Thinking Languages in L2 Writing: Research Findings and Pedagogical Implications

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This article reports the findings of part of a major study exploring the disciplinary writing processes and perceptions of 15 Chinese graduate students in sciences and engineering at a major Canadian university. The findings relate to the thinking languages of the participants in writing disciplinary assignments. The study reveals that whether an L2 writer thinks in L1 or L2 may not depend on one factor as proposed in earlier studies (Friedlander, 1990; Qi, 1998), but on a number of factors including the language of knowledge input, the language of knowledge acquisition, the development of L2 proficiency, the level of knowledge demands, and specific task conditions. It is the interplay among these (and possibly other) factors that determines the writer's choice of the thinking language, which may switch back and forth between L1 and L2. Further, although translation may be a positive strategy for a student with limited L2 proficiency, it may gradually phase out as the student thinks more in L2 and writes L2 in approximation to the language of native writers. Thus a thinking language continuum may exist along which the use of translation varies.

Cet article fait état des conclusions d'une partie d'une étude importante sur les processus et les perceptions en rédaction spécialisée. Quinze étudiants gradués chinois en sciences et génie inscrits à une grande université canadienne ont participé à l'étude. Les conclusions portent sur la langue dans laquelle les participants réfléchissent quand ils écrivent des rédactions spécifiques à leur domaine et indiquent que, contrairement à ce que proposent d'autres études (Friedlander, 1990 ; Qi, 1998), il n'y aurait pas un seul facteur pour expliquer le choix effectué entre la L1 et la L2 lors de la rédaction en L2. Une pluralité de facteurs y joueraient un rôle, dont la langue d'étude, la langue d'apprentissage, le développement de la compétence en L2, le niveau de complexité cognitive de la tâche, et des conditions spécifiques à la tâche imposée. L'action réciproque de ces facteurs (et possiblement d'autres) détermine le choix de langue de réflexion qu'effectue la personne qui écrit. Il peut avoir alternance entre la L1 et la L2. Le recours à la traduction, qui peut constituer une stratégie utile pour l'étudiant à compétence limitée en L2, pourrait être abandonnée graduellement au fur et à mesure que l'étudiant pense plus souvent dans son L2 et que sa rédaction en L2 se rapproche

de celle des locuteurs natifs. Il pourrait donc exister un continuum des langues cognitives le long duquel varie le recours à la traduction.

Introduction

I conducted an extensive study in 1997-2000 at a major Canadian university to explore the disciplinary writing processes and perceptions of 15 Mainland Chinese graduate students in sciences and engineering (Hu, 2000). This article reports and discusses the findings of a part of the study, concentrating on the thinking languages of the participants when they prepared to write and wrote the assignments for academic disciplines. Whereas a thinking medium can be linguistic or graphic, my study was concerned with the linguistic medium only. Following Qi (1998), I name the switch from one language to another to process or facilitate thinking as *language-switching*. In the report I relate my study findings to the theories proposed in earlier research on thinking and writing by bilinguals. Particularly, these theories include propositions about separate knowledge storage and retrieval (Friedlander, 1990; Paivio, 1991) and factors concerning language-switching in the thinking process for writing (Qi, 1998). I argue that although the theories are valid in view of those studies, the dynamic propositions I offer based on my study may better account for a greater variety of situations involving thinking languages by bilinguals. Finally, I offer implications for the instruction and assessment of second language (L2) writing and education of L2 students in the disciplines.

Review of the Research

Researchers have been trying to find out whether L2 students write better target language when thinking in the first language (L1) or L2. Friedlander (1990), for example, hypothesized that "L2 writers will plan for their writing more effectively, write better texts containing more content, and create more effective texts when they are able to plan in the language related to the acquisition of knowledge of the topic area" (p. 112). For example, if ESL students from China who speak Chinese as their L1 are to write an English essay on a topic related to their Chinese experience, they are likely to write better essays if they use Chinese to generate and organize ideas to be included in the essay.

This hypothesis is consistent with the separate store hypothesis concerning bilingual memory (Paivio, 1991), which posits that languages are stored separately in the memory if they were learned at separate times. The separately stored languages would be retrieved separately via the language of storage and can only interact with each other through translation. To test his hypothesis, Friedlander (1990) studied 28 Chinese-speaking subjects at a US university. The subjects wrote on two essay topics in both English and

Chinese, one on an experience in China (i.e., *Qingming*, a traditional Chinese festival) and the other on a situation at the US university (i.e., the subject's difficulty in adapting to the new cultural and educational system of the university). His study confirmed the hypothesis. Friedlander found that the subjects wrote better essays when planning in the language in which the knowledge or experience was acquired, namely, the Chinese experience in Chinese and the US experience in English. However, regardless of the language used, the subjects produced better plans and texts on the Chinese topic. One reason was that the subjects were much more ingrained in the Chinese experience than the US experience. Friedlander concluded that switching to L1 to retrieve information learned in L1 in the case of complex questions definitely has a positive effect on L2 writing. On this basis, he proposed that when writing in English about a topic learned in Chinese, Chinese speakers would benefit by producing plans in Chinese and then using those plans to generate their English texts. Similarly, if writing in English about a topic learned in English, these speakers would benefit by producing their plans in English.

Other researchers have agreed with Friedlander's (1990) conclusions about the benefits of using L1 in L2 writing. Comparing composition via translation and direct composition, Kobayashi and Rinnert (1992) found in their study of Japanese English as a foreign language (EFL) students that the students wrote much better English compositions by writing via translation from Japanese than by writing directly in English. The students reported that they were able to think more deeply in their L1, and then to express their thoughts and opinions more clearly using a dictionary. In an earlier study, Lay (1988) reported that when the ESL students found it difficult to write in the L2, they switched to the L1 to generate ideas for the essay, especially on topics related to their native cultures or unfamiliar topics. Uzawa (1996), in a study of low-proficiency Japanese ESL students in a Canadian university, confirmed the benefits of translation. She noted that during translation the students were able to concentrate on linguistic activities, "stretching their linguistic levels to the 'i + 1 level'" with the help of dictionaries, thus writing English at a higher level than their current English proficiency. On the other hand, the students writing the L2 essay without translation wrote at the "i – 1" level as they used only words, expressions, and structures readily accessible to them (Uzawa & Cumming, 1989). One explanation offered by Cohen and Brooks-Carson (2001) for students' use of the L1, and therefore translation, is that the connection between concepts and the L1, the students' predominant language, is much stronger than the connection between concepts and the L2. These studies suggest that if the L2 students write a preliminary draft in their L1 and then translate it into English, they should be able to draw on a greater amount of topic area information and eventually produce richer texts.

Qi (1998) approached the issue by examining the factors relating to language-switching in the thinking process. In the study, one Chinese/English bilingual[1] from China enrolled in a master's degree program in social science at a Canadian university was asked to perform three sets of L2 composing tasks: text composition in English, written translation from Chinese to English, and problem-solving in math in English. Each set consisted of one task with low knowledge demands and another with high knowledge demands. Analysis of the think-aloud protocols and subsequent interviews with the participant found that the participant, while thinking, often switched to the language in which an idea could be most comfortably expressed—usually her L1. Then the content generated in L1 was transferred to L2 via translation. The reason was that the complexity of the information required for the difficult tasks would be too much of a burden if she used her weaker language (i.e., L2) to process it. Thus Qi concluded that high knowledge demands were a general factor for language-switching (to L1) during the thinking processes. Specifically, these factors included an implicit need to encode efficiently a nonlinguistic thought in the L1 to initiate a thinking episode, a need to facilitate the development of a thought, a need to verify lexical choices by turning to the L1 to judge appropriateness, and a need to avoid overloading the working memory, which may result from attempts to process much complex information in L2 in a limited time.

Based on his analysis of the study findings, Qi (1998) further claimed that

> the effectiveness of language-switching provides important evidence supporting the notion that conceptual knowledge is shared across L1 and L2 and may be accessed cross-linguistically without the risk of affecting the quality at a conceptual processing level. In other words, knowledge may well be tied to a shared rather than a separate conceptual store in a bilingual's memory. (p. 429)

His claim supports Cummins' (1984) knowledge interdependency hypothesis that proposes that knowledge may be directly accessible in either of the two languages of a bilingual, but disagrees with the separate store theory supported by Friedlander (1990) described above. Qi's claim seems valid if the knowledge demand is very low for the bilingual. In other words, conceptual knowledge can be shared across L1 and L2 if the bilingual can comfortably, or freely, express the knowledge in both languages, such as in the case of a task with low knowledge demands. However, if the bilingual is unable to express the knowledge comfortably in both languages, or has to rely continually on a bilingual dictionary to translate the knowledge from one language to the other, it may be difficult to claim that the person can access the knowledge via L1 or L2 without affecting the quality of conceptual processing.

These researchers (Friedlander, 1990; Kobayashi & Rinnert, 1992; Lay, 1988; Qi, 1998; Uzawa, 1996) do seem to agree on their recommendation of using L1 and translation in performing complex writing tasks. They thought that switching to L1 and translating content generated in L1 may facilitate rather than inhibit L2 composing processes, although they approached the issue from different perspectives. In other words, translation benefits L2 writers, especially those with a low L2 proficiency. Thus the researchers thought it would be misleading to advise L2 students to refrain from using their L1 in L2 writing.

However, other researchers observed different effects of the use of L1 on L2 writing. For example, Cohen and Brooks-Carson (2001), in their recent study of 39 intermediate-level third-semester learners of French at a US university, found that two thirds of the students wrote better French when thinking directly in L2; only one third wrote better French through translation. They further noted that translating writing is not the most effective strategy for many under time pressure. Whalen and Ménard (1995) studied 12 Anglophone second-year French undergraduate students, who wrote an argumentative text in L1 and L2. For the five less strategically proficient writers, translation served only to slow down and confuse their writing processes. "Their constant search for appropriate lexical items in dictionaries, and their constant verification of morphological rules, further hindered their processing at higher [i.e., pragmatic and textual] levels of discourse" (p. 409). Actually, for one participant, using translation as an uninterrupted word-level linguistic processor during the writing process "had disastrous effects on strategy manipulation at other [i.e., pragmatic and textual] levels of discourse" (p. 410). The less strategically proficient writers applied translation to generate linguistic structures, namely, grammar and vocabulary, whereas the more strategically proficient writers did so to achieve pragmatic and textual goals more effectively while continuing to attend to all three levels of information processing. Further, Sasaki (2000) noted that whereas the novice writers stopped to translate the generated ideas into English, the expert writers stopped only to refine the expressions. Thus it appears that high-level L2 students do not typically resort to translation as a strategy to generate language and that translation may not produce L2 texts of high quality at all three (linguistic, pragmatic, and textual) levels.

In summary, there is no consensus about whether L2 students should or should not use L1 in writing in L2. Translation appears to be a positive strategy for lower-level students, and direct writing seems to yield better products for higher-level students. There seems to be a correlation between translation, lower-level L2 proficiency, and sometimes L2 writing at the i + 1 linguistic level. On the other hand, a similar correlation is apparent between direct writing, higher-level L2 proficiency, and L2 writing at higher linguistic, pragmatic, and textual levels. Indeed, Kobayashi and Rinnert (1992)

suggested variation in using L1 and translation at different levels of L2 proficiency, pointing to a possible continuum in L1 usage and translation. The translation strategy seems to benefit students at a lower level; but as their L2 proficiency improves, they seem to switch more and more to direct L2 writing. In order to explore further the use of L1, translation, and language-switching with my study participants as they wrote their disciplinary assignments, I designed some of my guiding interview questions (see below) to focus on these and other related issues in my study of the academic writing of Chinese graduate students at a major Canadian university (Hu, 2000).

Methodology and Procedures

Methodology

The study (Hu, 2000) took a qualitative approach to research, aiming to uncover an emic (i.e., research participants') perspective and interpretation of the participants' experiences in natural settings (Creswell, 1998; Denzin & Lincoln, 1994; Geertz, 1983; Flowerdew, 1999; Larson, 1997; Merriam, 1988; Norton Peirce, 1995). In conjunction with a qualitative approach, the study adopted a multiple case study design (Creswell, 1998; Yin, 1994). Multiple cases are believed to lead to better understanding, perhaps better theorizing, about a larger collection of cases than a single case (Stake, 1994). Such a design afforded both the depth and breadth necessary for my search for insights into processes and issues concerning L2 academic writing, including insight into thinking languages.

Procedures of Data Collection

The main stage of data collection for the study consisted of two sections. The first section, from August 1997 to September 1997, focused on two Chinese doctoral students (Ming and Ting[2]) at the university in order to pre-test and refine the research questions, methods, and interview guides. The second section, from September 1997 to April 1998, collected data from 13 other participants. Tables 1 and 2 provide background information about the participants when they were at the Canadian university and in China respectively. The major techniques I adopted were semistructured qualitative interviews where I was guided by, but not restricted to, a list of predesigned questions (Marshall & Rossman, 1995) and document analysis. Some of the questions were adapted from Riazi (1995), and others were based on my experiences as an L2 English student, teacher, and writer. The questions about thinking languages in the interview guides included the following.

1. When you read academic writing (e.g., an article in your field), do you normally think in English or Chinese?
2. In what language do you normally think about your writing? Why do you use this language?

Table 1
Student Participants at the Canadian University

Name	*Program*	*Major*	*Entry time*	*Sex*	*Year of birth*	*TOEFL (TWE)*	*GRE*
Ming	PhD	Science	05/96	M	1964	597 (4.0)	1910
Ting	PhD	Science	09/96	M	1966	583 (4.5)	NA
Ling	PhD	Science	09/96	F	1968	597 (4.0)	1970
Feng	PhD	Science	01/97	M	1965	603 (No)	No
Hang	MS	Science	01/96	M	1964	601 (3.5)	1680
Ning	PhD	Science	09/96	M	1957	593 (3.5)	NA
Ding	PhD	Science	09/96	M	1971	603 (3.5)	No
Ping	MAS	Engineering	01/97	M	1969	653 (5.0)	2210
Qing	MAS	Engineering	09/96	F	1968	610 (4.5)	1910
Xing	PhD	Engineering	01/97	M	1964	627 (4.5)	2000
Wang	MAS	Engineering	09/96	M	1964	630 (5.0)	1800
Kang	MAS	Engineering	09/96	M	1970	620 (5.0)	2050
Bing	MS	Engineering	09/96	F	1965	593 (No)	No
Ying	MS	Audiology	09/96	F	1967	627 (NA)	No
Zong	PhD	Science	09/89	M	1963	580 (NA)	No

Notes. "No" indicates that the participant did not take the test. "NA" indicates that the participant took the test but was unable to provide the score.

3. Do you ever switch between languages (jumping from one to the other)? If so, in which direction? Under what circumstances do you switch? Do you revert to Chinese for difficult problems/concepts?

Following the standard ethical procedure approved by the university, I obtained permission from the 15 participants for interviews. Except Zong and Ying, with whom I had one and two interviews respectively, I held three to five individual interviews with each of the participants. Each interview lasted one to two hours and was audiotaped with permission from the participants. I tried to transcribe the interview before meeting the participant again and clarified/verified my understanding of the previous interview at our next meeting. I also asked questions and member-checked with the participant by e-mail, especially when another interview was impossible or more than two days away. The language of the interviews was primarily English, although the participants had the option of speaking Mandarin. Most of the participants considered the interview an opportunity to practice their spoken English.

In addition to the interviews, I collected course outlines and writing samples of lab reports, term papers, project reports, and thesis/dissertation proposals from the participants. I made sure to have at least one writing

Table 2
Student Participants' Educational Backgrounds in China

Name	*Degree*	*Major*	*Time (Year 19__)*
Ming	BS	Wood Sci	81-85
	MS	Wood Sci	85-88
	PhD	Wood Sci	88-91
Ting	BS	Forestry	84-88
	MS	Forestry Eng	88-91
Ling	BS	Wood Sci & Tech	86-90
	MS	Wood Sci & Tech	90-93
Feng	BS	Biology	82-86
	MS	Cell Biology	86-89
Hang	BS	Forestry	81-85
	MAgronomy	Forest Genetics	85-88
Ning	BM	Medicine	77-82
	MM	Pharmacology	84-87
	PhD	Toxicology	90-93
Ding	BS	Public Health	87-91
	MS	Animal Sci	94-96
Ping	BE	Automatic Control	87-92
	BE	Environmental Eng	87-92
	ME	Automatic Control	92-94
Qing	BS	Automation	85-89
	MS	EE	89-92
Xing	BS	Industrial Automation	80-84
	MS	Control Theory & Applications	86-89
Wang	BE	Electronics	83-88
	ME	Electronics	90-93
Kang	BE	Eng & Nuclear Physics	88-93
	MS	Electronics	09/93-12/95
Bing	BS	Environmental Biology	81-85
	MS	Environmental Biology	87-90
Ying	BA	English Literature	85-89
Zong	BS	Forestry	79-83
	MS	Wood Manufacturing	83-86

sample from each participant (except Zong[3]) so that I could refer to the written product when necessary. After obtaining the documents, I read them, marked the samples, and asked questions about the documents at the next interview. The participants appreciated my feedback on their writing.

Procedures of Data Analysis

In congruence with the tenets of qualitative research (Denzin & Lincoln, 1994; Lincoln & Guba, 1985; Meloy, 1994; Merriam, 1988; Norton Peirce, 1995; Strauss & Corbin, 1990), I adopted an interpretive, inductive approach in my treatment of the data. I read and reread the transcripts of the interviews and other collected documents to search for recurrent themes. Specifically, to treat the data collected in the first section (see above), I coded the transcripts on paper, searched for interrelationships between codes, and then for themes and subthemes. I then pooled the segments with the same codes together in my discussion of the themes. The research questions and the interview guides greatly influenced my induction of the themes. I felt that I did not have total freedom to treat all the data equally, but felt obliged to search for answers to the research questions. However, this does not mean that I found satisfactory answers to all the questions. For example, based on my reading of the literature (Leki, 1995a; Prior, 1991, 1995; Riazi, 1995), I had asked the following question, among others, in my research proposal: "How do the students react to faculty response?" I had assumed that the faculty in one department would provide plenty of feedback on the students' written assignments, as did the faculty studied by Leki (1995b), Prior (1991, 1995), and Riazi (1995), and my own faculty in the university. But as it turned out, the instructors offered little feedback, and as I discovered later, this is common with science and engineering instructors. More disturbing is that many of the instructors simply did not return students' assignments. So while still maintaining my interest in exploring students' response to faculty feedback, I removed the question as a major research question. Thus although the research questions I had asked guided my data collection and analysis, the former did not control the latter. In "inquiry-guided" (Mishler, 1990) research, "research questions and answers evolve[d] in a mutually informative, dialectical manner" (Ramanathan & Atkinson, 1999, p. 53).

The analysis of the data collected in the second section was much more elaborate than that for the first. While reading and rereading the transcripts, I coded meaningful segments in pencil on paper, and meanwhile wrote the codes in pencil on a large spread sheet that allowed me to see all the codes on one surface like an unfolded map. Having all the codes on one map enabled me to compare the codes and categorize them as I added more or moved them around. Often I had to rename or modify the codes to stay closer to the meaning conveyed, to merge themes, or avoid confusion with other codes. Modification of the coding system continued throughout the process of analysis (Glesne & Peshkin, 1992) whenever a new theme emerged or a new understanding of a theme necessitated recategorization. After I coded all the transcripts on paper, I coded them again in my computer file while continuing to refine the coding system. It is worth noting that each modification of the codes or the system signified for me a deeper understanding of the data.

Out of the individual files, I was able to build several larger files, which allowed me easily to search for all the segments, or as many as necessary, under one code—without losing the context of the segments.

Results: Thinking Languages of the Participants

To present the thinking languages of my participants in this article, I divide the participants into two groups and two cases. The two groups include those with (a) similar L1 and L2 disciplinary fields (I), and (b) loosely related L1 and L2 disciplinary fields. The two cases include one with (c) entirely different L1 and L2 disciplinary fields, and another with (d) similar L1 and L2 disciplinary fields (II). The difference between the first group and the second case is that the former generally had underdeveloped knowledge in both L2 and content, whereas the latter was highly developed in both L2 and content. By analyzing the participants' thinking languages and relating them to the theories reviewed above, I offer an interpretation that may better account for a greater variety of situations involving the thinking languages of bilinguals.

Similar L1 and L2 Disciplinary Fields (I)

Group 1 includes those participants who studied in a discipline at the university that was closely related to what they had done in China and who had been at the university for only a short time (i.e., six months to two years). Due to their fairly short stay in Canada and science and engineering backgrounds, their English proficiency was generally underdeveloped. These participants include Ming, Ting, Feng, Ling, Ping, Qing, Wang, Xing, Bing, and Hang. The participants often thought in English while reading English texts. However, because their English was not strong in contrast to Chinese, their L1, they had to use the Chinese language and their Chinese background knowledge to process and retain the information learned from English sources. This difference between the language of knowledge input and that of knowledge storage is revealed in my interview with Ping.

> *J:* But how come you said you translate it into Chinese in order to memorize it?
> *P:* Because when I [was] reading, I just got the concepts. But I cannot get the exactly way,[4] the whole way to express the concepts in English. So if I try to remember the whole thing, I cannot do so in English.
> *J:* So it seems that while you are doing readings, you think in English. But after you finish the article, then you come and sit back to process the information in Chinese?
> *P:* Yes.
> *J:* Why do you do so?
> *P:* The reason is—I have mentioned.

J: This part I know: You read English; you think in English. How come you got the second part [i.e., processing the information in Chinese]?
P: Because the second part—I cannot think always in English. I can not. That's the reason. If I can, I don't bother to translate between Chinese and English. That's the reason. But when I was reading, I can't [think in Chinese] because everything has been written here [in English]. I just get. But I cannot process myself all in English. That's the problem.
J: What's the difficulty?
P: I think there are two difficulties. One is habit. I'm used to doing so. The second is there are some problem because I cannot remember exactly how such meanings are expressed in English. I cannot do it all by myself. And also it's not convenient for me. You know people like to do things if possible.
J: So it's easier for you to process it or bank it, keep it in Chinese. You have a more solid memory if you keep it in Chinese. If you keep it in English, you may lose it?
P: Yes.
J: Is it because you cannot relate to your Chinese background?
P: It's part of the reason. (Interview with Ping, November 29, 1997)

As is evident, if Ping tried to store new concepts in English, the concepts might be quickly forgotten for lack of an English storage system to attach them to because he (and most other participants in this group) had not firmly established a strong English storage system. Ting's complaint to a similar effect provides further illustration: "When I listened in class, I felt I understood [the professor]. But after class I forgot everything. I don't have anything in my memory. This lack of memory suggests I was listening at the level of an elementary school student to the lectures of professors" (August 27, 1997). It is not that Ting completely failed to understand what the professor said in English; rather, he was unable to remember what he heard—without having the opportunity to translate the English information into Chinese.

When these students planned their writing, that is, when they generated and organized ideas, they mostly thought in Chinese although they might jot down notes in English phrases and sentences because they were to write English assignments. They seldom wrote their outlines entirely in Chinese, against what Friedlander (1990) advised, even if they employed their disciplinary knowledge learned in Chinese. Most of these students (except Xing) continued to use Chinese for thinking for much of the writing by accessing and retrieving information from their Chinese memory and temporarily relying on their Chinese thinking skills. So their writing involved first translation and subsequently thinking in English. The latter process seemed to vary with the individuals. For example, Xing, who had a relatively high English proficiency, might be thinking in English more than Hang, who

was still practicing translation in order to improve his disciplinary writing skills. Compare:

J: In what language do you normally think about your writing?
X: English.
J: Do you ever switch between languages (jumping from one to the other)? If so, in which direction? Under what circumstances do you switch?
X: I usually think in English. But sometimes I do it in Chinese especially if it is a difficult concept. (Interview with Xing, November 18, 1997)

J: In what language do you normally think about your writing?
H: I think I still use Chinese. For some topic if I'm very familiar, maybe I just write in English.
J: I see. Your thinking in Chinese would be true for the outline as well as for the writing of the paper itself?
H: I think the same. (Interview with Hang, December 5, 1997)

As can be seen, Xing thought in English in normal cases and in Chinese only in case of difficult concepts. In contrast, Hang usually thought in Chinese. Only when the content was very familiar did he think in English.

The amount of thinking in Chinese also varied relative to the sources from which these students first obtained the information. If the information came from their own laboratory experiments, field trips, or some other hands-on experiences, that is, was obtained first hand, Chinese would probably be the language because they were thinking in Chinese, their own language, in performing the experiments. Feng offered some reasons why he used Chinese for his research in the following.

F: When I read English articles, [I] think in English. When I read Chinese articles, [I] think in Chinese. But after that, I think in Chinese. After reading, because you get some information here, so you think about some information and try to look for, dig out some important information and come back to your research program, and design your experiment. All this process is in Chinese thinking.
J: Therefore after you read an English article, you have to process that information to see which part is useful for your research, and which can be incorporated into your bank of knowledge.
F: Not really. Because sometimes you read an article, only for report, like you give a presentation. In this case you don't need to translate into Chinese. You just think in English and talk with English. That's fine. But if you want to dig out some important information and try to design some experiments related to your research work, in this case, yes, in Chinese.
J: That means when you do your research work, most of the thinking,

the processing, is done in Chinese.
F: Yeah.
J: That's why you come back to Chinese. It makes sense. Why do you use Chinese when doing research?
F: I think it's faster to get idea. Get new idea is very fast. I think maybe so many years you used Chinese, especially calculations. When you use Chinese, [it is] very fast.
J: True. Your English is not so fluent as Chinese for that purpose. (Interview with Feng, November 19, 1997)

Feng used Chinese in research experiments because Chinese clearly was his much stronger and more efficient language and also it would be much easier for him to "dig out" needed information to generate new ideas, suggesting that the information he retrieved was probably stored in his Chinese memory. This supports Friedlander's (1990) argument that the knowledge or experience acquired in L1 or L2 would be best retrieved via the same language. Noteworthy about my participants is that they took in and stored the information in Chinese even if they were in Canada. On the other hand, if they obtained the information from English sources, that is, second hand, they might think in English and keep the information in short-term English memory in order to use the information to write English texts such as reports and literature reviews (as Feng did). Even if the students tried to comprehend English sources in English, they still had to resort to translation into Chinese in order to understand difficult concepts. They even had to translate the concepts into Chinese in order to store them in long-term memory. Pennington and Zhang (1993), in a survey of Chinese graduate students at a US university, also found that the majority of the students thought in Chinese to some extent while writing in English. Lay's (1988) Chinese ESL students and Myers' (1998) Chinese graduate students did the same. This practice may change, however, if the students gradually build up a strong English storage system, as we see in the second case below.

Loosely Related L1 and L2 Fields

Kang, Ding, and Ning, making up Group 2, shifted from their fields of study in China to new fields that were only loosely connected with their previous studies. Because their English language skills were not strong in contrast to their solid Chinese academic backgrounds and because they were normally thinking in Chinese, they admitted that they thought primarily in Chinese in the beginning, but moved much more quickly than most of those in Group 1 to thinking in English because they did not have a similar specialized knowledge in L1 to turn to. A case in point is Kang, as revealed in the interviews.

J: When you read academic writing (e.g., an article in your field), do you normally think in English or Chinese?

K: Guess now I think in English, 'cause there are many academic terms in my paper [of which I do not know the Chinese for]. (Interview with Kang, November 22, 1997)

But when Kang met difficult sentences, he would come to his mother culture to get a sense and then continue with the reading.

J: So you switch from Chinese to English. Do you go backwards from English to Chinese?
K: Yeah, if I met some tough sentence, I really can't find the exact meaning to explain that in English, so I will come back to my mother language, because when you [try to] understand some sentence, you have to use your cultural background to understand that. I think you must have such experience, right?
J: Sometimes I do.
K: So you have to come back to your mother culture background and get a sense about that, and go back and you understand what this is in this English environment, what's the meaning for that. (Interview with Kang, November 22, 1997)

However, while planning to write, they mainly used Chinese for thinking because Chinese was still their stronger language. It was easier and more efficient to generate ideas and organize them (Lay, 1988). For example,

D: When I write, I usually do an outline. Usually for the outline I think in Chinese. But when I do the writing I try to think in English.
J: Why use Chinese for the outline?
D: I think it's pretty easy, because I always think that's for outline, just know the whole things. It doesn't matter. It won't affect your writing. It's easier and quickly to think about it. (Interview with Ding, December 29, 1997)

While writing, whenever they came to difficult concepts to process or complex ideas to analyze, they would still come back to Chinese. For example, Ding would think in Chinese first and then think about it again in English: "But what I mean is if what I did is too complicated to use English to express, so you use Chinese to think about. When you think it through, so you just use English to think this again" (December 29, 1997). One reason they thought in Chinese was that their Chinese culture supplied them with the logic skills, as well as the basic knowledge, necessary for generating ideas and getting their thinking going. This finding is in keeping with Qi's (1998) claim that high knowledge demands were a general factor for language-switching (to L1) in the thinking processes and that L1 students should use their L1 to plan complicated writing tasks.

Worth noting is that it is this group of the participants who relied on modified copying[5] most, either through notetaking and information collec-

tion on the computer (Ning and Kang) or memorization (Ding). Because they had shifted to a fairly new knowledge area, they had no closely related specific disciplinary knowledge from their Chinese education to access. The Chinese education and culture could provide them only with a broad knowledge base and thinking skills, which they exploited on demand. Their specific disciplinary knowledge had to come chiefly from the English sources they had just read or otherwise accessed (e.g., through lectures). Yet their English was not strong enough, at least in the beginning, to accommodate the storage of the entire corpus of English knowledge they learned. Therefore, they had to reprocess a portion of the English knowledge and store it in Chinese while keeping the rest (such as technical terms) in English. The former was evident in that the participants often used Chinese to generate ideas in planning and sometimes during writing. In the latter case, they had to rely on the computer considerably to help store the English knowledge, again reflecting their underdeveloped disciplinary knowledge as well as English proficiency. Therefore, when they wrote their disciplinary assignments in English, they used "unfamiliar discourse" (Howard, 1995; Hull & Rose, 1989) in terms of both content and language. Also, in this respect, it would be only partly right to assert that these students had an interdependent language system, as although one portion of their knowledge was readily accessible via both L1 and L2, another was accessible only via L2.

Entirely Different L1 and L2 Disciplinary Fields

Similar to Group 2, Ying, who appeared as a special case (but represents a potential group), was also studying in a new area, shifting from English language and literature in China to audiology and speech pathology at the university. She shared the challenge of learning new specific disciplinary knowledge and using it in written assignments. But unlike the Group 2 students, Ying, as a former English major, had the crucial advantage of a developed English proficiency. Therefore, she was able to learn English knowledge from the assigned sources and to encode that knowledge by using English, which was strong enough to accommodate the storage of the knowledge. Thus when she accessed and retrieved knowledge for thinking and writing, she did so in the same language, namely, English. Furthermore, also owing to her strong English and experience in using English, she was able to use her logic skills in English. Thus her whole process of thinking and writing for the purpose of the assignments was predominantly in English. As evidence, she found it difficult to explain her studies to Chinese speakers in Chinese because she had to translate everything into Chinese, which she was not used to and which would involve using Chinese equivalents that she did not know.

J: In what language do you normally think about your writing?
Y: English.

J: All the time from planning to proofreading?
Y: Yeah.
J: Why don't you use Chinese?
Y: I don't know how Chinese—it's hard to translate and back. Just all the readings are English. All the terminology are English. I don't have a background in this area in Chinese....
J: You said sometimes you switch from Chinese to English.
Y: When I talk to Chinese people but—
J: Why do you do so?
Y: It's faster. It's something you don't have to [translate] ... I think it's vocabulary in Chinese; sometimes it's limited.
J: Or you don't know.
Y: You don't know. You just don't think readily what's the Chinese proper translation for the English words. (Interview with Ying, November 24, 1997)

As is clear, Ying had a preference for thinking in English, her stronger and more efficient language as far as her discipline was concerned. This is in sharp contrast to most of the students in Group 1. My own experience as a bilingual writer supports Ying's evidence in that I always think in English during both planning and composing stages of disciplinary writing as almost all my academic knowledge has been acquired in English for the past 24 years. It must be admitted that, as adult ESL speakers, the English we use for thinking may still be called a variety of "interlanguage" (i.e., the internal system of the target language constructed by a learner at a given point in time; see Selinker, 1972) rather than the same language as that used by native English speakers in the same circumstances. Ying's experience provides further evidence for Friedlander's claim that knowledge acquired in a certain language would be best accessed in that language, and counter-evidence for the claim that the knowledge of a bilingual can be readily accessible via either L1 or L2 (Cummins, 1984; Qi, 1998).

Similar L1 and L2 Fields (II)

A second special case was Zong. Like the participants in Group 1, he had roughly the same field of study at the Canadian university as his field in China. So he had a good background knowledge from his Chinese education of wood science. But unlike those in Group 1, he enjoyed a highly developed level of both disciplinary knowledge and English language proficiency. By the time of the interview he had completed his doctoral studies and had been working at high-profile research institutions in an almost entirely English environment as a promising scientist. Thus Zong can be said to have a solid knowledge of his discipline in English. In that environment, even if he talked to another Chinese L1 speaker, he would speak English. He informed me: "I have some Chinese people in our group. I find it's hard to talk to them in

Chinese because you are in this English environment. Naturally you become accustomed to speaking English" (April 8, 1998). His English was so developed that when he now planned writing and composed research texts, he thought in English all the time. But at the beginning when he put his first couple of articles together, he had to write in Chinese first and then translate them into English, as Friedlander (1990) predicted.

> *J:* When you write, do you think in English?
> *Z:* English.
> *J:* At the planning stage, do you use English?
> *Z:* Yeah.
> *J:* In the beginning did you do this?
> *Z:* Let me see. No, I had a lot of difficulties at the beginning. I probably, when I put the first couple of journal articles together, put Chinese first, then translate. (Interview with Zong, April 8, 1998)

The progress Zong made in thinking in English did not occur overnight, but through many years of exposure to English, both oral and written; an eagerness to learn what he considered to be good English; and tremendous practice in applying what he learned. He reflected:

> I found ... it's such a learning curve. You really can't pick one thing—that's the way I got to a different level. It's a process. So I think I pay a lot of attention to how other people write. Sometimes I even stop and think: hey, if I write this sentence it would be different; why? I would admire people who write well. Gradually you learn the way the native [English-speaking] people would express themselves. (Zong, April 8, 1998)

Zong's case demonstrates a superb example of development over a number of years from thinking and writing in Chinese to be translated into English, to thinking and writing directly in English. In the process, his stronger language for English academic writing shifted from his L1 to L2. But on the other hand, because he had a strong knowledge background of wood science in both Chinese and English, it is likely that he had an interdependent knowledge storage to a greater extent than any of the other participants, and he may have been able to access much of his disciplinary knowledge via both L1 and L2.

Discussion

Friedlander (1990) hypothesized that "ESL writers will be able to plan more effectively and produce texts with better content when they are able to plan in the language related to the acquisition of topic-area knowledge" (p. 113). In my study, the findings in the first special case (i.e., Ying) strongly support his hypothesis. However, the cases in Groups 1 and 2 are more complicated.

Some of the members of Group 1 were so used to thinking in Chinese, especially about difficult concepts, that they would reprocess the English texts in Chinese and integrate the knowledge gained in the texts with the knowledge they had learned in China in order to store the knowledge in long-term memory. Wang was one of them.

J: So while you read, it's in English. After you read, you process it in Chinese.
W: I think so.
J: Because you want to relate to something you learned before.
W: Most probably in Chinese. I think only when you say in your mind in Chinese "OK, I understand," then you are really understand about this paragraph. And if in your mind your Chinese is totally a mess, then you really don't get the point. (Interview with Wang, December 5, 1997)

Thus while planning to write their papers, most of the students in Group 1 thought in Chinese as they retrieved the information stored in their Chinese memories. The students in Group 2 (such as Ding) still often thought in Chinese while planning to write in English even though they received their knowledge input in L2 and had little corresponding L1 disciplinary knowledge from China. But these students did think more in English while composing texts than most of those in Group 1. Thus it appears difficult for Friedlander's hypothesis to account for these complexities.

However, an alternative theory proposed by Qi (1998) based on cognitive demands seems to fall into place. If the task is complex and demands a high level of knowledge, the students tend to use their L1, that is, their stronger language, for thinking. This occurred in cases such as Kang in breaking his reading blocks and Ding in breaking his writing blocks. But if the task is not cognitively demanding relative to both the students' disciplinary knowledge and language proficiency (such as giving advice to the international student advisor on how to meet the needs of international students in Friedlander's study), then the students may think in English in planning to write, and then in writing English texts.

As can be discerned from the above, a significant factor that determined whether the students were able to store the knowledge learned in English in their memory in English was the student's English language proficiency, that is, whether the students had strong enough English language to support the storage of the knowledge. For example, although Ying kept her English knowledge in mind in English without much difficulty, most students in Groups 1 and 2 found it hard to remember the knowledge in English. As Ping stated, it is not that he did not want to think in English to reprocess the information he just read; he wanted to but was unable to. "I cannot get the exactly way, the whole way to express the concepts in English" (November 29, 1997). So he automatically fell back on his Chinese memory system.

Nonetheless, as he continued to use English in his studies, he began to think more and more in English in writing as well as reading. In this respect, Zong, the second special case, was similar.

J: When you read articles you would think in English?
Z: I never analyzed it in a definite fashion. I think now when I talk to you, I don't think of anything in Chinese.
J: What about reading?
Z: I would say more in English than Chinese. Something—
J: Not clearly cut?
Z: Something you would develop over the years.
J: Perhaps at the beginning you probably thought more in Chinese; as time goes on, you think more in English.
Z: I think so. (Interview with Zong, April, 8, 1998)

It is worth reiterating that the development of English language proficiency is a gradual process. As students' English proficiency develops, the students will be able to think more and more in English for both reading and writing (Kobayshi & Rinnert, 1992).

The case of Zong also supports Qi's (1998) claim, which agrees with Cummins' (1984) language interdependency theory, that ESL students have an interdependent storage system of conceptual knowledge in their memory. That is, conceptual knowledge is shared across languages and can be accessed via both L1 and L2. For some knowledge that Zong had learned in China and that he relearned or reprocessed in Canada, he might have an interdependent storage system that could be accessed without much difficulty via either English or Chinese. However, my study findings in general suggest that whether conceptual knowledge is shared across languages also depends on at least two other factors that are interrelated: cognitive demands of the knowledge (Qi, 1998) and L2 proficiency. If the knowledge is not cognitively difficult and the student has both L1 and L2 skills sufficient to process the knowledge comfortably, then the knowledge may be shared across languages and be accessible via either language. An excerpt from my interview with Hang supports this claim.

J: But do you find it hard to translate? The thing is if you think in Chinese, and you have to write in English, there must be a process of translation going on.
H: Yeah. But if the topic is familiar, English and Chinese are the same. But if some topic is very difficult, maybe I think in Chinese. (Interview with Hang, December 15, 1997)

This same illustration simultaneously supports a counterclaim that if the knowledge is too difficult or complex for the student to process in one language, then the student may be able to process it only in the other rather

than either of the two. In my study, English was the weaker language for most participants; therefore, they normally resorted to Chinese, their stronger language, to process difficult knowledge. Such examples were abundant in my interviews with the students, especially from Group 1.

On the other hand, Ying had learned her conceptual knowledge in audiology and speech pathology in English and then had almost no opportunity to reprocess the knowledge in Chinese. Therefore, she stored the knowledge only in her English memory and retrieved the information in the same language. She did not appear to have a Chinese memory for her conceptual knowledge. Although as a Chinese L1 speaker she might use Chinese as her stronger language for everyday and social topics, in the realm of her scientific discipline, English was obviously her stronger language (see above for the transcript of an interview with Ying). One reason the students preferred to use the stronger language to process complex knowledge is that the knowledge complexity or difficulty would be too much of a burden or an obstacle for them (Qi, 1998) if they used their weaker language to process the knowledge.

Qi (1998), in his study of one Chinese graduate student at a Canadian university, made similar observations about his participant. However, Qi (1998) overgeneralized his case study findings. He argued that because his participant depended on her L1 to complete composing tasks of high knowledge demands, "it would be extremely misleading to advise our L2 students to refrain from using their L1 in L2 performance" (p. 429). I argue that whether teachers should advise or encourage ESL students to think in L1 or L2 depends to a large extent on how proficient the students are in the L2 relative to the subject matter. If the proficiency level of the L2, in this case disciplinary L2, of the ESL student is fairly low, then in accordance with the research findings (Friedlander 1990; Lay, 1988; Qi, 1998; Uzawa, 1996), teachers should encourage the ESL student to think in L1, especially when performing difficult tasks, rather than asking the student to think in L2. But on the other hand, if the L2 proficiency of the student is high relative to the task to be performed, and the student would feel at least moderately comfortable thinking in English, then it would be unwise to advise or encourage the student to think in L1 rather than in L2. The case of Ying discussed above provides strong evidence for this claim. Sasaki's (2000) study also indicated that L2 proficiency is a powerful variable for L2 writing competence (Sasaki & Hirose, 1996).

Thinking in L1 before or during L2 writing, although helpful in generating ideas and straightening out thoughts, is inevitably bound by the constraints of translation and is accompanied by problems that result from L1 influence and writing through translation (see Gass & Selinker, 1992; Kellerman & Sharwood Smith, 1986; Odlin, 1989, for further discussion). The problems manifested in the works of the participants (or admitted by them)

included missing articles (e.g., "have only slight effect"), misuse of prepositions (e.g., "in nowadays"), subject-verb disagreement (e.g., "Biotic system require"), stylistic inappropriateness (e.g., "is got"), misuse of the comma (e.g., "However, the hot pressing method was not used until later research, since a big difference [was] expected in density profile in thickness between the cold pressing boards and hot pressing boards, the use of cold pressing data to predict flakeboard properties is questionable."), Chinese punctuation (e.g., "I. Introduction:"), and what has often been termed "Chinese English" or literal translation (e.g., "So far, the only study on fractal dimension directly applied to wood exists [Brown, Smith[6] 1994]").

Further, although translation may be a positive writing strategy for a developing student, it may phase out as the student increasingly thinks in L2 and develops his or her writing proficiency in approximation to native speakers' writing. We can reasonably assume, therefore, that there is presumably *a thinking language continuum* along which the use of translation varies. In other words, *L2 students start by thinking of L2 in L1 (often through translation), and as the L2 develops, gradually think more in L2 and less in L1, and finally, come to think in L2 primarily or even entirely.* This observation is consistent with Lay's (1982) assertion that L1 is more useful in the beginning stages of L2 development and that as L2 develops, L1 use would lessen. Kobayashi and Rinnert (1992) made a similar observation (see above). Further support is evident in the developmental view of bilingual memory organization (de Groot & Hoeks, 1995), which suggests that L2 learners start to process the L2 via the L1 (i.e., translation), but with L2 practice, they develop the direct connections between L2 word-form representations and the conceptual memory common to both L1 and L2 words. With advanced L2 proficiency, the L1 word-meaning associations gradually pass into disuse, giving way to direct L2 word-meaning associations. One of my participants, Zong, provides vivid exemplification of this developmental process. At the time of the interviews, Zong and Ying seemed to occupy positions closer to the L2 end of the continuum, whereas the others seemed to take varied positions closer to the L1 end.

Thus whether one thinks in L1 or L2 when reading or writing in the L2 may not depend on one factor or another in a fixed fashion as suggested in earlier studies (Friedlander, 1990; Qi, 1998), but rather on the interplay among a number of factors, which include, but are not limited to, the language of knowledge input, the language of knowledge acquisition (Friedlander, 1990) or storage, the development of L2 proficiency (de Groot & Hoeks, 1995; Sasaki, 2000), the level of knowledge demands (Qi, 1998), and the task conditions (e.g., time pressure). It is the interplay among these (and possibly other) factors that determines the user's choice of the thinking language for a particular writing task or task component (which can be as big as writing up the whole piece and as small as searching for a desired word).

It is worth pointing out that, as already implied, the writer may alter the thinking language as required during reading, planning to write, and especially, writing proper.

Implications

The above findings present some important implications for teaching L2 writing, education of ESL students in their disciplines, and assessment of L2 writing, both general and academic. ESL educators and disciplinary instructors may need to encourage ESL students who have just arrived with an underdeveloped L2 proficiency to feel free to think more in their L1 and then to use translation to generate content for writing and to keep writing going. Translation can be a valuable strategy in the initial stage of the students' studies. Further, these students should be permitted whenever possible to choose writing topics related to their L1 education, native culture, and working experience, especially in the beginning, rather than being forced to write on a topic solely of the instructor's interest (as occurred with Ting). The latter situation might leave the student uninterested, incompetent, disempowered, and unmotivated. But when dealing with L2 students with advanced L2 proficiency, particularly after the students have studied in an English-speaking institution for several years, teachers should advise or encourage them to think in English. Thus their texts may be better appreciated by their instructors and other reviewers and may stand a better chance of acceptance by academic publishers. In this respect, Zong and Ying were good examples.

ESL educators and disciplinary instructors need to tell ESL students not to be disappointed if they fail to produce satisfactory writing at first. The students should know that a continuum exists between thinking entirely in L1 and thinking entirely in L2 and also that learning to write well in English is a process. Coming to think entirely in L2 and learning to write well both take time. But ESL students must keep up their efforts. With sound guidance and eagerness to learn, the students will eventually be able to produce native-like texts, as Zong did.

With an understanding of the findings, particularly the fact that translation can be an inevitable but positive strategy for ESL students with limited English proficiency, disciplinary instructors need to be encouraged to be more tolerant of the writings of the students, especially in terms of rhetoric (e.g., good diction and sentence structures). Meanwhile, these instructors can offer constructive guidance by providing written feedback and, ideally, face-to-face conferences to explain what is desirable, how to improve, and why, without disrespect for the students, their thinking, or their writing. Many ESL students (e.g., Ping) simply are not aware that they have made mistakes or followed inappropriate formal conventions; nor do they know how to improve. Ideally, the instructors should have some understanding of the culture of the ESL students and of the English language in order to offer

effective guidance. This understanding can be achieved through faculty development. If ESL students write poor academic texts, university faculty should take on the responsibility to educate them.

Notes

[1]A bilingual in Qi (1998) refers to a person with "any proficiency level in more than one language" (p. 414).

[2]All the participants' names are pseudonyms.

[3]Unlike the other 14 participants, Zong had completed his graduate studies by the time of the interviews. I included him in the study on the recommendation of a faculty member who was impressed by Zong's academic success as a graduate student. My interview with Zong addressed his writing experiences as a former student and as a researcher.

[4]To retain the authenticity of the participants' oral language, I did not correct the language errors in my transcription. However, I supplied some missing words in brackets to facilitate the comprehension of the transcripts.

[5]Modified copying means that the source sentence(s) is/are changed somewhat in diction and/or structure when reused.

[6]The names of the two cited authors have been changed to preserve anonymity.

Acknowledgments

I would like to thank all the participants who spent their valuable time sharing their life and writing experiences with me for my study. I owe special thanks to Bonny Norton, Carl Leggo, and Helen Snively for their insights and comments on earlier versions of this article. I would also like to thank the anonymous reviewers and the editors for their helpful suggestions and comments.

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