2021). Therefore, it is necessary to go back to a Leitner algorithm-based item proposed by Sebastian Leitner. Leitner's (1972) study

explains how his spaced repetition method considers item difficulty with paper flashcards (see Figure 1).

Table 1 *Essential Features for Flashcard Software Checklist*

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1. Flashcard creation: Can learners create their own flashcards?

2. Multilingual support: Can the target words and their translations be created in any language?

3. Multi-word units: Can flashcards be created for multi-word units as well as

single words?

4. Types of information: Can various kinds of information be added to flashcards besides the word meanings (e.g., parts of speech, contexts, or audios)?

5. Support for data entry: Does the software support data entry by automatically supplying information about lexical items such as meaning, parts of speech, contexts, or frequency information from an internal database or external resources?

6. Flashcard set: Does the software allow learners to create their own

sets of flashcards?

7. Presentation mode: Does the software have a presentation mode, where new items are introduced and learners familiarise themselves with them?

8. Retrieval mode: Does the software have a retrieval mode, which asks learners to recall or choose the L2 word form or its meaning?

9. Receptive recall: Does the software ask learners to produce the meanings of target words?

10. Receptive recognition: Does the software ask learners to choose the meanings of target words?

11. Productive recall: Does the software ask learners to produce the target word forms corresponding to the meanings provided?

12. Productive recognition: Does the software ask learners to choose the target word forms corresponding to the meanings provided?

13. Increasing retrieval effort: For a given item, does the software arrange exercises in the order of increasing difficulty?

14. Generative use: Does the software encourage generative use of words, where learners encounter or use previously met words in novel contexts?

15. Block size: Can the number of words studied in one learning session be controlled and altered?

16. Adaptive sequencing: Does the software change the sequencing of items based on learners' previous performance on individual items?

17. Expanded rehearsal: Does the software help implement expanded rehearsal, where the intervals between study trials are gradually increased as learning proceeds?

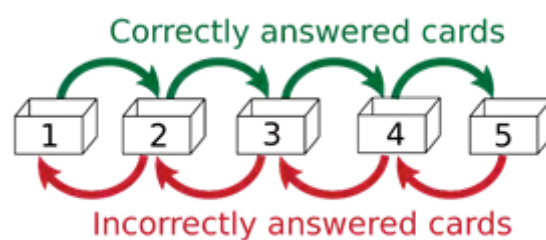*Note*. Checklist is adapted from Nakata (2011, p. 27).

Figure 1 *The Leitner System*

This method utilises three to five physical boxes. Each flashcard will begin in box 1. You move a card to the next box every time you get it right. You move the card back to the previous box every time you make a mistake. If an item remains in Box 1 after the first round or moves back to a box after that, such items will be repeated more often than an item remembered correctly on each exposure. The user can rate a given item according to its difficulty with the Leitner algorithm-based

item ordering. This provides the extra review necessary for more difficult items in a set, thus improving the efficacy of learning. Rogers (2017b) found that this system could provide another benefit by providing difficult items folders. For instance, when learners need to learn 1,000 words that are divided into 50 items in each set, the difficult items in each set could move to difficult folders for more review.

Despite there being knowledge of the strengths of Leitner-based spaced repetition algorithms for some time now, Rogers (2014) found that only 10 out of 161 educational flashcard smartphone apps featured a Leitner algorithm. It seems that digital designers ignore the Leitner system. It could be that they are unaware of the benefit of this feature or its cost. Therefore, some researchers have developed their flashcards and the Leitner system was added as the main feature to their apps, such as MemReflex (Edge *et al*., 2012), MemoryLifter (Mubarak & Smith, 2008).

Since intentional activities, such as decontextualized word lists and flashcards, may not lead to fluent language use or production (Qian & Lin, 2020), digital flashcards with multiple sides could be a solution to gain MWUs via some sample example sentences. Therefore, side A and B illustrate MWUs and L1 translations, and side C provides some sample examples. This type could be used by all kinds of learners to compare concordancers which are not supported L1 translation equivalents and are complicated for beginner learners. Therefore, this study indicated that spaced repetition, item difficulty (The Leitner System) and flashcards with multiple sides might be considered when selecting any software.

Discussion and Conclusion

The literature review indicated that a high level of communication and language fluency relies on knowledge of MWUs. This article reviewed the effectiveness of incidental and intentional learning of MWUs to find the best way to teach MWUs items to L2 learners. Based on the discussion above, it can be assumed that in situations where a learner does not have frequent exposure to MWUs in the target language, exposure intervals may be too large for learners to acquire them via intentional activities. Consequently, the process of incidental learning MWUs is likely to be slow.

In addition, EFL textbooks and authentic materials are likely to have insufficient MWUs and do not bring MWUs to learners' attention. Many EFL textbooks do not use any techniques to bring attention to MWUs, such as highlighting or underlining, despite such a method being known to be essential to successful incidental vocabulary learning (Pellicer-Sanchez & Boers, 2018). Finally, MWUs are likely to be stored as chunks (e.g., Wray, 2000; Nation, 2013), and the frequency of exposure is a fundamental aspect of storing them as a whole unit, but unfortunately, MWUs occur in much lower frequencies than necessary for achieving such learning in authentic materials.

Since methods such as encouraging students to notice new MWUs, repetition, and more frequent encounters with MWUs have the potential to improve upon the efficacy of learning, intentional activities such as usage of word lists and flashcards are recommended. Some researchers, such as Sen (2019) and Tsai (2015), recommend that materials developers consider collocation lists for language learners. The weakness of collocation lists and flashcards is that they are decontextualized and may not support learners properly using MWUs in context. In comparison, well-designed digital flashcard materials are likely to keep learners motivated to retrieve the form and meanings of words during study periods and thus acquire knowledge of the items more efficiently.

According to the literature, this current study suggests the following pedagogical implications for L2 teachers and materials developers. First, if the learner is still at a beginner stage, an L1 translation is

recommended for one side of a flashcard. If the learner is at a more advanced stage, that side could instead feature an L2 definition, a synonym, or other similar information in the L2. Several studies indicate that an item's lack of L1-L2 congruence is often the source of many L2 learners' errors. An L1 translation could raise awareness of differences between L1 and L2 of MWUs, especially for collocations that do not have literal equivalent translations. Laufer and Girsai (2008) highlighted the benefit of using L1 translation. They found that explicit contrastive analysis and translation gained the best results compared to students who read a text, engaged in a group discussion, filled in gaps, or did a multiple-choice activity. Given this advantage, the most frequent MWUs should be selected and translated into L1 to identify items that have low congruency to help facilitate the learning of such collocations.

Second, instead of presenting MWUs in an isolated form, it is better to provide a sample sentence containing the MWU highlighted somehow (such as having it in italics, underlined, or in bold) to encourage noticing and providing contextual use. Durrant and Schmitt (2010) concluded that the failure of non-native learners to learn collocational knowledge could be attributed to inadequate input rather than a native-like approach to learning. Furthermore, they found that "fluency-oriented repetition of individual sentence contexts" facilitates collocation learning more effectively than exposure to the same collocations in new contexts (p. 182). Therefore, the use of sample sentences provides a benefit for learners.

With advances in technology leading to further development of flashcard software, future materials development should thus consider L1-L2 congruency in content creation, the use of a Leitner algorithm by focusing on item difficulty, and usage of multiple sides of flashcards to give learners a chance for productive practice as crucial factors in creating MWUs flashcards that lead to a long-term recall. Since one of the benefits of using digital flashcards is tracking performance, teachers should also consider this to track students' study times inside and outside of classrooms. Besides these essential factors, Nakata's checklist (2011) could be a fundamental criterion.

However, further research is still required to confirm the effectiveness of such software for the learning of MWUs by second language learners. Also, only a few studies have investigated incidental and intentional learning, and conducting a meta-analysis to introduce the benefit of these methods to gain MWUs is recommended.

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