Towards the correlation of working memory and incidental vocabulary learning

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Abstract: Working memory means a lot in incidental vocabulary learning and retention.The present study examines the correlation between two types of working memory—complex working memory and phonological short-term memory—and incidental vocabulary learning from captioned videos. After conducting an empirical research to 125 young learners of English as a foreign language with two working memory tests: an operation span test, which measured complex working memory, and a non-word repetition test, which measured phonological short-term memory. It showed that complex working memory did not significantly predict the effects of captioning types on incidental vocabulary learning and retention. However, phonological working memory significantly affects incidental vocabulary learning and retention. The findings suggest that the role of working memory varies as a function of captioning types. Complex working memory and phonological short-term memory may have different predictive effects in incidental vocabulary learning and retention under different captioning types.

1 INTRODUCTION

The constraints in incidental vocabulary learning from captioned videos may be due to learners' limited working memory resources[1]. This limitation suggests a need to research how learners cognitively remember the words demonstrated by different types of captions while considering their working memory resources. A study on the association between working memory and incidental vocabulary learning may offer some implications.

2 LITERATURE REVIEW

2.1. Captions on language learning and working memory

Of the theoretical frameworks supporting the effectiveness of captions on language acquisition, dual-coding theory[2], working memory model[3], and multimedia principle[4] stand out. According to the dual-coding theory, there are voluminous and meaningful referential interconnections helpfully linking the dually coded items. The two representational systems—the verbal system and the imagery system (mental images and pictures), though separate, can co-activate each other. The captions in the target language with soundtrack in videos offers an overview of a dynamic speech, guiding learners to better gain language recall and acquire new vocabulary.

The working memory model includes three components: central executive, visual-spatial sketchpad, and phonological loop, the latter two of which are storage subsystems. As a memory control system, the central executive component is involved in coordinating information retrieved from the two memory subsystems. Visual coding, represented by the visual-spatial sketchpad, is responsible for handling spatial imagery information. Phonological loop, a component of acoustic coding, plays a great role in vocabulary learning and speaking competence. This model brought out the assumption that processing knowledge can be effectively enhanced when the textual information is simultaneously demonstrated in both verbal and pictorial forms via audio-visual input.

2.2 Working memory and incidental vocabulary learning

There is a growing evidence that working memory played a significant role in vocabulary learning [5-7]. As a brain system, working memory is crucial in language learning because it helps simultaneously storing and processing information [8]. Of the three subcomponents, the visual-spatial sketch pad helps comprehend the visual images when watching videos together with the speech-based information, thus facilitating the language vocabulary learning. In the light of the model of working memory[3], the phonological loop is assumed to be a significant factor in language learning as it contributed a lot to the short-term memory of acoustic information, including word recognition, speaking fluency, as well as reading comprehension [7,9-10].

Atkins and Baddeley[11] investigated the relationship between working memory and distributed vocabulary acquisition using both auditory and visual

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span tests. Through a sample of 30 adults subjects learning 56 English-Finnish translation pairs, the visual-spatial recall test and tests of short-term memory were administered. They found that the phonological memory span had a reliable correlation with the rate of vocabulary learning when semantic strategies are successfully applied. Visual-spatial span did not significantly affect word acquisition, suggesting the key role of the verbal temporary memory in vocabulary learning. Besides, the subjects were less likely to recall the words that were difficult during the initial learning after one week despite deliberately learning.

Based on a total of 121 Hungarian secondary students who took the Cambridge First Certificate Exam, Kormos and Sáfár[12] also found a high correlation between working memory and vocabulary learning. In particular, vocabulary learning is influenced by the central executive component of working memory that controls attention, as specified by Baddeley[13]. Another study done by Martin and Ellis[14] with 40 monolingual native English participants learning artificial lexical material in an American university documented the positive correlation between vocabulary production and working memory. One surprising result was that there is no significant correlation between working memory and vocabulary comprehension. This gives implications in language learning and teaching as it illustrated that working memory plays different role on different aspects of vocabulary learning.

Montero Perez[1] examined how the subjects' existing vocabulary knowledge and working memory correlated with incidental L2 vocabulary acquisition from captioned videos. A total of 63 higher-intermediate students learning French as a second language took part in four unprompted word tests on form and meaning after watching a French documentary video containing 15 pseudowords. Data demonstrated that the participants picked up new words incidentally at the level of form and meaning recognition and that their previous vocabulary knowledge was highly related to new vocabulary learning gains from watching videos. As for the working memory, it revealed that the degree of complex working memory was positively related to the vocabulary learning. That said, the higher the complex working memory was, the more incidental vocabulary learning gains occurred.

The above studies showed that working memory positively correlates with vocabulary learning. However, different components of working memory facilitate vocabulary acquisition differently[6]. Moreover, learners' individual differences may be taken into account when it comes to evaluating working memory and incidental vocabulary acquisition from captioned videos.

2.3 The present study

This study examines the correlation of incidental vocabulary learning with working memory.Four types of captions are applied here, namely, full captioning, keyword captioning, and glossed captioning, and without captioning. Aiming to investigate the influence of working memory on learners' incidental vocabulary learning and retention through audio-visual input, the present study provides insight into incidental vocabulary learning from captions through addressing the following question: Does working memory predict learners' incidental vocabulary learning and retention gains in different captioning type?

3 METHODOLOGY

3.1 Participants

A total of 125 students in grade 6 (61 boys, 64 girls) were recruited from a primary school where Chinese is used as the main language for daily instruction. All participants(Mage=12.17, SD=1.06) started their English learning from third grade as foreign language (EFL). An original number of 134 students were invited. A consent form were signed by both the participants and their parents informed that they would accomplish some English exercises after watching corresponding video clips.The participants were randomly assigned to four groups: glossed captioning (n=31), full captioning (n=32), and keyword captioning (n=32), and the control group of watching the clips without captioning (n=30).

3.2 Working memory

The present study focused on the assessment of learners' phonological and complex working memory. The two WM tests were developed through JavaScript and administered via a link. Each participant finished the tests through an IPad. The system could automatically record learners' performance and reaction time.

3.2.1 Phonological short-term memory (STM)

The assessment of phonological STM was through a non-word repetition task[15], which only focused on the storage component of STM[16]. The participants were required to listen to 22 lists of target words for this test. After listening to each list, they were required to repeat the words in order. Each list comprised of 2-6 one-syllable consonant-vowel-consonant words. To minimize the influence of learners' prior L2 vocabulary knowledge on this WM test performance, the present study adopted non-words, which were drawn from the restricted pool of phonemes that were expected to be familiar to primary school students. All of the items within a list had a different vowel. In addition, the consonant composition of each list was as distinctive as possible. One issue to be noted was that it was quite impossible to repeat a single consonant within a single list on some trials for the five- and six-item sequences in considering the constraints imposed by the limited phoneme pool and the lexical condition list length increased over trials. Thus, testing first commenced with the two-item lists, followed by the three, four, and so on up to the six-item lists. Within each list length, the trials were unpredictably ordered.

The rate of presenting one item was approximately 750 ms. The final word of the list and the initial word of the second list was separated by a longer interval, which was approximately 1.5s. The learners were familiar with this through a trial session before the actual test. The test was completed within five minutes. A native speaker of English was invited to record the stimuli. The 22 lists of one-syllable words equalled to a total of 100 items. One point was given for each correctly recalled word. Learners' possible maximum performance was 100 points.

3.2.2 Complex working memory

The assessment of complex working memory was through O-span task, which was based on previous studies [17,18]. The O-span task focuses on both the processing and storage components of STM. This task required the participants to solve a series of math operations while attempting to remember a set of unrelated L1 words. The use of L1 words was to avoid the possibility that learners' individual differences in their L1 prior knowledge may influence their working memory capacity. One issue to be noted was that although the words were in L1, working memory is an individual cognitive variable that is not related to language [19]. The participants solved one math operation-word at a time. For each trial, the learners needed to read aloud and solve the math problem and then read aloud the word. For example, after seeing "7+9=?", the learners needed to calculate the answer while having to remember the subsequent target word "hua1yuan2 garden".

The operation–word strings were presented in sets of two to five items, which were also called set sizes. The order of set sizes commenced from two items, followed by three, four, and then up to five items. The learners had to recall the words in the order presented following each set size. This test included 60 operations and 60 target letters. At recall, the participants were required to click the word they regarded as remembered items in their mind. To avoid learners' deliberate memorization of target words while having wild guessing for the operation, we set an 85% accuracy criterion on the math operations[18]. Such requirements were also consistent with the test requirement, which was to understand the processing and storage components of STM. Learners were familiar with this test through three sets of practice. Following Unsworth et al.[18], we adopted absolute scores, for which only a correctly recalled item in the correct position was awarded with one point. The total number of correct items in the correct position reflect the total maximum scores, which were 60 points. Learners spent 10 minutes for this test.

3.3 Procedures

It took seven weeks to conduct this study. After filling the consent form as well as the pre-test, all learners were assigned to watch the designated video and try to understand its content. The participants were not allowed to know the main objective of the experiment until finishing all the experiment. When it came to the fifth week, participants of different groups received a treatment respectively. After watching each video, which was played only once, learners would do some comprehension exercises, as well as a vocabulary test. Following the immediate posttest, the learners spent 15 minutes for the two WM tests. And a delayed vocabulary test would be held two weeks later.

3.4 Data analysis

Data was normally distributed. A Generalized Estimating Equation (GEE) in SPSS was conducted to determine how the variables of phonological and complex WM explained the incidental vocabulary learning and retention gains. Only the data of the three experimental groups were used in this analysis. The advantage of GEE resides in the unbiased estimation of regression coefficients. The two WM variables were entered into the model .

4. RESULTS

The research explored the predictive effects of working memory on learners' incidental vocabulary learning and retention gains, GEE was adopted. Results were presented in Table 1.

Table 1 shows the standard regression coefficient for working memory as a predictor (B), the Wald Chi-Square in locating if explanatory variables in a model are significant, as well as the p value. The results reveal that phonological working memory was a significant predictor of the immediate form recognition post-test, B=.008, Wald Chi-Square=7.427, and p<.05, as well as the delayed form recognition post-test, B=.011, Wald Chi-Square=9.489, and p<.05. Phonological working memory was also a significant predictor of the immediate meaning recall post-test, B=.012, Wald Chi-Square=9.307, and p<.05, as well as the delayed form recognition post-test, B=.014, Wald Chi-Square=7.544, and p<.05. However, complex WM was not significant predictor of either the immediate or delayed test of meaning recall test.

Table 1. GEE results

Test	Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
				Lower	Upper	Wald Chi-Square	df	p
Form recognition (post-test)	Phonological WM	.008	.0028	.002	.013	7.427	1	.006
	Complex WM	-.006	.0033	-.012	.001	2.863	1	.091
Form recognition	Phonological WM	.011	.0035	.004	.017	9.489	1	.002

(delayed test)	Complex WM	-.005	.0041	-.013	.003	1.388	1	.239
Meaning recall (post-test)	Phonological WM	.012	.0040	.004	.020	9.307	1	.002
	Complex WM	-.008	.0047	-.017	.001	2.971	1	.085
Meaning recall (delayed test)	Phonological WM	.014	.0050	.004	.024	7.544	1	.006
	Complex WM	-.011	.0058	-.022	.001	3.415	1	.065

5. DISCUSSION

The present study explored the extent to which phonological and complex working memory were associated with the efficacy of different captioning conditions on incidental vocabulary learning gains and retention. GEE was conducted to determine whether the two types of WM were significantly associated with incidental vocabulary learning and retention gains. The findings revealed that phonological short-term memory was a significant predictor of the effects of captioning types on incidental vocabulary learning and retention gains. However, complex working memory was not a significant predictor.

The results echoed with previous findings that the phonological loop is mainly responsible for the temporary memory of acoustic information (i.e., word recognition, speaking fluency, as well as reading comprehension), thus facilitating the incidental vocabulary learning [7,9,10]. As the verbal short-term memory contributed a lot to vocabulary acquisition [11], the phonological memory span was highly correlated with the new word recognition when watching the captioned videos that offers sufficient opportunities for the learners to conduct the acoustic information, leading to possible meaning-making solutions.

The framework of Baddeley's[20] working memory model could also explain such predicting effects in incidental vocabulary learning. According to Baddeley[21], the two perceptual domains (i.e., a visual and verbal) worked separately without interfering with each other while the collaboration of verbal associations and visual imagery is administered by the central executive, a supervisory system that governs the flow of message, and the episodic buffer, a system that offers temporary storage of information. So, when the learners encounter imagery message, they could infer the verbal information from the auditory panel, presenting information in a dual modal [22] . Similarly, the mutual reinforcement of perceptual associations with pictorial coding and semantic associations with verbal inferring help enhance the dual-modal manifestations [2]. Thus, the learners' prior knowledge, together with the verbal and pictorial representations reinforce the working memory to better process the specific information relating to new vocabulary.

6. CONCLUSION

Although the students have much more access to TV videos than before, proper treatment of the auditorial and pictorial information would be necessary to facilitate their language learning, where vocabulary acquisition is the must. The results show that the Phonological short-term memory has a significant predicting effect towards incidental vocabulary learning. More treatment on the visual and pictorial information of the videos may benefit the students in incidental vocabulary acquisition.

Pedagogically, it is beneficial to EFL learning and teaching to a certain degree. Further researches could be done to investigate the working memory towards incidental vocabulary learning. Like what kind of pictorial and auditory information would best respond to the Phonological short-term memory? Is it possible to stimulate the Complex working memory more positive in predicting learners' word learning? There are more efforts to come.

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