

# Eye-tracking in Recent L2 Learner Research A Review of Chinese and English Literature

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## ABSTRACT

This paper reviews the eye-tracking L2 learner process studies published between 2013 and 2021. Specifically, the paper focuses on reviewing the eye-tracking L2 learner process research areas, the issues addressed by the studies in each area, and the comparison of domestic and foreign studies. It was found that eye-tracking has been used in eight L2 learner process research areas: vocabulary processing and learning, listening comprehension, syntactic processing, written text production, reading comprehension, text-based computer-mediated communication (CMC), oral communication, and data validation. The paper reveals that data collection and analysis approaches have differed from one area to another, and it provides some research and methodological suggestions.

**Keywords:** eye-tracking, language learning

## 1. INTRODUCTION

Eye tracking is a scientific method of observing second foreign language learning and teaching behavior, which provides language researchers with data dimensions and insights obtainable from no other source. [18] It describes the eye movement of the learning process by allowing the subject to wear an eye tracker while operating related equipment. When learning a second foreign language, due to the large difference in learning atmosphere, the performance of native speakers and second foreign language learners varies in many aspects. Researchers have done very specific empirical studies on vocabulary processing, syntactic processing, reading comprehension, oral communication and other aspects of second foreign language learning.

In order to further study the learner's behavior in second language learning and analyze the cognitive process more deeply, researchers usually adopt some observation methods, such as saccade and fixation. By understanding the eye movements of the learner, the learning habits are further reflected, thereby guiding the second foreign language learner to learn more efficiently. For example, Lian Xiaoying and Kang Zhifeng (2019) obtain the quick effect of sight interpreting of the eye tracking target area. And in a study by Guan Qun, Li Yifei, and Li Xinguo (2021), an eye-movement experiment was designed for English second-language

readers to investigate how text features and individual differences affect readers' integration processes.

This article aims to collate and review Chinese and foreign literature on second foreign language learning and teaching based on eye tracking technology, especially the literature published in important domestic and foreign journals. Based on the above, this review focuses on the process of eye tracking learners, and discusses the problems that have an impact on second language learning and teaching. This review includes the following stages: identifying research problems and scope of review, searching relevant research reports, evaluating studies included in the review, analyzing and extracting data, and finally making a summary. This paper covers the research on second language learners' eye movement process in recent years, and summarizes the relevant research results at home and abroad. From the international journals of Applied Linguistics / language education with high ranking and the academic database and Google Scholar and other search engines are used to retrieve the editorial volume and other relevant works published in internationally renowned journals. A total of 32 eye tracking studies were obtained. According to the research purpose and language processing type, 32 studies are divided into 6 research fields. The focus of reviewing the selected studies is not to synthesize their findings, but to determine the research fields and problems of eye tracking in the process of second language learners, and

explain the data collection and analysis methods used in the reviewed studies. This review aims to explain the application reasons and methods of eye tracking in various research fields at home and abroad, the shortcomings and deficiencies in the research, and how to Eye tracking technology will be fully utilized in the process research of language learners in the future.

## **2. SUMMARY OF THE REVIEW**

### ***2.1. Listening Comprehension Process Studies***

Intuitively, eye-tracking has been used in the listening comprehension studies employing video-based tasks in which listeners process visual elements. [16]

There are two eye-tracking studies using traditional video-based listening tasks focused on L2 listeners' auditory word recognition. [17,18] Sible Andringa(2020)'s study was a first attempt to investigate the emergence of awareness in uninstructed learning through a method designed to follow the development of learning. They sampled participants' eye position every 8.3 milliseconds and it needs determiner onset corresponds to zero and there was no correction for the time it generally takes to launch saccadic eye movements. Perdomo Michelle et al. (2021) investigated eye-movement behavior of native speakers of English and Chinese learners of English in their use of contrastive intonational cues to restrict the set of upcoming referents in a visual world paradigm. And they found that both native speakers and learners used contrastive pitch accent to restrict the set of referents. This suggests that learners are able to integrate information across multiple domains to build information structure in the L2 but may not do so predictively. Prosodic processing was not affected by proficiency or working memory in the L2 speakers.

The eye-tracking process will be affected by a variety of individual cognitive factors, such as attention and memory, etc. (Yan Weiwei, Kuang Xiaofang et al. 2020) The differences in these related cognitive factors may lead to different language learning effects. Among them, attention control is a very important component. It is not only closely related to a variety of higher-order cognitive functions, such as intelligence quotient (IQ), but also the main cognitive factor that affects second language acquisition. Language input is a sufficient and necessary condition for absorption.

Attention in second language acquisition is claimed to be the necessary and sufficient condition for conversing input to intake, and it is one of the main cognitive factors affecting L2 learning. Currently, most studies focus on attention allocation, and few work on the attention transfer pattern of L2 learners. However, the temporal features of attention transfer can reflect the thinking process of L2 learners more accurately. Yan Weiwei, Kuang Xiaofang et al. (2020) investigated 19

students (including 10 boys and 9 girls, average age 6.42, standard deviation  $SD=0.507$ ) to watch a 4-minute English reading video during the experiment. The vocabulary in the video has never been exposed to these young second language learners, and is used to eliminate the attentional interference caused by familiar vocabulary to reflect the learner's ability to control the attention of the second language stimulus. They used deep learning technology and visualization technology to mine the attention control patterns of young second language (English) learners on second language audiovisual information. They analyzed the listeners' coordinates of the fixation point, duration of the fixation point, the sequence of the fixation and so on.

The last eye-tracking studies focused on reading-while-listening. Kathy Conklin, Sara Alotaib, Ana Pellicer-Sánchez, Laura Vilkaitė-Lozdienė(2020) asked first language (L1) and second language (L2) speakers to read two passages (one in a reading-only mode and another in a reading-while-listening mode) while their eye movements were monitored. In reading-only, L2 readers had more and longer fixations (i.e. slower reading) than L1 readers. They analyzed fixation/regression count fixation duration as well as measuring saccade duration and length.

With the development of first language acquisition, the requirements for attention control in the process of second language learning will be higher. Therefore, it is necessary to carry out targeted second language feature perception training or intervention for young second language learners in order to improve their attention control ability of second language features, and then improve their overall perception ability of second language features.

### ***2.2. Syntactic Processing Studies***

The eye-tracking syntactic processing studies have addressed learners' grammar learning processes from SLA- and psycholinguistics-oriented perspectives. [21]These studies show that the eye-tracking syntactic processing studies are limited to few data source, high demand for subjects and analysis tools.

Eye-tracking studies looked at the grammar application in real situations and language tests and trainings by second language learners of different language types. Cutter Michael G and Martin Andrea E (2020) find that participants were attempting to perform aspects of sentence integration on the basis of low-level orthographic information from the previewed word. Dudley Amber and Slabakova Roumyana(2021) suggest that L2 knowledge of the subjunctive, at least at the proficiency levels tested in this study, is largely metalinguistic (explicit) in nature and that reduced lexical access and limited computational resources (e.g. working memory) prevented learners from fully utilizing

their grammatical representations during real-time processing.

In a study by Bernard I. Issa and Kara Morgan-Short(2019), the role of attention has been central to theoretical and empirical inquiries in second language (L2) acquisition. Results for both manipulations indicated that learner attentional allocation to the form was affected; L2 gains were evidenced, although only the internal manipulation led to above-chance performance; and L2 gains were related to attention allocated to the form under the external manipulation and to a lesser extent the internal manipulation. In this situation, the chances are that findings inform theoretical perspectives on attention and elucidate cognitive processes related to L2 instruction. The research covered in other recent eye-tracking syntactic processing studies include: the effect of interpreting training: low-level phonological violation between two parafoveal words (Cutter Michael G,2020)and effects on response time and accuracy of technology-enhanced cloze tests( Héctor R. Ponce,2020).

Some eye-tracking syntactic processing studies focus on what influences learners' acquisition of the target grammatical form by conducting research on cognitive processing mechanisms. These influences include the vitality information and the linguistic context. For example, Lu Shiyi and Gao Lingyan(2020) used eye-tracking technology, we investigated the online cognitive processing mechanism of "NP+VP" for Chinese unmarked subject-verbal utterances. It was found that both the vitality information and the linguistic context of the first NP had significant effects on the processing of unmarked subject utterances. Meanwhile, Su Wenchao and Li Defeng (2019)used eye-tracking technology to gather empirical evidence to determine how training and experience affected the cognitive load, speed of interpretation, and quality of output of student interpreters. Results indicated that advanced students demonstrated higher processing efficiency and output quality than junior students in processing problem triggers for whole texts and low-frequency words, but did not demonstrate higher processing efficiency and output quality in problem triggers for complex noun phrases.

At present, a large number of domestic eye movement researches focus on the study of mother tongue, while the application of eye movement technology to second language acquisition research is still in its infancy. Eye movement can not only provide real-time and direct measurement for language understanding, but also can continuously measure the language understanding process without interfering with language input. Therefore, the study of second language acquisition combined with eye movement technology is bound to be the future direction of the researchers' in-depth research.

These studies show that it is necessary for us to conduct eye-tracking studies in the future. These future eye-tracking studies need to focus on continuously

expand data sources as well as enrich the measurement means for analyzing eye movement data to improve the scientific accuracy of experiments. Future eye-tracking studies needs also to focus on what influences learners' acquisition of the target grammatical form in the macro-level by conducting research on cognitive processing mechanisms.

### ***2.3 Reading Comprehension Process Studies***

In this section, we will review the potential of eye tracking as a diagnostic tool in recent years to examine how participants deal with visual content according to the differences in the environment, materials and motivation of reading texts. There are two studies using eye tracking to investigate the differences of reading habits driven by different reading motives. Nicolas and Helen et al. (2019) focus on the impact of two contextual features (reading goal and discourse language) on the process of second language reading. The subjects were divided into two groups with regression rate or time (the number of fixation or total time in regression) and total reading time (the total time spent on words or some texts) as four eye movement indicators. They were given different reading tasks to observe their cognitive process. Nicolas and Helen conducted a cue recognition test to understand whether the subjects' memory traces were affected by language, reading goals and information centrality. Through eye tracking technology and data collection and analysis, it is concluded that there is a statistically significant three-way interaction among language, reading target and average word frequency. In order to study how TESOL trained raters use eye tracker to quantitatively measure reading residence time, regression and skip count to distinguish the elements of reading L1 and L2 texts, grant and Wesley (2019) combined eye tracking with raters' professional habits to observe the details of their process of completing reading tasks. Due to TESOL training, raters use the "semi-structured" overall scoring standard, which is divided into four aspects: rhetoric, vocabulary selection, organization and grammar.

In order to explore whether eye tracking, as a diagnostic tool, can detect the non-nativity of readers when processing written texts, Valeria and Yulia (2019) combined with C-test tested the subjects' L1 and L2 levels, carried out text reading, and compared the five indexes of eye movement measurement (fixation duration, saccade duration, saccade amplitude, saccade acceleration and saccade speed) Comparative analysis was performed as a continuous variable. The experimental data were statistically analyzed by MS Excel and statistical version 13.3, and factor discrete analysis was used. From their experiments, it can be found that by calculating the saccade and gaze features when reading L1 and L2 texts, an adaptive threshold algorithm for L2 detection based on eye tracking can be

established. In another study, Stephen and Sathena (2019) used eye tracking to test the cognitive validity of two levels of English proficiency reading tests (CEFR B2 and C1). Using a mixed method, Stephen investigated the reading patterns of examinees in six item types through eye tracking, self-report checklist and stimulus recall interview. Their research focuses on the differences of English reading methods and strategies between successful and failed students in cloze test, reading comprehension, multiple topic selection, abstract and title matching. The two researchers used a mixed method to provide information for test validity and design through eye tracking four digital data (fixed duration, fixed technology, access duration, access count), self-report checklist and stimulus recall interview. The data presentation is carried out in the form of heat map, which intuitively shows the differences in the methods and habits of the two types of students in doing reading questions. Kathy and Sara (2020) combined eye tracking with online vocabulary test, and asked second language participants to fill in the language background questionnaire to investigate their reading behavior in the two situations of pure reading and listening while reading. In the study involving text preview strategies, the two researchers used the reading strategy questionnaire and eye movement measurement. They focused on fitting the generalized linear mixed effect model to the data, and judged whether the audio and reading behavior were consistent through the binomial variable results. They also used ASIO sound card to provide accurate audio timing for the experiment, send time messages to eye tracker, and accurately indicate the time of specific words heard by subjects during audio presentation.

Advancements in technology have also brought important methodological innovations in second and foreign language acquisition research. One of these important advancements is eye-tracking. In the 1980s, Shen Deli did a lot of research on eye movement reading, which made the research on eye movement has made great progress (Liu Yanmei, Ran Shiyang, Li Defeng, 2013). In a study by Guan Qun, Li Yifei, and Li Xinguo (2021), an eye-movement experiment was designed for English second-language readers to investigate how text features and individual differences affect readers' integration processes. Four referential conditions (direct, transformational, inferential, and control) were used in the text feature analysis, and individual difference features distinguished the working memory abilities of bilinguals. To study the integration process, the following metrics were counted: eye-movement metrics (Average First Fixation Duration, Gaze Duration) in the target word (e.g., the explosion) region and metrics of real-time integration of reading (Gaze Duration, Skipping Probability, and Look-Back Time) verified significant immediate text integration effects.

In this section, eye tracking technology as the main data source is an important basis for analyzing the dynamic change process of the subjects in the reading process. In another study, Ma Xingcheng and Li Dechao(2020) used eye tracking, questionnaire surveys and interviews to obtain data to explore the cognitive process of translation teachers and ordinary readers on translation reviews. In this study, they routinely used the total gaze duration and the number of annotations as eye movement indicators, and also selected three scales for the participants: the accuracy and fidelity of the translation, the quality of the language expression of the translation, and the communicative effect of the translation. In order to intuitively understand the participants' attention distribution patterns during the review process, the two researchers used the gaze point distribution map and the hot zone map to visualize the eye movement data. On this basis, after the two groups of people read different types of translation materials, four related research questions on the length of gaze, the number of gazes and the main effects of the area of interest were studied.

By reading the literatures of eye tracking in the second language reading comprehension process, we can draw the following conclusions: First, in terms of literature content, in the two papers of Lian Xiaoying and Kang Zhifeng(2019,2020), they focused on the field of sight translation, respectively taking the average speed of the eye tracking target area and the eye movement track as the research object, the close relationship between these two factors and sight translation was discussed. Secondly, Guan Qun, Li Yifei, Li Xinguo (2021) discussed the influence of different texts and individuals on the process of reading integration for second language reading. Finally, Ma Xingcheng and Li Dechao(2020) put forward higher requirements for the study of reading comprehension, rising to the level of translation review. They explored the cognitive process of translation teachers and ordinary readers on translation reviews.

Since the issues in these literatures were conducted based on eye-tracking data, the selection of eye-movement indicators is important according to different needs, and we found that gaze duration and gaze return rate are two eye-movement indicators that are used more frequently. In most of these experiments, the researchers adopted the eye-tracking trajectory visualization method and drew the gaze hot zone map and eye-tracking trajectory map to facilitate the analysis and interpretation of subjects' eye-tracking behaviors.

The above few studies have shown us how to make use of eye-tracking in investigating L2 readers' comprehension strategies. In each study we found such a commonality that different visualization and data processing methods are needed according to different research needs, and the selected metrics are flexible in their application. In future eye-tracking L2 reading

comprehension studies, the findings should be combined with practical applications to provide reference for second language learning research and teaching.

#### **2.4 Oral Communication Process Studies**

The eye-tracking oral communication process studies reviewed have focused on one distinct sub-areas concerned with Interpreting training.

As training and experience increases, translators and interpreters are believed to carry out translation and interpreting tasks more efficiently and with better quality, as accumulation, acquisition and practicing of skills eventually leads to more autonomous processing (Anderson, 2015). Studies have been conducted to examine the effect of translation/interpreting training and experience on translators' /interpreters' cognitive processes and their output quality, but have so far produced mixed findings (see Hervais-Adelman and Babcock, 2019 for reviews). These studies mostly focus on the training effect on word or sentence translation (Santilli et al., 2019; He, 2019), and few have focused on the effect on translation and interpreting at the textual level (except García et al., 2019). Besides, only a few studies have examined how training effects interact with translation directions. This study fills this gap by examining the effect of interpreting training and experience on the cognitive processes and the output quality of English-to-Chinese (L1 translation) and Chinese-to-English sight interpreting (L2 translation). But the study seemed to have found largely different results from Chmiel and Mazur (2013). It is difficult to pin down the reasons for the seemingly contradictory findings. Future research with more nuanced designs is needed to really get to the bottom of such differences.

#### **2.5 Vocabulary Processing And Learning Studies**

Since the eye-tracking is commonly used for collecting data about word or sentence processing, the largest number of the studies located dealt with L2 vocabulary processing and learning. The eye-tracking vocabulary studies reviewed have focused on three distinct sub-areas concerned with algebraic interpretation, concomitant vocabulary learning, nonconforming to material verb processing.

The variable constraint relationship in pronouns interpretation has not received enough attention, especially in the field of two-sentence clause processing (Nanjing University of Posts and Telecommunications Jia Guangmao, 2020). This study sought to answer the following question: Are variable constraints limited by syntax during English learners' pronouns? The study found that Chinese English learners prefer to establish full quantifiers of component pronouns as pronouns in the sentence comprehension test; in eye movement

experiment, first gaze time indicators showed that Chinese English learners are not sensitive to sentence structure and gender, while backtracking path time and total residence time are not sensitive to sentence structure, processing noncomponent sentences is less time-consuming than processing component sentences. This is the conclusion that for Chinese English learners, to successfully interpret pronouns, information structure, language order, potential word competition, distance, and processing efficiency. The main disadvantage of the study is not to replace the experiment of quantifier words with limited noun phrases, so it is impossible to know whether Chinese English learners handle the co-finger faction relationship is different from the processing variable constraints.

Accompanying lexical learning is done in completing non-lexical learning. During the task (for example, reading), The process of inadvertently acquiring a vocabulary (Li Hong, Tian Qiuxiang, 2005; Nagy, Herman, & Anderson, 1985), it is an important way for learners to accumulate their vocabulary (Frantzen, 2003; Frishkoff, Perfetti, & Collins-Thompson, 2011; Huckin & Coady, 1999; Ku & Anderson, 2001; Nagy et al., 1985) Nowadays, foreign researchers have used eye movement technology to examine the online understanding of non-berg verbs and non-lattice verbs in many languages. Domestic researchers used the self-paced reading task (Zhang Daqiu, Qiao Xiao, 2013; Zhu Xiujie, Wang Tongshun, 2018) and sentence judgment task (Zhaochen, Ge Shao, 2017) to investigate the online processing of English non-inger structure for Chinese English learners. In the research of Liu He Nation (1985) Language students with high levels successfully guessed that the correctness rate of the new word meaning was significantly high for students with a low language level; the higher the learners' language level, the more efficient learning new word (Bai Xuejun, 2019; Liang Feifei, Zhang Pneg, Zhang Qihan, Wang Yongsheng, 2017). The results did not find significant differences in the contextual cue effects of high and low Chinese level international students in accompanying vocabulary learning. This is compared to previous findings that compared with highly reading readers, readers with low reading ability are more dependent in identifying words during reading the contextual information (Liu Nina et al., 2019; Schvaneveldt et al., 1977; West & Stanovich, 1978; West et al., 1983) is not match.

The processing of incompatible verbs is a hot topic in domestic and foreign language circles in recent years (Friedmann et al. 2008; Bard et al. 2010; Lee & Thompson 2011; Momma et al. 2018; Vemice & Sorace 2018; Zhang Daqiu, Qiao Xiao, 2013; Zhao Chen, Ge Shao, 2017; Zhu Xiujie, Wang Tongshun et al., 2018). Perlmutter (1978) studies found different syntactic manifestations within refractory verbs and accordingly proposed the "Unaccusative Hypothesis"

which is classified into unaccusative verbs and unergative verbs. But the complexity of irrelevant verb syntactic information and the hierarchy of semantic information are reflected in the processing of native speakers, but whether similar outcome patterns will appear in two-language processing has not been deeply explored. On this issue, they start the research and the complexity of irrelevant verb syntactic information and the hierarchy of semantic information are reflected in the processing of native speakers. However, whether similar outcome patterns will appear in two-language processing has not been deeply explored.

## **2.6 Written Text Production Process Studies**

As to the L2 Written text production process studies, eye-tracking has been mainly used in composing process and translation process studies.

For the translation process, many researchers have mentioned parallel processing in translation. Wang Yifang (2019) used eye tracking and key-logging methods to obtain four eye movement-keystroke index data: pay attention to total time, pay attention to unit time and pupil dilation; use SPSS statistical software for analysis and calculation. Finally, it is concluded that the total amount of cognitive resources consumed by parallel processing and the allocation of cognitive resources of attention units are the least among all processing types. Later, Wang Yishan (2021) further updated his conclusion. Using the above four eye movement-keystroke index data and SPSS statistical software, he proposed that the cognitive resources consumed by target language processing are significantly greater than other types of processing, and the conclusion that target language processing > source language processing > parallel processing is used. In addition, Wang Yishan (2021) adopts the method of introspection to obtain the subjective feedback of the translator's own translation process. He found that most subjects believed that they spent much more energy on the source language (second language) comprehension than the target language (mother tongue) output. This is quite different from the previous survey results.

There are also some researchers who had studies on metaphor translation. Wu Guangjun and Wang Ruiyang (2019) studied the difference in the translator's cognitive effort between marriage metaphors and non-metaphors when translating economic texts, proving that interlingual language pairs does not affect the results of metaphorical and non-metaphorical cognitive efforts. In addition, they also found that the cognitive efforts paid for metaphorical expressions in different categories are different. They further studied three metaphor translation strategies: M-M (metaphor-metaphor), M-P (metaphor-paraphrase) and M1-M2 (metaphor1-metaphor2). They found that the M1-M2 strategy spent the most cognitive effort, while the M-P strategy spent the least. Wang

Yishan (2019) also did research on metaphor translation. He found that the influence of language type on the cognitive load consumed by parallel processing is inconsistent.

Yu Jingsong, Yang Chao, and Li Jingya (2020) have some discoveries about chunk translation. They believe that in the selection of teaching strategies, using the method of thinking first and then learning is better than directly providing bilingual example sentences, and it can improve the efficiency and fluency of translation.

Regarding the composing process, Wang Junju and Du Mingmei (2019) believe that eye movement technology is feasible in second language writing feedback because they found that when students read teacher feedback, their eye movements can pass through the mode of visual attention to provide detailed and in-depth information.

## **3. LIMITATIONS**

There are some limitations in our research of using eye-tracking in language learner process studies. Some issues to overcome technical problems and improve data analysis are needed. What's more, readers and researchers find themselves discussing more about eye-movements rather than language learners' cognitive processes. Therefore, language researchers need to find ways for transforming eye-tracking jargon into describing learners' actual cognitive processes. We can better use participants' concurrent verbalizations in future eye-tracking research to gain better insights into language learner real time processing.

As the above review shows, eye-tracking has been used in five L2 learner process research areas. The dates of the published studies indicate that eye-tracking it has become much more popular in L2 learner process studies in the last few years. However, some researchers believe that if technology advances and measurement accuracy is improved, it will be of greater benefit to the study of eye tracker on L2 learning. And the data is actually not accurate at this point. At the micro level, current devices cannot be accurately and completely measured. In addition, the problems of too single source of subjects as well as the difficulty and type of texts which indicates that further refinement of subjects and texts are needed in future experiments.

## **4. FUTURE PROSPECT**

As the above review shows, eye-tracking has been used in four L2 learner process research areas in English literature—listening comprehension process studies, syntactic processing studies, reading comprehension process studies and oral communication process studies, and it has been used in four L2 learner process research areas in English literature—vocabulary processing and

learning studies, listening comprehension process studies, syntactic processing studies, written text production process studies and reading comprehension process studies. The dates of the published studies indicate that eye-tracking it has become much more popular in L2 learner process studies in the last few years. However, there are two L2 learner process research areas we didn't find papers writing about these both in English literature and Chinese literature, one is text-based CMC study, and the other is data validation study. As Wang Yifang (2019) had mentioned, there are some data that current technical basically unable to achieve. How to further eliminate errors and differentiate the processing types in more detail that is the direction scholars are working hard on.

## 5. CONCLUSION

Focusing on the eye-tracking L2 learner process studies, this study compares and summarizes the relevant research results at home and abroad. In the eight L2 learner process research areas, the conclusion that data collection and analysis approaches have differed from one area to another is obtained. A limitation of this study is that researchers find themselves discussing more about eye-movements rather than language learners' cognitive processes. An additional uncontrolled factor is that the accuracy of eye trackers needs to be improved. By way of closure to this study, I would like to make the following recommendations for the further research. First, further refinement of subjects and texts is needed in future experiments. Second, text-based CMC study and data validation study are gaps in L2 learner process.

## AUTHORS' CONTRIBUTIONS

Qiao Huixian: Writing – Review & Editing.

Cao Ying: Conceptualization, Project Administration, Formal Analysis, Resources, Validation, Visualization, Funding Acquisition, Investigation, Writing - Original Draft, Writing - Review & Editing.

Sun Zhihan: Formal Analysis, Investigation, Resources, Validation, Visualization, Funding Acquisition, Writing - Review & Editing.

Yang Ziwei: Formal Analysis, Investigation, Resources, Validation, Visualization, Funding Acquisition, Writing - Review & Editing.

Li Dingyi: Formal Analysis, Investigation, Resources, Validation, Visualization, Funding Acquisition, Writing - Review & Editing.

Li Shihua: Conceptualization, Funding Acquisition, Methodology, Project Administration, Data Curation, Resources, Software, Supervision, Writing - Review & Editing.

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