Word Processing and Second Language Writing: a Longitudinal Case Study

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ABSTRACT

The purpose of this study was to determine whether word processing might change a second language (L2) leamer's writing processes and improve the quality of his essays over a relatively long period of time. We worked from the assumption that research comparing word-processing to pen and paper composing tends to show positive results when studies include lengthy terms of data collection and when appropriate instruction and training are provided. We compared the processes and products of L2 composing displayed by a 29-year-old, male Mandarin leamer of English with intermediate proficiency in English while he wrote, over 8 months, 14 compositions grouped into 7 comparable pairs of topics, altemating between uses of a lap-top computer and of pen and paper. All keystrokes were recorded electronically in the computer environrnent; visual records of all text changes were made for the pen-and-paper writing. Think-aloud protocols were recorded in all sessions. Analyses indicate advantages for the word-processing medium over the pen-and-paper medium in terms of: a greater frequency of revisions made at the discourse level and at the syntactical level; higher scores for content on analytic ratings of the completed compositions; and more extensive evaluation of written texts in think-aloud verbal reports.

KEYWORDS: word processing, composing processes, longitudinal research, revision, think-aloud protocols.

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I. INTRODUCTION

The effects of word processors on student composition have been studied extensively in the past two decades, mainly for English mother-tongue students. Reported findings differ widely, due to a variety of factors such as the design of studies, their duration of data collection, the length of time during which students were exposed to word processors, as well as the training students received on word-processing-assisted writing. Few studies on word-processing-based writing have addressed the issue of composing and revising processes in L2 environments. The present study investigated a L2 student's writing processes, thinking processes and quality of writing, aiming to find out if using a computer would promote more higher-level revisions and improve the person's quality of writing, when training is provided and when the participant was exposed to computer-assisted writing over a period of time.

1.1. Word Processors and L1 Writers

Bangert-Drowns (1993) discussed the effects of word processing on English mother-tongue (L1) writing, observing that a typical word processor allows the manipulation of texts to produce high-quality printed documents. Because word processors help reduce the mechanical difficulty involved in changing texts and offer a fluid and easily transformed communication, users might create longer compositions and do more revisions of their writing than they would do with pen and paper. Bangert-Drowns concluded that word processors may allow student writers "to attend to higher order decisions (e.g., revision for clarity of communication)" (p.72).

I. 1.1. Advantages and disadvantages of wordprocessing vs. pen andpaper

As shown in Table 1, several researchers have described various advantages of word processing as an educational tool that helps L1 students write compositions, whereas others have described disadvantages of word-processing-assisted writing.

Table 1: Advantages and Disadvantages of Word-processing-assisted Writing		
Functions of word processing	**Advantages**	**Disadvantages**
Spell checking	It eases students' fear of making spelling error and help them to produce essays with fewer spelling errors (Warschauer, 1998).	It may encourage surface-level revisions that focus on spelling of words (Joram, Woodruff, Lindsey, & Bryson, 1990).
Blocking moving, block deleting, and formatting	They free students from recopying texts and therefore facilitate revising and editing (Bean, 1983; Bernhardt, Wojahn, & Edwards, 1989; Collier, 1983; Daiute, 1986; Dickenson, 1986; MacArthur, 1988; Phinney & Khouri, 1993).	Eliminating the need to recopy may make students do fewer rereadings, which may prevent in-depth revisions (Dickenson, 1986; Hawisher, 1986; Kurth, 1987)
Storage	Students can put down their thoughts in a non-permanent mode, which eases their fear of making mistakes; they can also put their thoughts into a permanent mode so they need not fear losing their ideas nor be blocked by perfectionism (Daiute, 1983)	
Highly readable screen display and neatly printed hardcopies	They may heighten students' pleasure and pride in their writing (MacArthur, 1988); facilitate students' development of a sense of their audience (Hooper, 1987); encourage more reading of one's own text and so more in-depth and surface-level revision (Rodrigues, 1985).	They may prevent student writers from revising their superficially neat-looking but unfinished writing (Gerrard, 1989)
Motor and mnemonic skills needed for operating a computer		They complicate the task of writing (Collier, 1983; Daiute, 1983, 1985a). They can impede the writing process of students with poor typing skill and thus result in poorer essays (Dalton & Hannafin, 1987; MacArthur, 1988).

I. 1. 2. Effects of word processing vs. pen and paper on students' writing processes and written products

A large number of empirical studies have been conducted on the effects of word processing on the revision processes and quality of completed essays. The findings, however, are inconsistent. Many researchers have compared the revision processes between the two writing media. They found that with word processing, developing writers make more revisions, especially higher level revisions (Daiute, 1985b; Dalton & Hannafin, 1987; Frase, Kiefer, Smith & Fox, 1985; Lutz, 1987; McAllister & Louth, 1988). Other researchers, however, have reported less positive or even negative effects of word processing on students' revisions: Because of the polished look of a piece of writing text on the computer, students may be lured into concentrating on superficial modifications instead of in-depth, substantive revisions (Jorarn, Woodruff, Lindsey,

& Bryson, 1990; Owston, Murphy & Wideman, 1992). In some cases, students revise less with word processing than with pen and paper (Benesch, 1987; Coulter, 1986; Daiute, 1986; Harris, 1985).

Researchers have also investigated the effects of word processing on the quality of students' writing. In several studies holistic or analytic evaluations of the quality of the final writing produced by word processing were higher than those with pen and paper (Cirello, 1986; Kitchin, 1991; Owston et al., 1992; Pivamik, 1985; Sommers, 1985; Williamson & Pence, 1989). Other researchers have found no significant difference in quality between computer-based writing and paper-and-pen writing (Hawisher, 1986; Hawisher & Fortune, 1988; Kurth, 1987).

1.2. Word Processing and L2 Learners

In terms of computer-assisted writing, L2 students have many characteristics in common with English L1 students. The above-mentioned advantages and disadvantages also apply to L2 leamers. Such functions as spell checking and grammar checking are especially significant for L2 writers. Not only can L2 writers easily find their spelling errors and recognize the correct ones from a list of options, their fear of making spelling errors may be eased as well (Warschauer & Healey, 1998). As a result, their anxiety in writing in a second language may be relieved, at least to a certain degree. In leaming writing in a second language that uses a Roman alphabet such as English, leamers from non-Roman language backgrounds may feel impeded by the difficulty in handwriting. The electronic keyboard of word processors, however, may help minimize this problem (Berens, 1986; Piper, 1987). Pennington (1996) observed that the ease of keyboarding and the ability of word processing to manipulate texts may further enable L2 writers to write freely and lead to improved attitudes towards writing in the second language. Eliminating mechanical difficulties in L2 writing and the ease of manipulating texts may make L2 writers less resistant to revising their written drafts. As a result, they may write more, write differently, and write better (Pennington, 1996).

Computers may cause problems for L2 writers as well. Phinney and Khouri (1993) commented that for ESL writers who have weak writing skills in their L1, the computer-assisted writing might merely add another hurdle. Ching (1990) remarked that less expenenced L2 writers have trouble identifying their own errors, and the difficulty of reading on computer screens may cause additional problems. As mentioned above, skills for operating a computer may make writing tasks more difficult for L1 student writers, especially for those with poor typing skills; these problems may be worse for those L2 writers who are anxious about writing in a L2 and who have not received adequate training in word processing.

I. 2. 1. Findings on computer-assisted L2 writing

Compared to L1, there are far fewer empinical research studies on computer-assisted L2 writing, and the findings are less conclusive. Similar to those in L1, findings are also mixed. A few researchers

found their L2 students made more and different types of revision (Chatwick & Bruce, 1989; Lam, 1991; Li, 1998). Other studies on L2 writers have reported participants focused on superficial and local changes instead of content-related revisions (Benesch, 1987; New, 1999; van Haalen, 1990). Quality of writing was reported to be higher on computers in a few studies (Kichin, 1991; Lam & Pennington, 1995; Li, 1998), whereas at least one study of computer-aided L2 writing found no difference in quality between the two writing conditions (Odenthal, 1992). Li (1990) found the quality of her students' computer-written essays improved in certain tasks.

A few researchers also conducted studies, mainly case studies, to investigate individual behaviors of L2 learners writing with word processors. Phinney and Khouri (1993) found that their ESL (English as a Second Language) students' previous experience with word processing was a more important factor than their writing proficiency in determining whether or not these ESL writers benefited from word processing. In their study, four participants displayed quite different attitudes towards word processing: two experienced computer users demonstrated high motivation to use word processing, whereas one claimed that he liked word processing but did not "display that attitude in class" (p. 260). A fourth person exhibited high anxiety over writing on the computer. Benesch (1987) found that her three ESL students utilized the word processor for fundamentally different purposes: one for generating ideas, one for editing, and the other for getting familiar with the technology, although none of them used the computer for revising. Ching (1990) found that some ESL students may become focused on learning computer skills and forget that "the ultimate object of the hardware and software is to facilitate their writing process" (p. 11). Pennington (1991, 1996) observed that the features of word processors that have potentially positive effects could have negative effects on students' writing under certain circumstances. In particular, inexperienced writers and beginning computer users who have not received sufficient training in word processing are not likely to make good use of the new technology. These indicate that proper training is essential in computer-assisted writing.

1.3. Lessons Drawn from Previous Research

Addressing the conflicting findings in the research on computer-assisted writing, a few systematic reviews of previous empirical studies, both in L1 and L2, have suggested some possible reasons why results from research on computer-assisted writing are inconsistent. These publications have concluded that because outcomes of studies depend on a variety of variables, the following factors should be taken into consideration in future research:

1.- When developing writers are motivated to utilize computers and their technical capacities, there is more chance for them to benefit from the new writing tool than for students who are not so motivated (Bangert-Drowns, 1993; Cochran-Smith, 1991; Pennington, 1993, 1996, 1999).

2.- When teachers encourage their students to use computers to write and when they provide

adequate training to empower their students with the essential skills and knowledge of computer-assisted writing, students are more likely to yield better **outcomes** in their computer-assisted writing (Cochran-Smith, 1991; Pennington, 1993, 1996). Cochran-Smith (1991) and Owston et. al (1992) observed that the revision skills that students possessed before they started using computers may be an **important** factor in determining whether the ease of using computers in writing may benefit them. **That** is, if students **have** not **been trained** (or learned) to revise at the content levels for better communication, then simply putting them on a computer cannot help them to **become** better revisers. **They** will tend to confine themselves to only **surface-level** revisions. Computers alone cannot bring about positive changes to developing writers. **Only** when they are combined with adequate training and **learning** opportunities in computer-assisted writing can students benefit in their writing.

3.- Researchers **have** also established that in the **several** studies reporting negative or no effects of word-processing-assisted writing, novice computer **users** were exposed to the new writing tool for a relatively short time. As a consequence, **future** studies need to **provide** a **lengthy** period of **exposure** to computer-assisted writing so as to give students enough time to adapt to the new writing medium **(Hawisher,** 1989; Pennington, 1993, 1996; Phinney & **Khouri,** 1993).

4.- Owston et. al (1992) suggested studies should investigate writing processes in detail instead of focusing only on **written** text products. Such research may be able to explain how computers influence the thinking and writing processes of student writers.

11. THE PRESENT STUDY

II. 1. Research Questions

As **observed** above, the number of empirical studies on word-processing-assisted writing **in** the context of L2 **is** limited; **almost** no longitudinal case studies **have been** conducted with think-aloud protocols or on the effects of training. **The** present case study was intended to make a contribution in these respects. Following the suggestions of previous **researchers** (described above), we conducted the present case study over a relatively long time, we considered the participant's motivation, we offered **training** in both computer-assisted writing and pen-and-paper-based writing, and we collected and **analyzed** data on the participant's thinking while composing and writing processes. We posed the following research questions:

1) Would word processing help this L2 **writer** make **higher-level** revisions?
2) How might word processing influence this student's thinking processes while composing?
3) Would word processing help this L2 writer improve the **quality** of his essays?

4) Would **training** be **essential** to this student in **utilizing** the potential advantages of word processing in his composition writing?

5) Would **continuous** exposure to the computer help produce more positive effects in favor of the word-processing-assisted writing?

For Question 2 we investigated **thinking** processes in **reference** to the decision-making episodes elicited **through** think-aloud protocols while the participant composed (see II. 3 and Appendix B for details). For Question 4, our operational definition of the potential advantages of word processing was the capacity of word processing to manipulate writing and to help produce essays of better quality. For Question 5, positive effects of the word processing-assisted writing refer to **higher-level** revisions and higher quality of essays as described in Questions 1 and 2.

11.2. Participant

A 29 year-old **Mandarin** Chinese speaker, Hsin (a pseudonym), who was learning English in Toronto, volunteered to participate in the study. An engineering graduate from Taiwan, his English proficiency **level** was "**high** intermediate" according to his placement in ESL **courses**[1]. He reported that prior to the study he had had **some experience** with a word processor called Personal Editor 2, popular in Taiwan years before. **This** word processor had fewer **functions** than most **commonly** used word processors on IBM and Macintosh computers at the time when the data for this study were collected. **Because** Hsin was applying for graduate studies in **Canada** and therefore likely would need word processing skills in his **planned future** studies, he had at least **some** motivation for learning word **processing**[2].

11.3. Procedures

Fourteen writing tasks, **grouped** into **seven** pairs with comparable topics in each pair (see Appendix A), were given to the participant over a period of eight months. The first four and the last four of the writing tasks were designed to elicit argumentative texts. Four were designed to elicit narrative texts. Two were letters to **certain officials** complaining about problems that Hsin felt concerned about. The topics within each pair were chosen randomly, using a table of **random** numbers. The paired compositions were written alternately with a word processor (using Word Perfect 5.1 on a laptop computer) and with pen and paper. We selected these topics to be comparable and general, but they were not pilot-tested or otherwise assessed for comparability, so the findings presented below must be considered tentative.

The first author of this article met individually with Hsin, once per week, over the period of eight months (except the year-end holidays). Hsin spent one session to **generate** an essay and another to revise **it**. The first author **also** encouraged him to do **some** revisions by saying "Could you please spend **some** time reading and revising your **essay**?" right after he had completed generating

the texts, which he did, though very briefly. The rationale for doing so was that we hoped to help Hsin to better revise his essays written with both media as suggested by Cochran-Smith (1991) and Owston et. al (1992). This was done in both computer and handwritten sessions. A tutorial session was given immediately after Hsin had finished revising his essay to help him further improve the essay in both writing conditions, but the further revised copies were not used as data in the present study. The first author encouraged Hsin to think aloud in either English or Mandarin while Hsin composed in all sessions, saying, "Could you please speak out whatever you're thinking about?" in Mandarin. The verbal reports were tape-recorded. From the fifth session on, the first author offered him brief training on the word processor, including the basic functions of word processing: selecting texts, copy, paste, block moving, block deleting, and spell checking. The reason for waiting until the fifth session was that we hoped to see if tutoring would make any difference to his composing. No time limits were imposed on the writing tasks. A special computer program was used to electronically monitor all keystrokes Hsin made during all computer sessions[3], providing data on the text generating and revising processes of his word-processed writing. During the pen and paper sessions, no eraser was allowed so that all changes Hsin made to his texts composed in this medium were also recorded.

To analyze the data we compared the computer-assisted writing and pen-and-paper writing for: frequency of revisions at various levels and analytic evaluations of the compositions. In terms of revisions, any moving, deleting or adding of a whole T-unit, i.e., a complete sentence, was considered a discourse change; any sentence structure change or sentence extension was regarded as a syntactic change; any adding, deleting or changing words and phrases was defined as a lexical change; any change, adding or deletion of free and bound morphemes was treated as a morphological change.

Data on think-aloud protocols collected from eight compositions[4] were analyzed according to the criteria developed in Cumming (1990); all discourse during which Hsin reported on his decisions about writing and revisions, i.e., all those thinking episodes that are not simply verbatim verbalization of the texts being produced, was isolated and then segmented into units of decision-making episodes when preceded and followed by pauses of 3 seconds or more. These episodes were coded into categories of global planning, local planning, reasoning about linguistic choices, rhetorical considerations, consulting a dictionary or the tutor for a word or phrases, evaluating what had been written down previously, and procedures for writing (see Appendix B for examples of coded statements). The first author counted the total number of think-aloud episodes (including decision-making episodes and non-decision-making episodes) and the number of episodes in each category of decisions. He then tallied the percentage of each category of decision-making episodes in respect to the total think-aloud episodes. (So, for example, the percentages in Figure 8 are only for decision-making episodes, whereas the majority of episodes involved generating or reading text). Reliability of the coding of the think-aloud protocol was established with a second reader, a native Mandarin speaker and an experienced L2 educator, who was completing a Ph.D. in education. The second reader coded approximately 10% of the think-aloud protocols and the inter-coder agreement

was found to be 78%.

Two raters, both experienced ESL teachers doing Ph.Ds in second language education, helped with the analytic evaluation of the compositions, which was carried out according to the criteria developed by Jacobs, Zinkgraf, Wormuth, Hartfiel, and Hughey (1981) reduced to a scale of 8, following Cumming (1989). They rated the compositions together, blind to the sequence or medium in which they were written, then reached a consensus on each score. If the scores they rated were the same, we simply used them; if the difference between their scores was only 1, we added the 2 different scores then divided the sum by 2; if the difference between their scores were 2 or more, the raters discussed the paper until they reached a consensus on a score. We typed the texts originally written with pen and paper into the wordprocessor so that all texts were pnnted out in the same style. Thus, there was no superficial difference between the computer products and hand-written products when they were rated. To elicit more information about the decisions the raters made, we intewiewed them jointly afterwards. During the inteview, we paired the essays and asked the raters why there were apparent differences in the ratings of certain aspects between each pair. The results of the inteview are reported in III.1.3.

III. FINDINGS AND DISCUSSION
III. 1. Results
III.1.1. Frequency of lower-order and higher-order revisions

The frequency of revisions in Hsin's computer-assisted writing was consistently greater than that of his pen-and-paper revisions at the discourse level except for the first session and the last session (see Figure 1)[5]; it was greater at the syntactic and lexical levels in most sessions (see Figures 2 and 3), and it was steadily higher at the morphological level except for the last session (see Figure 4).
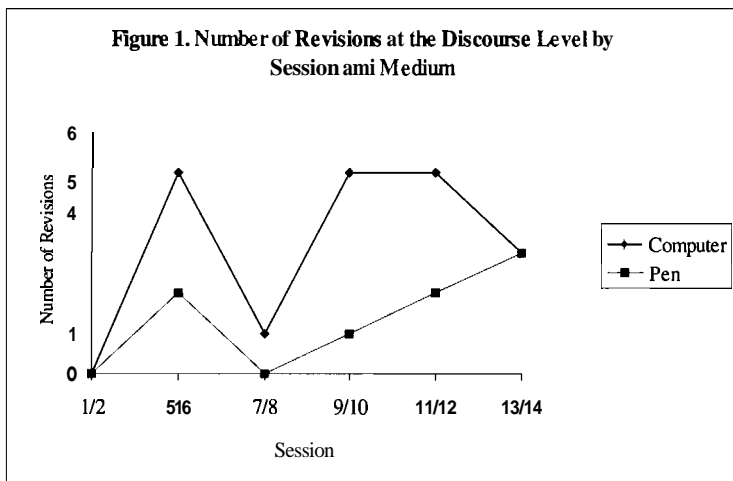

Figure 1. Number of Revisions at the Discourse Level by Session ami Medium

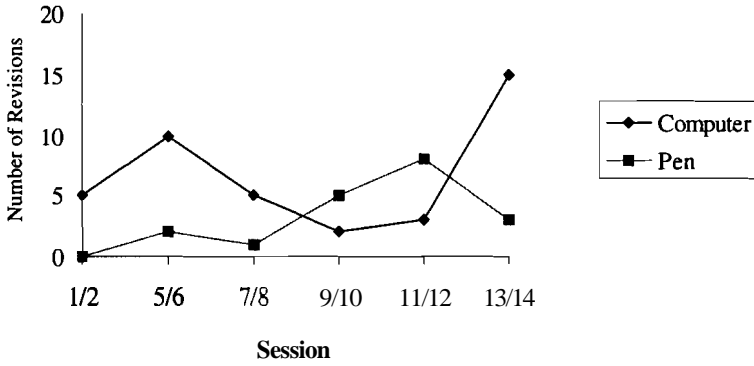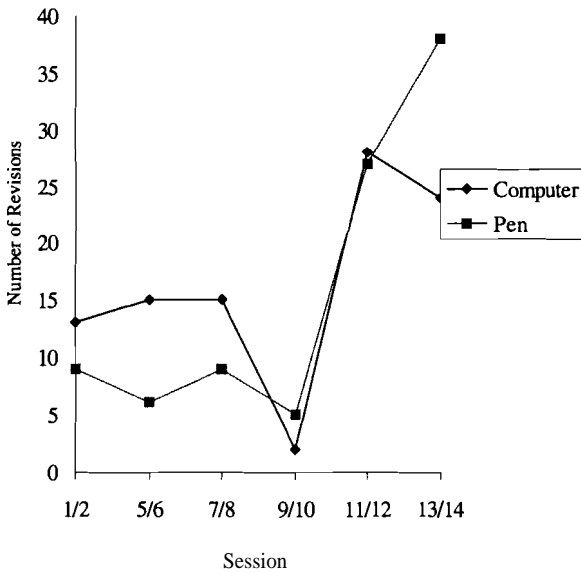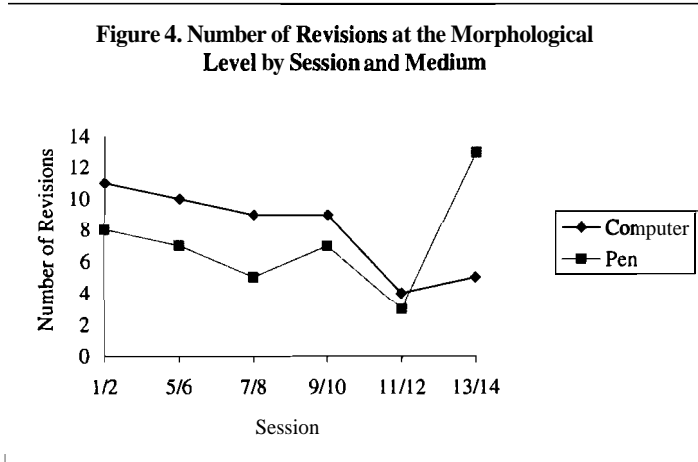**Figure 2. Number of Revisions at the Syntatic Level by Session and Medium**

Session

Figure 3. Number of Revisions at the Lexical Level by Session and Medium

Session

Figure 4. Number of Revisions at the Morphological Level by Session and Medium
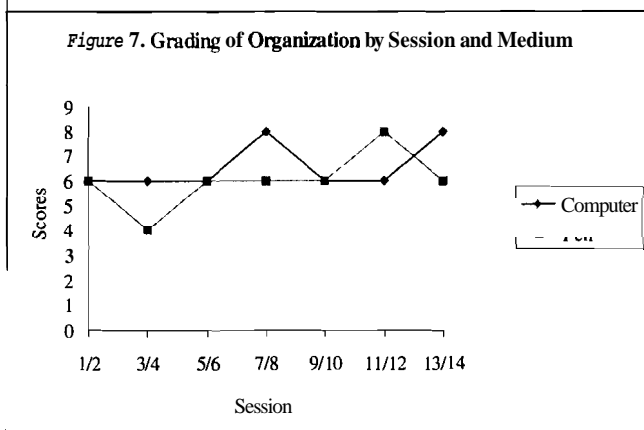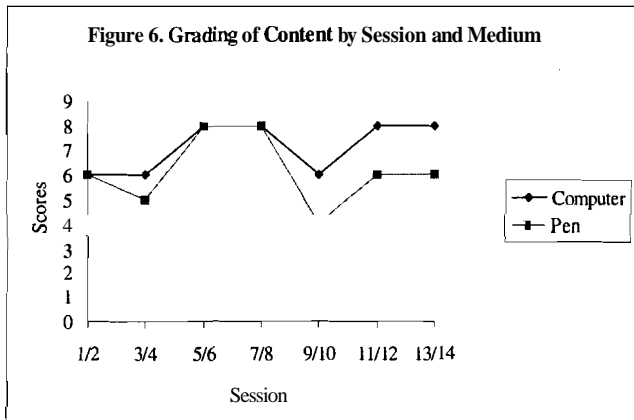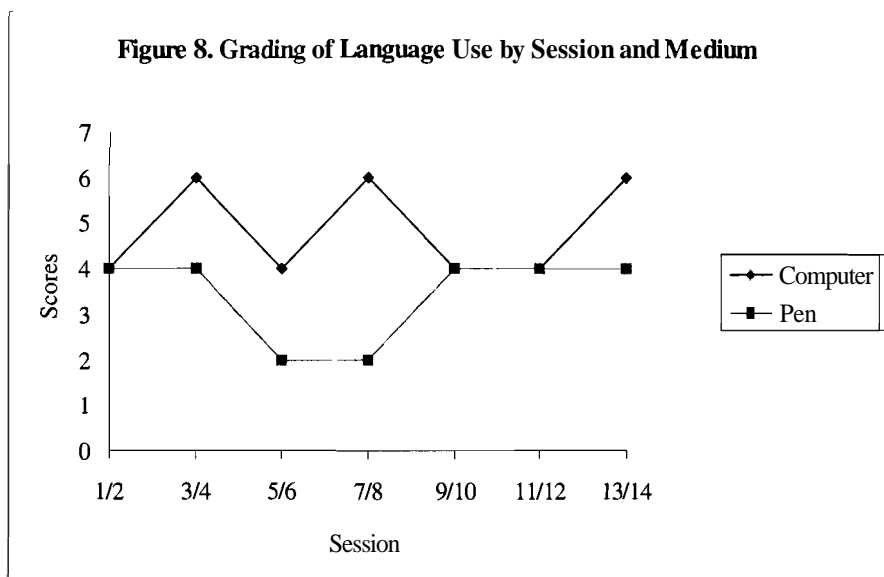

III.1.2. Thinking processes while composing

Figure 5 shows that on average Hsin performed more fiequent local planning, reasoning about linguistic choices, and evaiuation of appropriateness, and he referred to procedures for writing in the computer sessions more often, whereas he searched for the right words or phrases more fiequently in the pen-and-papersessions. For all other categories of decision-making episodes, the fiequencies were almost the same across the writing in either medium.

Figure 5. Percentage of specific decision-making episodes for eight compositions
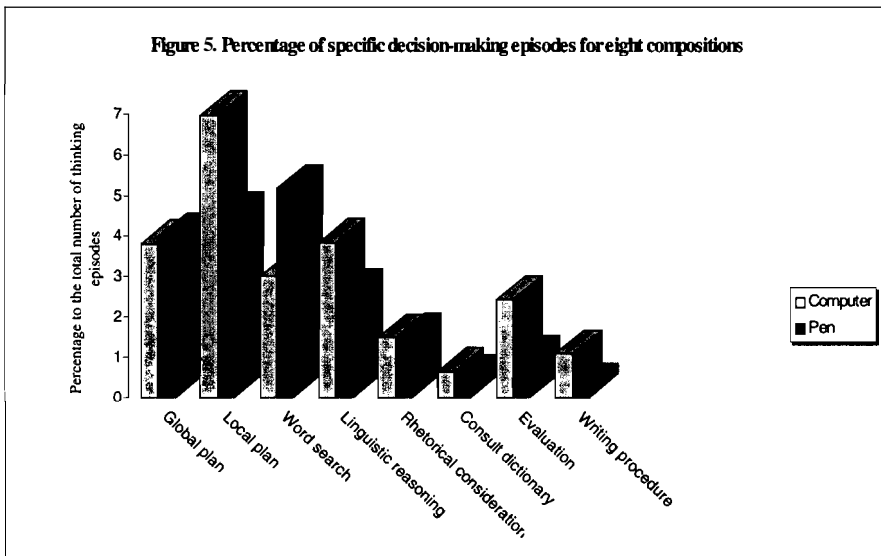
III.1.3. Quality of writing produced and interview with the raters

The analytic scores of Hsin's computer-written essays were invariably higher than or the same as those written with pen and paper in terms of content (see Figure 6), slightly though not significantly higher in terms of organization (M= 6.6. vs. 6.0; see Figure 7), and higher in most sessions in terms of language use (M= 4.9 vs. 3.3; see Figure 8). A detailed examination of the ratings of the essays revealed certain patterns: In the scoring of content, there was almost no difference until the ninth and tenth session when the computer-written essays started to be consistently two scores higher than the handwritten ones (see Figure 6). As for the grading of language, three pairs of computer-written and handwritten essays were rated as the same and four pairs of Hsin's computer-written essays were scored at least two points higher than their hand-written counterparts (see Figure 8). Another noticeable phenomenon is that in the first two sessions, there was no difference between the two types of writing in any of the three aspects of writing quality (see Figures 6, 7, 8).

Figure 6. Grading of Content by Session and Medium

Figure 7. Grading of Organization by Session and Medium

Figure 8. Grading of Language Use by Session and Medium

Figure 8. Grading of Language Use by Session and Medium

During the post-rating interview, the raters focused their remarks on the grading of language use in the essays from the seventh and eighth sessions, which demonstrated distinctive differences (see Figure **8**). The essay written with pen and paper in the seventh session received a score of only 2, whereas the word-processed essay in the eighth session received **6.** The raters said they had the impression that the essay written during the eighth session demonstrated more complexity in sentence structure and fewer errors compared to the essay written during the seventh session, in which they both said, not only were the sentence structures less complex and there were more errors, but also the meaning of certain sentences was vague. The raters even had the impression that the two essays were written by two different people.

One of the raters also talked about the computer-written composition from the fourteenth session, which also received a high mark (6) in language use. He thought that, similar to the essay of the eighth session, this text also demonstrated complexity of sentence structure and a low rate of errors, though there were not as many appropriate connectors in this essay as in the eighth session. In sum, the two major concerns the raters expressed in giving higher marks in language use to compositions were the complexity of sentence structure and rate of errors.

We also inquired about the rater's rationales for scoring the content of the computer-written essay in the twelfth session, **"A** problem concerning women" and that of the eleventh session, **"A** problem concerning old people". The former received a full mark of **8,** whereas the latter received 6 (See Figure **6**). The raters replied that the content of the twelfth essay was better developed, there

were more words, and the content was more relevant to the topic than in the eleventh essay. Since the raters mentioned that the length of the essay was also a consideration in marking the content, we asked them why the essay of the thirteenth session, "A problem concerning young people", only received a score of 6 in terms of content even though it was the longest essay of all. They answered that in this piece of writing many issues were raised but were not well developed, the theme was not clear, and the content was not particularly relevant.

III.1.4. Hsin S approach to writing over time

Hsin changed his approach to word-processing-assisted writing over time. In the first four sessions, Hsin was neither skillful with a word processor nor proficient on the keyboard. He seemed neither interested in, nor familiar with, the revising and editing functions of the word processor. The records of keystrokes showed that he only used some of these functions for some limited superficial editing and revising on the computer. When he made mistakes or found some parts of the writing needed changing, Hsin used the backspace key to delete the word(s) and letter(s) he did not want. Hsin also tended to move the cursor to add or change texts. He combined the movement of the cursor and the backspace key to delete certain words or letters that he had put down previously. He did not use such functions as block moving or deleting. At the end of the first session, he did not use the spell checker to correct misspellings until he was encouraged to. The hand-written drafts showed that Hsin did not make any revisions with pen and paper either; he only did superficial editing in this context.

From the fifth session on, before each session of computer-assisted writing, the first author offered Hsin brief training sessions on the word processor. He also encouraged Hsin to practice on the keyboard and work with the word processor by himself. The first author repeatedly emphasized the importance of revision and encouraged him to do as much revision as possible with both writing media. After Hsin had been trained to use the delete key and block-moving and block-deleting features at the beginning of the fifth session, he started to use these functions in this session. When Hsin planned to delete something to the right of the cursor, he used the delete key; when he planned to delete something to the left of the cursor, he still used the backspace key. He also used the block-moving feature three times in this session. However, he did not use the block delete feature, even when he deleted a whole sentence. Hsin continued such practices throughout the five remaining computer sessions. During this fifth session, Hsin made more discourse level changes, relocating two complete sentences, adding two, and deleting one.

In the sixth session, Hsin started to make some discourse level revisions with pen and paper for the first time: After he had made some revisions to his written product, he added a whole paragraph, composed of two sentences, as the last paragraph of the composition. This kind of discourse level revision with pen and paper at the end of the essay, however, seemed much easier than discourse level changes to other parts of the essay. Possibly Hsin still did not want to take the trouble to make discourse changes if he had to cross out sentences or add some in the middle of the essay with pen and paper. Because the monitoring program broke down, however, the seventh

session was written with pen and paper, and in it Hsin did not make any **discourse** changes at **all**. The only syntactic level change in this session was that he added a **relative** ciause, which was made up of **two** words, to the second paragraph. It seemed that he was not ready to make "real" discourse level revisions with pen and paper yet. The eighth session was a computer session, wherein Hsin made only one discourse level change although he spent **forty** minutes revising his essay after he had finished the **first** draft.

From the ninth session on, Hsin **started** to make **substantive** discourse changes with pen and paper: one in the ninth session, two in the eleventh session, and three in the thirteenth session. He continued to make such changes with the computer: three in the tenth session, five in the twelfth session, and three in the fourteenth session (see Figure 1).

III.1.5. Other writing behaviors

From the data collected **from** the keyboard monitor **program,** we **also** determined that Hsin demonstrated the following behaviors while he was writing with the word processor:

a) From the eighth session on, Hsin **wrote** down his plan for the composition on a piece of paper before he **started** writing on the computer. He did not do this when he was composing with pen and paper though he did spend time planning.

b) Hsin had a tendency to revise and edit what he had previously written while he was **still** composing another **part** of a composition both on the computer and in his pen-and-paper writing.

c) Throughout the study, Hsin often forgot to capitalize the initial letters of sentences (3 or 4 times per session), which we counted as **morphological-level** revisions. This never happened in **his** pen-and-paper writing. In such cases, however, Hsin usually realized the mistake irnmediately and used the backspace key to **delete** the whole word and retype it. From time to time, Hsin made "keyboard mistakes", for exarnple, misspelling words which he would not **have** misspelled with pen and paper.

d) Hsin often changed words or **phrases** nght after he had typed them, and **in** a few cases, he changed back to the **original** words or **phrases.**

e) When Hsin was revising **his** compositions, **from** time to time he used the cursor to go down **several** lines before he moved the cursor up again.

f) Hsin tended to spend more time writing on **the** computer (see Figure 9) and to **write** more words in most computer-written essays (see Figure 10) than he did with pen and paper.

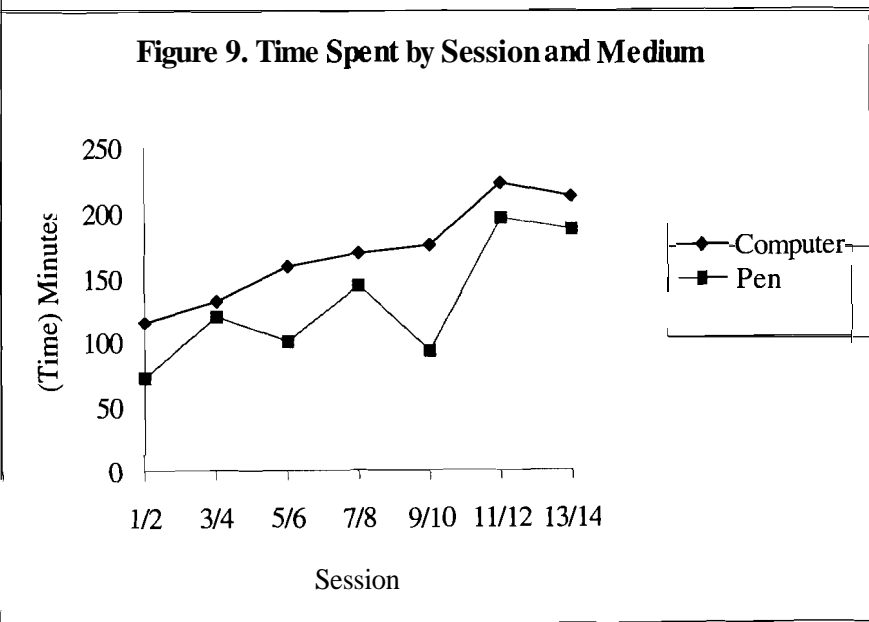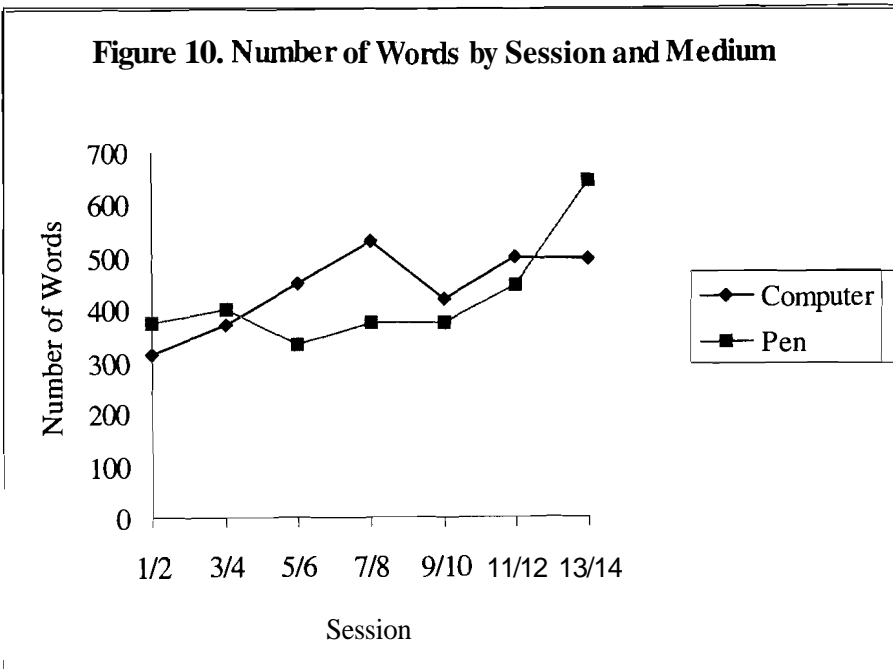## Figure 9. Time Spent by Session and Medium

Figure 10. Number of Words by Session and Medium

III. 2. Discussion

Hsin revised more at various levels in the computer medium. This suggests that because the word processor helped remove the mechanical difficulty involved in changing text, especially for discourse level changes, it was more convenient for Hsin to rearrange sentences with the computer-writing medium. Therefore, he revised more extensively in the word-processing-assisted writing.

Hsin's pen-and-paper revisions at the discourse level occurred weeks after he started such practice with the word processor. This indicates that he may have applied the skills he learned from the word processing to his pen-and-paper revisions. In other words, as an instructional tool, the word processor combined with the tutor's instruction and feedback seemingly did help Hsin learn to make higher-level revisions. This supports Bangert-Drowns' (1993) observation that once student writers have had sufficient practice on the word processor, combined with feedback from teachers and peers in writing instruction, they may continue such practice even when they write with pen and paper. In this way, word processing seems to have helped this L1 writer make revisions, including higher-level revisions. However, because of the small number of revision in this single-subject case study, the findings in this study cannot be generalized to other people or situations.

Hsin demonstrated different patterns of thinking between the two writing conditions. He conducted more local planning on the computer, like Haas's (1989) and Li's (1998) students who did significantly less pre-planning in their computer-assisted writing, and who as a result, had to "compensate" implicitly for their lack of preplanning by carrying out more local planning. The greater episodes of evaluations of written texts occurring in Hsin's computer-assisted writing may be explained by the convenience of text manipulation in the computer medium. Probably Hsin felt it easier to make changes on the computer and he therefore managed to evaluate the written texts more frequently with this writing medium. It seems that a higher frequency of evaluation of written texts coexists with higher frequency of revisions. The reason why Hsin conducted more searching for the right words or phrases in the pen-and-paper sessions remains a question. This is contrary to Li's (1998) finding that 23 ESL writers searched for words or phrases more extensively in their computer sessions.

The computer-written essays were mostly rated higher in content and language use than were the hand-written essays. From the interview with the raters we determined that a major part of their rationale for scoring language was greater complexity in sentence structures and fewer errors. By comparing the scores in language and syntactic level changes (see Figures 2 and 8), except for the first four sessions, there seemed to be a positive relation between the extent of syntactic revisions and higher marks in language use within each pair. That is to say, when more syntactic level changes occurred in a computer session, the scores in language use of that session tended to be higher than its comparable pen-and-paper session. Probably this is because the syntactic revisions, mainly sentence extending and sentence structure changes, added to the complexity of sentence structures and reduced errors. In addition, the use of a spell checker may also have helped Hsin to create essays with fewer spelling errors, which may also have contributed to higher scores

in language use on his computer-written essays.

By analyzing the records of keystrokes and the handwritten drafts we established that Hsin's discourse level changes mainly involved deleting and adding whole T-units, resulting in irrelevant content being omitted and the topics of essays being further developed. Because Hsin made more discourse revisions with the word processor, such revisions may have contributed to the higher scores in the content of the computer-written essays.

In addition, Hsin's more frequent evaluations of his written texts in the computer sessions may have helped him revise these texts, at various levels, and may also have contributed to the higher quality of the essays written on the computer, whereas more episodes of word/phrase searching during the pen-and-paper sessions may have helped to improve the texts only at the lexical level, which was not a major concem of the raters in their rating the quality of the texts. Thus, word processing probably helped Hsin to produce essays of higher quality in ceríain aspects of his writing: content and language.

As reported in III.1.4, after Hsin had been trained to use block moving and deleting, he immediately tried using these functions and for the first time made discourse revisions. He continued to make changes at this level in the consequent sessions, both computer and handwritten, although he did so in his handwritten session in a limited way. Had Hsin not received any training on revision and word processing, he might have continued with superficial editing instead of in-depth revisions. Therefore, training played an important role in Hsin's utilization of the potential advantages of word processing in his composition writing.

As mentioned above, two aspects of Hsin's compositions, content and language use, were significantly different between the two writing conditions. The influence of word processing on language use came early in the study, seemingly because Hsin used the spell checker to eliminate spelling errors in his computer-written essays, and a major concem of the raters in this study about language use was spelling errors. It may not take a long period of time for a L2 writer to make ceríain improvement in language use in writing once the person has started to use such functions of word processing as spell checking. This situation appeared in Li (1998), when 9 L2 writers were asked to edit their computer-written essays by using spelling and grammar checkers and to edit their hand-written essays by eyeballing them. Their essays had showed no differences in linguistic accuracy and linguistic appropriacy before the editing, but displayed significant differences in both aspects in favor of word processing after this when rated by the same two raters who had rated the essays before the editing.

The impact of word processing on the content of Hsin's writing, on the other hand, seemed to have taken a longer period of time to become obvious. Certain advantages of word processing associated with complicated skills and rhetorical structures may take a long time to materialize, as suggested by Pennington's (1993, 1996), Phinney and Khouri's (1993) and Reed's (1990) observations that long-term studies tend to produce stronger results in favor of computer-based writing than do short-texm studies. Continuous exposure to computer-assisted writing did seem to help Hsin to produce some positive effects in favor of his **word-processing-assisted** writing.

IV. CONCLUSIONS

The present study contributes to growing **evidence** that continuous exposure to **word-processing-**assisted writing combined with proper training can help L2 leamers to improve their writing skills and writing quality. From the above analyses we conclude that: **After** a long period of practicing writing with word processing plus **appropriate** training, the participant of this study, Hsin, was able to utilize more **functions** of the word processor more effectively as he changed his approaches to writing on the computer. This in tum, may **also have** changed **certain** aspects of his approaches towards writing with pen and paper **later** in the study. Specifically, Hsin **altered** his **thinking** processes while composing on the computer, making more revisions, especially **higher-level** revisions, which contributed to the improved quality of his **essays**. Nevertheless, as Cumming and Riazi (2000) **observed,** **learning** and teaching second language writing **are so** complex that tracing changes people make in this behavior **is** exceptionally **difficult.** Indeed, it may not be wise to attribute any achievement in ESL writing to a single factor such as the writing medium.

A few **limitations** to this study point toward **areas** to consider for **future** research. First, the research was limited to analyses of only one **person's** behaviors on specific writing **tasks,** each of which were only estimated to be comparable across the computer and handwritten contexts. Second, we did not adequately **assess** the relations between **Hsin's** attitudes towards word processing **and** his achievement in word processing-based writing. **Third,** more training on the word processor and keyboard might **have** helped Hsin **familiarize himself further** with the computer and thus helped us to **determine** more precisely the effects of such **instruction.** Finally, a computer with a larger screen (than the lap-top used) might **have** enabled Hsin to see more of his **compositions** at one time and may **have** encouraged him to read more of his writing and make more revisions at deeper levels and to a greater **extent.**

NOTES

1. Hsin **informed** us that he had tried sample TOEFL tests a few times and his scores ranged from 450 to 500.

2. Hsin stated during the **first** session that he **liked** using the computer, and since he was planning to pursue graduate studies **in North America,** he needed skills on the word processor. Months **after** he started participating in the study, Hsin **twice** mentioned that he was going to use Word Perfect 5.1 to **write letters** to some Canadian universities and a statement

about his research interests, although it seemed that he had written drafts with pen and paper before he typed the written documents into the computer and then edited and revised them on the computer.

3. The keystroke monitoring program was adapted from a program developed by the IEA's (Intemational Association for the Evaluation of Educational Achievement) Intemational Coordinating Center for their Computer Education Study. We thank Hans Pelgrum for allowing us to use this program.

4. There were problerns in the quality of the tape recordings, so only the tapes from 8 of the 14 sessions could be transcribed.

5. Due to a failure of the keystroke monitor program during this session, no dataon the writing and revising processes were collected frorn this session and the data on these aspects from the comparable pen-and-paper session, the fourth session. was also omitted from the graphs hereafter.

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APPENDIX A: Titles from the fourteen compositions

Session 1 (word processing): **A** problem in a city I have previously lived in**

Session 2 (pen and paper): **A** problem concerning television *

Session 3 (word processing): **A** problem in the City of Toronto*

Session 4 (pen and paper): **A** problem concerning newspapers *

Session 5 (word processing): **A** person who has had a good influence on me

Session 6 (pen and paper): **A** city which impressed me very much

Session 7 (pen and paper): **A** good movie

Session 8 (word processing): **A** day I'll never forget

Session 9 (pen and paper): **A** letter to the mayor of my home city

Session 10 (word processing): A letter to the president of a university

session 11 (pen and paper): **A** problem conceming old people

Session 12 (word processing): **A** problem conceming women

Session 13 (pen and paper): **A** problem conceming young people

Session 14 (word processing): A problem conceming young children

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* For these argumentative compositions, detailed prompts were offered such as "Many people have suggested improvement to cities around the world. Describe a problem in the city of Toronto. Suggest one or more solutions for the problem." These 4 prompts were part of a larger project (Cumming & Riazi, 2000). These prompts seem approximately comparable, but we did not verify this empirically.

APPENDIX B: Coded examples of think-aloud protocols

1. Global planning. Planning the overall text, including content planning:

> *A letter to the Mayor of my home city. I shouldpersuade him to do something.*
> (Before starting writing, the participant was planning his content) *My uncle immigrated to Canada 25 years ago and now his children gave birth to a thirdgeneration...*

2. Local planning. Planning a paragraph or part of a paragraph:

> *In first paragraph, I introduce myselfand my concern.*
> *Here I should give two examples.*

3. Searching for the right words or phrases. Seeking out a word or phrase, generating and assessing possible altematives:

> *The main idea happened ... fall ... showed up. the main idea showed up.*
> *... the problem which is .... which is the most .... most, most Uh, (in Chinese) Laobaixin zui guanxinde wenti (the issue ordinary people care most)*

4. Reasoning about linguistic choices. Using linguistic rules or intuition to check the appropriateness in syntax, morphology or semantics:

> *I should say "were" because it's past. There were ...*
> *Unfortunately, ... fortunately ... Unfortunately...*

5. Rhetorical consideration. Considering rhetoncal appropriateness:

> *Uh, this sentence is too long.*
> *The sentence doesn't connect well. I should ...*

6. Consulting. Consulting a dictionary or the tutor for a word or phrases:

> *Let me look up in the dictionary.*
> *How to say qifaxinde (heuristic)?*

7. Evaluation. Evaluating what has been written down previously:

> *This sounds weird. Maybe I should change it.*
> *In this paragraph, I just described the way I suggest about a network*

8. Procedures for writing. Speaking about procedures for writing:

> *First I organize ... my mind and write down the rough idea.*