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Investigating Cognitive Information Processing in Chinese-English Translation: An Empirical Study

Xu Yuemeng
Institute of Modern History, Chinese Academy of Social Sciences

Abstract
This study explores cognitive information processing in Chinese-to-English translation, focusing on differences among translators with varying experience levels. It uncovers two parallel processes: a conscious one common to all and a subconscious process seen more in experienced translators. Using a think-aloud protocol and interviews, the study involved 15 university students at three experience levels. Texts from *The Analects of Confucius* and a government report were used. Findings show that the conscious process involves a bottom-up approach, delaying analysis until the full context is grasped. Experienced translators, however, display a subconscious, immediate interpretation process, sensitive to textual coherence. The study suggests that with expertise, information processing becomes automated, matching incoming data with existing knowledge. Furthermore, short-term memory aids in new information retention, needing long-term memory integration for expression. This research offers insights into translation complexities and the role of expertise in efficient, high-quality information processing.
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1. Introduction

Translation is a multifaceted and intricate cognitive activity that involves numerous stages of information processing. This process, from input to output, encompasses input reception, analysis, decoding, semantic representation, synthesis, encoding, and final representation in the target language. Recent studies have highlighted the importance of considering both conscious and subconscious processes in translation, particularly as these relate to translator experience (e.g., Wang & Zhang, 2021). The cognitive underpinnings of translation are complex, utilizing both short-term memory (STM) and long-term memory (LTM) systems. This intricate interplay of cognitive processes has garnered significant attention from researchers seeking to unravel the mysteries of how translators process diverse texts (Kirschner & de Groot, 2020).

The present study delves into the cognitive information processing mechanisms at play during Chinese-to-English (C-E) translation. Specifically, it examines the dual processes that operate simultaneously during translation: the conscious process, which is ubiquitous among all participants, and the subconscious process, predominantly observed in more experienced translators. By investigating these processes, the study aims to provide insights into the intricacies of translation and how translator expertise influences information processing efficiency and quality.

2. Research Methodology

2.1 Research Methods

To investigate the translation process, a think-aloud protocol was implemented. This technique is a crucial method for eliciting data on cognitive processes (Jääskeläinen, 2011, pp. 96-103). To validate the data collected through think-aloud protocols, the current research employs a triangulation approach, incorporating interviews as an additional research method.

Think-aloud protocols involve concurrent verbal reports where participants articulate their immediate thoughts while performing a task. This reveals valuable insights into translation processes, enabling researchers to describe and analyze what transpires during these processes. However, some researchers challenge this approach, arguing that think-aloud data is subjective, incomplete, and unstructured, thus inadequate for reflecting translators' thinking processes. To address this concern, an additional approach is employed to verify the validity of think-aloud data.

Interviews serve as another means of eliciting essential information from participants (Edley & Litosseliti, 2010, p. 176). A significant advantage of interviews is that they allow researchers to directly inquire about participants' thoughts on key questions (Saldanha & O'Brien, 2014, p. 169). Although similar to verbal reports, interviews are more effective because participants may not always articulate their decision-making reasons during think-aloud experiments. Consequently, this method can either confirm or refute findings obtained

through think-aloud protocols.

2.2 Research Participants

To ensure data validity and reliability, fifteen participants were selected for the experiment. These participants were all university students, specifically, five senior undergraduate students in their final year, five first-year postgraduate students, and five senior postgraduate students. Due to resource limitations, it was challenging to recruit professional translators. The participants were categorized into three groups based on their translation experience. Selection criteria included academic marks, ensuring comparable language proficiency and translation skills among all participants.

Among them, the five senior postgraduate students possess practical experience as intern translators in publishing agencies, magazine companies, or translation firms, with a cumulative translation volume exceeding thirty thousand words. Consequently, they are designated as "professional translators". All are native Chinese speakers with a high proficiency in English.

The participants were fully informed about the study's details, including the recording of their performance and voices. They were assured that no identifiable personal information would be stored or disclosed in any published academic papers featuring excerpts from their think-aloud protocols, thus maintaining participant anonymity. Additionally, without revealing the study's objectives (Mackey & Gass, 2005), the participants were briefed on how their protocols would contribute to the research. These details were outlined in the participant instructions as follows:

> This experiment is designed to investigate the cognitive processes during Chinese-English translation. For this purpose, I would like to know what you are thinking when you are translating the following texts.

Furthermore, prior to the study, the fifteen participants will be provided with detailed instructions to ensure they understand the "think aloud" methodology and the type of information they are required to verbalize. It is crucial to clarify the thoughts and information that participants must articulate, as uncertainty may lead to extended pauses, affecting data integrity, or the omission of spontaneous thoughts. Therefore, participants must be aware that during the experiment, they are expected to verbalize every thought they would normally keep to themselves. Additionally, to prevent any complications during data analysis, it is imperative to specify that the language used for verbalization during the experiment—referring to the articulation of thoughts, not the translation of texts—must be Chinese.

2.3 Source Text

Sharon O'Brien emphasizes the significance of the source text's nature in translation research design. She identifies four key considerations in selecting source texts: suitability for participants, level of specialization or generality, exhibition of distinct linguistic traits, and difficulty level (2015). Aligned with these criteria, two Chinese texts were chosen, balancing challenge and accessibility. Texts that are excessively challenging may discourage participants, leading to casual translations lacking logical and analytical thought, whereas overly simple texts fail to highlight participants' problem-solving disparities.

For this study, excerpts were taken from both *The Analects of Confucius* and *the Report on the Work of the Government* (2015). These texts represent two distinct genres: expressive and informative. Informative texts prioritize content, aiming to convey specific data or information (Reiss, 2000/2014, p. 25). Conversely, expressive texts reflect the author's attitudes or emotions, emphasizing form over content (Liu & Xu, 2015b, p. 115), as "the form used to convey the content is the primary concern" (Reiss, 2000/2014, p. 25). Therefore, selecting diverse text types allows us to explore how text type impacts information processing.

Specifically, three individual sentences were chosen from *The Analects of Confucius*, while a paragraph was selected from the *Report on the Work of the Government* (2015). The selected passages are presented below:

Source Text 1：

子曰：仁远乎哉？我欲仁，斯仁至矣。(《论语·述而》)

[The Master said, "Is benevolence really far away? I want to be benevolent, and then benevolence is at hand".]

Source Text 2：

子曰：居上不宽，为礼不敬，临丧不哀，吾何以观之哉？(《论语·八佾》)

[The Master said, "If one occupies a high position but is not magnanimous, performs rituals without reverence, and faces mourning without sorrow, how can I bear to witness it?"]

Source Text 3：

子曰：为政以德，譬如北辰，居其所而群星共之。(《论语·为政》)

[The Master said, "Governing with morality is like the Northern Star: it stays in its place while all the other stars revolve around it."]

Source Text 4：

大力调整产业结构。着力培育新的增长点，促进服务业加快发展，支持发展移动互联网、集成电

路、高端装备制造、新能源汽车等战略性新兴产业，互联网金融异军突起，电子商务、物流快递等新业态快速成长，众多“创客”脱颖而出，文化创意产业蓬勃发展。同时，继续化解过剩产能，钢铁、水泥等 15 个重点行业淘汰落后产能年度任务如期完成。加强雾霾治理，淘汰黄标车和老旧车指标超额完成。

[Official English Translation: We channeled great energy into making adjustments in the structure of industry. We focused on fostering new areas of growth by encouraging the service sector to develop more quickly, and supporting the development of strategic emerging industries, including the mobile Internet industry, the integrated circuits industry, high-end equipment manufacturing, and the new-energy vehicles industry. Internet-based finance rose swiftly to prominence. E-commerce, logistics, express delivery services and other emerging businesses developed rapidly. We have seen creators coming thick and fast, and the cultural and creative industries have been developing with great vitality.]

After selecting the texts, a pilot experiment was conducted involving the researchers and an additional participant. The aim of this pilot was twofold: to familiarize the researchers with the task and to assess the suitability of the chosen texts for the subsequent experiment. It was essential to gain insight into the potential challenges participants might face during the task, particularly the moments when they might need more time to think or when verbalization ceases naturally until a solution emerges. This process typically takes a few seconds, thus eliminating the need to pressure participants into continuous verbalization.

3.Analyzing Cognitive Information Processing in Translation

Translation is an information processing process of human, as translation is a language transfer between two languages, which is a cognitive process—a sequence of internal states successively transformed by a series of information processes (Ericsson & Simon, 1984/1993, p. 11).

3.1 Memory and Recognition in information processing

Human memory functions like a database, storing and retrieving information as needed. It is broadly classified into two categories: short-term memory (STM), with limited capacity and duration, and long-term memory (LTM), characterized by vast capacity and relatively permanent storage (Ericsson & Simon, 1984/1993, p. 11).STM serves as the working memory, while LTM acts as a reference database, from which information is retrieved to match newly acquired information stored in STM. Recognition, the starting point of information processing, involves encoding sensory information and identifying familiar patterns and structures. Recognition plays a crucial role in translation processes, as recognizing information or stimuli is the starting point of information processing. The recognition process refers to “the processes or mechanisms by which sensory information is encoded and familiar patterns and structures are identified” (Ericsson & Simon, 1984/1993, p. 120). Recognition relies on long-term memory, as the information we receive is stored temporarily in working memory, while portions of such information are immediately recognized in relation to similar patterns already stored in LTM. Recent studies have further elaborated on the role of STM and LTM in translation. For instance, Segal et al. (2020) emphasize the role of STM as a “workspace” for temporarily holding and processing input information for translation decisions, while LTM provides the linguistic knowledge base to guide these decisions.

3.2 Information Processing during the Translation Processes

Information processing consists of a series of consecutive sub-processes that regularly proceed in a linear way, including three identifiable stages:

1. **Reception and Filtering**: The sensory information system (SIS) filters irrelevant information, allowing the brain to focus on relevant data. This information is stored temporarily in a sensory information store, ready for further processing.
2. **Short-Term Memory Processing**: The STM analyzes, stores, and filters the data further. During this stage, the translator may pause to retrieve relevant information from the LTM or select appropriate translation strategies.
3. **Long-Term Memory Integration**: The translator accesses the LTM to integrate new information with existing knowledge. This process involves matching received information with patterns already stored in the LTM. (Bell, 1995, p. 231) Recent research has also explored the impact of cognitive load on translation. Jiang and Wang (2021) found that complex sentence structures increase the cognitive load on translators, subsequently affecting the quality and speed of translation. This study took this into account when selecting source texts, balancing challenge and accessibility to ensure the validity of the research.

The SIS has the function to filter the irrelevant information that human brain receives through sensory systems, making the brain focus on the information that the system is paying attention to; otherwise, the brain will be overloaded by overwhelming information that it receives. The selected information will then be stored in a

sensory information store, waiting to be disposed or passed on the next stage for further processing. This stage is of crucial importance as it converts the sensory stimuli into a unit of information that is available for the processing of next stage.

3.3 Bottom-up vs. Top-down Processing

In addition to the three stages, information processing can be categorized into two types: bottom-up and top-down. Bottom-up is an inductive analysis of the information that the brain receives, that is, we do not begin the interpretation process until we get all the information; while top-down processing refers to the immediate and simultaneous interpretation of the information that we receive. Notably, both bottom-up and top-down processing may coexist during translation. Thus, the authors characterize bottom-up processing as conscious and top-down processing as subconscious. Conscious processing, synonymous with bottom-up processing, emerges as the predominant information processing model, as evidenced in think-aloud protocol data. This cognitive information processing method seems consistent among all fifteen participants. When translating passages from *The Analects of Confucius*, participants uniformly postponed their analytical procedures until they had read the entire sentence (see excerpts from Subject 1). Interview reports reveal that participants aim to grasp the full sentence's meaning prior to engaging in detailed textual analysis. This strategy is employed to enhance translation accuracy and coherence, ultimately minimizing revision efforts in subsequent stages.

The following are excerpts from Subject 1's translation process of the Source Text 2 from *The Analects of Confucius*:

Subject 1: 嗯，我先读下原文，“子曰：居上不宽，为礼不敬，临丧不哀，吾何以观之哉？”好，接下来翻译第一小句，“居上不宽”，嗯……

[Authors' translation:

Subject 1: Hmm, let me read the original text first. “子曰：居上不宽，为礼不敬，临丧不哀，吾何以观之哉？” Alright, next I will translate the first clause, “居上不宽”, Hmm…]

(Subject 1's Translation: The Confucius said: Being superior yet lenient, bearing no respects for acknowledged rules, and showing no sorrows for deaths, one cannot be seen in nature.)

The excerpt of Subject 1's interview recording:

The researcher: 在翻译《论语》节选时，你每次都先通读一下节选段落，请问你这么做的目的是什么？

Subject 1: 嗯，我认为翻译时不能提笔就翻，不能看见原文以后就直接翻译，最起码应该读一遍原文，了解原文大致意思，然后再开始翻译，这样可以避免对原文的片面理解。[Authors' translation:

The researcher: When translating excerpts from *The Analects*, you always read through the selected passage first. What is the purpose of doing so?

Subject 1: Hmm, I believe that when translating, one should not simply start translating upon seeing the original text. At the very least, one should read through the original text once to understand its general meaning, and then begin translating. This approach can help avoid a one-sided understanding of the original text.]

Minor variations exist in the processing of the *Report on the Work of the Government* (2015). Specifically, four translation students (Subjects 1, 3, 4, and 5) and two semi-professional translators (Subjects 6 and 10) initiated their interpretation and analysis upon completing the first sentence. Conversely, the remaining participants read the entire text before revisiting the first sentence (see excerpts from Subjects 6 and 11 below). This suggests that seasoned translators are more cognizant of textual coherence and strive to situate their translations within a broader context compared to their less experienced counterparts.

The following are excerpts from Subject 6's translation process of Source Text 4 from *the Report on the Work of the Government* (2015):

Subject 6: 好，现在翻译材料 4，“大力调整产业结构”，嗯……“大力调整产业结构”，我觉得应该先翻译“调整产业结构”，然后再找一个副词修饰“调整”，嗯？这句话好像没有主语，是不是应该加个主语“we”？对，应该加上一个主语……

[Authors' translation:

Subject 6: Alright, now let's translate Source Text 4. “Vigorously adjust the industrial structure”, hmm... “Vigorously adjust the industrial structure”. I think we should first translate “adjust the industrial structure”, and then find an adverb to modify “adjust”. Hmm? This sentence seems to be missing a subject. Should we add a subject like “we”? Yes, we should add a subject...]

(Translation of the sentence by Subject 6: We should significantly adjust the fabrics of industry.)

The excerpts of Subject 6's interview recording:
The researcher:你在翻译材料 4 时，为什么在读完第一句就开始进行翻译而不是将整段读完才开始翻译？
Subject 6: 我认为没必要看完全段再翻译，看完完整一句就可以了，翻完了再翻译下一句。
[Authors' translation:
The researcher: When translating Source Text 4, why did you start translating after reading the first sentence instead of waiting until you had read the entire passage?
Subject 6: I believe there's no need to read the entire passage before translating. Reading one complete sentence is sufficient. Translate that, and then proceed to the next sentence.]

The following are excerpts from Subject 11's translation process of Source Text 4 from the *Report on the Work of the Government* (2015):
Subject 11: 嗯，好的，我先读遍原文，"大力调整产业结构。着力培育新的增长点，促进服务业加快发展，支持发展移动互联网、集成电路、高端装备制造、新能源汽车等战略性新兴产业，互联网金融异军突起，电子商务、物流快递等新业态快速成长，众多"创客"脱颖而出，文化创意产业蓬勃发展。同时，继续化解过剩产能，钢铁、水泥等 15 个重点行业淘汰落后产能年度任务如期完成。加强雾霾治理，淘汰黄标车和老旧车指标超额完成。"嗯，原文看完了，好，接下来开始翻译第一句……
[Authors' translation:
Subject 11: Hmm, alright. Let me read the original text first. "Vigorously adjust the industrial structure. Focus on fostering new growth points, promote the accelerated development of the service industry, support the development of strategic emerging industries such as mobile internet, integrated circuits, high-end equipment manufacturing, new energy vehicles, etc. Internet finance has emerged as a new force, with rapid growth in new business formats such as e-commerce and express logistics. Many 'makers' have stood out, and the cultural and creative industry is booming. At the same time, continue to resolve excess capacity, with the annual task of eliminating outdated capacity in 15 key industries such as steel and cement completed as scheduled. Strengthen haze governance, with the targets for eliminating yellow-label cars and old vehicles exceeded." Hmm, I've finished reading the original text. Alright, next, let's start translating the first sentence...]
(Subject 11's Translation of the first sentence: We should readjust industrial structure with great exertion.)

The excerpts of Subject 11's interview recording:
The researcher:你在翻译材料 4 时，为什么在通读全文后才开始翻译？
Subject 11: 我觉得在翻译段落时，必须先通读一遍，这样才能够更好地从整体上把握全文的意思，不容易出现偏差，也能够更好地保持译文的连贯性。
[Authors' translation:
The researcher: When translating Source Text 4, why did you start translating after reading the entire passage?
Subject 11: I believe that when translating a passage, one must first read through it once. This allows for a better overall understanding of the passage's meaning, reducing the likelihood of errors and ensuring better coherence in the translation.]

Another intriguing finding from the interview data is that seven participants—three semi-professional and four professional translators—reported that during their initial reading of the texts, particularly *The Analects of Confucius*, the interpretation or English equivalents of the Chinese sentences spontaneously entered their minds without consciously focusing on translation. This subconscious interpreting process suggests that when information is received and stored in short-term memory (STM), an automatic association is formed, linking the new information with that stored in long-term memory (LTM). Based on these results, the author tentatively hypothesizes that subconscious processing correlates with translators' experience; specifically, the more experienced a translator is, the higher the likelihood of subconscious processing occurring. However, further data is required to validate this hypothesis due to the limited sample size of this experiment.

Additionally, the think-aloud protocols support the notion that information stored in STM can be accessed directly, whereas information in LTM cannot. This aligns with Ericsson and Simon's (1984/1993) assertion that information in LTM needs to be retrieved or transferred to STM before it can be articulated. Notably, participants took pauses between verbalizations, indicating that they were searching for possible equivalents of Chinese characters in their mental lexicon, selecting appropriate translation strategies, restructuring sentence formats, and revising translations (refer to excerpts from Subjects 2 and 7). Interviews confirmed this observation, as all fifteen participants reported similar thoughts during their pauses, specifically, attempting to recall relevant

information or patterns from memory, albeit not in those exact words. Consequently, these pauses can serve as an indicator of information retrieval from LTM.

The following are excerpts from Subject 2's translation process of Source Text 3 from *The Analects of Confucius*:

Subject 2: 嗯……“为政以德”、“为政以德”，这个“为政”应该指的是“从政”吧？……嗯……不对，不对，孔子这句话应该是说“皇帝在治理国家时不应该采用暴力，而是应该通过仁政、通过良好的道德来治理国家”……嗯，对，应该就是这个意思，那就按这个意思翻吧，“皇帝应该用美得治理国家”，嗯……“The emperor should rule the country with virtue”，好，下一句……

[The authors' translation:
Hmm... "Rule with virtue", "rule with virtue" – perhaps this "rule" refers to "participating in governance"?... Hmm..., no, Confucius's statement likely implies that "the emperor should not employ violence in governing the country, but should instead adopt benevolent governance and adhere to good morals" ... Yes, that seems to be the intended meaning. Therefore, we can translate it accordingly: "The emperor should govern the country with virtue". Alright, let's proceed to the next sentence...]
(Subject 2's Translation of the sentence: The emperor should rule the country with virtue.)

This excerpt shows that Subject 2's thinking activities of choosing a translation strategy; she chooses to translate the meaning of the source text, *i.e.* she chooses the translation strategy of free translation.

The following are excerpts from Subject 7's translation process of Source 4 of *Report on the Work of the Government (2015)*:

Subject 7: “着力培育新的增长点”，“着力”应该就是“重点”、“重视”的意思，嗯……“重点”、“重视”……那就翻译成“pay full attention to”吧，接下来是“培育”……“培育”就翻译成“cultivate”吧，或者“develop”应该也可以，嗯，然后是“新的”，这个好翻，就翻译成“new”应该就行，最后是“增长点”，这个好像不太好翻译，“增长”倒是可以翻译成“growth”，那“点”怎么翻？翻译成“point”？嗯……就先这么翻吧，一会儿再改，嗯，那这句话就是“pay full attention to cultivate/develop new growth point”，好，看下一句……

[The authors' translation: "Focus on cultivating new growth points" – "着力" should mean "focus on" or "emphasize". Hmm... "Focus on", "emphasize"... Let's translate it as "pay full attention to". Next is "Cultivate"... "Cultivate" would be an apt translation, or perhaps "develop" would also work. Hmm, then we have "新的", which is straightforward and can be translated as "new". Lastly, "增长点" seems a bit tricky to translate. "增长" can indeed be translated as "growth", but how about "点"? Should it be translated as "point"? Hmm... Let's go with that for now and revise it later. So, this sentence becomes "pay full attention to cultivate/develop new growth points". Alright, let's look at the next sentence...]
(Translation of the sentence by Subject 7: We should pay full attention to cultivate new growth point.)

This excerpt illustrates the processes involved in searching for English equivalents of Chinese phrases within one's mental lexicon. The pauses in the subject's response indicate that they are retrieving pertinent information from their long-term memory (LTM). Once the desired information is located, it is then transferred to their short-term memory (STM), enabling it to be verbalized.

4. Conclusion

Information processing forms the foundation of the translation process, encompassing stages such as information input, analysis, decoding, semantic representation, synthesis, encoding, and final representation in the target language. The findings align with recent research emphasizing the dual processes of conscious and subconscious information processing in translation (Wang & Zhang, 2021). As suggested by Kirschner and de Groot (2020), through repeated practice, translation becomes more automated, with experienced translators demonstrating a heightened ability to match incoming information with pre-existing knowledge in long-term memory. This automation, combined with the critical role of short-term memory in retaining new information, underscores the intricacies of translation cognition. Additionally, the research confirms that information retained in short-term memory can be articulated, as evidenced by the data analysis. The STM serves as a temporary repository for newly received information, and processing this data demands the formation of associations with the LTM.

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