

Effects of Written Corrective Feedback on Chinese EFL Learners' Cognitive Processes

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Abstract

Pauses, interruptions of the production process during writing, serves as windows to observe the cognitive processes when writing. This study involves 65 freshmen with 33 in the experimental group (EG) receiving written corrective feedback (WCF) and 32 in the control group (CG). Using Inputlog 8.0, this study records each student's writing process during writing to explore the effects of WCF on writers' pausing behaviors at both micro and macro levels. Research procedures follow a pattern of "writing, treatment and rewriting" and participants complete the writing tasks within three weeks. By dividing each writing event into 5 equal intervals, the results show that the total writing time of the EG is significantly longer in the rewriting stage, indicating that WCF can trigger "noticing" and prompt learners to focus more on the content and language form. The pausing features in each interval show that the writing stages of the EG are clear and concentrated, that is, the planning stage with low pause frequency and long pause time and the translation stage with high pause frequency and short pause time. In contrast, the CG has frequent cross-changes in pause frequency and duration in each interval, suggesting that the writing cognitive processes alternate frequently and text production is frequently interrupted. This indicates that WCF helps learners manage the writing process more effectively. Combined with the interview data, this paper further investigates the factors leading to differences in pausing behaviors among different groups to better inform L2 writing pedagogy.

Keywords: written corrective feedback, writing process, pausing behavior, cognitive processing, pause factors

1. Introduction

Writing is an important skill in many professions and fields. Corrective feedback, as a crucial interaction between teachers and students, is considered to be conducive to second language development (Long, 1996). Corrective feedback, which can be divided into

oral corrective feedback and written corrective feedback refers to responses to learners' expressions that contain an error (Ellis, 2006). Written corrective feedback (WCF) is teachers' responses to linguistics errors that are made by students in their writing in the written form, which plays an important role in second language teaching. Early studies focused on

issues about the effectiveness of WCF, what type of WCF is more effective, the potential contributing factors, and their mediating effects. Moreover, a vast majority of them have focused mainly on writing products (Bitchener & Storch, 2016). With the development of cognitive psychology, there has been a recent shift in second language writing research from studying writing products to learners' cognitive processes (Kellogg, 1996; Xu & Ding, 2014; Xu, 2021; Pascual et al., 2023), while attempts to investigate the effects of WCF on learners' writing process are still very few. Furthermore, from the perspective of research methods and instruments, due to the widespread use of digital media, computer writing is gradually replacing traditional pen-and-pencil settings (Zhang et al., 2021). The rapid development of science and technology makes it possible to use computer-aided instruments to record and analyze the writing process in real time. Keystroke logging, as a significant background-running observation tool of the computer, offers the possibility to precisely record the keyboard and mouse activities during the writing process at millisecond accuracy. This enables the accurate recording and analysis of the writing process without causing any disruption to the writers (Révész *et al.*, 2019). Therefore, by using the keystroke logging tool: Inputlog 8.0, our study will add a new contribution to whether and how the writing processes and pausological behaviors are altered by the effect of WCF in a digital setting.

2. Literature Review

2.1 Studies on Written Corrective Feedback

Early research mainly focused on the effectiveness of WCF. Truscott's (1996) found that CF was ineffective and, in some cases, even harmful to students' learning that should be abandoned in second language classrooms. However, Ferris (1999) held the view that WCF was helpful in improving the accuracy of language forms. Since then, a bulk of empirical studies on WCF have been directed at addressing Truscott's (1996) claim that there is no empirical or theoretical justification for correcting students' written errors. Evidence from these studies confirmed that WCF is a useful tool to help L2 writers in increasing their writing accuracy.

After a series of related empirical studies, scholars have started figuring out which type of

CF is more effective in promoting students' writing performance. Following the construction of the WCF typological framework (Ellis, 2006), the effectiveness of direct WCF, indirect WCF, and metalinguistic WCF has been widely discussed. However, the results of these studies are not consistent. For the reasons above, a number of studies have shifted their focus to identifying the potential contributing factors and examining their mediating effects. These factors can be divided into internal and external ones. As for the former, it comprises factors such as L2 learners' working memory, language proficiency, processing capacity, language learning aptitude, goals, interests, attitudes, and beliefs. Bitchener and Storch (2016) suggested that learners who had a feedback type preference would be able to improve the accuracy of their writing after receiving the type of written CF they believed was most helpful. Concerning external factors, these encompass macro and micro contexts, the type of corrective feedback, the role of instruction, and the type and modality of tasks. For example, after examining the effects of WCF on articles, past tense, hypothetical conditionals, and prepositions, Bitchener and Storch (2016) suggested that rule-based forms or structures are potentially more treatable than item-based forms or structures.

Above all, research on WCF has focused on either the writing product or the processing of WCF, while few of the studies reviewed thus far have addressed the role of writing processes before and after the provision of WCF and this study aims to bridge this gap.

2.2 Writing as a Process

Inspired by the area of problem-solving research in psychology, the 1980s witnessed a shift from writing production to dynamic writing processes, and a surge of interest and explosive growth in investigating the processes embedded in writing. The concept of "writing as a process" has gained great importance in writing research. The writing itself is no longer identified only as a final written product, but also viewed as a dynamic process during which complex cognitive activities are operated to convey ideas and meaning. Several writing models have been proposed to explain the underlying cognitive processes of writing, emphasizing the non-linearity in the writing cognitive processes. Among them, the most influential models are proposed by Hayes and Flower (1980) and

Kellogg (1996). According to these models, the writing cognitive process consists of three main processes: planning, translating, and reviewing.

In parallel with the shift in theoretical approach, methodological investigation of writing has shifted its focus from product analysis to process observations. Think-aloud protocol, one of the most used techniques, was the first new technique employed by researchers for studying the cognitive processes of writing in the 1980s. However, some scholars argue for their subjectivity and interference with the writing process since participants may intentionally modify what they actually think and give an unreliable description with a desire to satisfy the researcher. As computer and computer-based writing became ubiquitous, a relatively novel observation method called keystroke logging software began to be used in writing process research, which has broadened the scope of writing research. This method is superior to the traditional methods in that it can be run in the background of the computer and record the keyboard and mouse behaviors in the writing process without disturbing the writers. Besides, it has advantages in both efficiency and accuracy with millisecond precision to accurately record and analyze the data. Moreover, it not only records the frequency and duration of the writers' pauses during writing but also the distribution of these pauses. Such data can be used as indirect evidence to speculate about the writer's cognitive activities underlying writing processes. So far, keystroke logging has been used as a research tool by many language researchers in a variety of contexts, and it has proved to be an effective device for identifying writing strategies and interpreting cognitive processes of writing (Leijten & Van Waes, 2013).

From above, keystroke logging analysis tools provide a new perspective for the study of the temporal progression of writing. Following the previous research (Xu & Qi, 2017), the present study uses the keystroke logging tool Inputlog 8.0 to record the participants' writing processes, which helps to interpret the cognitive processing during writing.

3. Methodology

The operational procedures are refined to keep the research process on the right track, including the following three stages:

(1) Composing Stage

At this stage, each participant was given a

writing task to develop an essay of the title: The Value of Time. They were allowed 30 minutes to write the essay at least 120 words but no more than 200 words. Prior to data collection, Inputlog software was already installed on the desktop computers. After the presentation of the writing prompt and task instructions on the projection screen, the participants were asked to start the Inputlog interface and activate the software by clicking the "Start Recording" button, which marks the beginning of their writing session. They clicked the "Stop Recording" button when completing the task. Moreover, activities outside the reach of Inputlog recording, such as pen-and-paper drafting, peer discussion, and cellphone use, were prohibited during the writing event.

(2) Feedback Processing Stage

The feedback processing stage was for dealing with WCF. Before distributing the initial draft to students, teachers scored their texts and gave them WCF first. To ensure the validity of the scores, this experiment combined scores from the teacher and the Juku Correcting Network. Besides, teachers graded students according to the ESL Composition Profile. Referring to the WCF, included the feedback from Juku Correcting Network, largely rectifying errors in grammar and spelling aspects, and feedback from teachers, which mainly pointed out the merits and demerits of the article's structure and viewpoints. Moreover, students were required to reflect on the problems that existed in their compositions according to the WCF or the grades.

(3) Rewriting Stage

The rewriting stage involved the rewriting of the original texts following exactly the same procedure as in the composing stage. After participants had finished their tasks, they were immediately provided with a questionnaire, which both EG and CG completed. After that, 40 participants from two groups were led to a separate room one by one, where they were provided with a replay of their writing provided by Inputlog. In Chinese, each informant was engaged in a semi-structured interview of 10-20 minutes or so. Before the interview, the researcher developed an interview guide that included questions and topics to be covered during the conversation. The interviewer followed the guide during the interview and was able to probe topics that may stray from the

guide when she felt this was appropriate. The interviewees were entitled to the freedom to share their thoughts, like why they made pauses and revisions. Semi-structured interviews can provide comparable, reliable qualitative data on pausing behaviors. At the end of the interviews, informants were asked to give pedagogical suggestions for future WCF.

4. Result and Discussions of Findings

4.1 General Differences of Pause Patterns in the Writing Process

In this section of results, data on pausing behaviors in the global writing process were presented to capture the composing features of writers in different groups. Thus, by conducting repeated-measure ANOVAs, important dependent variables such as the total time spent on writing, the time spent on writing actively as well as the number and duration of pauses were examined and presented from a within-group (i.e. the effect from Writing 1 to Writing 2) and between-group perspective (i.e. to observe the effects of WCF between the EG and CG). The descriptive statistics showed that pauses took up a considerable proportion of the process time in argumentative writing. The pair-wise within-group comparisons showed that students either in EG or CG significantly reduced the total process time/total active writing time/total number of pauses/total pause time from writing 1 to writing 2 (all the p -values were less than 0.05). To better understand the potential effect of WCF provision, the between-groups comparison of Writing 2 revealed that a significant difference lay in the two groups ($p < 0.05$). Specifically, the EG devoted more time to the whole writing process than CG. Additionally, the EG paused more and devoted more time to both active writing and total pause time than the CG, whereas the differences between these variables of EG and CG were not statistically significant ($p = 0.237 > 0.05$; $p = 0.118 > 0.05$; $p = 0.061 > 0.05$). Therefore, it indicated the necessity of examining the impact of WCF on pausing behaviors at linguistic and temporal locations to have a deep insight into the writing process.

From above, in the case of both groups, all variables were significantly reduced from time 1 to time 2. Pauses were considered traces of “covert cognitive processes” (Barkaoui, 2019, p. 530). In any event, the apparent reduction of pausing time throughout the composition process might indicate that writers did not

experience the same amount of cognitive load as when writing for the first time. Following Kellogg’s (1996) model of writing, the task “rehearsal” of the initial writing and the review of their texts in the second stage allegedly supplied the students with sufficient support or background knowledge, even for the CG, which possibly eased the pressure in the participants’ central executive and visual-spatial sketchpad, since they potentially remembered what and in which order they had to write about, and so the pause frequency was reduced, which may point to better management of attentional resources.

Besides, the comparison of the revised version of the text revealed that the EG significantly devoted more time to the whole writing process than the CG ($p = 0.035 < 0.05$). Additionally, the EG paused more and devoted more time to both active writing and total pause time than the CG, but it did not yield any significant difference. The interpretation and empirical implications of these results were relevant for explaining the potential effects of triggering noticing (Swain, 2005) which WCF is thought to activate, especially given the substantial difference of time between the EG and the CG in writing the revised version. In essence, students in the EG, as a consequence of the provision of WCF, might have become more aware of the problems in their interlanguage when they engaged in writing their revised version of the text. Based on the interview results, 87% of the students in the EG mentioned that they noticed the problems existed in their texts from the WCF (such as errors with words, syntax, and content) and made some corrections during the rewriting process, while only 32% of the students in the CG indicated that they could identify some problems based on their scores, which were mostly spelling or simple grammar errors. That explains why students in the EG devoted a similar amount of time to writing actively despite the significant decrease in the total pause time.

Additionally, the explanation for the non-significant differences in other aspects was caused by the frequency of WCF. According to the Noticing Hypothesis (Schmidt, 1990), for learners to internalize language forms and their associated meanings, they need to notice the gap between their own production and the correct target language form. With just a single occurrence of corrective feedback, learners may not have sufficient opportunities to notice and

process the feedback thoroughly, thus leading to a relatively low frequency of attention. This limited attention frequency may result in learners only superficially noticing the errors and corrections without truly internalizing the correct forms, so they might not engage in deep cognitive processing to understand why the error occurred and how to avoid it in the revised version. Therefore, to explore the effects of WCF on students' writing process, it's necessary to examine the impact of WCF on pausing behaviors at linguistic and temporal locations.

4.2 Pauses at Temporal Locations

Examining pauses at successive time intervals could shed light on how pauses were distributed in a whole writing segment. It allowed researchers to observe the pausing features from a macroscopic perspective and provided valuable information on pausological behaviors and the effects of WCF. Repeated-measures ANOVA test was performed on the pause frequency of each interval in the EG and CG to examine the effects of each writing interval on the pause frequency within groups. Mauchly's Test of Sphericity suggested that the data in the EG met the sphericity assumption ($p = 0.800 > 0.05$). The results showed that writing intervals had significant effects on the pause frequency of the EG ($p = 0.000 < 0.01$). In the CG, it also met the sphericity assumption ($p = 0.434 > 0.05$) and the results showed the pause frequency of the CG in different intervals reached the level of statistical significance as well ($p = 0.001 < 0.05$). The pairwise comparisons were conducted to investigate whether the difference in the frequency of pauses in different intervals was significant for the EG and CG. The results indicated, for the EG, the pause frequency in interval 2, interval 3 and interval 4 were significantly higher than that in interval 5 ($p_1 = 0.004 < 0.05$, $p_2 = 0.000 < 0.01$, $p_3 = 0.040 < 0.05$) and the pause frequency in interval 2 was significantly higher than that in interval 1 ($p = 0.000 < 0.01$). While for the CG, only the pause frequency in interval 4 was significantly higher than that in interval 5 ($p = 0.015 < 0.05$). Moving on to the between-groups comparison of pause frequency in the revised version, the number of pauses in the EG was significantly higher than the CG in Interval 3 (EG = 25.24, CG = 20.56, $p = 0.041 < 0.05$) and there were no significant differences in other intervals.

Next, the present research also compared the differences in interval pause duration of the two

groups in the revised version. Likewise, in order to explore the differences in pause duration within groups, the Repeated-measures ANOVA test was used in pause duration. The result of Mauchly's Test of Sphericity in the EG was $p=0.000$, and the result of CG was the same, indicating groups did not meet the sphericity assumption. Therefore, Greenhouse-Geisser revised the F value. The difference in the pause duration of the EG and CG both reached the level of statistical significance ($p_1 = 0.002 < 0.05$, $p_2 = 0.021 < 0.05$). The results of pairwise comparisons in pause duration showed that there were significant differences between interval 1 and other intervals for the EG (the values of p were as follows: $p_1 = 0.000$, $p_2 = 0.001$, $p_3 = 0.002$, $p_4 = 0.002$). However, no significant differences were found in CG. Regarding the between-groups comparison of the duration of pauses, the pause duration in the EG was significantly longer than the CG in Interval 1 and significantly shorter than the CG in Interval 3 ($p_1 = 0.043 < 0.05$, $p_2 = 0.045 < 0.05$).

Globally considered, both groups decreased the number of pauses during all five intervals from writing 1 to writing 2. The features of pauses at temporal locations of different proficiency writers reflected the management differences in writers' cognitive process of writing. The writers in the EG and CG differed in their interval pausing patterns, showing that the WCF affected writers' management of writing processes. Long pauses in the initial stage are related to global planning, memory search, and conceptual integration (Wengelin, 2006; Spelman Miller, 2006b). In this study, the interval pausing patterns suggested that the EG may engage in much global planning at Interval 1, displaying longer and fewer planning pauses. Conversely, the CG displayed frequent and short pauses in Interval 1, indicating that this group started writing much sooner and Interval 1 was related to both planning and translating.

This could be explained by the fact that the writer's participation in the writing process largely depended on the writer's goals. Considering that the WCF established goals for writers by encouraging them to improve the quality of their initial compositions, it thus had an impact on learners' cognitive demands and attentional resources in the writing process. After the students in the EG received the WCF, they may have increased their efforts in retrieving ideas as suggested in previous studies

(Révész et al., 2019), so as to plan the structural content of the article more fully according to the WCF. In contrast, the CG, due to the absence of WCF, entered the translating stage quickly. The stimulated recall comments also indicated that students in the EG stated that they would think more about how to make the article more emotional and profound, as well as how to sublimate the theme and build ideas more comprehensively. They would re-plan the train of thought or correct grammatical errors according to the given suggestions. While most students in the CG stated that if they could not find errors, they would still follow the original train of thought.

A dip in mean pause duration together with an increase in pause frequency was found after Interval 1 in the EG. Based on Kellogg's working memory model of writing, this dramatic change in pausing behavior roughly indicated a transition from the planning stage to the translating stage. Pause patterns across Interval 2,3,4,5 remained generally consistent, which revealed a high degree of fragmentation of writing as the writer navigated across the composing stage. In the translating stage, a large number of short pauses were made at small units of texts for translating or revision purposes, which can also be evidenced by the pause patterns at the word boundaries as illustrated above. The findings in the EG were consistent with other tendencies revealed by previous studies (e.g. Barkaoui, 2019). However, in the CG, students entered the translating stage (with high pause frequency and short time) at interval 2, but different from the EG, they entered the re-planning stage of low production (with low pause and long time) at interval 3. In interval 4, they entered the translating stage again (with high pause frequency and short time). Besides, the pause behavior in interval 5 (with low pause frequency and short time) indicated that the writing cognitive activities in this period were not much different from those in the previous period, and to a certain extent, it involved the process of thorough reading and modification (with reduced pause frequency). With such frequent changes in pause frequency and pause duration, the CG indicated the frequent alternation of planning, translating, and reviewing, thereby the concentrated translating stage was often interrupted and appeared relatively late, that was in interval 4. The underlying reason may be that writers in

the CG suffered from a certain cognitive struggle since they paused more per minute. According to Hayes' (1980) and Kellogg's (1996) model, planning in the initial stage could reduce writers' cognitive demand and act as a liberator of working memory, enabling writers to better focus on other processes that require a higher degree of cognition, namely the translating process, and thus having better management of the cognitive resources in the writing process. This study further confirmed this view, evidently, as for the EG, there is a clear-cut in the writing process: writing planning (Interval 1) and translating (Interval 2-4). By contrast, the CG did not have a clear boundary in the writing process.

In addition, previous studies have shown that the participants who made fewer, but much longer, pauses in the first interval would pause significantly more frequently, but for shorter periods, in later intervals (Barkaoui, 2019). Different from previous research, compared to the CG, the long-term planning in interval 1 by the EG did not lead to fewer and shorter pauses in interval 3 and interval 4. The main reasons were as follows. Firstly, as mentioned earlier, compared with the CG, students in the EG produced more sentences, which may lead to more and longer pauses. Secondly, according to the interviews, some students in the EG stated that they have carefully thought about the WCF and avoided making the same mistakes while revising the text. Besides, they wanted to use some more advanced words and sentence patterns to replace the original contents, thus leading to an increase in pause frequency and duration. The fact that the pauses at the sentence level in the EG are more and longer than those in the CG in the previous section further confirmed this view.

Moreover, contrary to our expectations, this study did not find that WCF had an impact on the reviewing stage. The author mainly provided explanations for this result from the following three aspects. First, the thorough reviewing stage was either relatively short or even missing in the writing process. The fact that students had relatively fewer pauses at the after-sentence and after-paragraph in the previous section further confirmed this. The task type seemed to be another reason. Different from the previous research (Xu, 2021), this study adopted a time-limited writing task. Due to the time constraints, many students said that they

did not have time for the final thorough reading and revising. Finally, students' different levels of proficiency may also have an impact on the results. Previous studies (Xu & Ding, 2014; Xu & Qi, 2017) have reported that the skilled and less skilled L2 writers in their study differed significantly in terms of their pausing patterns at different intervals of the writing process. Compared to lower-proficiency writers, higher-proficiency writers had better management of attentional resources and thus had a clearer writing process, namely planning, translating, and reviewing stage. In our study, the presence of students with different proficiency levels in each group might contribute to overall results that deviated from those of previous studies.

4.3 Factors Leading to Pausing Behaviors

The qualitative analysis results revealed that the differences in pausing behaviors during writing mainly stemmed from linguistic factors (words, grammar, and content). Meanwhile, both groups' writing processes were affected by environmental factors (writing mode and environment) and individual factors (writing motivation and language proficiency). The EG spent more time on planning than the CG, and the pauses were mainly derived from the conceptions of syntax and lexical diversity. However, pauses in the CG were more inclined to considerations of word spelling and grammatical accuracy. From the grammar perspective, the research found that long pauses for the EG were more likely to try to use complex sentence structures such as the Subject Clause or the Non predicate verb. However, students in the CG mainly paused due to the uncertainty in grammar usage, for example, the Tense and Voice of words. Additionally, a close observation of the recording video from Inputlog suggested that the EG had a well-marked trail of planning before sentences, but the CG goes the other way around. This is consistent with the results that, for the EG, pauses were more likely to happen at natural loci for planning such as clause and sentence boundaries, while for the CG, pauses appeared in locations that suggested difficulties in spelling, word-finding, and other transcription processes. In terms of individual factors, the EG was more easily influenced by language proficiency, while the CG was more restricted by motivation. Environmental factors were common causes as both groups were influenced

by the writing mode and experiment environment.

5. Conclusion

The main aim of this work is to find out the differences in the features of pause between the groups with and without the WCF and further explore the effects of WCF on Chinese English learners' pausing behaviors in the writing process. Moreover, this research also delves into the factors leading to the pause behaviors between the two groups. Combing quantitative and qualitative analyses, the main conclusions are as follows:

The first finding is that students in the EG reduced total process time, total active time, pausing time, and frequency as well as the CG, which indicated that the cognitive load when writing the revised version in both groups might have been reduced, but reflective operations were still required possibly as a result of higher-level cognitive operations. Additionally, it was found that WCF could active the effects of trigger noticing since the decrease of the total process time was sharper in the CG. Owing to no significant differences in other aspects except for the process time, it was necessary to examine the effects of WCF at linguistic and temporal locations. Besides, data indicated that the pauses were not evenly distributed throughout the process. After receiving the WCF, the EG paused significantly longer than the CG at interval 1. Moreover, they paused more frequently and longer than CG at interval 3. Students in the EG exhibited well-defined writing stages, while students' writing stages in the CG were functionally cross-cutting and passive, with writing often bogged down. Moreover, it was found that WCF had no impact on the reviewing stage, caused mainly by the fact that the reviewing stage was either relatively short or even missing in the writing process. Moreover, for both EG and CG, the linguistic factors were the main causes for the pauses. For the EG students, more pauses derived from the grammar than the word, while the CG was exactly the opposite. The reason behind this was that the EG had difficulty with the conceptions of syntax and lexical diversity, but the CG had difficulty with word spelling, word choosing, and grammar usage due to the absence of the WCF. Moreover, individual factors including writing motivation and language proficiency also affected the pauses. Specifically, language proficiency had a greater impact on the EG,

while the CG was more affected by writing motivation. Finally, environmental factors (writing mode and environment) also explained some pause behaviors in the writing process according to the stimulated recall interview.

This study deeply explores the effects of WCF on Chinese EFL learners' pausing behaviors during writing and the findings provide some implications for English writing teaching. English teachers should pay more attention to students' writing processes in the future and guide students to actively use the pause strategy. Through the WCF, teachers can help students form effective writing process management strategies, thereby comprehensively improving their writing proficiency.

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