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The Effects of Meta-cognitive Strategies, Working Memory Capacity and Syntactic Awareness on L2 Reading Comprehension

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The present study explores the effects of meta-cognitive strategies, working memory capacity (WMC), and syntactic awareness on Chinese EFL learners' L2 reading comprehension. One hundred and sixty-seven Chinese college students who were enrolled in the required English class, aged from 19 to 21 years, participated in this study. A questionnaire related to meta-cognitive strategies, a reading span test, a syntactic knowledge test, and a reading comprehension test were administered to the participants to collect data. Descriptive statistics, one-way ANOVA, a correlation analysis, and a multiple regression were used to analyze the data. Results showed that there were significant differences in meta-cognitive strategy use, working memory capacity, and syntactic awareness among three groups of differing English reading abilities. Syntactic awareness was the most strongly correlated with reading comprehension. The result of a regression analysis indicated that meta-cogitation, WMC, and syntactic awareness all showed a statistically significant prediction for L2 reading comprehension. Accordingly, the results suggest that instruction for developing reading comprehension should prioritize syntactic awareness, and then focus on the activation of WMC together with the use of reading strategies for successful reading comprehension. From the results, some practical implications to effectively improve L2 reading comprehension are provided at the end.

Keywords: meta-cognitive strategies, working memory capacity, syntactic awareness, reading comprehension, Chinese EFL learners

1 Introduction

Reading English is one of the fundamental and important skills that EFL

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learners have to master to be a competent global citizen. Reading is regarded as a complex and dynamic process involving different types of factors, which includes linguistic and cognitive variables. Among the linguistic factors, syntactic awareness is an essential part of linguistic knowledge. With the help of syntactic awareness, people can correctly understand the syntactic and logical relationship between letters and words, distinguish the specific meanings in instances of polysemy, and then achieve understanding of the meaning of the sentences. Research has shown the importance of syntactic knowledge for L2 reading comprehension (Jiang, 2001; Liu & Bever, 2002; Sun, 2003; Tang, 2002).

As a complicated cognitive process, it is implied that reading may be affected by various cognitive factors as readers utilize prior knowledge and resources to decode the written text. Recently, among cognitive factors, meta-cognitive strategy and working memory capacity have been studied as major variables to understand the whole process of reading comprehension. Meta-cognitive strategies are those activities that make readers aware of their thinking while reading. Recent research has noted that meta-cognitive strategies contributed to EFL students' reading behaviors, indicating that meta-cognitive reading strategies have a positive relationship with reading comprehension performance (Ahmadi & Ismail, 2013; Carrell et al., 2012; Latawiec, 2010; Muñizswicegood, 1994; Phakiti, 2003; Zhang, 2009; Zhang & Seepho, 2013).

Research efforts have been extended to examine the relationship between working memory and language learning. The concept of working memory is based on the idea of short-term memory from Baddeley and Hitch (1974), which describes temporary information processing and storage. Researchers have observed that working memory plays an important role in advanced cognitive activities such as reading and reasoning (Conway et al., 2007; Jarrold & Towse, 2006; Loosli & Buschkuehl, 2012; Miyake & Shah, 1999; Miyake, 2001).

So far, however, few studies have attempted to investigate how meta-cognitive strategies, working memory capacity (WMC), and syntactic awareness were interrelated in L2 reading. Moreover, there is no empirical research that has ever covered the effects of meta-cognitive strategies, WMC, and syntactic awareness in L2 reading comprehension from a comprehensive perspective. Therefore, the present study aimed at examining: whether meta-cognitive strategies, WMC, and syntactic awareness make an influence on reading comprehension as independent variables; which correlations can be found between meta-cognitive strategies, WMC, syntactic awareness, and reading comprehension; and how meta-cognitive strategies, WMC, and syntactic awareness predict Chinese EFL learners' reading comprehension. In addition, this study intended to shed light on effective ways to improve Chinese EFL learners' reading abilities.

2 Literature Review

2.1 Meta-cognition and reading

Meta-cognition is the knowledge of one's own cognitive processes (one's thinking) (Flavell, 1979). It is considered to be a critical component of successful learning and a higher-order thinking skill. Two components of meta-cognition are generally recognized: (1) knowledge about cognition, and (2) regulation of cognition. Meta-cognition involves self-regulation of strengths, weaknesses, and the use of strategies, such as organizing, monitoring, and adapting. Additionally, it is the ability to reflect on the tasks or processes of undertaking, selecting, and utilizing appropriate strategies in intercultural interactions.

Bruner et al. (1956) proposed the concept of meta-cognitive strategy, referring to it as the effective monitor and control of cognitive processes and outcomes. Meta-cognitive strategy controls the flow of information, and it monitors and guides the implementation of cognitive processes, including planning strategies, monitoring strategies (note strategies), and regulation strategies. In brief, meta-cognitive strategies are related to how we think and learn.

The awareness of reading strategy use is often defined as meta-cognition, the thinking of one's thinking throughout the reading process (Flavell, 1981), and it is a documented aspect of reading success among students (Hyte, 2010). Paris and Winograd (1990) claimed that readers with varying reading skills use different reading strategies. Latawiec (2010) examined the effects of text structure awareness as a meta-cognitive strategy on EFL/ESL reading comprehension and academic achievement over 3 years of tertiary education of 115 Polish EFL learners, and the results showed a positive correlation between the use of meta-cognitive strategies and general reading comprehension.

To date, a number of studies have confirmed the positive influence of meta-cognition on L2 reading performance (Dabarera et al., 2014; Yang & Zhang, 2002). Prasansaph (2013) investigated the effect of meta-cognitive reading strategy instruction (MRSI) on EFL secondary school students' English reading strategy awareness and reading comprehension in Thailand. The study conducted an eight-week intervention with 50 EFL public secondary school students. The results of the study indicated that meta-cognitive reading strategy instruction led to a measurable increase in EFL students' reading achievement after eight weeks of instruction, bringing increased use of reading strategies to the students. Furthermore, those who use meta-cognitive strategies have higher rates of recall and spend less time reviewing (Leopold & Leutner, 2015).

In a study conducted by Kang et al. (2016), it was reported that Korean EFL learners' English reading ability was strongly related to their use

of meta-cognitive strategy. Additionally, Kim (2011) investigated information from 161 Korean EFL university students related to integrated meta-cognitive online reading strategy use in a mixed-methods study. This study used in-depth information from a questionnaire, observations, and think-aloud interviews concerning the strategies used while reading online. The findings revealed high proficiency students tended to use meta-cognitive strategies more often to plan, monitor, and evaluate their online reading processes, suggesting that developing and emphasizing meta-cognitive reading strategy can be one solution to poor reading comprehension, and that it is necessary in EFL teaching and learning processes.

Meanwhile, literature that offers contradictory findings has emerged. Korotaeva (2012) investigated the use of meta-cognitive strategies in reading comprehension of Russian education majors and found out that students have demonstrated extremely ineffective learning goals and meta-cognitive strategies. They do not use comprehension monitoring and control of their own cognitive activity. It can be stated that they demonstrate the "superficial" style of learning.

The study by Pammu and Amir (2014) found that Indonesian EFL learners used different meta-cognitive reading strategies but their use of meta-cognitive reading strategies did not correlate to their reading performance. In other words, the meta-cognitive strategy might have brought about explicit knowledge of strategy use, which is not yet observable in their reading performance. The findings have also indicated that while the meta-cognitive strategy was associated with consistent increases in reported strategy use, it did not bring about corresponding increases in the observed reading performance.

Also, Pei (2014) pointed out that meta-cognitive reading strategies did not result in better reading comprehension performance of Chinese EFL learners. Meta-cognitive reading strategies did not display any significant differences before and after instruction both in reading comprehension test and their reported meta-cognitive strategies uses. To the end, face-to-face interviews were conducted with 6 participants. One point they expressed in common is that what has been taught in the instruction program is taken for granted for they have been instructed to do so since they were elementary school students. Therefore, they do not appreciate the reasons why such strategies are useful and do not show interest or enthusiasm in the instruction.

2.2 Working memory capacity and reading

Working memory is generally understood as a limited-capacity processing and storage system that is necessary for carrying out a wide range of tasks (Baddeley, 2003). Working memory capacity (WMC) refers to the ability to simultaneously manipulate and store information. Baddeley's model of working memory (1986) constitutes the framework for most working

memory research. It consists of three components: a central executive, a phonological loop and a visuospatial sketchpad. The central executive is the task control center which takes responsibility for directing attention and allocating cognitive resources. The phonological loop stores and processes auditory information, while the visuospatial sketchpad is responsible for visual images and spatial relations.

In the case of reading, what is commonly used to measure WMC is the sentence-based reading span test (RST). Proposed by Daneman and Carpenter (1980), RST is a paradigm for reading span measurement of working memory to explain and predict individual differences in learners' language understanding and processing. This test generally consists of unrelated simple sentences ending with different words. The sentence judgement procedure measures the processing function of WM capacity, whereas the word recall measures the storage function. The reading span is taken to be a composite score involving each participant's sentence judgement score and total word recall (Waters & Caplan, 1996).

Since the concept of working memory was introduced to second language acquisition, L2 acquisition researchers began to examine how differences in L2 acquisition and development can be attributed to differences in WMC. N. Ellis (2012) argued that working memory not only affects L1 learning (especially vocabulary acquisition and development), but also applies to L2 learning.

Dixon et al. (1988) demonstrated that working memory efficiency during reading was related to comprehension, whereas a lower WMC was related to slower reading speed. According to Harrington and Sawyer (1992), Japanese college L2 learners with higher working memory performed better on the L2 reading comprehension test. Walter's study (2004) also found that working memory significantly correlated with reading comprehension ability. Leeser (2010) examined how WMC affected the beginning level of Spanish learners' reading comprehension. The results revealed that the differences in WMC played a pivotal role in reading comprehension. In the Korean context, Joh (2015) explored how WMC contributed to English reading comprehension of 60 Korean college students. The results of the study showed that WMC proved to be an independent contributor to L2 reading comprehension.

From another perspective, Beni et al. (2007) studied age-related differences in reading comprehension, analyzing the role of working memory and meta-comprehension components in a sample of young (18-30 years), young-old (65-74 years), and old-old (75-85 years) participants[1]. Text comprehension abilities showed that WMC as well as different meta-comprehension components, but not age, are the key aspects in

[1] To analyze the age-related differences in text comprehension, the researchers grouped the sample into groups according to age.

explaining the different patterns of changes in the comprehension of narrative and expository texts.

However, some other studies reported that there is no significant effect of working memory on language learning. Based on a small scale study of 13 German students, Chun and Payne (2004) reported that there was no significant correlation between working memory and L2 reading comprehension. Savage et al. (2007) demonstrated that no significant role for working memory is evident in longitudinal studies of reading acquisition. Existing evidence concerning working memory problems is hard to interpret for the reading performances of poor readers. Thus, further research is needed for a better understanding of how WMC relates to L2 reading comprehension.

2.3 Syntactic awareness and reading

As an important part of linguistic knowledge and language understanding, syntactic awareness is defined as the ability of an individual to reflect on the inherent grammatical structure of a sentence (Tunmer, 1984). Syntactic awareness promotes the ability of learners to form a meaningful syntactic group of words to be decoded, which is a process that is especially important for understanding written language. With the help of syntactic awareness, people can correctly understand the syntactic and logical relationship between words, distinguish the specific meanings in polysemic situations in specific sentences, and then achieve language understanding.

A number of studies have highlighted the fundamental role of syntactic awareness in the process of reading comprehension (Bowey, 1994; Brimo et al., 2017; Gottardo et al., 2017; Jiang, 2001; Mokhtari & Niederhauser, 2013; Sun, 2003; Tang, 2002). Bowey (1994) pointed out that syntactic awareness has a significantly predictive effect for reading. One study by Swanson et al. (2008) concluded that Spanish and English syntactic awareness in children's English has a significant contribution to English reading comprehension. Conversely, Lipk and Siegel (2007) reached different conclusions, that for students of English as a second language, English letter recognition and speech processing in kindergarten were highly significant in predicting third-grade reading ability, while syntactic awareness was not significant in predicting reading ability.

Brimo et al. (2017) examined the contributions of syntactic awareness to adolescents' reading comprehension. Path analysis was used to analyze the direct and indirect effects of syntactic awareness on reading comprehension. Students' syntactic awareness directly accounted for significant variance in reading comprehension. The study confirmed the significant effects of syntactic awareness on reading comprehension among adolescent students. This is one of the very few studies to examine the contribution of syntactic awareness to adolescent students' reading comprehension. A more recent

study by Deacon and Kieffer (2018) suggested a robust role for syntactic awareness in the development of reading comprehension.

Some studies discussed the effects of both syntactic awareness and WMC for the reading process. Gong et al. (2009) carried out a study targeted at higher proficiency readers and lower proficiency readers, and the results indicated that syntactic awareness was the only predictor for word reading and sentence reading comprehension, and a strong predictor for text comprehension. Working memory was not a significant predicator for all reading tasks.

Low and Siegel's large scale study (2005) compared cognitive processes in reading comprehension of L1 and ESL speakers. The study examined the relative role played by three cognitive processes — phonological processing, verbal working memory, and syntactic awareness — for understanding the reading comprehension performance among 884 native English (L1) speakers and 284 English-as-a-Second-Language (ESL) speakers in sixth-grade. The performance of both groups showed that the ESL speakers lagged behind L1 speakers in terms of syntactic awareness. That study also emphasized the importance of the three cognitive processes in establishing a common model of reading comprehension across English L1 and ESL reading.

2.4 Present study

Most previous studies have separately probed the effects of meta-cognition strategies, WMC, or syntactic awareness on L2 reading performance, and there has been little concern for how the three variables together contribute to the L2 reading comprehension.

With this in mind, the present study aimed to explore the effects of meta-cognitive strategies, WMC, and syntactic awareness on reading comprehension. More specifically, the study sought to answer the following research questions:

1. Are there differences in meta-cognitive strategies, WMC, and syntactic awareness for Chinese EFL learners with different levels of L2 reading comprehension?
2. What is the relationship between meta-cognitive strategies, WMC, syntactic awareness, and L2 reading comprehension?
3. How do meta-cognitive strategies, WMC, and syntactic awareness predict L2 reading comprehension gain?

3 Method

3.1 Participants

Participants in the study were 167 university students from four intact classes,

from a university located in Jilin Province, China. The age of the participants ranged from 19 to 21. All were sophomores majoring in electric engineering and automation; economic management; mechanical manufacture and automation; and accounting, and they were enrolled in an English course as a compulsory subject. All participants volunteered to take part in the study and none had spent time in English-speaking countries. Participants were at intermediate English level and obtained a scaled score from 339 to 596 out of 750 in CET 4 (College English Test 4) and a scaled score from 387 to 552 out of 750 in CET 6 (College English Test 6[2]), which are China's official national English proficiency tests. The basic information of the participants is shown in Table 1.

Table 1. Distribution of the Number of Men and Women Randomly Sampled

Valid data	Frequency	Percentage	Valid percentage	Cumulative percentage
Male	114	68.26%	68.26%	68.26%
Female	53	31.74%	31.74%	31.74%
Total	167	100%	100%	100%

3.2 Instruments

The instruments prepared for this study included the Meta-cognitive Awareness of Reading Strategy Inventory questionnaire, a reading span test, a syntactic awareness test, and a reading comprehension test.

Meta-cognitive Awareness Reading Strategy Inventory (MARSI)

The Meta-cognitive Awareness Reading Strategy Inventory (MARSI; Mokhtari, & Reichard, 2002) was used to measure the participants' use of meta-cognitive strategies. It consists of 30 items that measure three factors: Global Reading Strategies (13 items), Problem-Solving Strategies (8 items), and Support Reading Strategies (9 items). The global factor involves strategies related to the global analysis of text. The problem-solving factor reflects repair strategies that are employed when texts are difficult to read. Practical strategies like taking notes and consulting a dictionary are included in the support factor.

Reading Span Test

The Reading Span Test (RST), adapted from Waters and Caplan's (1996) modified version of Daneman and Carpenter (1980), was used to measure the participants' working memory capacity. The advantage of this modified version is that it can simultaneously measure the two major functional elements of working memory processing and storage. It was

[2] CET 6 is in a higher rank than CET 4, learners could take CET 6 test only if they have passed CET 4, i.e., they have got the score over 425 out of 750 in CET 4.

employed to measure and give an index for WMC. While reading sentences, participants were required to do two tasks: (1) decide whether the sentence was semantically plausible, which aims to assess whether participants processed the sentences, and (2) recall the last word of each sentence, which aims to evaluate their storage ability.

There are 70 sentences in the experiment. They are all common declarative sentences, and are between five and nine words long. For the purpose of the test, half of the sentences are unreasonable. Sentences are randomly divided into groups which contain five sentences in each group. The presentation of each sentence is a three seconds interval. When each sentence is presented, the participant needs to determine whether the sentence is reasonable or not (processing function). At the end of the presentation of each sentence, the subject needs to recall the last word of each sentence in the group (storage function). These words are common non-compound nouns and are between one and three syllables in length. There is no semantic association for the last word in each group. For example, in a three-sentence group, the participants will see three sentences in sequence: "Dogs always bark at strangers", "The cook is baking the chicken", and "The jacket doesn't believe in the bull". They need to fill in √ or × in parentheses on the answer sheet to check the rationality at the end of each sentence. When the three sentences have been rendered, the subject writes down the last word of each sentence. One point is given for every correct judgment of a sentence and one point for each word recalled, regardless of order of occurrence, case, or singular or plural form. The final score is the mean of the two parts.

Measuring WMC in L1 was popular in cognitive psychology and studies in L2 learning. This version of WMC test could help to avoid conflating WMC and L2 proficiency. However, since the participants in this study are college students and of intermediate level proficiency based on their performance in CET 4 and CET 6, the L2 RST was used in this study to examine the WMC instead of the L1 RST. In the case that misunderstanding of unfamiliar words may disturb the results, some words were provided with Chinese interpretation in bracket.

Syntactic Awareness Test

The syntactic awareness test was adapted from Shiotsu and Weir (2007). It is a simplified and validated version of the original Educational English Test (TEEP) grammar test developed by Weir (1983). The new modified version used in this study contains 32 multiple choices, requiring the subject to fill in the missing blanks with the appropriate structure. The de-contextualized nature of the test ensures the constructive validity of the metric, i.e., it expects all items to test syntactic knowledge rather than lexical or sentence semantics. Shiotsu and Weir (2007) pointed out that a syntactic knowledge test should attempt to lower the demand for semantic processing and minimize contextualization as much as possible. Each item is assigned 0.5 points, so the total score is 16. The reliability of the test is estimated to be

0.75 based on the alpha measurement.

Reading Comprehension Test

The reading test battery called "Asian and Pacific Speed Readings for ESL Learners" (Quinn, Nation, & Millett, 2007) was used to measure the participants reading comprehension ability. The battery contains twenty 550-word readings, each of which are followed by ten comprehension questions. The readings are based on topics related to Asia and the Pacific, and are written within the 1,000 most frequently used words of English. The grammar features are restricted by limiting the number of relative clauses, passives, and difficult time references in order to equalize the difficulty of the readings. Cobb (2008) and Fraser (2007) claim that reading speed will decrease when there are unknown words or unknown grammatical structures in the text, or when the reading purpose is other than general comprehension.

According to Nation (2005), a reasonable goal for skilled L2 learners is around 250-300 words per minute when the reading materials contain no unknown vocabulary or grammar and have easy content. Based on the matrix for words per minute, the reading speed of 250 words per minute means that a student would read any reading passage used in the current research in 2 minutes and 10 seconds. Therefore, the reading test battery "Asian and Pacific Speed Readings for ESL Learners" was believed to be reliable for measuring reading comprehension ability in the present research.

3.3 Procedures

The four tests were conducted in two successive sessions in July 2018 in regular English classes. After all the participants were accounted for, the researcher spent five minutes explaining the objective of the experimental procedure. In order to more effectively and efficiently manage the experiment, the researcher explained in Chinese. In the first session, the Meta-cognitive Awareness of Reading Strategy Inventory questionnaire, a syntactic awareness test, and a reading comprehension test were taken collectively and measured in a paper-and-pencil manner. The participants were given 15 minutes to complete the Meta-cognitive Awareness of Reading Strategy Inventory questionnaire, 20 minutes to answer the syntactic awareness test, and 10 minutes for the reading comprehension test. Three readings (pencil and paper test) from Asian and Pacific Speed Readings for ESL Learners (Quinn, Nation, & Millett, 2007) were distributed to participants. The first passage was not used for measuring reading comprehension gain in this study, but was for practice, and it helped the participants become familiar with the test in order to avoid the possibility that unfamiliarity might affect the scores. The second and third passage were scored and analyzed by the researcher. Considering the participants' English proficiency level in this study, five minutes was given for each reading passage. A week later, the WMC test was performed by individual method and took approximately 10 minutes for each participant.

3.4 Scoring

With regard to the reading span test, one point was awarded to each correct answer and no points for an incorrect answer, giving 14 points in total. For the syntactic knowledge test and reading comprehension test, 0.5 points were awarded to each correct answer, no point for an incorrect answer, giving 16 points for syntactic knowledge test and 10 points for reading comprehension test. For the meta-cognitive strategy questionnaire, which uses a five-point Likert scale ranging from always or almost true to never or almost never true, the points were calculated for each item using the scale.

3.5 Data analysis

The participants were divided into three subgroups: high level, middle level and low level, based on their overall mean score in the reading comprehension test. The reliability of the Meta-cognitive Awareness Reading Strategy Inventory (MARSI) was measured using Cronbach's alpha. The result of Cronbach's alpha was .868, revealing a very high reliability. A one-way ANOVA was conducted using the reading comprehension score as the dependent variable, and meta-cognitive strategies, WMC, and syntactic awareness as independent variables.

In addition, descriptive statistics and correlation analyses were employed in the study to see if there were any correlations between meta-cognition, working memory, syntactic awareness, and reading comprehension. Furthermore, a multiple regression was used to examine the predictive power of meta-cognition, working memory, and syntactic awareness on reading comprehension. Statistical data analysis was conducted using SPSS 24.0 for Windows.

4 Results

The results of data analysis are presented in the following section based on the research questions.

4.1 Differences in meta-cognitive strategies, WMC and syntactic awareness among groups with different reading comprehension

For the first research question, the differences in the performance of meta-cognitive strategies, WMC, and syntactic awareness among different levels of English reading comprehension was probed. Descriptive statistics for the reading comprehension scores in Table 2 showed that the mean score of the reading comprehension test (N=167) was 6.93 and the mode average was 8. The standard deviation was 2.34, the maximum value was 10, and the minimum value was 1. It can be seen that there is a big difference in reading

comprehension among participants, and the overall reading level is very unstable.

Table 2. Descriptive Statistics of reading comprehension

	N	M	SD	Variance	Mode	Minimum	Maximum
RS	167	6.93	2.34	5.46	8	1	10

Note: RS = Reading Score

Table 3 displays the distribution of participants according to their reading comprehension score. According to their score in the reading comprehension test, the participants were divided into three groups, high, middle, or low group. As seen in Table 3, the high-reading comprehension group consisted of 78 students whose scores ranged from 8-10 out of 10, the middle reading comprehension group consisted of 60 students whose scores ranged from 5-7 out of 10, and low-reading comprehension group consisted of 29 students whose scores ranged from 1-4 out of 10.

Table 3 Distribution of Participants in Reading Comprehension

Level	N	Score range
High	78	8-10
Middle	60	5-7
Low	29	1-4

Descriptive statistics was conducted on the meta-cognitive strategies, WMC, and syntactic awareness for the three groups. It was found that all the scores of the high group were distinctively higher than those in the middle and low reading group. As Table 4 indicates, the high group gained the highest scores of meta-cognitive strategies, WMC, and syntactic awareness: M=107.756, SD=9.170 in meta-cognitive strategy, M=9.808, SD=1.438 in WMC, M=10.872, SD=2.060 in syntactic awareness. Obviously it seemed that there were differences in the means of meta-cognitive strategies, WMC, and syntactic awareness among the three groups.

Table 4. Means and Standard Deviations for Meta-cognitive Strategies, WMC and Syntactic Awareness among Three Groups of Reading Comprehension

Groups		MCS	WMC	SA
Low	Mean	79.759	6.379	4.586
	N	29	29	29
	SD	15.783	1.083	1.881
Middle	Mean	95.183	8.275	8.517
	N	60	60	60
	SD	13.801	1.354	2.236
High	Mean	107.756	9.808	10.872
	N	78	78	78
	SD	9.170	1.438	2.060

Total	Mean	98.377	8.662	8.934
	N	167	167	167
	SD	15.947	1.841	3.078

Note: MCS = Meta-cognitive Strategies, WMC = Working Memory Capacity,
SA = Syntactic Awareness

A one-way ANOVA was undertaken to statistically investigate the differences among groups for meta-cognitive strategies, WMC, and syntactic awareness. The results in Table 5 shows that there were significant differences among the groups in meta-cognitive strategy (F=58.271, Sig.=0.000), syntactic awareness (F=96.882, Sig.=0.000), and WMC (F=71.707, Sig.=0.000).

Table 5. Results of One-way ANOVA

Test		Sum of Square	df	Mean Square	F	Sig.
MCS	Between Groups	17526.568	2	8763.284	58.271	0.000
	Within Groups	24686.665	165	150.528		
	Total	42213.234	167			
WMC	Between Groups	262.479	2	131.240	71.707	0.000
	Within Groups	300.155	165	1.830		
	Total	562.635	167			
SA	Between Groups	851.540	2	425.770	96.882	0.000
	Within Groups	720.736	165	4.395		
	Total	1572.275	167			

Note: MCS = Meta-cognitive Strategies, WMC = Working Memory Capacity,
SA = Syntactic Awareness

4.2 Correlation between meta-cognitive strategies, WMC, syntactic awareness, and reading comprehension

The Pearson correlation analysis was employed to examine the second research question regarding the correlation between the three variables and reading comprehension. As the results depict, there were fairly close correlations between meta-cognitive strategies, WMC, syntactic awareness, and reading comprehension (respectively, .676, .697, .750). Syntactic awareness turned out to be the most highly correlated with reading comprehension.

Table 6 Pearson Correlations between Variables

	SA	WMC	MCS
RS	.750**	.697*	.676**

*Correlation is significant at the 0.01 level (2-tailed).
Note: RS = Reading Score, MCS = Meta-cognitive Strategies, WMC = Working Memory Capacity, SA = Syntactic Awareness

4.3 Regression analysis of meta-cognitive strategies, WMC, and syntactic awareness for reading comprehension

A multiple regression was performed to examine the predictive effect of meta-cognitive strategies, WMC, and syntactic awareness with respect to reading comprehension. The results are shown in Table 7, Table 8, and Table 9. According to Tables 7 and 8, the adjusted R square was 0.659, with an F value of 108.029 (df= 167, sig.=.000), which means meta-cognitive strategy, WMC, and syntactic awareness accounted for 66% of the total variance in the participants' reading comprehension performance. Table 9 shows that syntactic awareness (t=5.928, B-value=0.399, Sig.=0.000), WMC (t=3.867, B-value=0.242, Sig.=0.000), and meta-cognitive strategies (t=4.610, B-value=0.290, Sig.=0.000) all had significant predictive effects on reading comprehension.

Table 7. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error
1	.816[a]	.665	.659	1.365

a. Predictors: (Constant), meta-cognitive strategies, WMC, syntactic awareness

Table 8. Summary Statistics from the Multiple Regression Analysis: ANOVA

ANOVA[a]					
Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	603.571	3	201.190	108.029	.000[b]
Residual	303.567	164	1.862		
Total	907.138	167			

a. Dependant variable: reading comprehension
b. Predictors: (constant), meta-cognitive strategies, WMC, syntactic awareness

Table 9. Results of Regression Analysis

Coefficients[a]						
Model		B	Std. Error	Standardized *Beta*	t	sig.
1	(Constant)	-2.624	.723		-3.631	.000
	MCS	.042	.009	.290	4.610	.000
	WMC	.307	.079	.242	3.867	.000
	SA	.303	.051	.399	5.928	.000

a. Dependant variable: reading comprehension
Note: MCS = Meta-cognitive Strategies, WMC = Working Memory Capacity, SA = Syntactic Awareness

5 Discussion

For the first research question, the results of the ANOVA showed there were statistically significant differences in meta-cognitive strategies, WMC, and

syntactic awareness among groups according to participants' reading comprehension score. The high group performed better than the middle and low groups in meta-cognitive strategy, WMC, and syntactic awareness, while the low reading comprehension group had the lowest score in meta-cognitive strategies, WMC, and syntactic awareness. This indicates that meta-cognitive strategies, WMC and syntactic awareness play vital roles in L2 reading comprehension as independently significant variables.

With regard to the second research question, the Pearson correlation analysis illustrated that meta-cognitive strategy, WMC, and syntactic awareness were highly correlated with reading comprehension gain (.676, .697, .750). In particular, it showed that syntactic awareness was the most strongly correlated with reading comprehension. The findings also support Cain (2007) who asserted that syntactic awareness may promote the development of reading in context. Likewise, Cupples and Holmes (1992) held the view that good readers outperformed average readers in terms of accuracy on syntactic tasks. Readers' L2 linguistic competence was a significant predictor in using reading-oriented skills and the employing of reading-oriented skills was related with L2 reading comprehension (Park, 2001).

As for the third research question, a multiple regression analysis verified that meta-cognitive strategies, WMC, and syntactic awareness were significant predictors of L2 reading comprehension as criterion variables. Syntactic awareness was the most critical factor in L2 reading comprehension in terms of the relative contribution of three variables to L2 reading comprehension. Collectively, these results accord with recent studies (Brimo et al., 2017; Peng et al., 2018) indicating that meta-cognitive strategies, WMC, and syntactic awareness have positive effects on learning a second language.

Putting all the results together, syntactic awareness is proven to be the most significant predictor of reading comprehension at different levels. This result is consistent with most studies on syntactic awareness and L2 reading (Bowey, 1994; Jiang, 2001; Lipk and Siegel, 2007; Sun, 2003; Tang, 2002; Tunmer & Grieve, 1984), supporting Nassaji's (2003) statement that syntactic awareness could distinguish between adult L2 learners with high reading level from those with low reading level.

When the direct contribution of each predictive variable was analyzed using standardized Beta (β), the highest independent predictor was found to be syntactic awareness, and it made a significant contribution to explaining the variance of reading comprehension. With the findings of Jiang's (2001) and Tang's (2002) studies indicating syntactic awareness as the most significant predictor in overall reading comprehension ability, these results serve as strong evidence that linguistic knowledge (mainly EFL syntactic knowledge) is important for successful EFL reading comprehension (Gottardo et al., 2017; Mokhtari & Niederhauser, 2013)

At the same time, the results of this study showed that WMC was also a significant predictor in L2 reading, supporting McLaughlin's (1995) argument that working memory could be an integral part of foreign language learning because it plays a vital role in second language acquisition. In this study, the working memory scores of the high and middle groups were significantly higher than those of the low group. From this, it can be seen that working memory plays a certain role in the reading process. The difference in WMC between individuals can have a significant impact on the speed and accuracy of information processing of cognitive activities. As L2 reading comprehension belongs to a higher level of cognitive tasks, readers need to undergo a series of processes such as decoding phonetic information, memorizing information in context, and establishing psychological representation to complete the cognitive task of reading comprehension. During these processes, a large amount of WMC can be used. As a result, the limited WMC may affect the individual's understanding of cognitive tasks. When the working memory demand exceeds the capacity range, the individual's ability to process and store cognitive tasks may be weakened. This may explain the results of this study that learners with low WMC did not perform as well as learners in the middle and high groups.

In addition, the present study found out that meta-cognitive strategy use was an important variable in L2 reading comprehension. The high group showed more frequent use of meta-cognitive strategy than those in the middle and low group. However, the findings indicated that the strategy use did not function as strong a predictor of learners' reading comprehension gain as syntactic awareness. This may mean that although students frequently use meta-cognitive reading strategies, they may not be successful in their reading comprehension due to lack of adequate syntactic knowledge.

The results of the study confirmed that syntactic knowledge is a superior predictor of performance on reading comprehension tasks. Therefore, EFL reading comprehension instructors are recommended to include syntactic awareness instruction in their pedagogy, parallel with their attempts to increase the use of meta-cognitive strategies and WMC in order to enhance the learners' reading comprehension ability.

6 Conclusion & Implications

This study aimed to examine the effects of meta-cognitive strategies, WMC, and syntactic awareness on the reading comprehension of EFL learners in the Chinese context. The results indicated that meta-cognitive strategies, WMC, and syntactic awareness had significant effects on reading comprehension. Among these variables, it was found that syntactic awareness was the most significant predictor for Chinese EFL learners' reading comprehension abilities. From the results, it can be drawn that the participants with better

syntactic awareness, higher WMC, and more frequent use of meta-cognitive strategies are likely to achieve better performance in L2 reading comprehension.

These results provide some implications on how to effectively teach L2 reading comprehension to EFL college students. First and most importantly, as language learning has its own laws, syntactic knowledge is the foundation of language learning, and the mastery of basic knowledge cannot be neglected at any time. Without a solid language foundation, other factors cannot play a substantial role. Whether it is necessary or not to raise the similarities and differences between English and Chinese grammatical structures is not for this paper to discuss, but incorporating them into the various skills of EFL, such as listening and, predominantly, reading, is a necessary element of instruction and practice at every level of EFL. The more highly proficiently in English syntax these readers become, the greater their chances to become skilled English readers as well. Syntax awareness could be increased through more practice of sentence grammatical structure in and after class to further understand the syntactic relationship between words, distinguish specific meanings in specific sentences, and then achieve language understanding.

Secondly, the influence of WMC should also be paid more attention. American psychologist Miller (1956) proposed that in order to facilitate the memory, people can classify closely related information units into a small group, that is, chunks. Learners can combine isolated items (small lexical chunks) in memory material to form meaningful larger chunks based on prior knowledge (Anglin & Miller, 1968; Consortium et al., 2018; Peng et al., 2018).

From the perspective of information processing, a chunk is the organization or re-encoding of information and subsequent storage in long-term memory. Chunks can be a word, a phrase, or one or more sentences. The linguist Gui (2003) put forward that reorganizing and re-encoding several sub-blocks into large blocks can reduce the number of memories, improve memory efficiency, and reduce the load of working memory.

Thus, in L2 reading teaching, teachers can help learners expand the limited capacity of working memory through practice based on a lexical and grammatical collocation. If reading materials can be carried out in chunks or lexical collocation and processed, the reader can use existing schema stored in the brain to understand and memorize the information of the reading materials in a top-down manner. This high-level schema activation helps predict, analyze, and integrate new information (An, 2013).

It is especially beneficial that L2 learners are familiar with the background knowledge of the reading material, and the higher the probability that schema is activated in the mind, the higher the reading success rate. L2 reading teachers should encourage students to extend L2 reading beyond the classroom and expand their knowledge to increase the amount of background

knowledge schema information. The increase in background knowledge helps to reduce the requirements of the internal cognitive load and efficiently implement schema automation (Chen, et al., 2014). Unconscious automatic processing can greatly reduce the cognitive load of learners.

Thirdly, better reading comprehension ability will be obtained when meta-cognitive strategies are used more often. As the results indicate the value of raising awareness about the usefulness of meta-cognitive strategies in the reading process, teachers need to make more effort in encouraging learners to use meta-cognitive strategies more frequently. Teachers' understanding of the meta-cognitive strategies of reading and learner's academic achievement is absolutely necessary. Therefore, in English teaching, teachers need to provide students with a variety of well-designed types of meta-cognitive strategies, while students should have sufficient opportunities to practice these provided strategies.

Among the three categories of meta-cognitive strategies, the support reading strategies need more emphasis and practice. Teachers can guide students how to take notes and consult a dictionary effectively while reading. Reading strategies are in fact problem-solving strategies employed by readers to cope with reading texts. The major implications for EFL reading strategy instruction should focus not on individual strategies, but on meta-cognitive awareness-building and the use of reading strategies, raising students' abilities to employ multiple reading strategies.

As one of the best ways to capture thoughts and bring them back in visual form, mind maps can help learners become more organized, remember more, and solve problems more effectively, beyond just note-taking. Some people read words accurately but don't derive anything more than a superficial understanding of the words (weak concept imagery). "Talking it out" or drawing a concept map helps to fully engage the individual in the process, and helps one to understand what one knows, what one doesn't know, and what one wants to know (Malekzadeh & Bayat, 2015). Mimicking the way our brains think and then bouncing ideas off of each other, rather than thinking linearly, mind mapping is a very intuitive way to organize thoughts. Ideas are generated very quickly with this technique and further encourages exploration along various creative pathways. Meta-cognition is often defined as "thinking about how you think". That is, being mindful of one's own thought processes and understanding how one takes in and processes information in order to solve problems. Teachers should make full use of meta-cognitive strategies and other reading strategies either simultaneously or in sequence, to improve learners' reading flexibly and effectively.

The current study also has some limitations. One limitation is that the number of participants in the current study is not sufficient enough to confirm a generalized conclusion. Another limitation lies in the reading comprehension test. It would be beneficial if future research could apply various reading comprehension test formats to measure more diverse aspects

of reading proficiency, such as academic reading, narrative reading, and practical reading In addition, the WMC test can be measured by psychology software to measure the learner's response time and accuracy to ensure the reliability of the experimental data. Employing several tasks tapping into different aspects of the working memory system to measure WMC is strongly recommended. Tasks should be designed for either verbal, numerical, or figural-spatial stimuli and responses, or mixtures of two of these content domains. It is still necessary to conduct in-depth research on the factors that affect learners' reading performance with L2 learners from different L1 backgrounds. The findings of such studies might help teachers to gain more insight into EFL learning and teaching.

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Appendix
Meta-cognitive Awareness of Reading Strategies Inventory

Gender: _____ Age: _____ Grade: _____ Major: _____
Years of Studying English: _____
Experience of Studying or living abroad: _____ (Yes/No)

DIRECTIONS: Listed below are statements about what people do when they read academic or school-related materials such as textbooks, library books, etc. After reading each statement, circle the number (1, 2, 3, 4, or 5) that applies to you using the scale provided. Please note that there are no right or wrong answers to the statements in this inventory. Five numbers follow each statement (1, 2, 3, 4, 5) and each number means the following:

1 means "I never or almost never do this."
2 means "I do this only occasionally."
3 means "I sometimes do this." (About 50% of the time.)
4 means "I usually do this."
5 means "I always or almost always do this."

TYPE	STRATEGIES	SCALE				
GLOB	1. I have a purpose in mind when I read.	1	2	3	4	5
SUP	2. I take notes while reading to help me understand what I read.	1	2	3	4	5
GLOB	3. I think about what I know to help me understand what I read.	1	2	3	4	5
GLOB	4. I preview the text to see what it's about before reading it.	1	2	3	4	5
SUP	5. When text becomes difficult, I read aloud to help me understand what I read.	1	2	3	4	5
SUP	6.I summarize what I read to reflect on important information in the text.	1	2	3	4	5
GLOB	7. I think about whether the content of the text fits my reading purpose.	1	2	3	4	5
PROB	8. I read slowly but carefully to be sure I understand what I'm reading.	1	2	3	4	5
SUP	9.I discuss what I read with others to check my understanding.	1	2	3	4	5
GLOB	10. I skim the text first by noting characteristics like length and organization.	1	2	3	4	5
PROB	11. I try to get back on track when I lose concentration.	1	2	3	4	5
SUP	12. I underline or circle information in the text to help me remember it.	1	2	3	4	5
PROB	13. I adjust my reading speed according to what I'm reading.	1	2	3	4	5
GLOB	14. I decide what to read closely and what to ignore.	1	2	3	4	5
SUP	15. I use reference materials such as dictionaries to help me understand what I read.	1	2	3	4	5
PROB	16. When text becomes difficult, I pay closer attention to what I'm reading.	1	2	3	4	5
GLOB	17. I use tables, figures, and pictures in text to increase my understanding.	1	2	3	4	5
PROB	18. I stop from time to time and think about what I'm reading.	1	2	3	4	5
GLOB	19. I use context clues to help me better understand what I'm reading.	1	2	3	4	5
SUP	20. I paraphrase (restate ideas in my own words) to better understand what I read.	1	2	3	4	5
PROB	21. I try to picture or visualize information to help remember what I read.	1	2	3	4	5
GLOB	22. I use typographical aids like bold face and italics to identify key information.	1	2	3	4	5
GLOB	23. I critically analyze and evaluate the information presented in the text.	1	2	3	4	5
SUP	24. I go back and forth in the text to find relationships among ideas in it.	1	2	3	4	5
GLOB	25. I check my understanding when I come across conflicting information.	1	2	3	4	5
GLOB	26. I try to guess what the material is about when I read.	1	2	3	4	5
PROB	27. When text becomes difficult, I re-read to increase my understanding.	1	2	3	4	5
SUP	28. I ask myself questions I like to have answered in the text.	1	2	3	4	5
GLOB	29. I check to see if my guesses about the text are right or wrong.	1	2	3	4	5
PROB	30. I try to guess the meaning of unknown words or phrases.	1	2	3	4	5

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