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# Individual metacognition in technology-assisted collaborative translation: comparing higher- and lower-achieving teams

Wenting Yang<sup>1</sup>, Ricardo Muñoz Martín<sup>2</sup> & Xiangling Wang<sup>1</sup>

The upsurge of translation technology has fostered complex socio-cognitive communication environments where metacognition emerges as a crucial mediator among translators and other relevant agents. Most research has centered on individual translators, and evidence is scarce on how translation teams navigate such environments and how individual metacognitive activities impact the teams' translation performance. This study bridges this gap by exploring trainees' metacognitive activities in the technology-assisted project. This study split between higher- and lower-achieving teams based on their project outcomes and explored their socio-cognitive behaviors and team-averaged metacognitive differences. Data were collected and cross-referenced from self-reflection reports, focus group interviews, questionnaires, log data, chat data, and classroom observations. The analyses suggest that (1) all the teams engaged in various collaborative inquiries; higher-achieving teams prioritized mutuality, engaged in more self-directed activities, and displayed greater learner autonomy, whereas lower-achieving teams relied more on instructor scaffoldings and participated less actively in discussions and complex tasks; (2) teams in both conditions had similar levels of metacognitive knowledge of person and strategy, but the higher-achieving teams showed higher metacognitive knowledge of task and metacognitive regulation; (3) higher-achieving teams exhibited more critical self-evaluations and more analytical approaches to tasks, indicating their enhanced metacognitive awareness than lower-achieving teams. In light of these results, metacognition and self-autonomy are important in translation and other complex communication tasks.

<sup>1</sup>Hunan University, Changsha, China. <sup>2</sup>University of Bologna, Forlì, Italy. ✉email: [xl\\_wang@hnu.edu.cn](mailto:xl_wang@hnu.edu.cn)

## Introduction

As AI and big data technologies ceaselessly emerge and advance, research on the cognitive capabilities of translators in technology-assisted working environments is gathering momentum. The swift diversification in the industry has expanded translation into multilectal-mediated communication events at both social and cognitive levels (Halverson, Muñoz Martín 2020). Now translators are seen to interact not only with service-related agents, but also with emerging technologies, such as computer-assisted translation (CAT) tools, machine translation (MT) systems, and collaborative platforms (Vandepitte et al., 2016). Such interactions turn technology-assisted collaborative translation into complex socio-cognitive processes, posing greater challenges for translators (Sannholm, 2021). Professionals need to constantly acquire and update their skills and experience to keep up with this fast pace and for the best results in the translation industry.

The new technologized environments have significantly impacted many cognitive processes (e.g., PC screens are used as external working memories), highlighting the importance of mental skills such as metacognition, or *thinking about thinking* (Flavell, 1979). In general, metacognition entails the ability to regulate one's learning and performance and improve learning outcomes (Cale et al., 2023). With metacognition, individuals shape their consciousness of what to learn and where to learn (Carneiro, 2007). It is also crucial in helping translation trainees adapt to their task environments and excel in the professional market (Echeverri, 2015; Mellinger, 2019; Shreve, 2006). Metacognition helps in autonomous and lifelong learning, and becomes a developmental and pivotal factor in the professional careers of translators (Pietrzak, 2022). Despite its importance, most metacognition research in the translation realm centers on individuals, and we still lack evidence on how translation teams navigate complex socio-cognitive communication environments and which metacognitive elements contribute to improved performance in collaborative translation tasks.

This study explores the team-averaged differences in the individual metacognition of translation trainees working on a technology-assisted project, where trainees can develop their expertise through various online and offline communications. Team dynamics offer a unique context for understanding how individuals share and negotiate metacognitive activities, which provides valuable insights into translator training, especially in professional settings where collaboration is often key. In materials and methods, we address several aspects including that the simulated collaboration scenario was a self-directed translation project embedded in a translation technology course. Based on their project performance in this project, teams were categorized as higher- or lower-achieving. We then discussed their socio-cognitive behaviors and metacognitive differences, specifically, metacognitive knowledge and regulation. This exploratory study allows for tentative conclusions on the specific indicators of metacognition that distinguish high-quality translation performance and inspire translation learners to improve translation expertise in the digital age.

## Related research

**Technology-assisted collaborative translation.** The massive deployment of information and communication technologies (ICTs) by language service providers has endowed collaborative translation with new connotations and placed additional requirements on translators (Esselink, 2020). New technologies and methods, particularly MT and CAT tools, have fostered diverse collaboration patterns among agents and technologies (Vandepitte et al., 2016). Such confluence presents a rich and

complex mesh of translation processes, turning translation into dynamic social events involving multilectal parties' co-creative processes (Halverson, Muñoz Martín (2020); Pfeiffer et al., 2020). Translators are thereby situated both at social and cognitive levels (Sannholm and Risku, 2024). In brief, technology-assisted collaborative translation represents a dynamic intersection of socio-cognitive processes, where technology and human interaction collectively influence translation outcomes. How translators interact with translation technology and diverse human profiles and how these interactions affect their socio-cognitive performance is now pertinent and meaningful more than ever before (Kung, 2021). Collaborative translation tasks increasingly involve ill-structured problems with even more multiple potential solution paths (Muñoz and Olalla, 2022). Technological advancements have influenced how translators approach tasks and communicate with other agents. Leveraging the strengths of technology and human collaboration becomes a must. Considering this, critical approaches to translation technology are even more imperative for translators (Kenny, 2020), by virtue of which, the ability to evaluate tools and their optimal environments can be honed for translators' adaptation to the professional landscape (Alotaibi, Salamah 2023).

How to employ such critical approaches becomes a focal point of discussion, where metacognitive skills have sparked interest. For example, Bowker (2015) argues that metacognitive skills such as the ability to engage in critical analysis and problem-solving should be cultivated; Rico (2017) suggests that necessary skills include creativity, the ability to work autonomously and to acquire new knowledge. Whyatt and Naranowicz (2020) validate that complex metacognitive skills, including planning, self-monitoring and self-revision, help translators to be tolerant of the variations imposed by market dynamics and new technologies. All relevant research has underscored the pivotal role of metacognition in translator development. With metacognitive skills, translators can shape critical approaches and gradually grow autonomous to fit the ever-changing professional market (Pietrzak, 2022).

**Metacognition and translation expertise.** Metacognition has been widely discussed in educational settings. There are many definitions and models of metacognition, but research in a nutshell distinguishes between knowledge of cognition and control over cognition (Pintrich, 2002). Two essential components of metacognition include metacognitive knowledge and metacognitive regulation (Mellinger, 2019; Muñoz Martín (2014); Shih and Huang, 2022). Metacognitive knowledge pertains to knowledge or belief about what and how various factors affect cognitive processes and outcomes (Flavell, 1979). Metacognitive knowledge is categorized into three dimensions — person, task, and strategy — and directly impacts the implementation of learning tasks (Flavell, 1979; Pintrich, 2002). Metacognition is task-specific at first but evolves as learners accumulate more metacognitive knowledge (Shih and Huang, 2022). With metacognitive knowledge, learners can shape awareness towards self and others to contribute to their task outcomes (Li and Yuan, 2022).

Nonetheless, metacognitive knowledge alone does not always ensure effective learning but must be paired with metacognitive regulation (Li and Yuan, 2022; Zhang and Zhang, 2019). Metacognitive regulation involves the deliberate efforts to plan, monitor and evaluate cognitive engagement (Quintana et al., 2005; Schraw, 1998). Facilitated by metacognitive regulation, learners can consciously control their awareness and deliberate their efforts to maximize learning achievements (Zheng et al., 2023).

Most research on metacognition has focused on individual learners, but it is essentially a socio-cognitive construct involving both individual and collective scales (De Backer et al., 2012) and can be best promoted through interactions (Schnaubert et al., 2021). Research has revealed the benefits of collaborative learning and project-based interventions in promoting metacognition in different task domains (e.g., Pifarre and Cobos, 2010; Sandi-Urena et al., 2011). Collaborative tasks encourage individuals to pool their metacognitive resources to create a shared understanding and collective knowledge. Metacognition has thus been empirically reported to be a predictor of project performance, but the associations between different metacognitive components have been largely ignored (Li et al., 2024; Wu et al., 2020). Still, some learners may fail to use metacognition adequately during the collaboration process, leaving much space to explore individual metacognition in the team-based context (Li W et al., 2023).

The interplay between metacognition and translation expertise has also become an intriguing research topic. Overall, metacognition in translation refers to awareness and executive control, and it involves active management of the cognitive processes engaged in translation and may vary with the levels of translation expertise (Shreve, 2006). Metacognition works as a facilitator in the professional endeavors of translators (Pietrzak, 2022). Metacognition research in cognitive translation studies mainly focuses on the effect it has on translation performance (e.g., Chen, 2024; Hu et al., 2021; Mellinger, 2019), and how to exploit it to improve translation expertise (e.g., Bergen, 2009; Fernández and Zabalbeascoa, 2012a, 2012b; Pietrzak, 2022).

Metacognition in collaborative translation has also been observed and explored (e.g., Li and Yuan, 2022; Chen, 2024). However, current research primarily centers around individual translators. We still lack adequate socio-cognitive evidence on translators' interactions in teams, and their underlying metacognitive activities remain unclear. Particularly, much remains underexplored regarding which metacognitive elements distinguish high-quality project performance in technology-assisted environments. This study tries to address these gaps by prioritizing an investigation into these specific aspects.

This study aims to distinguish and compare the metacognitive processes between higher- and lower-achieving groups in technology-assisted collaborative translation. In translator training, translation projects create a collaborative scenario that encourages socio-cognitive interactions and complex metacognitive skills among trainees (Hurtado Albir (2015); Tekwa et al., 2024). Therefore, we believe such a scenario would be insightful for our research to be grounded on. We grouped project teams into higher-achieving (HIG) and lower-achieving (LAG) based on their final project outcomes; then explored their socio-cognitive processes, metacognitive differences, and subjective perceptions during the communication and collaboration. Three research questions (RQs) are specified as follows:

**RQ1:** How are the socio-cognitive processes of HIG and LAG informants? Are there any systematic behavioral differences between them?

**RQ2:** Are there any team-averaged individual metacognitive differences between HIG and LAG informants?

**RQ3:** How do HIG and LAG informants averagely perceive their collaborative translation processes? Are there any differences?

## Methodology

This section discusses the informants, course context, the self-directed translation project, and the categorization of project teams into higher- and lower-achieving. We also explain our data collection and analysis methods and emphasize that the data were

multiple and cross-referenced. The study was approved by the research ethics committee of the participating university. The informants were ensured that their anonymity and confidentiality would be maintained throughout the study, and consented after being properly informed.

**Informants.** The 34 informants were 4th-year translation undergraduates: 26 females (76.47%) and 8 males (23.53%), with an age range from 20 to 22 ( $M = 20.94$ ,  $SD = 0.65$ ). They were all L1 Chinese speakers with English as their L2. The translation technology course, where this study was carried out, was scheduled in the first semester of their fourth year. As part of their training program. Before enrolling in this course, they had mastered the basic knowledge and skills of translation. Besides, according to the background questionnaire conducted at the beginning of the course, they had never participated in any translation technology training or CAT projects. So it could be reasonably assumed that they had not interiorized any conception or routine regarding translation technology or translation projects before taking the course. Informants were identified using the HIG/LAG-X-X numbering format, wherein the first digit represents the team number within either HIG or LAG group, while the second digit indicates the intra-team sequence number.

**Course context.** The translation technology course was an eight-week compulsory workshop for the translation undergraduate degree. The main course goal was to enable trainees to effectively utilize translation technology and prepare for the professional market. Learning contents included resources and strategies for information search, corpus tools, machine translation and post-editing, two CAT tools (Snowman and memoQ), and pre-editing and post-editing tools.<sup>1</sup> Various activities, like concept and principle explanation, case method, individual practice, group discussions, etc., were adopted to instruct informants on the learning contents. These activities were expected to help informants master translation technology and understand translation project workflows, as building blocks for the subsequent project.

**Materials and methods.** As part of the course, informants were oriented to work in teams to develop a technology-assisted collaborative translation project, requiring them to find authentic texts in need of translation (Kiraly, 2000). Informants were freely organized into eight teams of 3 to 5 members, with most teams having 4 informants. As all informants had taken the same translation workshop in the prior semester guided by a qualified instructor, we adopted their scores in this workshop to assess the comparability of translation skills across teams. We conducted a Kruskal-Wallis H test to examine whether there were statistically significant differences in final exam scores among teams. The results indicated no significant difference ( $H = 12.573$ ,  $df = 7$ ,  $p = 0.083 > 0.05$ ), suggesting that the teams exhibited comparable translation skills. The translation direction was not specified, and both English-to-Chinese and Chinese-to-English translations were permitted. Roles, such as project manager, translator, and editor, were not assigned but naturally enacted (Kiraly, 2000), making translation and co-creation the shared responsibility of all team members.

The project spanned two weeks and consisted of two milestones: one week for translation, followed by one week for revision and reflection. The informants were required to use both Snowman and memoQ to familiarize them with the tools' features and functionalities. Specifically, this involved creating translation memory and termbase, enabling hands-on experience in building CAT resources. However, for the "Translate text" task, they were free to choose either tool based on their preference, allowing them

| Table 1 Project milestones within the didactic sequence. |                             |                                                                                                                                     |
|----------------------------------------------------------|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Milestone                                                | Task                        | Task description                                                                                                                    |
| Translation                                              | Propose translation project | Select the translation text and analyze the project feasibility                                                                     |
|                                                          | Create translation memory   | Search for originals of the same or related topics and their translations and create translation memory with both Snowman and memoQ |
|                                                          | Create translation termbase | Extract terms from translation memory and enlarge the translation termbase with both Snowman and memoQ                              |
|                                                          | Translate text              | Translate and proofread the selected text collaboratively via either CAT tool                                                       |
| Revision and reflection                                  | Intergroup peer assessment  | Comment on other teams' projects and provide suggestions                                                                            |
|                                                          | Improve project quality     | Improve their own team's project products                                                                                           |
|                                                          | Intragroup peer assessment  | Comment on your project and the performance of team members                                                                         |
|                                                          | Self-reflection             | Write structured reports to reflect upon the team's collaboration process, problems and resolutions                                 |

to focus on the translation process without being constrained by the choice of tool. The project milestones are detailed in Table 1.

**Team classification.** The teams' final project outcomes were rated by the course instructor, who had received training and had been teaching translation technology for two years—also the first author of this paper—and a translator with over three years of professional experience primarily in the engineering field.<sup>2</sup> Outcomes were measured with the following criteria inspired by Hurtado Albir (2015): suitability of the brief as specified (verisimilar and appropriate, 10%), termbase (10%), translation memory (10%), translation quality (30%), improvement at the revision (20%), and inter-group assessment report quality (20%). The final outcomes were collected and anonymized by two teaching assistants before rating. Raters scored each team's materials independently based on the pre-established criteria. We then performed Spearman's rho correlation test to assess the levels of agreement between the two raters, and the results indicated good inter-rater reliability between raters ( $\rho = 0.970$ ,  $p = 0.000 < 0.05$ ). The researcher averaged their ratings into a final score for each team.

Based on the average rating scores, the eight teams were categorized into two groups using the median split method, with the data being split at its median value (Iacobucci et al., 2015). The top four teams, scoring above the median value, were classified as HIG and the last four LAG ( $M_{HIG} = 86.08$ ,  $SD_{HIG} = 2.78$ ,  $M_{LAG} = 78.98$ ,  $SD_{LAG} = 2.23$ ). The total number of HIG and LAG informants was the same, with 17 informants in each group. The Shapiro-Wilk test was used to assess the normality of team scores and the results indicated that both HIG and LAG followed a normal distribution (HIG:  $p = 0.875 > 0.05$ ; LAG:  $p = 0.347 > 0.05$ ). So we conducted an independent samples *t*-test and the result suggested a statistically significant difference between HIG and LAG ( $t = 3.983$ ,  $p = 0.007 < 0.05$ ).

**Data analysis.** Multiple data sources were gathered to track teams' interactions and reveal the socio-cognitive processes and metacognitive differences between HIG and LAG.

Data used to observe teams' socio-cognitive processes include log data, chat data, and classroom observations. Chat data was collected from teams' QQ group chats.<sup>3</sup> Log data refers to the supporting documents that teams generated during the project to facilitate collaboration. Informants were encouraged to submit all relevant documents stored in their computers, and they were informed that their collaboration and communication process would be tracked and analyzed for research purposes. The documents they submitted included mind maps, screenshots, video recordings, and other relevant materials. Classroom observations were made by the course instructor to observe informants' behaviors in the team. Team dynamics, individual

participation, communication strategies, and challenges during the project were documented, helping situate informants' communication and collaboration. The three sources of data could be indicative of engagement in project-related interactions and supplement informants' self-reported data by focusing on the not-mentioned or unspoken events and behaviors (Cohen et al., 2018).

Self-reflection reports and focus-group interviews were taken as primary resources to characterize informants' metacognitive activities. The two combined self-reported measures enable the recall of the entire project process and the identification of metacognitive engagement in the project (Li and Yuan, 2022). A total of 34 self-reflection reports were collected at the end of the "revision and reflection" milestone (see Table 1). The focus-group interviews, with one for each team, were conducted at the end of the project. Each interview lasted no less than 30 minutes and involved issues like team interactions, problems and solutions, perceptions of translation technology and technology-assisted projects, etc. The interviews were recorded and transcribed verbatim into texts for further content analysis.

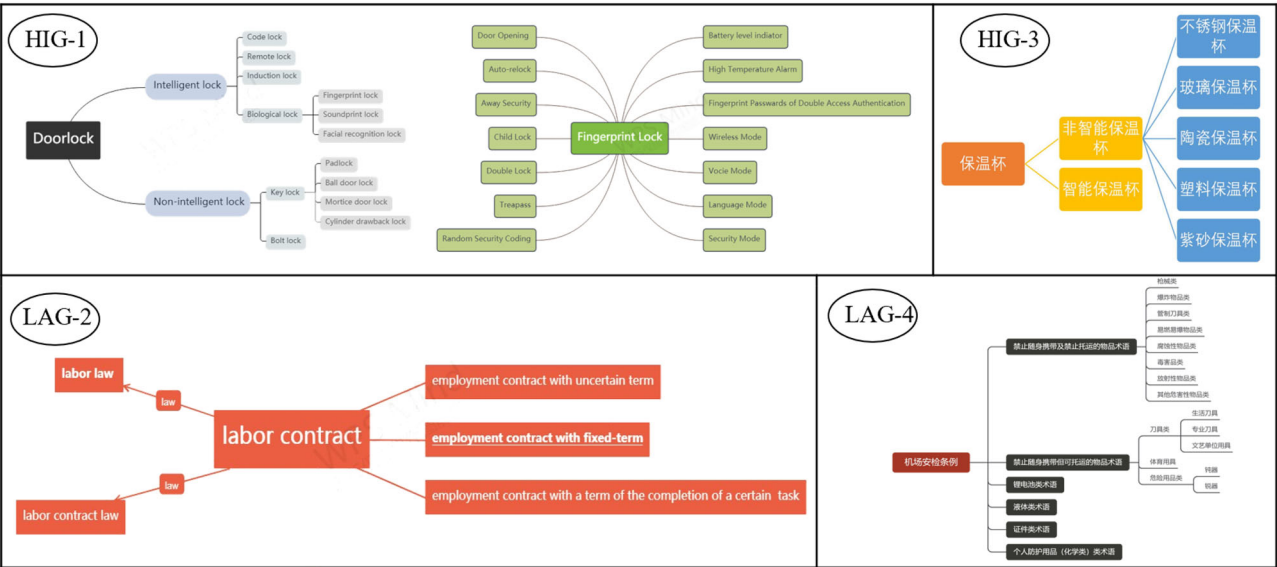
Based on the conceptual framework of metacognition (Shih and Huang, 2022), a qualitative thematic analysis approach was employed to code the two sources of data, with observations categorized into one of the dimensions (see Table 2) as nodes. The coding process was assisted by QSR Nvivo 12, a qualitative data analysis software. To ensure coding reliability, it was completed independently by the same two teaching assistants, both master's students in translation studies with prior experience in the course content and familiarity with the coding framework. After initial coding, Cohen's kappa was calculated to assess inter-coder agreement. The coefficient value of 0.896 ( $> 0.80$ ), indicated a high level of agreement. Then the differences in coding were discussed with the course instructor until reaching an agreement.

An 8-item questionnaire, adapted from Hwang et al. (2018)—a frequently cited study on peer interaction and their complex thinking skills in technology-assisted educational context—surveyed informants' perceptions of their collaboration and communication. Answers were scored using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The validity and reliability tests on the questionnaire showed that Cronbach's  $\alpha$  coefficient reached 0.742 ( $> 0.7$ ),  $KMO = 0.702$  ( $> 0.6$ ),  $p = 0.003$  ( $< 0.05$ ), the rotation percent of variance for each dimension is over 10%, the total variance explained is 64.445% ( $> 60\%$ ), and the factor load coefficient of each item was greater than 0.4. Thus, the questionnaire exhibited good validity and reliability (Cohen et al., 2018) and could be further examined.

**Results**  
**Results of socio-cognitive behaviors.** In general, all teams applied different technology tools and resources and widely



| Table 2 Coding of informants’ metacognition in teams. |            |                                                                 |                                                                                                                                                               |
|-------------------------------------------------------|------------|-----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Component                                             | Dimension  | Definition                                                      | Examples (translations from Chinese)                                                                                                                          |
| Metacognitive knowledge                               | Person     | Knowledge about self and all relevant factors in the task       | If we think that learning CAT tools is useful and interesting, our learning will be more effective.                                                           |
|                                                       | Task       | Knowledge about the task’s purpose, nature and demands          | CAT can greatly improve translation speed, but only if the translation memory is large enough.                                                                |
|                                                       | Strategy   | Knowledge of the strategies applicable to achieving task goals  | If I run into problems with memoQ, I can find learning resources from the Internet, explore them together with team members, or ask the teacher for help.     |
| Metacognitive regulation                              | Planning   | Selection of appropriate strategies and allocation of resources | We discussed and decided that our termbase would include the appearance and temperament of pet cats, and expand to other areas such as diet and medical care. |
|                                                       | Monitoring | Understanding and awareness of task performance                 | We realized that we needed to include brands from multiple brands in our bilingual corpus, as one brand might limit the corpus and reduce the matching level. |
|                                                       | Evaluating | Evaluating the products and regulation of the task process      | We checked and found that some terms were absent from the termbase and the translation memory.                                                                |



**Fig. 1 Visual representation generated in the project.** This figure is a combination of several examples of brainstorming diagrams collected from teams’ log data. The project teams used those diagrams to help them sort out what terms to be included in the termbase.

engaged in collaborative inquiries, such as brainstorming, offline and online discussions, drawing logical flowcharts, creating shared documents, etc., to facilitate the project. Figure 1 displayed several examples of teams drawing brainstorming diagrams to decide what terms to add to their termbase. One interesting phenomenon was that informants who outperformed in previous translation courses were not always the decision makers and problem solvers, but were more equally engaged in the project.

Nevertheless, HIG communicates better than LAG and three major behavioral differences could be identified. First, information and solution-seeking. HIG preferred to seek information and solutions from partners or through self-directed work, whereas LAG often waited for the instructor’s assistance. This was rather obvious in the “propose translation project” task. HIG searched for information, discussed with team members and drew mind maps to organize their thoughts, but LAG relied more on the instructor for selecting the translation text. Second, is project planning. HIG spent more time understanding project requirements and planning before submitting project proposals, while LAG made several more failed attempts before realizing the need for careful planning. Third, conflict resolution. When conflicts or

disagreements occurred, HIG preferred mutual negotiation, but LAG often saw one member dominating the situation, with others acquiescing. For example, when they had difficulty in searching for a corpus to create translation memories, the HIG-2 team discussed searching for different possible topics and collaboratively deciding on which one to use (see Table 3); in contrast, LAG-1 members simply agreed with LAG-1-1 on her repeated requests without discussing other solutions (see Table 4).

**Results of metacognitive differences.** Table 5 shows the metacognitive differences between HIG and LAG. Regarding metacognitive knowledge, HIG displayed more nodes than LAG. The Shapiro-Wilk test showed normality in the coding distribution of dimensions. Then the one-way ANOVA analysis was employed to test the metacognitive differences between HIG and LAG. The results suggested no statistically significant difference between HIG and LAG in the person and strategy knowledge ( $F_{\text{person}} = 0.030$ ,  $p = 0.868 > 0.05$ ;  $F_{\text{strategy}} = 0.013$ ,  $p = 0.914 > 0.05$ ). However, HIG showed more inclinations to report the task knowledge, with a statistically significant difference between the two groups ( $F_{\text{task}} = 9.529$ ,  $p = 0.021 < 0.05$ ).

**Table 3 Chat history of HIG-2 (excerpt).**

| Informant | Chat content                                                                                                  |
|-----------|---------------------------------------------------------------------------------------------------------------|
| HIG-2-1   | I found the document that HIG-2-3 and I extracted was mostly about camera pen but little of the recording pen |
| HIG-2-3   | Yes, the matching level is very low [ <i>send the document</i> ]                                              |
| HIG-2-2   | Yes, looks like not good for later operation. Perhaps we can change to another topic?                         |
| HIG-2-3   | Yes, changing the subject might be troublesome now, but it may save time later                                |
| HIG-2-4   | I agree. I think, no matter what topic we choose, it is the corpus that matters                               |
| HIG-2-1   | Then now we don't build the corpus? but find available texts first?                                           |
| HIG-2-2   | Yes, I think we should search for text first and then decide which topic to use                               |
| HIG-2-4   | Maybe we can mark the repetition part while we are searching                                                  |
| HIG-2-2   | perhaps we can build a rough memory and check its matching level with the translation                         |
| HIG-2-1   | Two of us can search for texts on different subjects and the other two do the matching                        |
| HIG-2-3   | Ok                                                                                                            |

**Table 4 Chat history of LAG-1 (excerpt).**

| Informant | Chat content                                                                                                                                          |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| LAG-1-4   | Can you find texts that have similar parts?                                                                                                           |
| LAG-1-1   | I don't know if this manual is usable [ <i>sent the document</i> ]. The texts from the official website do not have many similarities. So annoying... |
| LAG-1-3   | Let's check, if not, we can search together                                                                                                           |
| LAG-1-3   | Is this only one manual? So long. I would work to death today                                                                                         |
| LAG-1-1   | Don't worry. It puts Chinese and English together                                                                                                     |
| LAG-1-1   | Can we each extract some material for memory? I can't do this all by myself                                                                           |
| LAG-1-4   | But we only need to build one memory                                                                                                                  |
| LAG-1-3   | There must be a repeat if we each make one. we need to find a way out                                                                                 |
| LAG-1-1   | Can we just pick four different series?                                                                                                               |
| LAG-1-4   | Shouldn't all the text be imported into our translation memory?                                                                                       |
| LAG-1-1   | Can we just pick four different series?                                                                                                               |
| LAG-1-1   | Ok. Hope the instructor won't ask us to search again                                                                                                  |
| LAG-1-3   | Hahaha, ok                                                                                                                                            |

**Table 5 Analysis of team-averaged metacognitive differences.**

| Component                | Dimension  | Group | N  | M     | SD    | Sum | F     | p     |
|--------------------------|------------|-------|----|-------|-------|-----|-------|-------|
| Metacognitive knowledge  | person     | HIG   | 17 | 9.75  | 2.872 | 39  | 0.03  | 0.868 |
|                          |            | LAG   | 17 | 10.25 | 4.992 | 41  |       |       |
|                          | task       | HIG   | 17 | 23.50 | 3.317 | 94  | 9.529 | 0.021 |
|                          |            | LAG   | 17 | 14.25 | 4.992 | 57  |       |       |
|                          | strategy   | HIG   | 17 | 5.25  | 3.594 | 21  | 0.013 | 0.914 |
|                          |            | LAG   | 17 | 5.00  | 2.582 | 20  |       |       |
| Metacognitive regulation | planning   | HIG   | 17 | 21.75 | 4.992 | 87  | 6.12  | 0.048 |
|                          |            | LAG   | 17 | 13.75 | 4.113 | 55  |       |       |
|                          | monitoring | HIG   | 17 | 19.25 | 2.217 | 77  | 9.741 | 0.021 |
|                          |            | LAG   | 17 | 12.00 | 4.082 | 48  |       |       |
|                          | evaluating | HIG   | 17 | 19.25 | 3.594 | 77  | 6.65  | 0.042 |
|                          |            | LAG   | 17 | 11.75 | 4.573 | 47  |       |       |

Regarding metacognitive regulation, both groups showed similar distribution percentages across the three dimensions, with particular emphasis on planning. HIG surpassed LAG across all three dimensions. The Shapiro-Wilk test showed a normal distribution for each dimension. A further one-way ANOVA analysis revealed statistically significant differences between HIG and LAG ( $F_{\text{planning}} = 6.120$ ,  $p = 0.048 < 0.05$ ;  $F_{\text{monitoring}} = 9.741$ ,  $p = 0.021 < 0.05$ ;  $F_{\text{evaluating}} = 6.650$ ,  $p = 0.042 < 0.05$ ).

**Results of subjective-rated perceptions.** Table 6 displays the result of the teams' averaged subjective-rated perceptions. Overall, informants in teams held a positive attitude toward their collaboration and communication. As the Shapiro-Wilk test revealed non-normal distribution within the dataset of each item, a Mann-Whitney U test was performed to examine the statistical

differences between HIG and LAG. Two tendencies could be reported concerning the between-group variations. First, the mean score of most questionnaire items in HIG was lower than that in LAG, except Q1. Second, there was no substantial difference between HIG and LAG in most items except Q3, where a statistically significant difference was found ( $U = 76.000$ ,  $Z = -2.536$ ,  $p = 0.011 < 0.05$ ) with a medium effect size ( $r = -0.435$ ).

## Discussion

Overall, both HIG and LAG critically adopted translation technology to achieve project requirements and gathered evidence of metacognitive activities. Their performances reflect the efficacy of technology-assisted collaborative projects in eliciting rich metacognitive experiences, as this context not only facilitated the

**Table 6 Results of subjective-rated perceptions.**

| Items                                                            | Group | N  | M    | SD    | U       | Z      | p     |
|------------------------------------------------------------------|-------|----|------|-------|---------|--------|-------|
| Q1: I believe our team could cooperate successfully              | HIG   | 17 | 4.65 | 0.493 | 127.500 | −0.687 | 0.492 |
|                                                                  | LAG   | 17 | 4.53 | 0.514 |         |        |       |
| Q2: Work was split based on our abilities                        | HIG   | 17 | 3.82 | 1.015 | 96.000  | −1.781 | 0.099 |
|                                                                  | LAG   | 17 | 4.41 | 0.507 |         |        |       |
| Q3: I finished my assignments efficiently                        | HIG   | 17 | 3.76 | 0.831 | 76.000  | −2.536 | 0.018 |
|                                                                  | LAG   | 17 | 4.47 | 0.624 |         |        |       |
| Q4: I tried to provide useful and sufficient information         | HIG   | 17 | 4.29 | 0.588 | 134.000 | −0.403 | 0.734 |
|                                                                  | LAG   | 17 | 4.35 | 0.702 |         |        |       |
| Q5: I trusted my peers when they offered me suggestions          | HIG   | 17 | 4.41 | 0.618 | 120.500 | −0.942 | 0.413 |
|                                                                  | LAG   | 17 | 4.59 | 0.618 |         |        |       |
| Q6: I was verbally and behaviorally supportive of my peers       | HIG   | 17 | 4.53 | 0.624 | 140.000 | −0.178 | 0.892 |
|                                                                  | LAG   | 17 | 4.53 | 0.514 |         |        |       |
| Q7: I cared about how my peers felt when communicating with them | HIG   | 17 | 4.59 | 0.507 | 136.000 | −0.348 | 0.786 |
|                                                                  | LAG   | 17 | 4.65 | 0.493 |         |        |       |
| Q8: I had good communication with my peers                       | HIG   | 17 | 4.18 | 0.636 | 102.500 | −1.636 | 0.150 |
|                                                                  | LAG   | 17 | 4.53 | 0.514 |         |        |       |

mastering of translation technologies for project completion, but also supported the development of complex thinking skills, such as assessing their choices, monitoring progress and adapting strategies as needed (Unal and Cakir, 2021; Zalavra and Papanikolaou, 2022). This suggests that promoting self-directed collaborative learning in translator training can be an effective strategy for enhancing both technology skills and metacognition, ultimately improving translation performance. Nevertheless, HIG yielded more socio-cognitive behaviors and metacognitive activities than LAG.

**Analysis of socio-cognitive behaviors.** As reflected in the socio-cognitive processes, we can notice, both in HIG and LAG, informants' more equal participation within their teams, regardless of their previous translation performance. This phenomenon is consistent with their non-significant difference in (metacognitive) person knowledge. Informants realized that having achieved higher scores in previous translation courses did not always lead to higher levels of technological mastery. This realization increased their confidence and willingness to participate in team discussions, instead of simply following others as they had done in other translation courses, as mentioned by informants such as LAG-1-2 and HIG-4-3. Both mentioned in the interviews that they noticed some team members, despite higher translation expertise, were less proficient in using tools, and this disparity in technological skills motivated them to take a more active role in decision-making within the team.

Nevertheless, HIG communicated better than LAG. Tekwa et al. (2024) also observe such differences between high- and low-performing teams. HIG prioritized mutuality with team members, engaged in more self-directed activities, and displayed greater autonomy. Their behavior tendencies are consistent with previous studies, which have shown that high-achievers tend to conduct more self-directed behaviors and are more autonomous, and thereby positively impact on their learning achievements (e.g., Li Y et al., 2023; Ozer and Yukselir, 2023). In contrast, as revealed by classroom observations, LAG counted more on the instructor's scaffoldings, performed simpler and more routinized tasks and participated less actively in discussions, especially at the initiation phase of the project. For example, LAG-3-3 mentioned in the self-reflection report, "We didn't know what to do at first, and I was somewhat procrastinating, so we just waited for the instructor's feedback". Reinhold et al. (2020) also observe low-achievers' reliance on scaffoldings. This suggested that metacognitive scaffoldings may be essential in translator training at the initial

stage. Wang et al. (2024) also reported that metacognitive scaffoldings facilitate EFL learners' writing development through collaborative writing tasks.

One possible explanation behind their behavioral variances is that self-directed activities and autonomy can promote self-regulation, which helps informants realize and control their cognition to improve performance and thereby achieve project goals (Hawkins, 2018; Guo et al., 2019). This interpretation matches the differences in metacognitive regulation between HIG and LAG. It also finds some indirect support from the interviews of HIG. For example, informant HIG-2-3 stated that "it was a challenging project, but while we collaborated, I realized this process can be useful for our future career development, so I started to consciously discuss more frequently with team members and devote more to the project". HIG-4-1 expressed that "when I was irritated, I saw my team members still patiently trying to work out the problems, I was somewhat embarrassed and controlled myself to calm down and continue my task". To summarize, our findings on teams' differences in socio-cognitive processes support Vieira et al., (2021) viewpoint, who advocated that an ideal way for CAT learning would be to encourage learner autonomy after introducing the rationale in-depth for the tool functionalities.

**Analysis of metacognitive differences.** Generally, HIG exhibited more traces of metacognitive activities than LAG. This result aligns with Shreve (2006), who proposed that metacognition increases with translation expertise. Regarding metacognitive knowledge, there was no significant difference between HIG and LAG in the person and strategy knowledge. And both groups reported the least on strategy knowledge. This might be due to the difficulty of acquiring abundant metacognitive strategies from one single project (Tarricone, 2011). Informants came to understand the importance of utilizing social and cognitive strategies to achieve their tasks, but their metacognitive knowledge of those applicable strategies seemed to remain stable and similar with previous experiences. For instance, organization strategies, which are one of the general strategies used to create connections between content elements for better comprehension (Pintrich, 2002), were observed in teams. Informants declared that they tried to think from different perspectives, but still tended to adopt strategies similar to those they had used in previous practices. Enhancement of the strategy knowledge might need long-term and intensive exposure to metacognitive experiences and training of metacognitive skills.

There was a substantial difference between HIG and LAG in the task knowledge, with HIG demonstrating a greater

understanding of the project's nature and demands. Zheng et al. (2023) also find high achievers were more able to link the tasks to requirements than low achievers. Task knowledge could lead to a heightened awareness about the project demand and engagement of the orientation of project requirements, which correlates with better project outcomes (De Backer et al., 2012).

HIGs' overall higher degree of metacognitive regulation supports findings that this factor distinguishes experts from novices (De Bruin et al., (2007)<sup>4</sup>. Whyatt and Naranowicz (2020) also state that metacognitive regulation might require translators' higher level of translation expertise to become transferable to translation-like tasks. Compared with LAGs, HIGs reported more on planning what resources they would need, monitoring project progress, and evaluating work efficiency. Their reported differences in metacognitive regulation are compatible with their socio-cognitive behaviors.

Moreover, their differences suggest that metacognition may increase their awareness of the effects of their observed behaviors (Mirriahi et al., 2018). Compared with LAG, HIG were less likely to describe their collaboration as smooth, but they expressed more enthusiasm for future interactions with both technology and human agents. For one thing, they (e.g., HIG-1-5, HIG-2-3) felt more capable in problem-solving through comprehensive thinking and organized methods after completing the project. For another thing, they (e.g., HIG-2-4, HIG-3-5) believed that CAT tools were similar, allowing them to continue learning the use of translation technology independently. So, we can conclude that their enhanced metacognition facilitated their ability to critically engage with tasks and adapt to new challenges, which is relevant to the dynamic professional landscape.

**Analysis of subjective-rated perceptions.** HIGs' answers to most questionnaire items were generally scored lower than LAGs' ones. This discrepancy with their socio-cognitive processes is likely due to HIGs' enhanced metacognitive awareness. The latter lets them specify their aims and find their superior aspects and shortcomings (Akcaoglu et al., 2023). This was evident in their responses to Q2 and Q3, related to self-evaluation of work division and efficiency. Regarding Q2, some HIGs (e.g., HIG-3-1, HIG-4-4) claimed that, in actual translation projects, it is optimal for team members to focus on their areas of expertise to enhance work efficiency; however, considering that it was a classroom setting and they were still in the learning process, they should challenge themselves beyond current abilities and strive for holistic development.

For Q3, some HIGs were not so satisfied with their work efficiency for wasting time on some trivial errors. For example, HIG-3-4 reflected upon that she set the language direction of translation memory in reverse at first and checked several times before identifying the problem. HIG-4-1 also mentioned that she forgot to set the language options of memoQ LiveDocs. This suggests that HIGs might have been more critical, showed a higher quality of metacognitive self-evaluation, and exhibited higher metacognitive awareness than LAG. Fernández and Zabalbeascoa (2012a) also found that high-quality metacognitive self-evaluation was positively correlated with translator performance. Enhanced metacognitive awareness prompts more frequent self-directed behaviors (DiFrancesca et al., 2016), aligning with the observed behavioral differences between HIG and LAG. Given this, providing regular feedback on translation trainees' metacognitive process can potentially encourage their self-evaluation and continuous skill development.

## Conclusion

This study distinguished higher-achieving teams from lower-achieving teams within a technology-assisted communication

environment to inspect traces of their team-averaged individual metacognition when performing a collaborative translation project. Generally, HIG engaged in more socio-cognitive behaviors and metacognitive activities than LAG. HIGs prioritized mutuality, engaged in self-directed activities, and displayed greater learner autonomy, which enhanced their project performance. Whereas LAGs relied more on instructor scaffolding and participated less actively in discussions and complex tasks. HIGs' higher degree of task knowledge and metacognitive regulation, including better planning, monitoring, and evaluating, contributed to their improved project performance. Despite little difference in metacognitive person and strategy knowledge, both groups showed limited metacognitive strategy knowledge, suggesting that prolonged exposure and training may be needed to enhance these skills. Interestingly, HIGs scored lower on subjective-rated perceptions than LAGs, likely due to their greater metacognitive awareness. This awareness allowed for critical self-evaluation and analytical approaches to tasks, promoting self-directed behaviors and improving overall performance.

The findings suggest the potential value of metacognition in enhancing translation performance and helping translators adapt better to the evolving professional market. It not only boosts informants' self-regulation over their behaviors to enhance project performance in technology-assisted collaborative translation, but also promotes their self-autonomy in future interactions and communications with both technology and human profiles. Our findings encourage the introduction of more metacognitive practices in educational settings. However, given the socio-cognitive behaviors of LAGs, total self-directed learning of translation technology would be difficult at the first stage. Instructions and metacognitive scaffolds from translator trainers are still indispensable.

There are limitations in abstracting research findings out of real classroom data, which are nevertheless very informative. First, this study is exploratory with a reduced sample size. Future studies may consider informants from multiple semesters or a longitudinal study to generate a larger sample. Second, monitoring all socio-cognitive behaviors was difficult, because the collaboration involved both synchronous and asynchronous communications, and ongoing data collection may increase informants' mental demands and disrupt their workflows. Further studies might use a palette of collaboration contexts and methods to collect informants' socio-cognitive interactions and probe into their metacognitive processes within loosely controlled experimental settings. Of course, individual differences, including gender differences, might influence aspects of metacognition and collaboration preferences. We hope to be able to investigate these differences more comprehensively in future studies.

## Data availability

The datasets analyzed in the current study are not publicly available because they are concerned with individual informants, and we made it clear in the informed consent form that their confidentiality would be ensured. However, the data are available from the first author upon reasonable request.

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## Notes

- 1 Snowman (<http://www.gcys.cn/index.html>) and memoQ (<https://www.memoq.com/>) are popular CAT tools in the Chinese language service market.
- 2 According to the official guidelines set by China Foreign Languages Publishing Administration, to be considered an expert translator, one must have a master's degree in translation or a related major, and at least three years of translation experience after



- passing the China Accreditation Test for Translators and Interpreters, Level 2 (CATTI 2). So, a three-year experience is expected to ensure that the translator rater has a solid understanding of the translation process. Please refer to [https://www.gov.cn/zhengce/zhengceku/2019-12/03/content\\_5458036.htm](https://www.gov.cn/zhengce/zhengceku/2019-12/03/content_5458036.htm) for the guidelines.
- 3 QQ is an instant messaging software that allows both individual and group chats, allowing users to communicate through text, image, and voice, as well as share resources and documents.
- 4 In this study, the acronym *HIG* refers to the group of higher-achieving teams, while *HIGs* denote the informants within these teams.

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## Author contributions

Wenting Yang put forward the original research ideas, prepared the data, wrote and revised the manuscript; Ricardo Muñoz Martín discussed the research ideas and helped revise for the improvement of the manuscript; Xiangling Wang contributed to the writing and revising of the manuscript. All authors commented on previous versions of the manuscript and approved the final manuscript.

## Competing interests

The authors declare no competing interests.

## Ethical approval

The authors declare that the work is written with due consideration of ethical standards. The experiment was conducted in Anqing Normal University and was approved by the university academic committee on 1 September 2020 (No. AQNU-2020-0901). The approval covers all aspects of the study, including informant recruitment, data collection, and data analysis. All the procedures were conducted following the relevant guidelines and regulations applicable to human research, including the Declaration of Helsinki.

## Informed consent

Informed consent was obtained from all informants prior to their participation in this study. They were informed of the research scope, assured anonymity and confidentiality, and signed an informed consent form.

## Additional information

**Correspondence** and requests for materials should be addressed to Xiangling Wang.

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