The Effect of Working Memory on Bilingual Learning Ability

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Abstract. There is a growing concern about bilingualism, as acquiring two languages has gained popularity and is essential for communication living around the globe. Research suggests that higher working memory capacity could help store vocabulary and other linguistic information, thus enhancing one's ability for second language acquisition. However, some research proposes that there is a second language interference for bilinguals, and they have poorer performance than their counterparts in working memory and lexical tasks. It is because bilinguals' working memory capacity is impeded by the dominant language due to the simultaneous activation of both languages in their brain. Therefore, this literature review attempts to investigate the effect of working memory on bilingual learning ability by providing empirical studies to expound on the working memory capacity difference between monolinguals and bilinguals. The testing of working memory capacity is mainly conducted by lexical decision task and digit span task. The results found a bilingual advantage in working memory capacity, as they have been trained for better executive control.

Keywords: Working memory capacity; Second language acquisition; Bilingualism; Lexical decision task; Digit span task.

1. Introduction

The role of first language (L1) knowledge is of fundamental importance to bilingual development when a learner starts learning a new second language (L2). As Wolter suggests, the L1 conceptual structure has a strong influence on developing L2 lexical network as people can make semantic connections and assumptions about the target language [1]. However, it is suggested that such interaction between L1 and L2 conceptual knowledge is only useful for vocabulary learning in the initial stage. Second language learners cannot wholly rely on their L1 collocational knowledge as it does not suffice for building the L2 lexical network once the systems of two languages begin to diverge [1]. Hence, the lexical decision task is a good measure to indicate high level of language development as it tests word recognition and vocabulary size. The digit span task could also measure the working memory capacity, which helps to understand if there is a bilingual advantage [2, 3]. It is hypothesized that higher working memory capacity could help with second language acquisition, as one could use more working memory resources to store information and vocabulary. The literature has investigated the relationship between working memory and bilingualism, suggesting that working memory is essential for storing vocabulary and other lexical information [4, 5]. Therefore, this paper aims to investigate the effect of working memory on bilingual learning ability. As the number of bilinguals far exceeds the number of monolinguals, acquiring a second language has become an important skill to foster communication with one another. The literature review is to provide insight into bilingual learning ability by examining the working memory capacity difference between monolinguals and bilinguals.

2. Method

A literature search was conducted using the database Google Scholar. The following search terms were entered: bilingualism, working memory, working memory capacity, second language acquisition, and executive functions. Studies were selected if they included empirical data (compare monolinguals to their counterparts) and were published after 2000. A total of 10 empirical studies were identified from the literature.

3. Literature Review

3.1 Definition of Working Memory

Working memory is a brain system that has a limited capacity to temporarily stores information within a short time [6, 7]. According to Baddeley [7], working memory is an important system for storing and processing information simultaneously, which is required for performing cognitive tasks such as language learning and comprehension. Working memory consists of three components, each of which has a distinct function. The role of the central executive is to manage attention and coordinate information from the two slave systems [7]. For the slave systems, the phonological loop is essential for speech comprehension and production, as well as for storing phonological information [7]. Hence, it helps to hold and recall phonological information for vocabulary acquisition. The visuospatial sketchpad operates to manipulate and retain visual images [7].

3.2 Research Paradigms

3.2.1 Lexical decision task

Lexical decision task is mostly used to test the word recognition of bilinguals regarding their ability to process words in their second language. In Scarborough et al.'s study, they employed the lexical decision task to examine the priming effect of repetition on word recognition [8]. They investigated whether there is a lexical transfer of word recognition across both languages in the two lexicons. In their experiment, the Spanish-English bilinguals were first exposed to the target words in either English or Spanish and were subsequently presented with the repeated words of the translation equivalents in the second section. Results showed that there were priming effects within languages as subjects conducting tasks in both languages answered more accurately and responded faster to the repeated stimuli [8], especially for the low frequency words. However, no significant effect was found on subjects primed with translated Spanish words for word recognition in English, suggesting that repeating words in translation would not speed up word recognition in the other language [8]. Thus, bilinguals do not benefit from translations in recalling words of the other language, as it is unnecessary for bilinguals to translate words in their word recognition practice [8]. Since no transfer of lexical knowledge is found in the word recognition of translation, Scarborough et al. [8] postulated that word recognition is functioned as an independent process and bilinguals would not be interfered by the knowledge in the other language. In the second experiment, subjects were asked to respond negatively to stimuli that included non-words and real words in the non-targeted language. Results found that bilinguals could quickly reject non-words stimuli that were derived from words in the other language, suggesting that their ability to recognize words is not affected by their knowledge of the other language [8]. Hence, it is evidenced that bilinguals could selectively access lexical information in one lexicon and remain unaffected by the possible word association in another language [8].

As bilinguals possess the ability to speak two languages, they make use of their bilingual knowledge and code-switch on a regular basis. Code-switch is a common practice for bilinguals in which they mix two languages in a single conversation when speaking to interlocutors who speak and understand the same languages [9, 10]. To take account of their linguistic behavior, Soares and Grosjean conducted a pioneering study focusing on the lexical access of code-switching by a derived auditory lexical decision task [10]. The task was targeted at fluent Portuguese-English bilinguals, and it tested their ability to recognize words and non-words in a single sentence. They were first presented with sentences in English and Portuguese, respectively, followed by code-switched sentences in both languages. Their reaction time to words and non-words was then compared to the English monolinguals who only participated in the English section. Results found that there was no significant difference between the Portuguese-English bilinguals and the English monolinguals in the reaction time to words, but the bilinguals reacted slower to the code-switched words. The similar reaction time to word stimuli in one language for both bilinguals and monolinguals suggested that bilinguals did not process the residual activation of the other language when they were in a monolingual speech mode [10]. Soares and Grosjean also noted a surprising result from their study, the bilingual's reaction

time to non-words was similar across all modes and was substantially slower than those to words [10]. Soares and Grosjean [10] suggested that bilinguals operated in bilingual speech mode when they encountered a non-word. The non-words triggered their dual search in which they accessed lexical items from both lexicons [10]. They first completed a thorough word search from the base language lexicon, followed by a brief search of the other lexicon [10], thus delaying their reaction time to non-words.

3.2.2 Digit span task

On the other hand, some suggest that bilinguals would have a better working memory capacity than monolinguals, as language processing is heavily dependent on one's working memory [11]. They suggested that there is a bilingual advantage regarding executive function tasks, as bilinguals need to manage and select different languages in their daily use that require executive control [11]. The language management process requires working memory resources, as both languages are activated in the brain region even when bilinguals only need to use one language at a time [11]. As language selection requires a large number of working memory resources, consistent practice increases bilinguals 'working memory capacity and hence demonstrates their greater ability for attention control [11]. Therefore, Grundy and Timmer hypothesized that bilinguals would have a greater working memory capacity than monolinguals [11]. To test their working memory, Ardila carried out a digit span test to compare the working memory capacity between Spanish-English bilinguals and Spanish monolinguals [12]. Results showed that the Spanish-English bilinguals performed better than the Spanish monolinguals when the task was conducted in their first language. The age of second language acquisition is also an important factor in working memory tasks. Early bilinguals who acquired the second language before age 12 showed better performance in both digits forward and backward tasks conducted in English and Spanish than those late bilinguals [11]. It suggested that the more simultaneous bilinguals have a greater working memory capacity than the sequential bilinguals, exhibiting the bilingual advantage. Blom et al. [4] also conducted a study testing the working memory of bilingual Turkish-Dutch children. They noted that bilingual children are more competent in inhibiting incongruent task information as they have been training their executive control when managing dual language [4]. Therefore, they would also have better storage of visuospatial information. It is also evidenced in the results of Blom et al.'s [4], as the Turkish-Dutch bilingual children outperformed their monolingual counterparts in the working memory task, despite having a lower receptive vocabulary score. Blom et al. [4] also reported that the Turkish-Dutch bilinguals performed better in the backward digit recall task, as it requires executive control for both storage and processing. Although these participants were sequential bilinguals with a knowledge deficit of Dutch, they still outperformed the Dutch monolinguals in different working memory tasks. Therefore, it examined the bilingual advantage of having better executive control that would help improve their second language learning ability.

3.3 The Effect of Working Memory on Bilingual Learning Ability

A lot of research suggested a bilingual disadvantage in working memory as they consistently found a poorer performance of bilinguals than monolinguals in different memory tasks. Researchers suggested that the bilinguals' language storage system might contribute to their poorer performance in working memory tasks. As bilinguals have separate mental lexicons for storing lexical information of the two languages, it puts them at a disadvantage as more time is required for retrieving information from different locations in their memory [13, 14]. Apart from that, some researchers also noted that language dominance could also be a factor affecting their performance, as bilinguals usually are not balanced bilinguals who are equally proficient in both languages. The previous studies often compared bilinguals with their monolingual counterparts, which might not accurately reflect their working memory capacity difference as the monolinguals would be more familiar with the target language and possess more extensive vocabulary knowledge [13]. Therefore, Ransdell and Fischler [13] moderated the language familiarity effect by selecting native English-speaking bilinguals and

English monolinguals as their participants. They observed that bilinguals reacted slower to both words and non-words stimuli than monolinguals in the lexical decision task, with no significant differences in their accuracy rates [13]. It is suggested that the second language interference would negatively affect the bilinguals' performance on word recognition, as both languages were activated during lexical access in semantic memory [13].

However, researchers have found that higher working memory capacity could enhance bilingual learning ability, as working memory is associated with cognition and language processing [15, 16]. Since working memory operates concurrently to store and process information at the same time, the Constrained Capacity Model suggests that both processes consume and compete for resources of working memory with a limited capacity [15]. Therefore, people with high working memory capacity could have more cognitive resources for language processing and storing lexical information. Zhou et al. [15] conducted two experiments on 50 Chinese-English bilinguals whose English proficiency was at an intermediate level. First, they were asked to participate in a grammatical judgment task to identify grammatical and ungrammatical wh-questions by extracting subjects and objects as stimuli in the sentences. The subjects were divided into two groups to differentiate their working memory capacity according to their results in the OSPAN task. Results noted a negative correlation between working memory capacity and mean reading times. It suggested that the higher working memory group was faster at responding to the stimuli. However, there is no significant difference in accuracy rates between subjects with high and low working memory capacity.

The results were consistent with the Constrained Capacity Model, as judging grammatically correct sentences demands a considerable number of cognitive resources to pay attention to sentence processing [15, 17]. Hence, higher working memory capacity can provide more cognitive resources that are available for storing and processing information, thereby consuming less reading time [15]. Apart from the grammatical judgment task, the subjects were asked to translate the L2 target words into their first language verbally. The results of the translation task contrasted with that of the grammatical judgment task, which only showed the effects of working memory capacity on accuracy rates but not the reading latencies [15].

3.4 Non words Activation and Judgments

Researchers are particularly interested in second language interference on lexical access because the interaction hypothesis proposes that both languages are activated simultaneously during language processing [18]. Altenberg and Cairns [18] conducted a study on English-German bilinguals to test the effects of phonotactic constraints on their lexical judgement. Subjects participated in an English lexical decision task and were told to reject non-word stimuli that were made up of phonotactic violations of both languages. The results found that the phonological constraints of the second language heavily affected the non-word judgement of bilinguals in the base language. The English-German bilinguals spent similar time rejecting words that were illegal in the target language but legal in the other language and vice versa [18], showing that non-words that violate the phonological patterns of the non-targeted language would also be activated regardless of which language is used in the lexical decision task [18, 19]. Thus, the phonotactic constraints of both languages interact and were internalized by bilinguals when they retrieve words in the lexicons.

4. Implications

The empirical studies showed that bilinguals outperformed monolinguals in digit span tasks, thus suggesting a bilingual advantage in working memory capacity. It is suggested that improving one's working memory capacity could enhance their second language learning ability, as it is associated with better executive control for storing lexical information and managing dual language. Future studies could focus on other factors affecting bilingual learning ability, such as age and cognition. Research could also conduct longitudinal studies to monitor the gain in bilingual learning ability and

performance in second language tasks after intensive training for improving working memory capacity.

5. Conclusion

To conclude, this literature review has examined the effect of working memory capacity on bilingual working ability. Research suggested that bilinguals possess higher working memory capacity than monolinguals, as they are better at inhibiting nonrelevant information and possessing lexical information. This paper aims to investigate the effect of working memory on bilingual learning ability. As the number of bilinguals far exceeds the number of monolinguals, acquiring a second language has become an important skill to foster communication with one another. Bilingualism consumes a heavy load of working memory resources, which includes language selection, vocabulary choice, and inhibiting conflicting information. It is essential to improve working memory capacity to be more competent in learning a second language. Acquiring a second language is associated with one's working memory, hence suggesting that improving one's working memory capacity could provide more resources to store lexical information and language processing. Therefore, this literature review is to provide insight into bilingual learning ability by examining the working memory capacity difference between monolinguals and bilinguals, it provides insights for second language learners regarding bilingual learning ability, as expanding their working memory capacity could assist their language learning. They could process and react to the relevant information faster. It gives some pointers on future research on how to improve bilingualism to better make use of bilingual advantage on different lexical tasks.

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