

**Roles of Reading Anxiety and Working Memory in
Reading Comprehension in English as a Second Language**

Abstract

This study investigated the relationships between affective and cognitive factors and reading comprehension in English as a second language (ESL). Specifically, we evaluated the contributions of reading anxiety and verbal working memory to ESL reading comprehension in Chinese students. A total of 105 Chinese ESL undergraduates were included. Structural equation modeling results showed that reading anxiety, represented by reading trait and state anxiety, and verbal working memory were unique predictors of ESL reading comprehension. In addition, there was no significant reading anxiety \times working memory interaction effect. Mediation analyses revealed that reading anxiety partially mediated the relationship between verbal working memory and ESL reading comprehension. These results highlight the importance of affective and cognitive factors in predicting ESL reading comprehension and shed light on the methods in enhancing ESL learning.

Keywords: Reading anxiety, verbal working memory, reading comprehension, English as a second language

Roles of Reading Anxiety and Working Memory in Reading Comprehension in English as a Second Language

Reading acquisition is a complex process involving the contributions of various factors. Empirical evidence has focused on the contributions of cognitive and linguistic factors to reading, but knowledge about the affective correlates of reading is relatively limited (Katzir et al., 2018). Affective and cognitive contributors to reading comprehension tend to be investigated separately in past studies. How affective and cognitive factors simultaneously affect reading comprehension remains underexplored, especially in English as a second language (ESL) reading. As such, the present study aims to fill in the research gap by investigating the contributions of affective (reading anxiety) and cognitive (verbal working memory) factors to ESL reading comprehension in a single study. This study is grounded on three theoretical frameworks: a) the Component Model of Reading (Aaron et al., 2008), b) the Attentional Control Theory (Eysenck et al., 2007), and c) the Deficit Model (Naveh-Benjamin et al., 1981). These frameworks support the investigation of both affective and cognitive and their interplay in contributing to reading ability. The present study scrutinizes the relative contributions of affective and cognitive factors and the possible effects of their interplay on reading comprehension, which is essential for enhancing our knowledge of the underlying mechanisms of their contributions to reading comprehension. While past studies on reading anxiety largely focused on trait anxiety (i.e., general anxiety toward reading), the present research is the first to explore the relationship between reading anxiety which is tapped by both reading trait anxiety and reading state anxiety (i.e., anxiety during or immediately after hands-on reading experience) in ESL reading comprehension among Chinese students. It is particularly important to investigate these links in the context of ESL because a) learners frequently experience higher anxiety in second language (L2) learning than in their first

language (L1), and b) reading in L2 is often more cognitively demanding than that in L1, thus highlighting the important roles of reading anxiety, working memory and their interplay in L2 reading. The findings are crucial to the understanding of the affective and cognitive correlates of reading comprehension and shed light on the effective methods in enhancing ESL learning.

Anxiety and Reading

Anxiety is one of the important affective factors in reading comprehension, which refers to “the subjective feeling of tension, apprehension, nervousness, and worry associated with an arousal of the autonomic nervous system” (Spielberger, 1983, p.1). Anxiety has three types, namely, trait, state, and situation-specific anxiety. Trait anxiety refers to a generally stable tendency to become nervous in a wide range of situations, whereas state anxiety reflects a transient emotional state, such as feelings of worry or stress that takes place at a particular moment (Spielberger, 1983). Situational-specific anxiety refers to anxious feelings specified with certain situations and can be seen as trait anxiety in a particular context. Foreign/L2 language anxiety is a type of situation-specific anxiety uniquely associated with foreign/L2 language usage (Horwitz, Horwitz & Cope, 1986).

Research studies have indicated the uniqueness of reading anxiety as a situational-specific anxiety compared to general anxiety and their links with reading proficiency (e.g., Grills et al., 2014; Macdonald et al., 2021). For example, Macdonald et al. (2021) has posited that reading anxiety and general anxiety are related yet distinctive constructs, and they are differentially related to L1 reading performance in primary school students. Specifically, they found that reading anxiety was significantly correlated with reading comprehension, but general anxiety was not. Past studies on L2 acquisition have demonstrated a moderate, negative relationship between L2 language anxiety and language comprehension ($r \approx -.36$; See Teimouri et

al., 2019 for a meta-analysis; see also Al-Shboul et al., 2013; Wood et al., 2016). In studies focusing on Chinese individuals learning ESL, a negative relationship between ESL anxiety and performance has been indicated. For instance, Wang and Li (2011) reported an adverse impact of ESL anxiety, measured using the Foreign Language Classroom Anxiety Scale (FLCAS), on English reading comprehension proficiency in Chinese undergraduates. Similarly, Lu and Liu (2011) found a moderate, negative relationship between language anxiety measured by FLCAS and English performance.

Many of the past studies have examined anxiety in speaking experienced by learners in the classroom, measured by the FLCAS. Relatively little is known about foreign language/L2 reading anxiety, which refers to the feelings of apprehension when reading in a foreign language/L2 (Saito et al., 1999). Reading anxiety is more difficult to detect because, at least for silent reading, immediate reactions are often not required, unlike during oral communication. In Chinese ESL learners, previous studies have established negative links between foreign language reading anxiety measured by Foreign Language Reading Anxiety Scale (FLRAS) with reading performance (e.g., Chow et al., 2018). However, past studies have mainly tested reading anxiety as trait anxiety that reflects a general anxiety tendency in reading contexts, using scales such as FLRAS. While these scales measure general feelings toward reading, transient anxiety level during or immediately after reading should also be examined. In the context of reading, trait anxiety referring to relatively stable individual personal characteristics may be associated with a constant high arousal associated with reading, whereas state anxiety referring as a more transient intense emotional state may correlate with a temporary increased sympathetic nervous system activity during reading. Reading trait anxiety and reading state anxiety are closely related. Specifically, individuals with a higher general anxiety tendency in reading contexts are more

likely to feel more anxious in reading tasks. The present study thus tested the links of reading anxiety and comprehension with both trait and state anxiety taken into account by constructing a reading anxiety latent variable with trait anxiety and state anxiety as indicators in the models.

Working Memory and Reading

Working memory is among the most studied cognitive factors of reading comprehension. Working memory consists of complex cognitive operations such as maintenance, retrieval, manipulation, and transformation of verbal or visual input. Previous research findings have consistently shown a robust, positive relationship between working memory and reading comprehension in L1 learning ($r \approx .29$; Carretti et al., 2009 & Peng et al., 2018, for meta-analyses; see also Arrington et al., 2014; Cain et al., 2004; Georgiou & Das, 2016; Goff et al., 2005; Seigneuric et al., 2000; Seigneuric & Ehrlich, 2005). Carretti et al. (2009) showed that memory tasks that demand attentional control and require verbal information processing are best at distinguishing between readers with poor and good comprehension skills. Individuals with higher working memory capacity tend to perform better in text comprehension (Daneman & Hannon, 2007; Friedman et al., 2017). A similar positive correlation has been established in the L2 context (Andersson, 2010; Jeon & Yamashita, 2014; Linck et al., 2014; Pae & Sevcik, 2011; Shin, 2020). For example, Adams and Shahnazari-Dorcheh (2014) tested 55 L1 Persian ESL learners and found a positive relationship between working memory and performance in English expository reading comprehension in those with lower levels of ESL proficiency. Choi (2013) also found that working memory was a stronger predictor of ESL reading comprehension than vocabulary in Korean undergraduates. In a meta-analysis study, Shin (2020) indicated a medium-sized relationship between working memory and L2 reading comprehension. Compared with L1, executive function seems to play a relatively more important role in L2, given the

demands of bilingual language processing (Ransdell et al., 2006). Specifically, bilinguals and L2 learners must manage the conflict between potentially competing representations from both languages (Dijkstra, 2005). Therefore, L2 processing requires more cognitive resources to manage conflicts and prevent interference from distracting information. Owing to limited linguistic knowledge in their L2, readers also tend to rely more on bottom-up processing to decode words, hence depleting resources for top-down strategies that contribute to meaning construction (Alptekin & Erçetin, 2009). The effortful processing in L2 places heavier demands on cognitive load in L2 learning than in L1 learning (Li & Clariana, 2019; Rai et al., 2015). These highlight the strong link between working memory and L2 reading comprehension. This study adds to the existing field of L2 research by investigating the link between working memory capacity and ESL reading comprehension with affective factors taken into consideration.

Notably, verbal working memory was a stronger predictor of reading performance than visuospatial working memory (e.g., Gathercole et al., 2003; Linck et al., 2014), suggesting that phonological loop is strongly associated with reading processing. Similarly, Pham and Hasson (2014) found that visuospatial and verbal working memory predicted reading fluency and reading comprehension in children, and the latter accounted for more variance in reading ability than the former. This finding is consistent with that of Seigneuric et al. (2000), in which they found that verbal working memory rather than spatial working memory accounted for a significant amount of variance in reading comprehension after vocabulary and reading fluency were controlled. Therefore, the present study focused on verbal working memory.

Anxiety and Working Memory

In this study, the investigation of the interplay between reading anxiety and working memory is grounded on three theoretical frameworks. The Component Model of Reading

emphasizes both affective and cognitive factors play an important role in reading ability (Aaron et al., 2008). Investigating the contributions of affective and cognitive factors simultaneously provides a more thorough picture of reading comprehension development. The Attentional Control Theory proposes anxiety affects cognitive processing centering on the central executive component of working memory (Eysenck et al., 2007; Eysenck & Derakshan, 2011). The Deficit Model proposes that low cognitive abilities lead to high anxiety (Naveh-Benjamin et al., 1981; Nelson et al., 2015). They highlight the interplay between anxiety and working memory in cognitive processing and provide alternative hypotheses on their relationships. Linking the aforementioned frameworks, the present study examines the contributions of affective (reading anxiety) and cognitive (verbal working memory) factors and their interplay to ESL reading comprehension. While there has been considerable attention on their individual contributions to reading comprehension, our understanding of their interplay in predicting reading comprehension remains limited. Some studies have found a negative relationship between anxiety and working memory (e.g., Ashcraft & Kirk, 2001; Darvishzadeh et al., 2012; Eysenck et al., 2005; Sari et al., 2017; Wright et al., 2014). A meta-analysis review study revealed a robust association between anxiety and working memory, suggesting that anxiety can restrict the working memory capacity (Moran, 2016). Katzir et al. (2018) indicated that working memory is positively correlated to the reading rate at word level which is in-turn negatively contributed to reading anxiety. Even though the link between anxiety and working memory has been established, how they jointly contribute to reading remains unclear.

Past studies have postulated three alternative mechanisms. First, the Attentional Control Theory (Eysenck et al., 2007) proposes that high anxiety adversely affects negative attentional control (inhibits attention to task-irrelevant stimuli) and positive attentional control (switches

attention flexibly to maximize performance), which in-turn lowers cognitive performance (Derakshan & Eysenck, 2009). In the reading context, anxiety influences readers' allocation of cognitive resources which in-turn affects the process of reading comprehension. When readers experience anxiety, their attention is more likely to be on irrelevant rather than relevant text information, which reduces their processing resources during reading. This suggests anxiety lowers working memory capacity, limiting the information individuals can retain and process during reading, hence having a detrimental effect on their reading performance (Eysenck et al., 2007). In other words, anxiety is linked to reading comprehension through the mediation of working memory. Second, according to the Deficit Model, individuals' experiences and skills related to reading influence their reading affect. Specifically, readers with poor working memory have to devote more effort to attentional control which takes up cognitive resources, posing greater challenges in comprehending texts. This increases their negative affect on reading, like reading anxiety, consequently leading to lower reading performance (Bahmani et al., 2017; Nelson et al., 2015; Ramirez et al., 2019). In this way, working memory is linked to reading comprehension through the mediation of anxiety. Third, cognitive ability and reading-related emotions interact in contributing to reading performance. Positive affective factors can compensate for cognitive capacity limitations in processing texts while adequate cognitive capacity can compensate for negative affective factors in processing texts (List & Alexander, 2017). Past research showed that high activating-negative emotions (i.e., anxiety, anger, and shame) were linked to poor reading comprehension when working memory was low or moderate, but they were not associated with poor reading comprehension when working memory was high, demonstrating an interaction effect between negative affect and working memory in predicting reading comprehension (Zaccoletti et al., 2019). In other words, while negative affect is

detrimental to reading performance in readers with low or moderate working memory, high working memory is a protective factor of the harmful influences of negative affect on reading. In the present study, we aim to extend past research by testing these alternative hypotheses, clarifying the mechanisms of the interplay of reading anxiety and working memory in contributing to ESL reading comprehension performance.

The Present Study

This study examines the contributions of affective and cognitive factors to ESL reading performance in Chinese undergraduates. Specifically, it aims to investigate the roles of reading anxiety (trait and state) and verbal working memory in ESL reading comprehension. There are two main research questions. First, what are the relative contributions of reading anxiety and verbal working memory to ESL reading comprehension? Second, how do reading anxiety and verbal working memory jointly predict ESL reading comprehension? Four sets of hypotheses were examined: 1) Reading anxiety and verbal working memory are significant correlates of ESL reading comprehension; 2) verbal working memory mediates the link between reading anxiety and ESL reading comprehension; 3) reading anxiety mediates the link between verbal working memory and ESL reading comprehension; and 4) there is an interaction effect of reading anxiety and verbal working memory on ESL reading comprehension.

Method

Participants

A total of 105 Chinese undergraduate students (37 males and 68 females) in Hong Kong participated in the study. The students were ESL learners, aging from 18 to 25 ($M = 20.81$, $SD = 1.58$ years). The sample included students from various disciplines, including arts, sciences,

engineering, and social sciences. The average starting age of learning written English was 3.82 ($SD = 1.29$) years old ($M = 3.87$, $SD = 1.44$ for males; $M = 3.79$, $SD = 1.22$ for females).

Procedure

This study was granted ethical approval from the Human Subjects Ethics Sub-Committee of City University of Hong Kong and was conducted in accordance with ethical principles in research with human participants. After informed consent for participation was obtained from the participants, tests for English reading comprehension, English reading anxiety, and verbal working memory were administered individually in a psychology laboratory. Participants were asked to fill in a questionnaire with questions on demographic information including age, gender, major discipline, and starting age of learning written English. The session lasted for approximately an hour.

Measures

English Reading Comprehension

The York Assessment of Reading for Comprehension Secondary Test (Stothard et al., 2010) was adopted to assess reading comprehension performance in English. Three passages and four corresponding questions for each passage were administered. Specifically, one narrative, one descriptive, and one argumentative passage were included. The number of English words in the passages ranged from 376 to 472. Each passage had four questions, three of which were literal information and inference questions. Each correct answer scored one mark in these questions. Furthermore, each passage had a summarization question which was scored based on key points. Each summarization question had seven to nine maximum key points, each of which was worth one mark. Participants were required to read silently and answer the questions in 20 minutes. The maximum score for English reading comprehension was 37. A total of 30 cases

were randomly selected and rated by two coders independently. The inter-rater reliability was .96.

English Reading Anxiety

English reading anxiety was measured by an adapted version of the State-Trait Anxiety Inventory (STAI; Spielberger, 1983). The STAI contains two subscales with 20 items each, measuring trait and state anxiety respectively. The trait subscale measures trait anxiety, referring to how one generally feels. The state subscale measures state anxiety, referring to how one feels at the moment (Marteau & Bekker, 1992). In this study, we kept the original structure and the set of adjective words for items in both subscales of the STAI but adapted the items to measure reading anxiety specifically. For example, “*I am tense.*” was revised to “*I am tense when I read English.*” The adapted *English reading trait anxiety* scale, which measured how one generally felt about English reading in daily life, was administered before the English reading comprehension test. The adapted *English reading state anxiety* subscale, which measured how one felt about English reading at particular moment (i.e., right after engaging in reading comprehension), was administered immediately upon the completion of the English reading comprehension task. Both subscales were scored on a four-point Likert scale, ranging from “not at all” to “very much.” A high score would indicate high levels of trait or reading state anxiety. The maximum score for the reading trait anxiety/ reading state anxiety scale was 80. An average score was used, as shown in Table 1, for easy interpretation of the scores as reference to the 4-point Likert scale. The Cronbach’s α for the English reading trait and state anxiety scales were .93 and .92, respectively.

Verbal Working Memory

The Woodcock-Johnson III Tests of Cognitive Abilities Auditory Working Memory subtest (Woodcock et al., 2001) was used to measure verbal working memory. Participants were

orally presented with 21 items, each comprising of a mixture of numbers and words. For each item, participants were asked to repeat the numbers and words in a particular order. Two points were given if they reported the words in a correct order followed by digits in a correct order; one point was given if they reported words or digits in correct order, on the premise that they attempted words first. No point was given if neither words nor digits were reported in a correct order, or digits were presented first. The maximum score was 42, and the Cronbach's α was .78.

Results

Table 1 shows the descriptive statistics of variables, and the bivariate correlations among variables. Reading trait and state anxieties were highly correlated ($r = .81, p < .001$). English reading comprehension was positively correlated with verbal working memory ($r = .34, p < .001$) and negatively related to reading anxiety ($r = -.41$ and $-.48, p < .001$ for trait and state anxiety respectively), but was not significantly correlated with age. Independent sample t-tests revealed that female students had significant higher English reading comprehension scores than male students ($t = 2.20, p < .05$), but no significant gender differences was found for reading trait anxiety ($t = -.52, p = .52$), reading state anxiety ($t = .85, p = .40$), verbal working memory ($t = -.25, p = .80$) or starting age of learning written English ($t = .27, p = .79$). Past studies have found that females outperform males in English reading comprehension (Afsharrad & Sadeghi Benis, 2017; Rachmajanti & Musthofiyah, 2017). Therefore, gender was included as a control variable in subsequent analyses.

Contributions of Reading Anxiety and Working Memory to ESL reading comprehension

Structural equation modeling was conducted to examine the unique contribution of reading anxiety and working memory to English reading comprehension (hypothesis 1). In this model, the links between a latent reading anxiety factor (represented by reading trait and state

anxiety) and working memory were tested, with age, gender and starting age of learning written English entered as control variables (Figure 1). Table 2 shows the final standardized beta weights and the effect sizes of the structural equation model. Fisher's Z proposed by Cohen (1988) was computed to represent effect sizes, using CMA 3.0 software. The function of sample size, correlation index, and correlation direction indicator were used to measure the Fisher's Z . A Fisher's Z value of 0.10, 0.31, and 0.55 corresponds to a small, medium, and large effect respectively. Results showed that this structural equation model had satisfactory goodness-of-fit, $\chi^2(6) = 6.26$ ($p = .40$), CFI = 1.00, TLI = .99, RMSEA = .02, SRMR = .03, and explained 33% of the variance in English reading comprehension. After the variance explained by age, gender and starting age of learning written English were accounted for, reading anxiety was negatively related to English reading comprehension ($\beta = -.42$, $p < .001$, Fisher's $Z = .44$), indicating a medium effect size. Working memory was positively related to English reading comprehension ($\beta = .35$, $p < .001$, Fisher's $Z = .37$), indicating a medium effect size. These results indicate that both reading anxiety and working memory were important correlates for reading comprehension.

To clarify the mechanisms of the interplay of reading anxiety and working memory in contributing to ESL reading comprehension, we conducted an interaction and two mediation analyses to test the three sets of hypotheses on the interplay between reading anxiety and working memory. Analyses were conducted using the lavaan package (Rosseel, 2012) in the R statistical language (R Development Core Team, 2013).

Mediation Relationships

Two mediation models were conducted to examine the second and the third hypotheses. The first mediation model evaluated the contributions of reading anxiety to English reading comprehension via verbal working memory (Figure 2). The mediation model had satisfactory

goodness-of-fit (Mediation Model 1: $\chi^2(3) = .25$ ($p = .97$), CFI = 1.00, TLI = 1.12, RMSEA = .00, SRMR = .01). The model explained 33% of the variance in reading comprehension. Verbal working memory as a mediator was negatively associated with reading anxiety ($\beta = -.23$, $p < .05$) and positively associated with English reading comprehension ($\beta = .24$, $p < .01$). However, the standardized indirect effect was not significant ($\beta = -.05$, $p = .07$, 95% confidential interval for the indirect effect [-1.39, .05]; Fisher's $Z = .05$) (see Table 4).

The second mediation model evaluated the contribution of working memory to English reading comprehension through reading anxiety as a mediator (Figure 3). The model had satisfactory goodness-of-fit (Mediation Model 2: $\chi^2(7) = 7.39$ ($p = .39$), CFI = 1.00, TLI = .99, RMSEA = .02, SRMR = .04). The model explained 34% of the variance in reading comprehension. Reading anxiety as a mediator was negatively associated with working memory ($\beta = -.23$, $p < .05$) and English reading comprehension ($\beta = -.44$, $p < .001$). The standardized indirect effect was significant ($\beta = .10$, $p < .05$, 95% confidential interval [.01, .21], Fisher's $Z = .10$). Thus, verbal working memory contributed to English reading comprehension directly and indirectly through reading anxiety.

Interaction Relationship

Interaction analyses were conducted to test the reading anxiety x working memory effects on ESL reading comprehension (hypothesis 4). First, we used `lavPredict` function to obtain the standardized scores of the latent reading anxiety factor based on reading trait and state anxiety. Then, we created the interaction term by multiplying the standardized scores of reading anxiety and the standardized score of working memory. Structural equation modeling was conducted to test the interaction effect, with control variables and corresponding independent variables included as previous steps. Table 3 shows the model fit, final standardized beta weights, and

effect size of the interaction model. Results showed that the interaction effect was insignificant, which did not support hypothesis 4.

Discussion

This study investigated the contributions of reading anxiety and verbal working memory and their interplay on English reading comprehension in Chinese undergraduates. Three major findings were obtained. First, reading anxiety (trait and state) and working memory were significant predictors of ESL reading comprehension. Second, there was no significant reading anxiety \times working memory interaction effects. Lastly, reading anxiety partially mediated the relationships between working memory and reading comprehension.

Contributions of Reading Anxiety and Working Memory to ESL reading comprehension

The present study showed that reading anxiety, represented by both reading trait and state anxiety, was negatively associated with ESL reading comprehension, supporting our hypothesis 1. Our results are consistent with previous findings in which reading anxiety inhibits comprehension and acquisition of second language (e.g., Mohd. Zin, 2007; Saito et al., 1999; Sellers, 2000; Wang & Li, 2011; Zhao et al., 2013). Extending past research, our study measured not only general anxiety toward reading (trait anxiety) but also anxiety during or immediately after reading (state anxiety). A strong correlation between reading trait anxiety and reading state anxiety was found, indicating that individuals with high general anxiety toward reading likely have a high level of anxiety during reading. Both types of anxiety were significantly and negatively related to English reading comprehension with a moderate correlation. In the reading context, trait and state anxiety are closely related to high arousal of tension and/or intrusive thoughts about worries regarding reading, which may weaken the attentional control and the inhibition of irrelevant stimuli.

Empirical evidence from previous studies has indicated that learners with good verbal working memory tend to have adequate cognitive resources for maintaining salient information encountered in reading, accessing knowledge from long-term memory, generating semantic associations, and attentional control which enhancing reading performance (Daneman & Hannon, 2007; Sesma et al., 2009). However, poor verbal working memory contributed to reading difficulties (Jacobson et al., 2011; Swanson & Jerman, 2007). Extending these findings, our results showed that verbal working memory uniquely explained ESL reading comprehension, even after the variance explained by age, gender, starting age of learning written English, and reading anxiety was controlled for. This study has indicated both anxiety, as an affective factor, and verbal working memory, as a cognitive factor, are significant predictors of reading comprehension. These findings support the Component Model of Reading which highlights the prominent roles of affective and cognitive factors in reading. Poor reading anxiety and poor verbal working memory may be sources of reading difficulty and trainings which aim to lower anxiety and enhance working memory may be effective interventions for readers with reading difficulty.

Research has shown that the links between reading anxiety and word reading accuracy and fluency differed across age. Reading anxiety predicted word reading accuracy in first and second graders (Ramirez et al., 2019). However, reading anxiety significantly predicted reading comprehension, but did not predict word reading accuracy and fluency, after working memory, verbal knowledge, general anxiety and demographics were controlled for, in fourth and fifth graders (Macdonald et al., 2021). These findings suggest that reading anxiety tends to correlate with word-level reading ability in young children and the link diminishes when the children grow older. One possible reason is that word reading is more important in early stages of learning and

it becomes less important in reading acquisition when other higher-order reading-related skills, such as inferencing, come into play. Also, word decoding is automatic in experienced readers. In our study, the participants were undergraduates who were experienced readers. Based on the findings of past studies, it was assumed that the links between reading anxiety and word reading and fluency would be negligible in the relationship between reading anxiety and reading comprehension among undergraduates, and therefore word reading and fluency were not included in this study as covariates. However, higher-order reading component skills can be important covariates but they were not tested in this study. Further research is needed to investigate the contribution of reading anxiety to comprehension via higher-order reading component skills.

The Interplay of Reading Anxiety and Working Memory

Our study explored the effect of how reading anxiety and working memory jointly contribute to ESL reading comprehension. The results in this study revealed there was no significant reading anxiety x working memory interaction effect on ESL reading comprehension, which does not support our hypothesis 4. Studies focusing on more a general cognitive ability related to educational attainment have demonstrated an anxiety x working memory effect (e.g., Owens et al., 2014). The findings of these studies and the present research suggested that the extent to which this interaction effect plays a role in students' cognitive skills differ across various cognitive domains. However, when focusing on the reading domain, the finding in this study is inconsistent with Zaccoletti et al. (2019) who found an effect of interaction between activating-negative emotions and working memory in reading comprehension performance. One possible reason for the different results is that the activating-negative emotions measured in Zaccoletti et al.'s (2019) study included not only anxiety, but also anger and shame. Therefore, it

is plausible that different domains of affective factors on reading could have different relationships with working memory and reading comprehension. It is promising to further investigate how each of these affective factors is linked to reading comprehension.

A significant partial mediation effect of reading anxiety was found between verbal working memory and reading comprehension, supporting our hypothesis 3. This mediation relationship is consistent with past research findings indicating a robust association between reading anxiety and working memory (e.g., Lukasik et al., 2019; Moran, 2016; Shi et al., 2019). The finding suggests that compared to those with a better working memory, individuals with poorer working memory have to devote additional effort to inhibition/attentional control which takes up cognitive resources in the reading process, and hence are more likely to find the reading task difficult, causing higher anxiety. The anxiety distracts them from the reading task which in turn impairs reading performance. It is worth noting that although the findings suggest that working memory is linked to reading comprehension through reading anxiety, the plausible mediating effect of working memory should not be neglected. In this study, the indirect effects in the models with working memory as a mediator were not significant, but the indirect paths were significant. The non-significant indirect effects despite significant paths may be owed to the larger power of test of path coefficients than that of their products (i.e., indirect effect). Therefore, future studies could test the associations with a larger sample to corroborate the results. This helps extend the Attentional Control Theory to ESL reading comprehension, and clarify the interplay of anxiety and working memory in cognitive processing as proposed by this theory. In fact, research examining the mediating effect of working memory has yielded mixed results. In testing the links between anxiety, working memory and academic performance, Owens et al. (2008) found that working memory mediated the association between trait anxiety and verbal,

math and quantitative reasoning abilities, but not the association between trait anxiety and academic performance in English, math and science.

It is important to note that although mediation analyses are widely employed to examine the mechanisms of the links among variables in research, these analyses which involve concurrent data only provide links that are correlational in nature and do not prove causation. Although possible temporal precedence is implied, cautious interpretation of the results on the links among variables is required. To scrutinize the causal relationships, future research using a longitudinal design is needed. Past research has elucidated the mediating relationships of reading proficiency, amount and motivation using a longitudinal design (Soemer & Schiefele, 2018). Specifically, reading comprehension at time 1 predicted reading amount at time 2 which in-turn contributed to intrinsic reading motivation at time 3, demonstrating reading amount as a mediator in the relationship between reading comprehension and motivation in elementary school students. Building on the results of the present study, further studies can employ a similar design with data of reading anxiety, working memory and reading comprehension at three time points analyzed to clarify the casual and mediating relationships among them.

Overall, our findings support a component model of ESL reading comprehension underscoring the contribution of affective (anxiety) and cognitive (working memory) components as well as their interplay to ESL reading comprehension. They have helped clarify the mechanisms of how reading anxiety and working memory jointly predict ESL reading comprehension.

Limitations and Further Studies

This study has four major caveats. First, this study tested the relationships of variables at a single time point only, and therefore, the relationships are correlational in nature. Further

research could adopt a longitudinal design to examine the causal relationships in future studies. Second, this study used self-report reading anxiety ratings collected before and after the reading comprehension test. However, participants' awareness that they would attempt a reading task may have affected their responses in the trait anxiety test administered before the reading comprehension test. Additionally, the fact that the reading test had already finished may have affected their responses in the state anxiety test, hence resulting in unconscious bias. Future research could administer trait anxiety and reading tests at different times, and adopt behavioral measures (e.g., eye gaze) or physiological responses (e.g., heart rate) as additional indicators of state anxiety (e.g., Daley et al., 2014). Third, further studies could include general test anxiety as a control variable so that the unique role of reading anxiety in L2 reading comprehension could be better understood. Lastly, future studies could include word reading and fluency and language proficiency measures to provide a more comprehensive view of how reading anxiety is also linked to these componential skills as a critical part of reading comprehension. However, the choice of variables should depend on the reading experience of the target groups, as the links between reading anxiety and word reading accuracy and fluency differed across age (Macdonald et al., 2021; Ramirez et al., 2019). This study has established the links between reading anxiety, working memory and reading comprehension. Further research is needed to investigate the mechanisms, for instance, the contribution of reading anxiety to comprehension via language and decoding variables.

Conclusions

In summary, the present study has provided evidence for the contributions of affective (reading anxiety) and cognitive (verbal working memory) factors to ESL reading comprehension. This study has also extended previous study by showing the partial mediating role of reading

anxiety in the relationship between verbal working memory and reading comprehension in ESL. By identifying the influential affective and cognitive correlates and the potential interactive effects, the findings further our understanding of the underlying mechanisms of ESL reading comprehension development. Our findings suggest that trainings to reduce reading anxiety and enhance working memory in learners may be useful for promoting ESL reading comprehension performance. For example, training individuals with high ESL reading anxiety to divert their attention away from anxiety-arousing thoughts and focus their attention on the reading task could be beneficial to ESL reading. Also, trainings which enhance working memory could foster processing efficiency while reading. These are particularly important to L2 reading because L2 reading is more effortful and poses greater cognitive demands than L1 reading. The findings also highlight the importance of affective and cognitive factors in identifying difficulties in reading comprehension and suitable intervention methods. Specifically, educators and parents should consider the affective and cognitive profiles of students with ESL reading comprehension difficulties and employ corresponding intervention methods based on learners' needs.

References

- Aaron, P. G., Joshi, R. M., Gooden, R., & Bentum, K. E. (2008). Diagnosis and treatment of reading disabilities based on the component model of reading: An alternative to the discrepancy model of LD. *Journal of Learning Disabilities, 41*(1), 67–84.
- Adams, R., & Shahnazari-Dorcheh, M. (2014). The relationship between working memory and L2 reading comprehension. *Applied Research on English Language, 3*(2), 19–34. <https://doi.org/10.22108/are.2014.15492>
- Afsharrad, M., & Sadeghi Benis, A. R. (2017). Differences between monolinguals and bilinguals/males and females in English reading comprehension and reading strategy use. *International Journal of Bilingual Education and Bilingualism, 20*(1), 34–51. <https://doi.org/10.1080/13670050.2015.1037238>
- Alptekin, C., & Erçetin, G. (2009). Assessing the relationship of working memory to L2 reading: Does the nature of comprehension process and reading span task make a difference? *System, 37*(4), 627–639. <https://doi.org/10.1016/j.system.2009.09.007>
- Al-Shboul, M. M., Ahmad, I. S., Nordin, M. S., & Rahman, Z. A. (2013). Foreign language anxiety and achievement: Systematic review. *International Journal of English Linguistics, 3*(2), 32–45. <https://doi.org/10.5539/ijel.v3n2p32>
- Andersson, U. (2010). The contribution of working memory capacity to foreign language comprehension in children. *Memory, 18*(4), 458–472. <https://doi.org/10.1080/09658211003762084>
- Arrington, C. N., Kulesz, P. A., Francis, D. J., Fletcher, J. M., & Barnes, M. A. (2014). The contribution of attentional control and working memory to reading comprehension and decoding. *Scientific Studies of Reading, 18*(5), 325–346. <https://doi.org/10.1080/10888438.2014.902461>

- Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology: General*, *130*(2), 224–237.
<https://doi.org/10.1037/0096-3445.130.2.224>
- Bahmani, R., & Farvardin, M. T. (2017). Effects of different text difficulty levels on EFL learners' foreign language reading anxiety and reading comprehension. *Reading in a Foreign Language*, *29*(2), 185–202.
- Cain, K., Oakhill, J., & Bryant, P. (2004). Children's reading comprehension ability: Concurrent prediction by working memory, verbal ability, and component skills. *Journal of Educational Psychology*, *96*(1), 31–42. <https://doi.org/10.1037/0022-0663.96.1.31>
- Carretti, B., Borella, E., Cornoldi, C., & De Beni, R. (2009). Role of working memory in explaining the performance of individuals with specific reading comprehension difficulties: A meta-analysis. *Learning and Individual Differences*, *19*(2), 246–251.
<https://doi.org/10.1016/j.lindif.2008.10.002>
- Choi, S. (2013). Working memory capacity, vocabulary knowledge, and reading comprehension of EFL learners. *English Language Teaching*, *25*(1), 25–42.
- Chow, B. W.-Y., Chiu, H. T., & Wong, S. W. L. (2018). Anxiety in reading and listening English as a foreign language in Chinese undergraduate students. *Language Teaching Research*, *22*(6), 719–738. <https://doi.org/10.1177/1362168817702159>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.
- Daley, S. G., Willett, J. B., & Fischer, K. W. (2014). Emotional responses during reading: Physiological responses predict real-time reading comprehension. *Journal of Educational Psychology*, *106*(1), 132–143. <https://doi.org/10.1037/a0033408>

- Daneman, M., & Hannon, B. (2007). What do working memory span tasks like reading span really measure? In N. Osaka, R. H. Logie & M. D'Esposito (Eds.), *The cognitive neuroscience of working memory* (pp. 21–42). Oxford University Press. <http://doi.org/dsdp>
- Darvishzadeh, P., Aguilar-Vafaie, M. E., & Moradi, A. R. (2012). A comparative study of working memory executive functions processing efficiency considering high and low levels of anxiety. *Procedia - Social and Behavioral Sciences*, 32, 40–44.
<https://doi.org/10.1016/j.sbspro.2012.01.007>
- Derakshan, N., & Eysenck, M. W. (2009). Anxiety, processing efficiency, and cognitive performance. *European Psychologist*, 14(2), 168–176.
<https://doi.org/10.1027/1016-9040.14.2.168>
- Dijkstra, T. (2005). Bilingual visual word recognition and lexical access. In J. F. Kroll & A. M. B. De Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 179–201). Oxford University Press.
- Eysenck, M. W., & Derakshan, N. (2011). New perspectives in attentional control theory. *Personality and Individual Differences*, 50(7), 955-960.
<https://doi.org/10.1016/j.paid.2010.08.019>
- Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion*, 7(2), 336–353.
<https://doi.org/10.1037/1528-3542.7.2.336>
- Eysenck, M. W., Payne, S., & Derakshan, N. (2005). Trait anxiety, visuospatial processing, and working memory. *Cognition and Emotion*, 19(8), 1214–1228.
<https://doi.org/10.1080/02699930500260245>

- Friedman, L. M., Rapport, M. D., Raiker, J. S., Orban, S. A., & Eckrich, S. J. (2017). Reading comprehension in boys with ADHD: The mediating roles of working memory and orthographic conversion. *Journal of Abnormal Child Psychology, 45*(2), 273–287. <https://doi.org/10.1007/s10802-016-0171-7>
- Gathercole, S. E., Brown, L., & Pickering, S. J. (2003). Working memory assessments at school entry as longitudinal predictors of National Curriculum attainment levels. *Educational and Child Psychology, 20*(3), 109–122.
- Georgiou, G. K., & Das, J. P. (2016). What component of executive functions contributes to normal and impaired reading comprehension in young adults? *Research in Developmental Disabilities, 49–50*, 118–218. <https://doi.org/10.1016/j.ridd.2015.12.001>
- Goff, D. A., Pratt, C., & Ong, B. (2005). The relations between children's reading comprehension, working memory, language skills and components of reading decoding in a normal sample. *Reading and Writing, 18*(7–9), 583–616. <https://doi.org/10.1007/s11145-004-7109-0>
- Grills, A. E., Fletcher, J. M., Vaughn, S., Barth, A., Denton, C. A., & Stuebing, K. K. (2014). Anxiety and response to reading intervention among first grade students. *Child & youth care forum 43*(4), 417-431. Springer US. <https://doi.org/10.1007/s10566-014-9244-3>
- Horwitz, E. K., Horwitz, M. B., & Cope, J. (1986). Foreign language classroom anxiety. *The Modern Language Journal, 70*(2), 125–132. <https://doi.org/10.2307/327317>
- Jacobson, L. A., Ryan, M., Martin, R. B., Ewen, J., Mostofsky, S. H., Denckla, M. B., & Mahone, E. M. (2011). Working memory influences processing speed and reading fluency in ADHD. *Child Neuropsychology, 17*(3), 209–224. <https://doi.org/10.1080/09297049.2010.532204>

- Jeon, E. H., & Yamashita, J. (2014). L2 reading comprehension and its correlates: A meta-analysis. *Language Learning, 64*, 160–212. <https://doi.org/10.1111/lang.12034>
- Katzir, T., Kim, Y.-S. G., & Dotan, S. (2018). Reading self-concept and reading anxiety in second grade children: The roles of word reading, emergent literacy skills, working memory and gender. *Frontiers in Psychology, 9*, Article 1180. <http://doi.org/10.3389/fpsyg.2018.01180>
- Li, P., & Clariana, R. B. (2019). Reading comprehension in L1 and L2: An integrative approach. *Journal of Neurolinguistics, 50*, 94–105. <https://doi.org/10.1016/j.jneuroling.2018.03.005>
- Linck, J. A., Osthus, P., Koeth, J. T., & Bunting, M. F. (2014). Working memory and second language comprehension and production: A meta-analysis. *Psychonomic Bulletin & Review, 21*(4), 861–883. <https://doi.org/10.3758/s13423-013-0565-2>
- List, A., & Alexander, P. A. (2017). Cognitive affective engagement model of multiple source use. *Educational Psychologist, 52*(3), 182–199. <https://doi.org/10.1080/00461520.2017.1329014>
- Lu, Z., & Liu, M. (2011). Foreign language anxiety and strategy use: A study with Chinese undergraduate EFL learners. *Journal of Language Teaching and Research, 2*(6), 1298–1305. <https://doi.org/10.4304/jltr.2.6.1298-1305>
- Lukasik, K. M., Waris, O., Soveri, A., Lehtonen, M., & Laine, M. (2019). The relationship of anxiety and stress with working memory performance in a large non-depressed sample. *Frontiers in Psychology, 10*, Article 4. <https://doi.org/10.3389/fpsyg.2019.00004>

- Macdonald, K. T., Cirino, P. T. Miciak, J., & Grills, A. E. (2021). The role of reading anxiety among struggling readers in fourth and fifth grade. *Reading and Writing Quarterly*, 37(4), 382-394. <https://doi.org/10.1080/10573569.2021.1874580>
- Marteau, T. M., & Bekker, H. (1992). The development of a six-item short-form of the state scale of the Spielberger State-Trait Anxiety Inventory (STAI). *British Journal of Clinical Psychology*, 31(3), 301–306. <https://doi.org/10.1111/j.2044-8260.1992.tb00997.x>
- Mohd. Zin, Z. (2007). *The relationship between reading anxiety and academic reading performance among ESL learners* [Master's thesis, Universiti of Putra Malaysia]. UPM Institutional Repository. <http://psasir.upm.edu.my/id/eprint/4755/>
- Moran, T. P. (2016). Anxiety and working memory capacity: A meta-analysis and narrative review. *Psychological Bulletin*, 142(8), 831–864. <https://doi.org/10.1037/bul0000051>
- Naveh-Benjamin, M., McKeachie, W. J., Lin, Y., & Holinger, D. P. (1981). Test anxiety: Deficits in information processing. *Journal of Educational Psychology*, 73, 816–824.
- Nelson, J. M., Lindstrom, W., & Foels, P. A. (2015). Test anxiety among college students with specific reading disability (dyslexia): Nonverbal ability and working memory as predictors. *Journal of Learning Disabilities*, 48(4), 422–432. <https://doi.org/10.1177/0022219413507604>
- Owens, M., Stevenson, J., Hadwin, J. A., & Norgate, R. (2014). When does anxiety help or hinder cognitive test performance? The role of working memory capacity. *British Journal of Psychology*, 105(1), 92–101. <https://www.doi.org/10.1111/bjop.12009>
- Owens, M., Stevenson, J., Norgate, R., & Hadwin, J. A. (2008). Processing efficiency theory in children: Working memory as a mediator between trait anxiety and academic performance. *Anxiety, Stress, & Coping*, 21(4), 417–430.

<https://doi.org/10.1080/10615800701847823>

- Pae, H. K., & Sevcik, R. A. (2011). The role of verbal working memory in second language reading fluency and comprehension: A comparison of English and Korean. *International Electronic Journal of Elementary Education*, 4(1), 47–65.
- Peng, P., Barnes, M., Wang, C., Wang, W., Li, S., Swanson, H. L., Dardick, W., & Tao, S. (2018). A meta-analysis on the relation between reading and working memory. *Psychological Bulletin*, 144(1), 48–76. <https://doi.org/10.1037/bul0000124>
- Pham, A. V., & Hasson, R. M. (2014). Verbal and visuospatial working memory as predictors of children's reading ability. *Archives of Clinical Neuropsychology*, 29(5), 467–477. <https://doi.org/10.1093/arclin/acu024>
- R Development Core Team. (2013). *R: A language and environment for statistical computing* [Computer software]. R Foundation for Statistical Computing. <https://www.r-project.org>
- Rachmajanti, S., & Musthofiyah, U. (2017). The relationship between reading self-efficacy, reading attitude and EFL reading comprehension based on gender difference. *J-ELLiT (Journal of English Language, Literature, and Teaching)*, 1(1), 20–26.
- Rai, M. K., Loschky, L. C., & Harris, R. J. (2015). The effects of stress on reading: A comparison of first-language versus intermediate second-language reading comprehension. *Journal of Educational Psychology*, 107(2), 348–363. <https://doi.org/10.1037/a0037591>
- Ramirez, G., Fries, L., Gunderson, E., Schaeffer, M. W., Maloney, E. A., Beilock, S. L., & Levine, S. C. (2019). Reading Anxiety: An early affective impediment to children's success in reading. *Journal of Cognition and Development*, 20(1), 15-34. <https://doi.org/10.1080/15248372.2018.1526175>

- Ransdell, S., Barbier, M.-L., & Niit, T. (2006). Metacognitions about language skill and working memory among monolingual and bilingual college students: When does multilingualism matter? *International Journal of Bilingual Education and Bilingualism*, *9*(6), 728–741. <https://doi.org/10.2167/beb390.0>
- Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling and more. Version 0.5-12 (BETA). *Journal of Statistical Software*, *48*(2), 1–36. <https://doi.org/10.18637/jss.v048.i02>
- Saito, Y., Garza, T. J., & Horwitz, E. K. (1999). Foreign language reading anxiety. *The Modern Language Journal*, *83*(2), 202–218. <https://doi.org/10.1111/0026-7902.00016>
- Sari, B. A., Koster, E. H., & Derakshan, N. (2017). The effects of active worrying on working memory capacity. *Cognition and Emotion*, *31*(5), 995–1003. <https://doi.org/10.1080/02699931.2016.1170668>
- Seigneuric, A., Ehrlich, M.-F., Oakhill, J. V., & Yuill, N. M. (2000). Working memory resources and children's reading comprehension. *Reading and Writing*, *13*(1–2), 81–103. <https://doi.org/10.1023/A:1008088230941>
- Seigneuric, A., & Ehrlich, M.-F. (2005). Contribution of working memory capacity to children's reading comprehension: A longitudinal investigation. *Reading and Writing*, *18*(7–9), 617–656. <https://doi.org/10.1007/s11145-005-2038-0>
- Sellers, V. D. (2000). Anxiety and reading comprehension in Spanish as a foreign language. *Foreign Language Annals*, *33*(5), 512–520. <https://doi.org/10.1111/j.1944-9720.2000.tb01995.x>

- Sesma, H. W., Mahone, E. M., Levine, T., Eason, S. H., & Cutting, L. E. (2009). The contribution of executive skills to reading comprehension. *Child Neuropsychology, 15*(3), 232–246. <https://doi.org/10.1080/09297040802220029>
- Shi, R., Sharpe, L., & Abbott, M. (2019). A meta-analysis of the relationship between anxiety and attentional control. *Clinical Psychology Review, 72*, Article 101754. <https://doi.org/10.1016/j.cpr.2019.101754>
- Shin, J. (2020). A meta-analysis of the relationship between working memory and second language reading comprehension: Does task type matter? *Applied Psycholinguistics, 1*–28. <https://doi.org/10.1017/S0142716420000272>
- Soemer, A. & Schiefele, U. (2018). Reading amount as a mediator between intrinsic reading motivation and reading comprehension in the early elementary grades. *Learning and Individual Differences, 67*, 1-11. <https://doi.org/10.1016/j.lindif.2018.06.006>
- Spielberger, C. D. (1983). *Manual for the State-Trait Anxiety Inventory*. Consulting Psychologists Press.
- Stothard, S. E., Hulme, C., Clarke, P., Barmby, P., & Snowling, M. J. (2010). *YARC York assessment of reading for comprehension (secondary)*. GL Assessment.
- Swanson, H. L., & Jerman, O. (2007). The influence of working memory on reading growth in subgroups of children with reading disabilities. *Journal of Experimental Child Psychology, 96*(4), 249–283. <https://doi.org/10.1016/j.jecp.2006.12.004>
- Teimouri, Y., Goetze, J., & Plonsky, L. (2019). Second language anxiety and achievement: A meta-analysis. *Studies in Second Language Acquisition, 41*(2), 363–387. <https://doi.org/10.1017/S0272263118000311>

- Wang, Y., & Li, J. (2011). The interference of foreign language anxiety in the reading comprehension of agricultural engineering students. In *2011 International conference on new technology of agricultural* (pp. 660–663). IEEE. <https://doi.org/10.1109/ICAE.2011.5943882>
- Wood, S. G., Hart, S. A., Little, C. W., & Phillips, B. M. (2016). Test anxiety and a high-stakes standardized reading comprehension test: A behavioral genetics perspective. *Merrill-Palmer quarterly*, 62(3), 233–251. <https://doi.org/10.13110/merrpalmquar1982.62.3.0233>
- Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). *Woodcock-Johnson III Tests of Cognitive Abilities*. Itasca, IL: Riverside.
- Wright, C. A., Dobson, K. S., & Sears, C. R. (2014). Does a high working memory capacity attenuate the negative impact of trait anxiety on attentional control? Evidence from the antisaccade task. *Journal of Cognitive Psychology*, 26(4), 400–412. <https://doi.org/10.1080/20445911.2014.901331>
- Zaccoletti, S., Altoè, G., & Mason, L. (2019). The interplay of reading-related emotions and updating in reading comprehension performance. *British Journal of Educational Psychology*, 90, 663–682. <https://doi.org/10.1111/bjep.12324>
- Zhao, A., Guo, Y., & Dynia, J. (2013). Foreign language reading anxiety: Chinese as a foreign language in the United States. *The Modern Language Journal*, 97(3), 764–778. <https://doi.org/10.1111/j.1540-4781.2013.12032.x>

Table 1

Descriptive Statistics and Bivariate Correlations among Variables

	All		Male		Female		<i>Correlations</i>						
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	
1. Age (years)	20.81	1.58	21.24	1.79	20.57	1.42	-						
2. Starting age of learning written English (years)	3.82	1.29	3.87	1.44	3.79	1.22	.11	-					
3. Reading trait anxiety [4]	2.14	.46	2.11	.50	2.16	.44	-.07	.07	-				
4. Reading state anxiety [4]	2.11	.44	2.16	.48	2.09	.43	-.04	.03	.81***	-			
5. Verbal working memory [42]	27.73	4.49	27.57	5.53	27.82	3.95	-.25*	-.03	-.19	-.22*	-		
6. English reading comprehension [37]	18.89	4.90	17.49	5.68	19.65	4.27	-.09	-.02	-.41***	-.48***	.34***	-	

Note. Maximum possible score is given in bracket. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 2*A Structural Equation Model Predicting English Reading Comprehension*

Dependent variable	Factors	β	z	Fisher's Z		
English Reading	Age	.01	.11	.01		
Comprehension	Gender	.19	2.28*	.19		
	Starting age of learning written English	.01	.15	.01		
	Reading anxiety	-.42	-4.67***	.44		
	Verbal working memory	.35	3.72***	.37		
Model fit index	χ^2	DF	CFI	TLI	RMSEA	SRMR
	6.26	6	1.00	.99	.02	.03

Note. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 3*A Structural Equation Model Predicting English Reading Comprehension with an Interaction Term*

Dependent variable	Factors	β	z	Fisher's Z		
English Reading Comprehension	Age	-.01	-0.07	.01		
	Gender	.23	2.77**	.23		
	Starting age of learning written English	.02	0.18	.02		
	Reading anxiety	-.35	-4.03 ***	.37		
	Verbal working memory	.28	3.15**	.29		
	Reading anxiety \times Verbal Working memory	-.04	-0.43	.04		
Model fit index	χ^2 5.73	DF 4	CFI .96	TLI .78	RMSEA .06	SRMR .05

Note. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 4

Two Mediation Models Predicting English Reading Comprehension

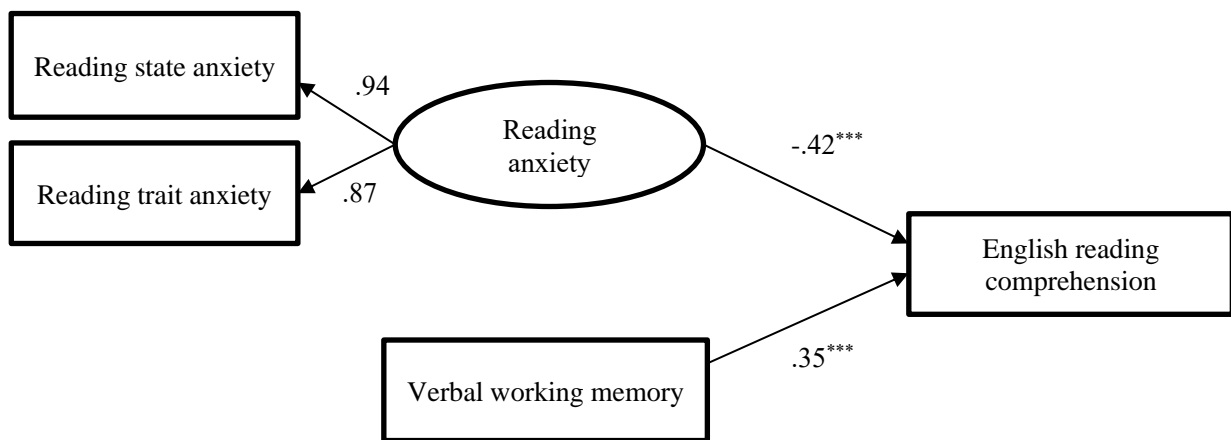
Mediation model 1: Working memory as a mediator, reading anxiety as an IV							Mediation model 2: Reading anxiety as a mediator, working memory as an IV					
	Indirect effect	95% CI	Direct effect	Total effect			Indirect effect	95% CI	Direct effect	Total effect		
β	-.05	[-1.39, .05]	-.44***	-.49***			.10*	[.01, .21]	.23**	.33***		
Fisher's Z	.05	NA	.47	.54			.10	NA	.23	.34		
Model Fit Index	χ^2	DF	CFI	TLI	RMSEA	SRMR	χ^2	DF	CFI	TLI	RMSEA	SRMR
	.25	3	1.00	1.12	.00	.01	7.39	7	1.00	.99	.02	.04

Note. 95% CI refers to indirect confidential interval at 95% level. * $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 1

Structural Equation Model 1: Reading Anxiety, Verbal Working Memory and Control Variables

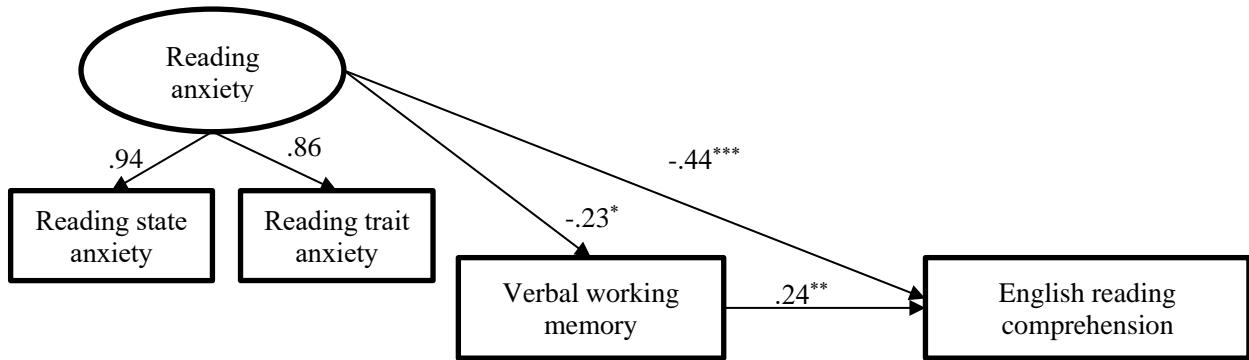
Predicting English Reading Comprehension



Note. Age, gender and starting age of learning written English were entered as control variables in the model. * $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 2

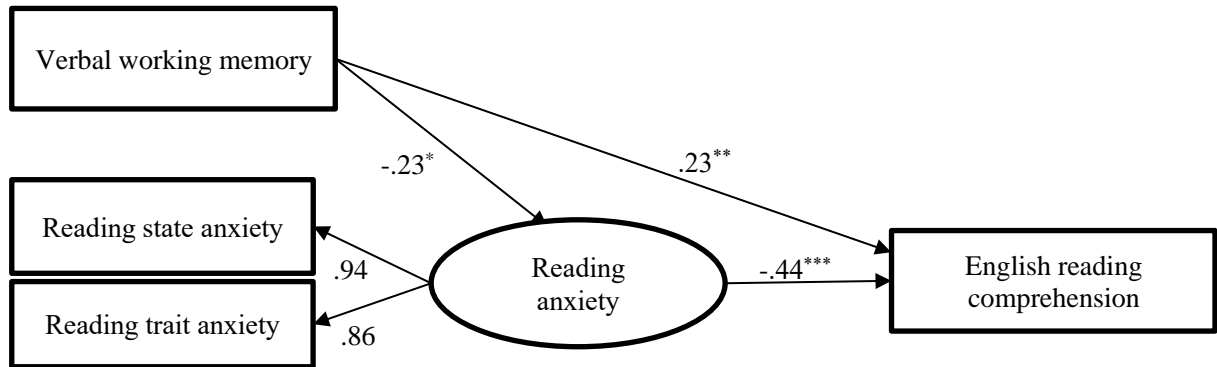
Mediation Model 1: Verbal Working Memory as a Mediator, Reading Anxiety as an Independent Variable



Note. Age, gender and starting age of learning written English were entered as control variables in the model. * $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 3

Mediation Model 2: Reading Anxiety as a Mediator, Verbal Working Memory as an Independent Variable



Note. Age, gender and starting age of learning written English were entered as control variables in the model. * $p < .05$. ** $p < .01$. *** $p < .001$.