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Computer-Assisted Interpreting Tools: Status Quo and Future Trends

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***Abstract*—Computer-assisted interpreting (CAI) tools have the potential to benefit the interpreting profession and to improve its ecosystem considerably. Academic interest in this field has intensified in recent years. However, there have been no thorough analyses of the definitions and classifications of CAI tools or of the empirical studies on the subject. This study overviews CAI tools holistically. It describes advances as well as gaps that remain to be filled. It also provides an in-depth examination of the status quo and suggests potential avenues for improvement. The article begins by distinguishing between CAI tools in the broad sense and CAI tools in the narrow sense. By bridging the conceptual gaps between the two, we propose a unified description and a categorisation that reflects the main features of CAI tools. This comprehensive review analyses 27 empirical studies and examines the manner in which CAI tools affect interpreters' performance. Since the influencing factors that have been identified in previous experiments vary between interpreters-related (e.g. interpreters' profiles) and settings-related (e.g. reference information display modes), the contribution of CAI tools to overall interpreter performance can be different. Product-driven, practice-driven, and process-driven studies are identified as future trends in studies of CAI tools.**

***Index Terms*—computer-assisted interpreting tools, interpreting, empirical studies, automatic speech recognition, state of the art**

I. Introduction

Recent years have seen scholars and practitioners take more interest in the role of technology in interpreting. Several scientific books and papers, including *Interpreting and Technology*, *The Role of Technology in Conference Interpreting Training* (Melchor et al., 2020), and *Computer-Assisted Simultaneous Interpreting: A Cognitive-Experimental Study on Terminology* (Prandi, forthcoming), have been published. The Knowledge Centre on Interpretation at the European Commission has created a research and technology space to promote the use of technology in interpreting. Several European higher education institutions have introduced master's degrees in Technology for Translation and Interpreting that focus on information and communication technology. Translating and the Computer, which is organised by The International Association for Advancement in Language Technology, and Interpreting and Technology: Interplay and Transformation, which was convened by Hong Kong Baptist University in 2022, are two of several conferences that focus on technology in translation and interpreting.

Currently, interpreting is undergoing a technological shift, and technology-afforded interpreting may change both the interpreting ecosystem and its socio-economic aspects (Fantinuoli, 2018c, p. 3). Fantinuoli wrote that three prominent technologies will play a central role in this technological shift: computer-assisted interpreting (CAI), remote interpreting (RI), and machine interpreting (MI). As far as CAI is concerned, Pöchhacker (2016, p. 184) indicated that speech and text processing technologies have the potential to benefit both simultaneous and consecutive interpreting. These technologies include applications that are based on automatic speech recognition (ASR; e.g., term extraction from source speech and real-time transcription). Despite growing interest in CAI tools, few have focused on their definition or the analysis of empirical studies on the subject.

This study makes three contributions to the field: 1) it proposes a new definition and categorisation of CAI tools by bridging conceptual gaps and by formulating inclusion and exclusion criteria for definitional and taxonomical purposes, 2) it outlines a framework for current empirical studies of CAI tools by considering a wide range of databases and by developing a comprehensive parallel comparison, and 3) it predicts future trends in studies on CAI tools on the basis of the progress that has been made and by reference to gaps in existing research. Our aim is to draw academic attention to this topic. This would give a strategic direction to future studies and raise awareness of professional and scientific research on CAI tools.

In order to meet these objectives, we sought to answer the following research questions:

1) How are CAI tools defined and categorised?

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2) What empirical studies on CAI tools have been concluded, and what do they indicate?
3) What needs to be done to improve research on CAI tools?

II. Current Definition and Categorisation

Unlike the literature on CAT tools, which has been developed over several decades, research on CAI tools is still in its infancy. In the early 2010s, scholars referred to this type of tool as "conference-interpreting information and communication technology" (ICT; Berber-Irabien, 2010). Later, the term "technology tools for interpreters" (Pastor et al., 2014) gained traction. Pöchhacker (2015) described these tools as technologies that aid interpreters or as forms of computer-aided interpreting (p. 412). In recent years, Fantinuoli's research (2016, 2018a, 2018b; Fantinuoli & Prandi, 2018) has made a significant contribution to the definition of CAI tools. He proposed that ICTs, as used in interpreting, can be divided into process-oriented and setting-oriented technologies (Fantinuoli, 2018a). The latter, such as booth consoles, RI devices, and training platforms, primarily influence external conditions; the former can be called CAI tools. According to Fantinuoli (2018a),

> CAI tools are computer programs specifically designed and developed to assist interpreters in at least one of the different sub-processes of interpreting, for instance, knowledge acquisition and management, lexicographic memorisation and activation, etc. (...) [T]hey are an integral part of the interpreting process and are directly linked to and might have an influence on the cognitive processes underlying the task of interpreting, for example, the cognitive load distribution between different tasks during simultaneous interpreting. (p. 155)

Fantinuoli's definition treats CAI tools as an integral part of interpreting and emphasises their functionality in interacting with the corresponding cognitive processes. Although this definition has been cited repeatedly, there is still disagreement about the range and scope of CAI tools. In general, a distinction can be drawn between *CAI tools in the narrow sense* and *CAI tools in the broad sense*, as seen in Figure 1. Fantinuoli (2018a), a scholar who focused on the former category, argued that CAI tools should usually be called "terminology management software" or "corpus-based CAI tool specifically developed to support interpreters during the preparatory phase" (p. 161). He distinguished between CAI tools on the bases of architecture and functionality, writing of first-generation and second-generation tools (Fantinuoli, 2018a, p. 164). First-generation tools were proposed more than a decade ago, while second-generation tools reflect a holistic approach to terminology and knowledge in interpretation tasks. The features that are embedded in them provide advanced functionalities that extend beyond basic terminology management. The examples include InterpretBank, Intragloss, and other corpus-based tools. Fantinuoli and his colleague (Fantinuoli & Montecchio, 2022) also argued that AI-enhanced CAI tools could accommodate more complex and context-based natural language processing (NLP) features. Prandi (2020) adopted a similar view and conducted several empirical studies (2015, 2018). The two senses of the term "CAI tool", their most prominent instantiations, and the relevant proposals are shown in Figure 1.

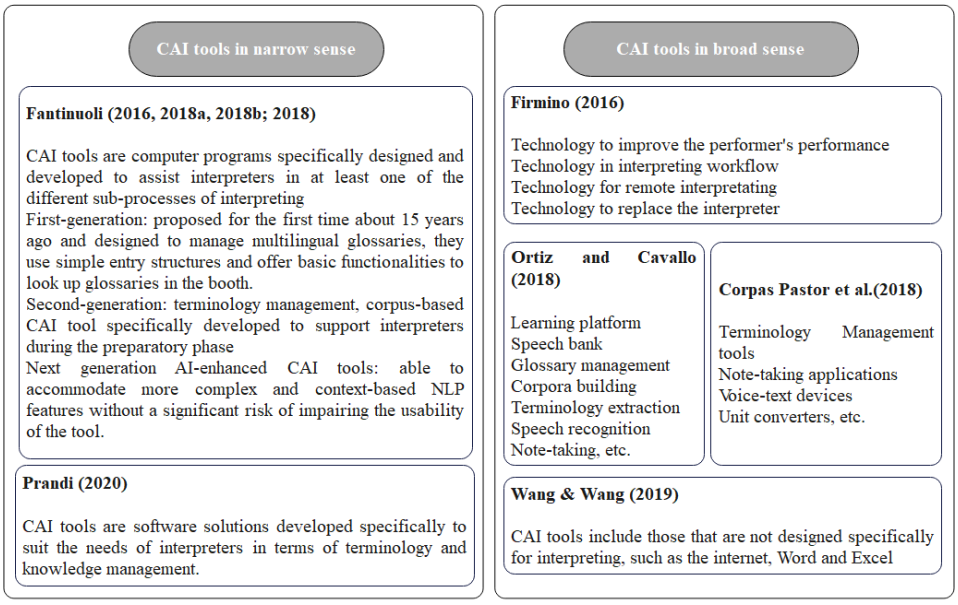

Figure 1. Main Trends and Recent Definitions or Categorisations of CAI Tools

As for CAI tools in the broad sense, Gloria Corpas Pastor and her colleagues classified them into three categories (Pastor et al., 2014): terminology lookup tools, such as InterpretBank and Interplex UE; unit converters, such as ConvertUnits and Convert; and corpus management tools (CMT). Note-taking software, voice-recording applications, and similar technologies can also be considered CAI tools in the broad sense. Pastor (2017) subsequently refined her categorisation and identified five types, namely terminology management software, note-taking tools, speech-to-text

converters, CAIT tools, and other assistance applications. The following year, she made further changes (Pastor, 2018). The final set of categories includes terminology management tools, note-taking applications, voice-text devices, and unit converters. CAIT tools were removed from the categorisation, and voice-text devices received more attention.

Other taxonomies also pertain to CAI tools in a broad sense (Firmino, 2016; Ortiz & Cavallo, 2018; Wang & Wang, 2019). Firmino (2016) defined four kinds of interpreting technologies: technologies that improve interpreters' performance, including training systems, search tools, digital databases, and audio editing and recording software; technology for interpreting workflows, such as online dictionaries, online encyclopaedias, personal digital glossaries, and speech recognition software; RI software; and MI software. Ortiz and Cavallo (2018) listed 40 CAI tools and identified 24 as being in current use and receiving regular updates. Among them, 10 had been designed specifically for interpreters, while the other 14 were suitable for general use. The 24 tools were divided into 11 categories on the basis of their primary function. Thus, the tools can be training materials, speech banks, learning platforms, glossary management tools, corpora building tools, terminology extraction tools, speech recognition tools, note-taking applications, audio and video conferencing tools, pieces of automatic text translation software, and speech-to-speech systems. Wang and Wang (2019) experimented with an automatic speech translation (AST) CAI tool to assess the impact of CAI tools on consecutive interpreting (AST is described in greater detail in Section VI). They concluded that the category of CAI tools should be extended to tools that were not designed specifically for interpreting, such as the internet, Word, and Excel.

III. Conceptual Gaps: Divergences and Limitations

After reviewing the primary definition and the categorisations of CAI tools in the narrow and the broad sense, we found that the answers that scholars give to various questions differ. These differences, in turn, have led to variations in scope and categorisation, which are shown in Table 1. Table 1 lists key differences in the answers to three questions and points to several advantages and disadvantages of each approach.

Table 1
Different Opinions on the Definition and Categorisation of CAI Tools

Must CAI tools be designed specifically for interpreting?	[Yes]	In Fantinuoli's opinion (2016, 2018a), this question must be answered in the affirmative.
	[No]	Pastor (2017, 2018, 2021), Firmino (2016), and Ortiz and Cavallo (2018) posited that CAI tools need not be designed specifically for interpreting and can be devices or note-taking systems.
Can CAIT, RI, audio and video conference software, and search engines be seen as CAI tools?	[Yes	In 2017, Pastor included CAIT tools in the category of CAI tools. Ortiz and Cavallo (2018) categorised RI, audio and video conference software, search tools, and CMT as CAI tools.
	[No]	In 2017, Pastor removed CAIT tools from the categorisation. In Fantinuoli and Prandi's opinion (2018), CAIT, RI, audio and video conference software, and search engines do not belong to this category (p. 167).
Is ASR and AST software a CAI tool?	[Yes]	Several empirical studies (Lin, 2013; Wang & Wang, 2019; Zhang, 2021; Zhou, 2019), which are reviewed in the section that follows, treat ASR and AST as CAI tools. Using such software for interpreting is becoming common among Chinese interpreters and has been studied since 2013.
	[No]	Several scholars (e.g., Defrancq & Fantinuoli, 2021; Pisani & Fantinuoli, 2021) have tested the number rendition accuracy of ASR technology in simultaneous interpreting; in their view, ASR software is not a CAI tool when used in isolation because it is not specifically designed for interpreting.

These differences in definition and categorisation are attributed to the late start of the development of CAI tools, which has resulted in a limited number of practical and theoretical studies on this topic. It is thus unsurprising that no scholarly consensus has emerged so far. However, technological advances and the wider availability of tools for interpreters mean that the ambiguous inclusion and exclusion criteria that are used to define CAI tools can obstruct future research efforts. Unequivocal definitions and categorisations of CAI tools should be prioritised.

IV. A Proposed Solution: A New Definition

The literature that we outlined in the preceding pages, as well as certain practical considerations, prompted us to attempt to bridge the gap between CAI in the narrow and the broad sense and to propose a unified definition that addresses the questions that we formulated above.

CAI tools are pieces of computer software, mobile phone applications, or digital devices that can be used during the interpreting process to reduce the cognitive stress that interpreters face and to enhance overall processing capacity. They are an integral part of the interpreting process. They are also directly linked to and might positively affect the cognitive processes that underlie the task of interpreting by reducing working-memory stress, eliminating production difficulties, and such. This definition accounts for the three main features of CAI tools which are illustrated in Figure 2.

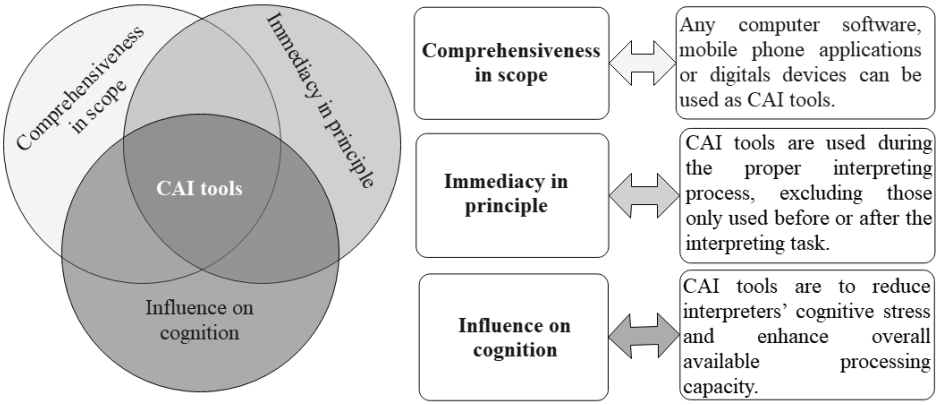

Figure 2. Main Features of CAI Tools and Explanations

A. Comprehensiveness in Scope

According to this definition, any tool that can lessen the interpreter's cognitive burden during an interpreting task can be seen as a CAI tool. This definition is consistent with the definition of CAT tools. As Bowker (2002) wrote, "CAT technology can be understood to include any type of computerised tool that translators use to help them do their job" (p. 6). According to O'Hagan (2011), "CAT tools range from general-purpose applications such as word-processors, optical character recognition (OCR) software, Internet search engines, etc., to more translation-oriented tools such as multilingual electronic dictionaries, corpus analysis tools, terminology extraction and terminology management systems" (p. 48). Thus, technologies like digital dictionaries, terminology management tools, note-taking software, MI, unit converters, ASR software, and devices are all CAI tools. Early wrist-borne and eyeglass-based real-time translation applications are now available. It is highly probable that such devices will be included in the set of CAI tools in the future.

B. Immediacy in Principle

The factor that distinguishes interpreting from other types of translational activity most clearly is immediacy. Pöchhacker (2016) reformulated Kade's definition as follows: "Interpreting is a form of translation in which a first and final rendition in another language is produced based on a one-time presentation of an utterance in a source language" (p. 10). Interpreting is therefore an immediate translational activity that is performed in real-time and which is intended for immediate use (ibid., p. 11). The definition that we propose emphasises the adoption of CAI tools during the interpreting process, demonstrating their immediacy principle. Platforms or resources that are used exclusively for training and not during interpreting tasks are therefore excluded.

C. Influence on Cognition

The differences between interpreting and translation have to do with the cognitive stress that interpreters face under time pressure (Gile, 2009, p. 3). Thus, one critical difference between CAI tools and CAT tools is that the former reduces cognitive stress. The impact of CAI tools on cognitive processes can be multi-dimensional. For instance, the use of terminology management tools during interpreting tasks can expand interpreters' productive capacity but may also lead to simultaneity, which increases cognitive pressure. Therefore, the overall effect of CAI tools on different interpreting tasks still needs to be investigated. The criteria that we formulated here exclude setting-oriented or RI technologies, such as headsets, telephones, and internet and video conferencing, because they exert a substantial influence on the medium or environment of interpreting but not on the cognitive effort that it entails.

V. Categorisation of CAI Tools

Our definition emphasises the practical use of CAI tools rather than the purpose of their design. The definition creates an explicit boundary between CAI tools and non-CAI tools, it reflects findings from the literature, and it accommodates the three main features of CAI tools that we outlined. The comprehensiveness of this definition enables the objects and subjects of research to be expanded, enriching CAI-related research and presenting new opportunities to the interpreting profession and ecosystem. Drawing on this unified definition, we propose to categorise CAI tools and their expanded range as a part of ICT for interpreting, as shown in Figure 3.

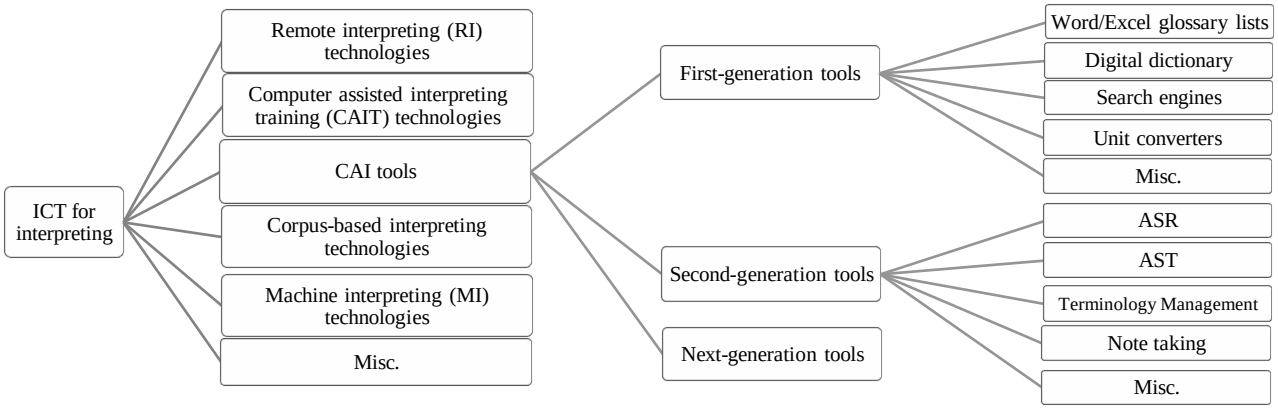

Figure 3. Categorisation of CAI Tools

Fantinuoli (2018c, p. 3) identified the three main domains of interpreting technology as CAI, RI, and MI. The three main areas of interest in the field of interpreting ICT are RI, CAIT, and CAI. Most academic studies concentrate exclusively on the first two (Fantinuoli, 2018a). We consider five main types of ICT for interpreting: RI, MI, CAIT, CAI and corpus-based interpreting. The first four were mentioned by Fantinuoli (2018a, 2018b); we add corpus-based interpreting technologies, which have gained traction over the last few years (Bendazzoli et al., 2018).

As for the classification of CAI tools, we agree with Fantinuoli (2018a; Fantinuoli & Montecchio, 2022) that they can be categorised into different generations. Our taxonomy, however, is slightly different. In our view, first-generation CAI tools are relatively conventional CAT tools that have existed for decades and are used to support the process of interpreting. Examples include digital dictionaries, Word or Excel glossary lists, search engines, and such like. Since most of these tools are not designed specifically for interpreting nor are sensitive to the time constraints of interpreting, their influence is limited, and most interpreters are reluctant to use them.

Second-generation CAI tools account for the immediacy of interpreting. They include ASR software, AST software, terminology management tools, note-taking applications, and devices like Notability, LectureNotes, and so on. Note-taking applications or devices can play digital recordings of source speech as well as provide other digitalisation functionalities. Interpreters use these second-generation tools more frequently than first-generation tools. All these tools, irrespective of whether they are specifically designed for interpreting, can, to a certain degree, expand the processing capacity of interpreters. However, adoption rates are still low, and there is a lack of empirical studies that test their efficiency. As for next-generation CAI tools, we second Fantinuoli and Montecchio's (2022) opinion that AI-enhanced CAI tools could accommodate more complex and context-based NLP features. The next generation of CAI tools will be more intelligent and more accessible to interpreters, which means that more professionals are likely to adopt them.

VI. Empirical Studies of CAI Tools

When we searched for English-language empirical studies on interpreting with CAI tools on Google Scholar and Web of Science, we identified seven articles that were published in the past 10 years (Defrancq & Fantinuoli, 2021; Desmet et al., 2018; Fantinuoli & Montecchio, 2022; Pisani & Fantinuoli, 2021; Prandi, 2015, 2018; Wang & Wang, 2019). Most focus on the adoption of InterpretBank. Then, we expanded our research to the CNKI database, using Chinese to conduct a systematic review of all empirical studies that are related to CAI tools. We found 20 articles or theses that had been published between 2012 and 2021. All were only indexed on CNKI or other Chinese databases. The articles in question had not been cited frequently in papers that were indexed on popular English-language databases. Incorporating these articles into the present study increased our knowledge of CAI tools and their implications for the profession. As far as we know, the present article is the first attempt to review all of these CNKI CAI-related articles comprehensively and to link mainstream English papers to Chinese ones.

In total, we analysed 27 empirical studies. The experiments in question reflect the use of diverse software products. For example, the authors of 11 of the studies had used the products of iFlytek (a Chinese ASR company) and its ASR-related software, such as iFlyrec, iFlytek ASR, iFlynote, or iFlytek Interpreting Assistant. Six of the experiments are based on InterpretBank, two are based on the Dragon Nuance Natural Speaking ASR software, and eight report on the use of other simulation systems (such as systems using PPT or videos to simulate the ASR software).

Although these CAI tools have various brands and display modes, their functions, as far as they pertain to interpreters' workflows, are similar. Their display modes can be divided into four types, as shown in Figure 4, namely 1) an ASR system that displays the whole source text that is recognised; 2) an AST system that integrates cascade ASR and machine translation systems, displaying complete translations of target texts; 3) systems that show both the source text and the target text, usually a combination of ASR and AST; and 4) systems that only show parts of texts, such as terms, numbers, or names. In Figure 4, the example of interpreting from English to Chinese illustrates the workflows of these CAI tools and the four main display modes. The display panels in Figure 4 mimic real-life recognition functions, with

identified content from a speech in black and the last recognised sentence shaded. The grey colour means that the text that is displayed is provisional rather than final.

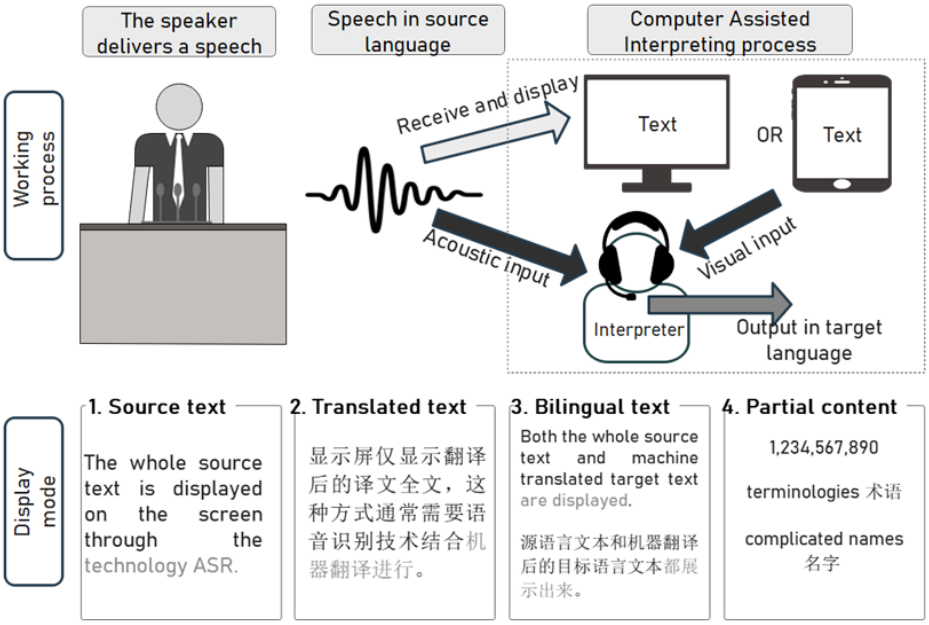

Figure 4. An Example of CAI Workflow and the Display Mode of a CAI Tool

We present the main findings from these studies, which reflect three main arguments.

A. CAI Tools Can Improve the Accuracy With Which Interpreters Render Numbers or Terms

A total of 15 out of the 27 empirical studies mentioned improvements in this dimension; four experiments (He, 2018; Ma, 2020; Xiang, 2018; Xu, 2015) had been conducted by using iFlytek ASR or iFlynote ASR software for Chinese-to-English simultaneous interpreting (SI). Their authors concluded that the participants had benefited the most from the accuracy of the numerical and terminological output of the software. Two other experiments (Li, 2021; Sun et al., 2021) explored the impact of ASR on English-to-Chinese SI. Sun et al. (2021) observed an overall improvement in number rendition accuracy, while S. Li (2021) noted that average number rendition accuracy increases by 19% when the screen displays the whole source text. In consecutive interpreting (CI) the advantages of using CAI tools were also observed, such as the work on Chinese-to-English CI by Zhu (2015) and Qin (2019), that on Japanese-to-Chinese CI by Bu (2021), and others. Other studies also report positive outcomes. For example, in SI, a number recognition mock-up system precipitated a 30% gain in the accuracy of number interpreting (Desmet et al., 2018). The same metric increased by 22.5% for SI from English to Dutch (Defrancq & Fantinuoli, 2021) and by 41.5% for SI from English to Italian (Pisani & Fantinuoli, 2021). Prandi (2015), Zhang (2021) and Zhou (2019) tested the performance of InterpretBank in SI and concluded that the software helps interpreters to render terms more accurately. CAI tools' facilitation to interpreters' rendition is for two reasons. Firstly, the tool is attuned to the intuitive observations of interpreters. Secondly, the rendering of both numbers and terms is more cognitively demanding and calls for the adoption of specific strategies on the part of interpreters (Gile, 2009; Setton & Dawrant, 2016). The tool reduces those loads and enables interpreters to focus on other cognitively demanding tasks.

B. The Impact of CAI Tools on Interpreters' Overall Performance Is Subtle

Although CAI tools can, to some extent, facilitate the rendition of numbers and terms, there is no consensus on their influence on overall interpreting performance. Several studies report an apparent delay. He (2018) found that delaying ASR results by more than 5 seconds affects performance negatively. Ma (2020) estimated ASR average display latency at 4.5 seconds and reported on a significant delay in production for all participants. Zhang (2020) wrote that participants who use ASR exhibit considerably higher latency. Meanwhile, they are generally inferior in terms of fluency and more likely to make false starts, hesitate, and use filler words. Some authors adopt a neutral stance on the impact of CAI tools. For example, Wang and Wang (2019), who experimented with English-to-Chinese CI using the AST system, found that the average accuracy and fluency diverged between different interpreters. Xiao and Wang (2020) conducted a large experiment with 177 third-year undergraduate students who spoke Chinese as a native language and who were expected to major in English in the near future. They had just attended an introductory class on interpreting skills. The authors concluded that the CAI tool had no significant positive or negative influence on performance. However, the literature is not univocal. For example, Zhou (2019) was convinced that InterpretBank improves overall performance, even though it affects the renditions of some participants negatively. According to Sun et al. (2021), participants who use iFlytek Interpreting Assistant generally perform slightly better than participants who do not. The same positive results have also

been observed in some CI studies. Li (2016), drawing on an English-to-Chinese CI experiment, concluded that participants who use ASR take fewer notes and achieve scores that are 30% higher than those of participants who do not use the tool. In a similar experiment, Gao (2018) found that ASR improves the performance of all participants and reduces note-taking by 10%. Liu (2019), in a Russian-Chinese CI experiment that involved using a piece of ASR software called Dictate, found that users outperformed non-users by 20%.

C. Several Factors Can Influence the Effect of CAI Tools on Interpreters' Performance

The precision and latency of ASR are the most commonly cited influencing factors. According to Lin (2013), if speech recognition software has a precision rate of below 85%, interpreter performance deteriorates. Conversely, when the precision rate is above 95%, reaction times and latency are lower than when no CAI tool is used. When display latency exceeds 4 seconds, performance declines. In his opinion (2018), when the delay exceeds 5 seconds, performance is affected negatively. In Xiang's study (2018), the maximum ASR latency was one or two sentences, which, given the average ear-voice span, is too long, causing the tool to become a distraction rather than a prop. Qin (2019) argued that incorrect recognition harms performance because interpreters tend to over-rely on the information that is displayed. The interpreters' profiles can also influence overall performance. Zhu (2015), Xiang (2018), and Wang and Wang (2019) argued that interpreters with better sight interpreting skills or higher language proficiency benefit more from CAI tools. In contrast, Desmet et al. (2018) and Qin (2019) took the view that individuals who score poorly without support or who are low-to-intermediate-level interpreters benefit the most from access to CAI tools. Directionality can also be problematic. Shen (2014) observed that in English (Language B) to Chinese (Language A) SI, most participants perform worse with ASR, while in Chinese-to-English SI, most participants perform better with ASR. Display mode is another relevant factor. According to Lin (2013), fidelity is at its highest when the text display mode is bilingual, reaction times are lowest when the source text is displayed, and verbal expression is superior, relative to the other two options when the target text is shown. Language pairs, accents, speed of delivery, and such like can also influence interpreting with CAI tools.

VII. Future Trends

It is evident from the preceding section that academic and professional interest in CAI tools has intensified. However, no clear conclusions have been drawn about the impact of CAI tools and the factors that influence it. Therefore, we would like to propose three avenues for future research on CAI tools, namely product-driven, practice-driven, and process-driven research, as shown in Figure 5.

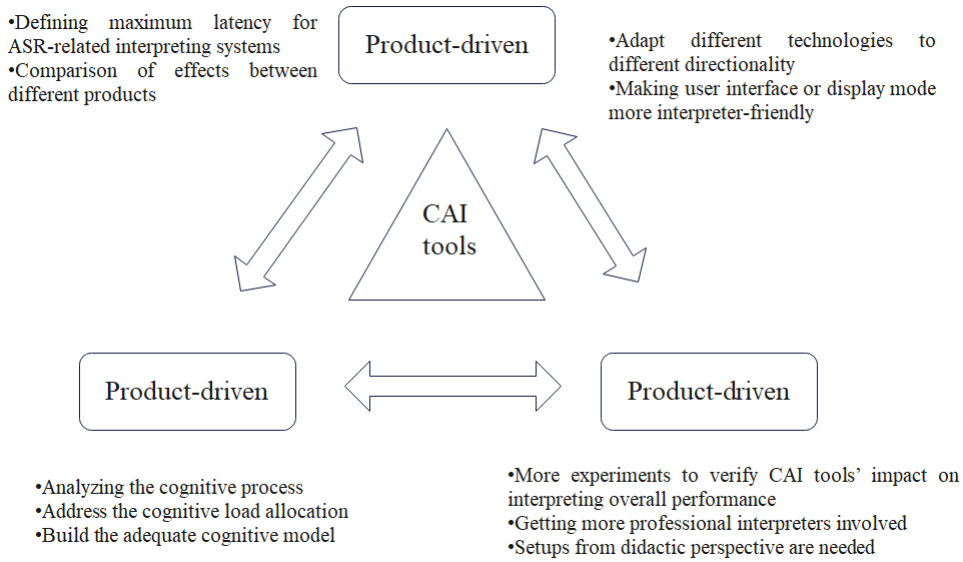

Figure 5. Future Trends for CAI Tools-related Studies and Example Topics

A. Product-Driven Studies That Account for the Perspective of Users

The authors of four of the 27 empirical studies used InterpretBank with manual lookup functions for terms, while the other 23 involved ASR technology. Many in the interpreting profession and its ecosystem have high expectations of ASR technology. The most recent versions of CAI tools, such as InterpretBank, integrate ASR. However, numerous participants in empirical studies have identified problems with ASR systems, including long latency, insufficient precision when delivery is rapid or accented, volatile effects that vary with directionality, and distraction due to display modes that are not suitable for interpreters. Several attempts have been made to solve those problems. For example, Gaber et al. (2020) endeavoured to develop an accurate ASR tool for *ad hoc* corpus compilation and term extraction from video recordings of speeches by conducting a comparative study of nine ASR tools and by using data on several

topics, while Fantinuoli and Montecchio (2022) conducted an empirical experiment to measure the maximum acceptable latency of an automatic suggestions feature for simultaneous interpretation. The results indicate that interpreters can integrate suggestions *ad hoc* by extending their ear-voice span to 2 seconds without compromising the quality of their rendition and to 3 seconds without any significant disruption. We expect that more studies will be conducted to improve and supplement products that are related to CAI tools.

B. Practice-Driven Studies Based on Empirical Experiments

It is possible to identify gaps in the conclusions of the empirical studies that were presented above. Firstly, given that many investigators believe the positive influence of CAI tools on partial content rendering, i.e., rendering of numbers or terms, and that the impact of technology on the process as a whole remains controversial, more targeted experiments can be conducted to test the conditions under which the performance of CAI tools improves. Secondly, all 27 empirical studies were conducted with current or recently graduated MA students in interpreting or other language-related fields. None involved professional interpreters. Since some studies report that CAI tools have a better effect on interpreters with better sight interpreting skills or higher language proficiency (Xiang, 2018; Xiao & Wang, 2020; Zhu, 2015) and others report the opposite result (Desmet et al., 2018; Qin, 2019) that low-to-intermediate-level interpreters benefit the most, it may be expected that more experiments with experienced professional interpreters will be conducted so as to resolve the contradiction. Finally, only one didactic experiment (Prandi, 2015) has been conducted. Students should gain more practical experience with CAI tools. Future studies could focus on the role of CAI tools in interpreting pedagogy and practice in order to bridge a gap that has been identified by several surveys (Fantinuoli & Prandi, 2018; Riccardi et al., 2020), namely that CAI tools do not receive sufficient coverage in interpreting courses.

C. Process-Driven Studies That Account for Cognitive Loads

Several experiments (Bu, 2021; Lin, 2013; Zhang, 2020) have shown that ASR errors are associated with interpreter mistakes and that long latencies are associated with delays in the output of interpreters. This correlation indicates that it is the eye that leads the ear when one is interpreting with CAI tools, which is consistent with Chmiel et al.'s (2020) SI-with-text experiment. They found that interpreters focus more on the visual modality than on the auditory one. Although the conclusions are similar, the reasons differ depending on whether one is interpreting with CAI tools or conducting SI with text. In SI with text, interpreters may not interact with the text all the time, as Gile (2009) pointed out, "speakers often deviate from the written text by adding comments and changing or skipping segments. When interpreters focus on the written text, they may miss these changes" (p. 182). When one is interpreting with CAI tools, interpreters interact with both the speaker and the speech, as the real-time transcription of a speech is shown, and the language tends to be more colloquial than that which is found in written texts. The most widely cited cognitive models of interpreting, such as the effort model (Gile, 2009) and the cognitive load model of simultaneous interpreting (Seeber & Kerzel, 2012), do not, strictly speaking, apply to CAI tools, creating room for further research. Prandi (2018) advanced hypotheses on SI with CAI tools and suggested that eye-tracking measures or other process-related studies are necessary to gain further insights into the cognitive load.

VIII. Conclusion

By presenting a review of the most recent definitions and categorisations of CAI tools, this paper identified a distinction between CAI tools in the broad sense and CAI tools in the narrow sense. We found several motivational and conceptual differences between the two, which pertain to questions such as whether a CAI tool is specifically designed for interpreting, which phase a CAI tool is usually used in, and such like. Since these differences result in ambiguous inclusion and exclusion criteria, which might obstruct research on CAI tools, we suggested a unified definition and categorisation of CAI tools. The unified definition captures the main features of the technology as used in interpreting, such as comprehensiveness in scope, immediacy in principle, and influence on cognition. Based on this definition, we demarcated the set of CAI tools explicitly and classified them as first-generation, second-generation, and next-generation tools. Among the most frequently used second-generation tools, we focused on ASR software, AST software, terminology management tools, and note-taking applications or devices. This new definition and categorisation lay a clearer foundation for future research and expands the ecosystem in which CAI professionals develop.

To understand how CAI tools assist interpreters, we examined 27 empirical studies that have been published over the past 10 years. We collected them from both English and Chinese databases and conducted a comprehensive review of the field. Although there is no consensus about the contribution of CAI tools to interpreters' overall performance, many studies indicate that CAI tools may help to improve the accuracy with which interpreters render numbers and terms. The findings also reveal a strong correlation between the overall impact of CAI tools and interpreter profiles, ASR latency, the manner in which reference information is displayed, directionality, and so forth. These findings and the results from past experiments indicate that further research is needed to identify the conditions under which the effectiveness of CAI tools can be maximised. Accordingly, we propose three future directions for studies on CAI tools. We believe that scholars should conduct more product-driven studies that account for user perspectives, more practice-driven studies that are based on empirical experiments, and more process-driven studies that account for cognitive loads.

In conclusion, this study demonstrated that empirical research on the impact of CAI tools on overall interpreter

performance has yielded inconclusive results despite the potential of those tools to improve content delivery accuracy at least partially. Further research is needed to identify the conditions or factors that can maximise the effectiveness of CAI tools. To the best of our knowledge, the present study is the first comprehensive review of studies on CAI tools. We strove to arrive at a profound understanding of the status quo and trends in the field by producing a holistic and insightful representation of CAI tools. Since we could only review studies in English and Chinese, we hope that scholars who speak other languages will contribute to this promising research project.

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