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THE EFFECTS OF WORKING MEMORY AND BOREDOM ON L2 READING PERFORMANCE

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ABSTRACT

As an important issue in the field of psycholinguistics, working memory gradually becomes popular in Second Language Acquisition (SLA). Since working memory in language processing involves cognitive and affective perspective, the relationship between working memory capacity (WMC) and academic emotion can be further investigated, and boredom is chosen as a specific emotion in this study. On this basis, this study selected 46 undergraduate students at a research-oriented university located in northwestern China, explored the relationship between WMC and boredom, and discussed the effects of WMC and boredom on L2 reading performance. The results show that: 1) there exist negative correlation between boredom and WMC; 2) WMC has a main effect on L2 reading comprehension and L2 learners with larger WMC gain higher reading scores; 3) boredom does not affect participants' reading performance, which may be caused by limited sample size or other individual differences, such as learners' motivation and strategies in the process of language learning.

Keywords: Boredom, L2 reading comprehension, Working memory capacity

1. Introduction

1.1 Introduction to Working Memory from the Perspective of Psycholinguistics

Working memory (WM) generally refers to "the temporary storage of information that is being processed in any range of cognitive tasks" [1]. And several hypotheses related to working memory are briefly mentioned in the following words. Theoretically, according to the Baddeley-Hitch Model, WM is composed of three components: the central executive (a limited capacity pool of general processing resources), the visuospatial sketchpad (to temporarily maintain and

[1] Baddeley, A.. *Working memory*. New York: Oxford University Press, 1986.

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manipulate visuospatial information), and the phonological loop (to convert auditory and visual materials into phonological representations and hold them in the phonological store). Also, the implications of working memory capacity (WMC) and executive functions are pervasive and consequential for constraining and shaping everyday cognitive activities in language comprehension, arithmetic, reasoning, and many other cognitive tasks [2]. Therefore, as a system that can hold a limited amount of information in a heightened state of availability for use in ongoing information processing, WMC plays an essential role in learners' cognitive processing; whereas it could be affected by learners' individual differences and situational changes. Regulating individual emotion through psychological intervention can have a positive effect on working memory, which is beneficial to learners' language comprehension.

1.2 Introduction to boredom from the perspective of Second Language Acquisition

The past decade has witnessed a growing wave of research on emotions of SLA. Scholars are gradually recognizing the diversity and significance of language learners' academic emotions[3]. With the increasing number of theoretical and empirical studies, the research objects have been expanded from foreign language learning happiness to a variety of positive and negative academic emotions including love, enjoyment, shame, boredom, etc. Among the above range, this study will focus attention on boredom. Boredom, universally experienced in educational context, is an unpleasant emotional or psychological state, associated with low physical arousal and cognitive stimulation, as well as specific time perceptions and action tendencies[4]. Specifically, two kinds of boredom are recognized: trait boredom and state boredom. Trait boredom refers to a relatively stable proneness, disposition, or habitual and recurring boredom experience in relation to a learning activity or a subject while state boredom refers to momentary, transient boredom experience instigated in reaction to a given situation[5]. They permeate educational settings, consistently being detrimental for individual academic functioning, negatively affecting individual engagement, cognition, motivation, outcomes, etc.

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[2] Cowan, N.. *Working Memory Capacity*. Hove: Psychology Press, 2005.

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1.3 Interaction of emotion and working memory

Research on emotion and working memory mainly focuses on emotional states. The typical research method is to induce the subjects to enter positive or negative emotional states first, and then let them complete the working memory tasks. However, since the study of normal people's negative emotions is helpful to reveal the mechanism of psychological diseases such as anxiety and depression, the existing research mainly focuses on the effect of negative emotions on working memory. Emotional or affective working memory is a research trend that combines emotion and working memory, and it can be defined as the ability to successfully deploy WM in emotionally stressful context. Although emotional working memory is quite well investigated in general psychology, not much research has looked into its potential implications for second language acquisition (SLA) research until recently. Wen et al. (2022)[6] tried to propose and prove that WM had not just cognitive implications, but its affective dimension may also make complementary and unique contribution to language and SLA research. Based on their conceptual framework integrating cognitive and affective WM perspectives, it provides a theoretical basis and possibility for the present study to link working memory capacity and academic emotion to investigate their interrelationship and their effects on L2 learning.

2. Research Methodology

2.1 Research Questions

This study will discuss the influence of two factors on L2 learners' reading comprehension, that is, working memory capacity (WMC) and boredom emotion's functions in the process of L2 learning. The specific research questions are as follows:

Q1: What is the relationship between boredom and L2 learners' working memory capacity?

Q2: What are the effects of different working memory capacity and individual boredom degrees on L2 reading comprehension?

2.2 Experimental Tools and Data Collection

2.2.1 Working Memory Capacity – Reading Span Measures

[6] Wen, Z., Teng, M.F., Han, L. & Zeng, Y.. "Working Memory Models and Measures in Language and Bilingualism Research: Integrating Cognitive and Affective Perspectives". *Brain Sci*. 2022, 12, p. 729-745.

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In this study, Waters and Caplan's (1996)[7] modified version of Daneman and Carpenter's reading span experiment was adopted to test the participants' working memory span. Different from "simple span" tasks, such as the digit span and letter span, this modified version can measure both storage and executive functions of working memory. The procedure of reading span measure was first to read a series of unconnected sentences aloud at subjects' own pace, and they had to remember the final word of each sentence of the set at the same time. The end-of-sentence words in the originally presented order at the end of a set represented the storage function.

The stimulus sentences consisted of 40 sentences, which ranged in length from 5 to 9 words and half of these sentences were irrational. Testing began with sequences of two sentences, and the number of sentences in a set was incrementally increased. The total number of final words correctly recalled represented the participants' span. In this study, all subjects were tested on all span sizes from 2 to 6. At first, participants need to decide whether one sentence makes sense or not (processing function) and then to recall the end-of-sentence words in sequence (storage function). For example, an experiment at span size 3, three sentences would be presented sequentially to participants: 1) Dogs always bark at strangers; 2) The cook is baking the chicken; 3) The jacket doesn't believe in the bull. They should read each sentence aloud, judge the rationality of sentences, and then recall the three sentence-final words (strangers, chicken, bull) in the correct order. They could get 1 point for each sentence they judged correctly and 1 point for each word they recalled correctly, and the final score was calculated using the average of these two kinds of scores (40 points in total).

2.2.2 Foreign Language Boredom Scale (FLBS)

In this study, three factors including 18 items measuring boredom were adapted from the boredom subscale of Foreign Language Boredom Scale (FLBS; Li et al., 2020)[8]. FLBS was a 5-point Likert scale ranging from 1 "strongly disagree" to 5 "strongly agree", and it involved seven factors of boredom, including foreign language class boredom, under-challenging task boredom, PowerPoint presentation boredom, homework boredom, teacher-dislike boredom, general learning trait boredom, and over-challenging or meaningless task boredom. Since this study focused on L2 reading performance, totally 18 items of three factors were selected to measure

[7] Waters, & Caplan, S.. "The measurement of verbal working memory capacity and its relation to reading comprehension". *Q J Exp Psychol A*, 1996, 49(1), p. 51-75.

[8] Li, C., Dewaele, J. M., & Hu, Y.. "Foreign language learning boredom: conceptualization and measurement". *Applied Linguistics Review*, 2020.

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participants' boredom degree: 1) foreign language class boredom (α=0.949); 2) under-challenging task boredom (α=0.940); 3) general learning trait boredom (α=0.900).

2.2.3 L2 Reading Test

In order to investigate the effects of working memory capacity and boredom degree on L2 learners' second language reading performance, reading comprehension questions were used to test their reading comprehension differences. Due to the participants' foreign language proficiency had reached CET-4 and they were preparing for CET-6, the reading comprehension test used in this study was based on the reading comprehension section of CET-6 in December, 2021. In order to achieve objective testing and evaluation standards, only multiple-choice questions in Section C (10 questions, 2 points for each question, 20 points in total) were selected in this study, and subjective questions were not involved.

2.3 Participants

The sample size for the quantitative study was 46 undergraduate students at a research-oriented university located in northwestern China (a key university of Project 985). They were selected in the activities organized by the School of Foreign Studies, which aimed at helping non-English major students pass the CET-4 and CET-6, and this study merely focuses on L2 learners with CET-4 proficiency. The numbers of the participants from Year 3 and Year 4 were 18 (39.13%) and 28 (60.87%) respectively. A total of 34 (73.91%) participants were females and 12 (26.09%) males. The mean age was 21.65 (*SD=0.59*). The students were from disciplines including math, computer science and technology, business administration, biology, automation, law, and physics.

The author uploaded the composite questionnaire to an online survey tool Wenjuanxing and retrieved its QR code, which allowed the participants to scan the code with their mobile phones and get access to the online questionnaire. Because reading span test was more complex, the questionnaire just included two parts: the first part was basic information, such as gender, age, major of the participants; the second part was foreign language boredom scale (18 items; five-point Likert-scale: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree), which was applied to measure boredom degrees of the participants. After finishing the questionnaire survey, 46 participants' boredom scores were calculated, participants who scored in the top 10 and bottom 10 were selected for the high-boredom group and low-boredom group respectively. Then, these 20 participants took the reading span test for measuring their working memory capacity, and they were further divided into low-working memory capacity group (participants who scored in the bottom 10) and high-working memory capacity group (participants who scored in the top 10) according to their scores.

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2.4 Statistical method

The results of this study were found through quantitative data, a series of descriptive statistics, correlation analyses, and two-way ANOVA were conducted via SPSS 20.0 to answer the two RQs. Specifically, the author used Pearson correlation analysis to explore whether there was relationship between boredom and L2 learners' working memory capacity; and two-way ANOVA was selected to investigate the effects of WMC and boredom on La reading comprehension performance.

3. Results and Discussion

Since this study combines working memory and academic emotion together to investigate their correlation and their effects on L2 learners' reading comprehension, the author establishes a hypothesis-model (Fig. 1). The following discussion will be based on this model.

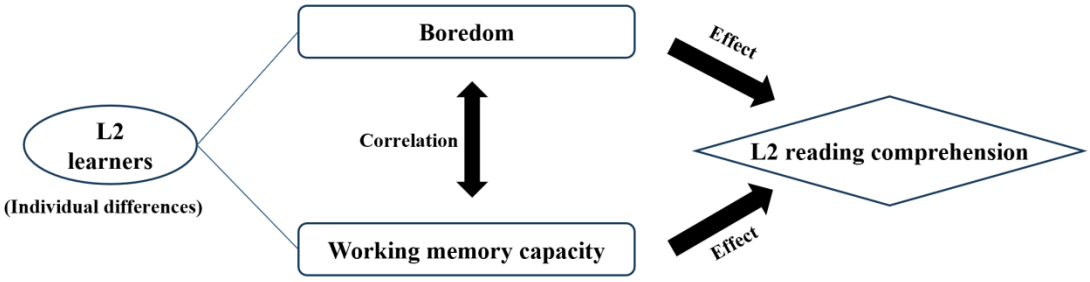

Fig. 1. The hypothesis-model of working memory capacity, boredom, and L2 reading comprehension

3.1 Relationship Between Working Memory Capacity and Boredom

The results of the descriptive statistics are presented in Table 1. The mean score of reading span test is 32.275 out of 40 (*SD=2.65*), the mean score of boredom is 52.3 out of 90 (*SD=18.84*), and the mean score of reading comprehension test is 15.2 out of 20 (*SD=1.51*). As indicated by the mean scores in Table 1, in general student participants showed high levels of working memory capacity and reading comprehension, and a moderate level of boredom.

Table 1. Descriptive Statistics of Working Memory Capacity and Foreign Language Boredom

Variable		N	Min	Max	Mean	SD
WMC	High-WMC	10	32.50	36.50	34.350	1.58
	Low-WMC	10	27.00	32.00	30.200	1.67

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	Total	20	27.00	36.50	32.275	2.65
Boredom	High-boredom	10	58.00	78.00	69.000	8.15
	Low-boredom	10	21.00	44.00	35.600	7.96
	Total	20	21.00	78.00	52.300	18.84
Reading comprehension		20	12.00	18.00	15.200	1.51

Note: WMC=working memory capacity.

In order to explore the relation between students' WMC and their level of boredom emotion, the author then conducted a Pearson correlation analysis to examine it (see Table 2). The results in Table 2 show a significant correlation between WMC and boredom (r=-.557, p=.011), and L2 learners' working memory capacity would be negatively related to boredom. In other words, students felt less bored tended to own high working memory capacity, while those who felt more bored may be endowed with low working memory capacity.

Table 2. Correlations Between Working Memory Capacity and Boredom (*N=20*)

	Correlations with Working Memory Capacity	
	r	***p***
Boredom	-.557*	.011

Note: * p<0.05, ** p<0.01, ***p<0.001.

3.2 The effects of working memory capacity and boredom on L2 reading comprehension

Before analyzing the respective effects of working memory capacity and boredom on second language reading comprehension, it is necessary to verify whether these two factors are relevant for the participants' reading comprehension. Thus, a correlation analysis is conducted (see Table 3).

Table 3. Correlations of Two Variables with Reading Comprehension

	Correlations with Reading Comprehension	
	r	***p***
WMC	.716**	.000
Boredom	-.384	.095

Note: * p<0.05, ** p<0.01, ***p<0.001; WMC=working memory capacity.

Using the Pearson correlation coefficient to indicate the strength of their correlations, from the table 3 it can be seen that: the correlation coefficient between reading comprehension and WMC is 0.716 and shows a significance of 0.000, thus indicating that there is a significant positive correlation between participants' reading performance and WMC. As for variable boredom, the

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correlation coefficient value between reading comprehension and boredom is -0.384, which is close to 0, and the p-value is 0.095>0.05, thus indicating that there is no correlation between reading comprehension and boredom.

Table 4. Two-way ANOVA of Working Memory Capacity and Boredom in L2 reading

Source	Quadratic sum	df	Mean square	F	Sig.
Intercept	3949.867	1	3949.867	2962.400	.000**
WMC	16.800	1	16.800	12.600	.003**
Boredom	.000	1	.000	.000	1.000
WMC*Boredom	1.867	1	1.867	1.400	.254
Residual	21.333	16	1.333		

Note: * p<0.05, ** p<0.01, ***p<0.001; WMC=working memory capacity.

Table 5. ANOVA of Working Memory Capacity and Reading Comprehension

	Working Memory Capacity (Mean±SD)		*F*	*p*
	High-WMC (n=10)	Low-WMC (n=10)		
Reading comprehension	16.20±1.14	14.20±1.14	15.517	.001**

Note: * p<0.05, ** p<0.01, ***p<0.001; WMC=working memory capacity.

Based on the correlation analysis, one-way and two-way ANOVA is used to further investigate the effects of working memory capacity and boredom on reading performance. It can be seen from Table 4 that: working memory capacity shows a significant (F=12.600, p=0.003<0.05), indicating the existence of a main effect that working memory capacity will have a differential relationship on L2 reading comprehension. Consistent with the results of the correlation analysis, boredom does not show significance (F=0.000, p=1.000>0.05), thus boredom will not affect participants' reading performance, and there is also no second-order effect between WMC and boredom (F=1.400, p=0.254>0.05). In Table 5, working memory capacity presents a significant influence on reading performance (F=15.517, p=0.001), and a specific comparison can be seen that students with high-WMC (*Mean*=16.20) perform better than those with low-WMC (*Mean*=14.20). Briefly, the independent variable working memory capacity plays a major influence on the dependent variable reading performance, i.e., the higher the working memory capacity of the L2 learners, the higher their scores in the reading test and the better their reading comprehension. However, the inclusion of another independent variable boredom neither shows significant effect on reading comprehension nor affects the original relationship between WMC and reading comprehension. And the hypothesis model is revised based on the findings (Fig. 2).

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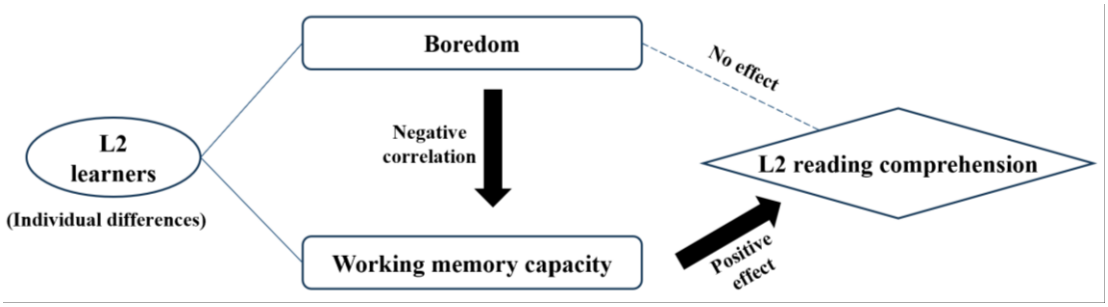

Fig. 2. The revised model of working memory capacity, boredom, and L2 reading comprehension

3.3 Discussion and Implications of the Findings

Boredom, as a negative emotional state, often accompanied by disinterest in cognitive task. Through data analysis, the results show that there is a negative correlation between boredom and working memory capacity, indicating that high boredom level impairs individuals' WMC and individuals with high boredom are easily distracted by psychological features such as lack of interest during working memory processing. Therefore, high-bored learners present lower WMC, which further influences their efficiency of completing cognitive processing tasks. Also, the present study shows that working memory capacity influences Chinese English learners' L2 reading comprehension to a great extent, while boredom has no effect on their reading performance. Baddeley once pointed out that language comprehension relies on working memory. Therefore, the capacity of working memory affects not only the time to store information in short-term memory, but also the processing speed to retrieve existing information in long-term memory. Thus, L2 learners with larger WMC could store more information and process it faster during reading. In this study, participants in high-WMC group have higher scores in reading span test than low-WMC group and therefore obtain higher scores in reading task. Text comprehension is positively correlated with WMC, and individual differences in cognitive skills can be predicted by individual differences in completing working memory task, which is consistent with previous studies. Therefore, foreign language reading teaching should focus on the improvement of students' working memory capacity.

Emotion plays an important role in cognitive activities and psychological mechanisms, and it is closely associated with learning activities. However, the experimental results of this study show that the size of working memory capacity have a significant effect on Chinese English learners' reading comprehension process, but boredom does not influence L2 reading scores. The reasons may be as follows: 1) The effect of individual differences in learning motivation and strategies have greater effect on reading than that of boredom; even though boredom affects WMC to some extent, it fails to influence L2 learners' reading performance by itself. 2) Participants show

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moderate level of boredom through boredom scale and have no excessively high or low boredom scores, which may lack predictability to the results, sample size is also a limiting condition. 3) Although internal emotions have certain influence on WMC, there also exist external factors. English is a foreign language that college students must learn, and the participants who in the preparation stage for CET-6 cannot slacken English learning and reading practice, Therefore, their performance would not be overly affected by boredom level in L2 learning, since working memory mechanism and motivation still play a major role in this process.

4. Conclusion

This study, based on the experiment and self-established model, aims to investigate the relationship between L2 learners' working memory capacity and boredom and the effects of these two factors on L2 reading performance. Therefore, this study associated emotion and WMC with second language reading in a novel way. Due to the limitation of time, the present study still has certain limitations. As for further studies, they can be improved by expanding the sample size in the aspect of type and further considering other types of academic emotions.

To begin with, the subject size is limited. The current study only focused on 20 English learners, and more participants should be invited to conduct a more comprehensive quantitative study. Multiple perspectives upon boredom and working memory capacity should be considered such as from the standpoint of teachers. English teachers could be interviewed regarding their observation and evaluation on their teaching so a reciprocal verification can be attained.

Secondly, it would be more persuasive and scientific to adopt a mixed method, namely quantitative and qualitative methods combined in this study. In this way, qualitative analysis can be significant supplement and extension of quantitative results. For example, in order to explore deeper causes of the insignificant relationship between boredom and L2 reading comprehension, the author can ask learners about their perceptions through interviews.

Additionally, participants in this study are a bit general, and they can be further subdivided by consider their language proficiency. And it would be more reasonable to take multiple emotions into account, instead of limiting to one type of emotions, i.e., boredom. In this way, it is possible to explore whether there are other emotions that have a significant effect on second language reading performance, such as positive emotions or other negative emotions like anxiety, anger, disgust, fear, etc.

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