Working Memory in Interpreting and Translation Research

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Abstract

This study aims at comparing the studies on working memory and interpreting with the ones on working memory and translation in terms of their main perspectives and focus. Primarily, the study posits that the number of studies on working memory and interpreting is higher than those on working memory and translation in literature. Still, it is possible to observe a growing attention directed to working memory in translation research during the last years (Li, 2020; Wang, 2021; Naranjo Ruiz & Giraldo Ospina, 2023). Also, this review article delves into the tools used in the studies by providing comparative analysis. At this point, the applicability of the tools widely used in interpreting research to translation research is investigated. The data was collected from two databases (Google Scholar and John Benjamin E-Platform) and accordingly, 24 studies (19 in interpreting research and 5 in translation research) were included and analyzed. Thus, the study examines from what perspectives working memory was investigated in interpreting and translation research and what tools were used to measure working memory capacity with a specific focus on potential differences and common grounds on a comparative basis. Accordingly, the results of the studies in interpreting research were also evaluated in the context of "interpreter advantage" concept in literature. The results of this research can reinforce the applicability of different research tools for the measurement of working memory in translation research. They also provide valuable insights into further studies to be conducted with the combination of a variety of perspectives and research tools.

Keywords: cognitive translation studies, interpreting, research tools, translation, working memory.

Sözlü ve Yazılı Çeviri Araştırmalarında Çalışma Belleği

Öz

Bu çalışma, çalışma belleği ve sözlü çeviri üzerine yapılan çalışmaları, çalışma belleği ve yazılı çeviri üzerine yapılanlarla ana perspektifleri ve odakları açısından incelemeyi amaçlamaktadır. Öncelikle, çalışma, literatürde çalışma belleği ve sözlü çeviri üzerine yapılan çalışmaların sayısının çalışma belleği ve yazılı çeviri üzerine yapılanlardan daha fazla olduğunu ileri sürmektedir. Ancak, geçtiğimiz yıllarda yazılı çeviri çalışmalarında çalışma belleğine ilginin arttığını gözlemlemek mümkündür (Li, 2020; Wang, 2021; Naranjo Ruiz & Giraldo Ospina, 2023). Aynı zamanda, bu derleme makalesi, çalışmalarda kullanılan araçları karşılaştırmalı analiz yaparak derinlemesine incelemektedir. Bu noktada, sözlü çeviri araştırmalarında yaygın biçimde kullanılan araçların yazılı çeviri çalışmalarına uygulanabilirliği araştırılmaktadır. Veriler iki veri tabanından (Google Scholar ve John Benjamin E-Platform) toplanmıştır ve 24 çalışma (sözlü çeviri için 19 ve yazılı çeviri için 5 olmak üzere) dahil edilerek analizi yapılmıştır. Bununla birlikte, çalışma, karşılaştırmalı düzlemde özellikle olası farklılıklara ve ortak noktalara odaklanarak, çalışma belleğinin sözlü ve yazılı çeviri araştırmalarında hangi perspektiflerden incelendiğini ve çalışma belleği kapasitesinin ölçümü için hangi araçların kullanıldığını araştırmaktadır. Bu doğrultuda, sözlü çeviri araştırmalarındaki çalışmaların sonuçları, literatürdeki "tercüman avantajı" kavramı bağlamında da

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değerlendirilmiştir. Bu çalışmanın sonuçları yazılı çeviri araştırmalarında çalışma belleğinin ölçümü için farklı araştırma araçlarının uygulanabilirliğini destekleyebilir. Aynı zamanda, çeşitli perspektif ve araştırma araçlarının kombinasyonuyla gerçekleştirilecek sonraki çalışmalar için değerli öngörüler sağlamaktadır.

Anahtar Kelimeler: bilişsel çeviri çalışmaları, sözlü çeviri, araştırma araçları, yazılı çeviri, çalışma belleği.

1. Introduction

In the studies that focus on working memory (WM), a recontextualization of the term WM can be observed. Many researchers use this term in the context of a system distinct from long-term memory (Baddeley, 2007). However, a group of researchers postulate that WM and long-term memory consist of a particular memory system (Crowder, 1982; Surprenant & Neath, 2008). A few scholars that conduct research on WM suggest that WM is intrinsic to long-term memory (Cowan, 1999). On the other hand, several academics put forward that WM involve various subsystems (Baddeley & Hitch, 1974; Daneman & Tardif, 1987; Shah & Miyake, 1996); whereas different scholars accept it as one (Anderson et al., 1996; Engle et al., 1992; Kyllonen & Christal, 1990). In this review article, our focus is based on the WM model suggested by Baddeley and Hitch (1974). According to their model, short-term memory is indispensable for the execution of various tasks that are not unambiguously memory tasks. Moving from this premise, they replace short-term memory with working memory in their model. In this respect, working memory can be delineated as "a system, or a set of processes, holding mental representations temporarily available for use in thought and action" (Oberauer et al., 2018, p. 886).

In the present review article, it is focused on two main concepts, namely "working memory in interpreting" and "working memory in translation." After the first search for literature review of this article, it was detected that working memory as a concept was mostly analyzed in the same context as in Interpreting Studies. However, this paper endeavors to provide a broader perspective including research based on not only interpreting but also translation as a practice, process, and product. To obtain larger data that cover both Translation Studies and Interpreting Studies with all translation and interpreting practices, the review includes a comprehensive analysis of the literature encompassing the concepts "working memory in interpreting" and "working memory in translation." Accordingly, the utility of the tools used to assess working memory in interpreting studies for translation research is also discussed for further studies to be conducted in pertinent scholarly literature.

Founded on the WM model suggested by Baddeley and Hitch (1974), this review article aims to answer the subsequent research questions:

1) From what conceptual frameworks was working memory studied in interpreting and translation research? This question is answered with a comparative analysis of the relevant studies, and common ground is tried to be found in regard to their results in different contexts.
2) What tools were used to assess working memory in interpreting and translation research? At this point, it is focused on what potential differences between the tools used in interpreting and translation research are and whether any adaptation of the tools used in interpreting research to the studies on working memory and translation is possible or not.

2. Method

Two databases (Google Scholar and John Benjamin E-Platform) were searched for all the sources that were published until the 17th of October 2025. All the searches involved variations of the key terms and concepts: interpret(er)(ing), translat(or)(ion)(ing) and working memory along with interpretation, a term used instead of interpreting in the earliest studies. Tables of contents were examined in peer-reviewed journals that have publications on translation, interpreting, cognition, and bilingualism-oriented issues. The online search, conducted by the researcher, scrutinized every one of titles and abstracts, retrieving articles based on their relevance to translation, interpreting and working memory in the same context.

The electronic search provided a total of 423.024 sources (212.802 sources for "working memory and interpreting" and 210.222 sources for "working memory and translation"). Various sources were included in both databases; therefore, duplicate sources were removed first. As the next step, the researcher went through the titles, abstracts, and keywords of sources for inclusion in accordance with their relevance to the main concepts of the article. Then, the sources except for articles and book chapters were removed. When the abstracts did not have satisfactory information for determining inclusion or omission, the entire texts of articles or book chapters were obtained and read thoroughly. Irrelevant or extraneous sources were excluded. After the application of selection criteria to available sources, 24 studies (19 for interpreting and 5 for translation) were deemed appropriate for inclusion in the review. In this context, Saldanha and O'Brien (2013, p. 217) suggest that nature of study, "relevance" and "availability" of sources and competence and history of researchers are instrumental in selection of materials. The included studies were collected under the main titles "Working Memory and Interpreting" and "Working Memory and Translation" in line with their context and primary focus.

3. Results

3.1. Working Memory and Interpreting

Interpreting is considered among extremely demanding language tasks, and its execution is straightforwardly associated with WM. The crucial function of WM in interpreting is observable both in theoretical approaches including the process models (Cowan, 1988; Mizuno, 2005) and in empirical research (i.e., Christoffels et al., 2003, 2006; Köpke and Nespoulous, 2006; Liu et al., 2004; Morales et al., 2015; Padilla et al., 1995; Signorelli et al., 2012; Timarova et al., 2014; Tzou et al., 2012). Although it is commonly known that the association between WM and interpreting is even so uncertain and debatable, it is possible to see a substantial amount of research conducted at the intersection of these two concepts. Earlier research concentrates on how the performances of proficient interpreters and trainee interpreters (or laypersons) are in WM tasks to delve into how interpreting training may affect WM. In this context, there are several studies that investigate whether interpreting training is effective in the enhancement of short-term memory (STM) span, WM span and WM updating (e.g., Köpke & Nespoulous, 2006; Morales et al., 2015; Padilla et al., 1995). In literature, this is also considered as an "interpreter advantage" in the performances of STM and WM acquired through interpreter training or experience.

In their study, Bajo and colleagues (2000) made a comparison based on working memory and language measures between expert interpreters, undergraduate interpreters, non-specialist bilinguals, and experts from other disciplines. In terms of language measures (reading speed, lexical decision, and word categorization), interpreters performed better than other groups. The researchers used "digit span and phrase span tasks" to assess working memory. The

performance of interpreters in these tasks was also better than other participants even under articulatory suppression conditions. In this respect, it is possible to state that this research provides supportive data for the concept of "interpreter advantage" in literature.

In another study, Christoffels et al. (2003) conducted research on simultaneous interpreting performances of only non-specialist bilinguals and concluded that simultaneous interpreting performance is predicted by word translation efficiency and reading span independently. In this research, they applied "reading span tasks" (RSTs) and "verbal digit span tasks" to measure working memory. However, it is not likely to evaluate any training effect in simultaneous interpreting performance due to the absence of any experimental group who would include professional or student interpreters. On the other hand, in another experimental research (Exp. 1) that was conducted by Christoffels and colleagues in 2006, it was concluded that Dutch–English professional interpreters performed better than non-specialist bilingual student controls in terms of speaking span, word span, single word translation and reading span (in L2) in the two languages. In this experiment, the interpreters' language performance was also measured, and they outperformed the student controls in terms of speed and accuracy along with their higher memory capacity when evaluated with the control group. The researchers used "word span tasks", "reading span tasks" and "speaking span tasks" to measure WM capacities of the participants. The outcomes of the experiment reinforce the concept of training effect within the scope of interpreting research, as it provides an opportunity for a direct observation of the differences between the performances of expert interpreters and undergraduate interpreters. In a follow-up study by the same researchers, however, in word translation, Dutch–English interpreters did not perform differently from greatly competent Dutch teachers of English; nevertheless, their working memory span was higher than that of the teachers (Christoffels et al., 2006, Exp. 2). On memory tasks, only the interpreters' performances were better than the English language teachers, which puts forward that rather than cognitive resources, proficiency is effective in performances on language tasks. Besides, the teachers had higher memory span scores in their L1 than their L2, but the scores of the interpreters were equal in their first and second languages. As for the second experiment, it is possible to observe an "interpreter advantage" in only memory-related tasks. In a general sense, the data gathered from these two experiments indicate the significance of WM for simultaneous interpreting performances of interpreters.

Liu et al. (2004) used pre- and post-test design and tested the performance of undergraduate interpreters in the last parts of their first year of training and their second year of training. The participants were 11 Mandarin–English expert interpreters and 22 undergraduate interpreters. 11 of them were tested in the last part of the first year of training, while the rest of the participants were tested in the last part of the second year of training. They made a comparison between expert interpreters and undergraduate interpreters, and a similarity was observed in a "listening span task" of WM. The expert interpreters performed better than two undergraduate interpreter groups on the tasks that measure the capability of evaluation and translating necessary idea units in the source language while they were interpreting into their L1. In line with the findings of this study, the performances of professionals are likely to result from their proficiency in presenting field-specific skills instead of a common improvement in WM capacity. In addition, in the study, one group of student interpreters received training that was only one year more than the other group's duration of training, which might not reflect a reliable assessment of training effect in the performance of student interpreters.

In Padilla et al.'s study (2005), nonetheless, the participants were included according to their reading span score. The control group consisted of psychology students, while the other group

involved expert interpreters and experts who were not bilingual. The researchers used "free recall tasks" and "reading span tasks" to evaluate working memory capacity of the participants. As a result of this study, it was concluded that the interpreters recalled words and non-words better than psychology students in articulatory suppression conditions as in Bajo et al.'s study (2000). Here, we can distinguish an "interpreter advantage" in memory recall tasks and in articulatory suppression conditions.

In two other studies (Köpke & Nespoulous, 2006; Liu et al., 2004), expert interpreters and interpreting students were compared. Köpke and Nespoulous (2006), however, compared French–English expert interpreters, bilingual controls from a different profession, interpreting students, and monolingual controls from a different profession in terms of several auditory working memory tasks and phonological and semantic tasks. In the study, there were 18 second-year interpreting undergraduates, 21 expert interpreters, and two control groupings (20 multilinguals and 20 undergraduates) among the participants. The tests involved a "listening span task", "short-term retention" and "processing in a recall task with articulatory suppression", "attention alone in a unilingual and bilingual Stroop test" and "a category and rhyme probe task". In simple span tasks and Stroop test, there did not appear any between-group difference. However, in other tasks including the category probe task, listening span task and free recall with articulatory suppression, there were significant group effects. The performances of undergraduate interpreters surpassed those of experts. The group differences between professionals and undergraduate interpreters and the ones between interpreters and the control group were limited. A substantial difference was not observed in the performances of undergraduate interpreters and expert interpreters on all the listening span tasks. On the other hand, undergraduate interpreters outperformed monolingual non-interpreters on one listening span task. In general sense, the interpreters performed considerably better than monolingual non-interpreters on only the task that requires semantic category judgments. On this task, bilingual controls also outperformed the monolinguals, which implies that the effect did not result from training. As clearly understood, the results of this study put forward that there is not any substantial difference between the performances of undergraduates and experts, which does not support the concept of training effect in interpreting.

In another study (Signorelli et al., 2012), the participants were interpreters and bilingual non-interpreters, and their working memory capacity was assessed in regard to various WM elements (including "reading span task", "order- and category-cued recall task", "non-word repetition" and "articulation rate") and age factor. The participants were 47 polyglot adults who were allocated to one of four sub-groups: 12 younger interpreters (8 female, age range: 30-40), 11 younger controls (6 female, age range: 26-41), 13 older interpreters (9 female, age range: 46-67) and 11 older controls (6 female, age range: 48-81). The control group had the equal number of languages (4–5) compared to the interpreters, yet they did not receive any training in interpreting and none of them had interpreting or translation jobs. According to the results, the interpreters performed in a better way than the control group did in RSTs and non-word repetition rather than in cued recall and articulation rate. Thus, it was concluded that interpreters could manage information in WM and sort out or gather sub-lexical phonological depictions but not recall words and their meanings. When their age range was considered, it was observed that younger interpreters outperformed in the tasks of non-word repletion and cued recall. In this respect, it can be suggested that age factors also need to be investigated at the intersection of WM capacity and interpreting performance.

On the other hand, in Tzou et al.'s study (2012), it was focused on the effects of second language competence and duration of formal training in interpreting in terms of interpreters'

performances in simultaneous interpreting and their working memory capacities. Thirty-six Chinese–English speakers twenty of whom were student-interpreters participated in the study. The other 16 participants in the research were undergraduates in various fields of study. To assess working memory capacity, "spoken digit span" and "reading span tasks" were applied. Language proficiency was measured with a behavioral measure, TOEFL score, and a self-report of competence. The participants in the study included the undergraduates with one year of formal training in interpreting, the ones with two-years long formal training experience and non-specialist bilingual controls. Simultaneous interpreting performance was significantly better in student-interpreters with two years of formal training in interpretation than student-interpreters with one year of the same formal training experience. The student-interpreters with one year of formal training also outperformed the bilingual controls. In the tasks of L1 and L2 reading span, the performances of both the first- and second-year students were better than the bilingual controls; however, there was not any substantial distinction between the first- and second-year undergraduates in the working memory tasks. The reasons behind this result can be the lack of training effects (as in Liu et al.'s study) or the small sample size in the study. Another result was related to the higher working memory span in the individuals with greater competence in their second languages. Tzou et al. (2012) assumed that various levels of language proficiency can be the reason why interpreting performances and working memory spans differed, and that language processing skills can be progressed by means of formal training in interpreting. In this study, researchers analyzed training effect on simultaneous interpreting performance from a linguistic perspective.

In 2013, Jihong Wang conducted an experimental study to examine bilingual working memory capacity of expert Auslan (Australian Sign Language) - English interpreters. 31 expert Auslan-English interpreters (14 L1 signers and 17 L2 signers) participated in the research. It was aimed to investigate the effects of age of signed language acquisition and test language on their working memory capacity (WMC). The researcher asked the participants to accomplish an Auslan "working memory span task" and an English "listening span task" to assess their WMC. After each task, a brief interview was conducted with the participants. The performances of the L1 signers did not differ from the L2 signers' performances in both English and Auslan WMC considerably, which shows that age of signed language acquisition did not have any major effect on the expert interpreters' WMC. There did not appear any substantial difference between WM capacities in Auslan and English, when L1 and L2 signers were taken as one major sub-group. Additionally, ranging from moderate to strong, positive correlation between WM capacities in English and the ones in Auslan for interpreters was found, which posits that English listening span task and Auslan working memory span task used comparable cognitive sources. However, the data obtained through interviews uncovered that several interpreters made use of semantic, visuospatial and phonological codes to remember the necessary words/signs. Significantly, the participants' comments put forward that the WM span tasks include accessible space of irrelevant words/signs, whereas simultaneous interpreting entails real-time recall of meaningful and consistent concepts. Based on the research results, it is possible to state that the findings also can be related to bilingual WMC research and interpreter training. In regard to bilingual WMC research, the study presents some evidence for the non-dependence of highly competent bilinguals' WMC on the test language. As for interpreter training, it can be suggested that simultaneous interpreting undergraduates should improve their skills of learning meaningful and relevant concepts, not single words/signs.

In another study, Injoque-Ricle and colleagues (2015), on the other hand, focused on the association between WM capacity, expertise, simultaneous interpreting performance and

effect of articulatory suppression. In this research, several working memory tasks including "digit span", "digit span with articulatory suppression", "listening span", "listening span with articulatory suppression" and "simultaneous interpreting tasks" were applied. The participants were 30 Spanish-speaking expert English interpreters (26 women and 4 men). According to the results of the study, there was observed a positive meaningful association between simultaneous interpreting capability and working memory and another one between simultaneous interpreting capability and the duration of working in a month. The correlation was found to be more concrete between the tasks that were applied under articulatory suppression. There was not any significant correlation between the variables and duration of interpreting practices. The researchers concluded that simultaneous interpreting performance can be improved by working memory capacity and the competence of interpreters to deal with the effect(s) of articulatory suppression. Thus, this study contributes to the importance of working memory capacity for improving simultaneous interpreting performances of interpreters from a broader point of view.

In another study conducted by Timarova et al. (2015), it was aimed to investigate whether there is a significant correlation at the intersection of WM capacity and evaluation criteria for simultaneous interpreting performance in a group of expert interpreters. Twenty-eight expert interpreters' WM capacities were assessed through "Corsi task", "letter span" and "complex span", while their interpreting performances were tested by the means of such measures as temporal delay, dealing with speed, lexical, semantic and syntactic processing and vocabulary richness. In addition, the measures of age, general cognitive ability and interpreting practices were taken into consideration. In this research, any correlation between the tasks of letter span, complex span and simultaneous interpreting performance was not observed. The only marginal relationship was found between letter span and accurateness of interpreting figures. Moreover, a negative relationship between WM measures, age and general cognitive ability was found, which does not support the hypothesis of exceptional working memory in interpreters ("interpreter advantage" concept) built on the results of the former studies. Regarding the findings of this research, it was stated that working memory capacity related to storage and continuation in simultaneous interpreting might not be as critical as formerly supposed. One year later, in Hiltunen et al.'s study (2016), the variables including executive control and memory in simultaneous and consecutive interpreters were analyzed in comparison with those in foreign language teachers and lay experts. For this purpose, two experimentations involving "free recall" and "cocktail-party dichotic listening" were conducted. The participants included 94 volunteers (22 to 26 people in each type of group) with 10 years or more of field experience. There were four sub-groups of volunteers: three sub-groups of foreign language experts (including 22 simultaneous interpreters and 22 consecutive interpreters and 26 foreign language teachers) and one sub-group of lay experts. The whole participants involved L1 speakers of Finnish or child bilinguals. In respect of the research results, it was found that the simultaneous interpreters exhibited superior performance than the lay experts in free recalls. Even though many of the simultaneous interpreters perceived their names in the cocktail-party test, there did not appear any mistake in their first and second words after this test. From this perspective, better performances of consecutive interpreters and their greater capability to leave out irrelevant data in the cocktail-party dichotic listening test resulted from high demands of their profession for avoiding peripheral interferences. In this regard, Hiltunen et al.'s study (2016) supports the concept of "interpreter advantage", which results from the requirement for divided attention when listening to the source text, verbalizing and transferring the target text, monitoring and matching the equivalences of two languages.

In another experimental study done by Jihong Wang again in 2016, the association between the WM capacities of signed language interpreters and their performances in simultaneous interpreting was analyzed. The participants including 31 professional Auslan/English interpreters (14 L1 signers and 17 L2 signers) accomplished simultaneous interpreting tasks including an English "listening span task" and an Auslan "working memory span task" from English into Auslan and vice versa. After completing interpreting tasks, short semi-structured interviews were done. In accordance with the quantitative results, a significant correlation between bilingual WMCs and general simultaneous interpreting performances was not observed in both directions. This was valid for the performances of not only L1 signers but also those of L2 signers, when taken as two distinct groups. Accordingly, the findings put forward that expert signed language interpreters' WMCs as evaluated by complex span tasks were not directly related to the general quality of their simultaneous interpreting performances. This conclusion does not comply with the results of the formerly analyzed studies above. However, the data related to educational and professional background of the participants present mixed patterns with respect to the participants' interpreting performances in each language direction. Thus, these patterns can be the driving force behind the results of the research, which needs to be proven with further studies in similar contexts. In the same year, a longitudinal study that includes memory measures and ASL-English interpreting undergraduates was conducted by Macnamara and Conway (2016). The instruments of working memory capacity, simultaneous interpreting performance and a few further cognitive abilities were tested on 34 ASL-English interpreter trainees over two years. The researchers analyzed duration of training, preliminary cognitive abilities, differences in cognitive abilities, and preliminary simultaneous interpreting performance as predictors of absolute simultaneous interpreting performance. A few different cognitive ability instruments were also applied to predict interpreters' performances in simultaneous interpreting, while WM capacity provided the most concrete and persistent results. Among the tools used to measure the WM capacity of the participants, there were "automated reading span tasks", "automated operation span tasks", "backward digit span tasks" and "letter-number sequencing tasks". Based on the results, it was stated that progress in training could be associated with improving performance; the early performance was a predictor of ultimate performance and WM capacity was a predictor of preliminary interpreting performance and an even more clear-cut predictor of absolute interpreting performance. The simultaneous interpreting performances and working memory capacities of the participants at the beginning justified 73% of the divergence in their simultaneous interpreting performances evaluated at the end. This finding posits that interpreting programs can assess these two components upon entry to foresee students' potential accomplishment in the program. In this respect, it is possible to accept working memory as an element that can be used to measure simultaneous interpreting performance either at the beginning or end of interpreter training. Since there is not any control group in this study, we cannot make a comparison between students and professionals or bilinguals, which might provide us data for supporting or objecting to the concept of "interpreter advantage".

However, the study conducted by Antonova Ünlü and Sağın Şimşek (2018) involves two studies that analyze the influence of formal interpreting training on WM capacity of interpreting undergraduates. The study's data originated from four distinct groups. Group 1 included 26 final-year undergraduates in the department of translation and interpreting (English-Turkish) who received the formal interpreting program. Group 2 involved 32 final-year undergraduates in the departments of foreign language education (FLE) who received formal pedagogical training. Group 3 comprised of 38 entry-level undergraduates in the department of translation and interpreting (English-Turkish) who did not receive formal

interpreting training. Group 4 included 38 entry-level undergraduates at the department of FLE who did not receive formal pedagogical training. In the first study, researchers made a comparison between the storage and processing WM capacities of final-year undergraduates with those of entry-level undergraduates and final-year FLE undergraduates. In the second study, they analyzed the impact of formal training on WMCs of undergraduates by making a comparison between their outcomes on WM tasks before and after their training process. In these studies, they used "digit span task" and "reading span task" to measure storage and processing WM capacities of the participants. According to the results of the first study, final-year undergraduates outperformed entry-level undergraduates and final-year FLE undergraduates on reading span tasks rather than on digit span tasks. In the second study, the researchers obtained consistent findings with the first study, which suggests that after formal interpreting training, the undergraduates showed better performance on reading span tasks rather than digit span tasks. These findings can be taken as evidence reinforcing that interpreter training is beneficial for both the improvement of undergraduates' interpreting skills and central executive and processing capacities of their WM. Agnieszka Chmiel (2018) also concentrated on the impact of experience and training in simultaneous interpreting on working memory by investigating the role of modality, language and recall in terms of working memory results, and tried to make a connection between memory results of trainees and quality in interpreting. For this purpose, the researcher evaluated the working memory scores of the participants including interpreting trainees, expert conference interpreters, bilingual controls through L2 "reading span tasks", L1 "reading span tasks" and L1 "listening span tasks". The data was gathered from a total of 68 participants. They were distributed into three groupings: 20 conference interpreting trainees, 24 expert conference interpreters, and 24 lay bilinguals. The first languages of all participants were Polish, while their second languages were English. According to the results of the study, performances of professional interpreters were better than the other participants on all working memory tasks. They showed better performance in L1 rather than L2 and their results did not change in accordance with modality or recall modes. Interpreter training was effective in the improvement of their working memory results. The trainees who had better results performed better in interpreting. The study based on conference interpreting provides evidence for the effect of interpreter training on the improvement of working memory capacity and prediction of interpreting performance. In the same year, Dong et al. (2018) investigated possible connections between consecutive interpreting (CI) and working memory functions and conducted a longitudinal study within this framework. Two groupings of Chinese EFL (English as a foreign language) learners (93 participants) were given consecutive interpreting (CI) training (50 participants) or conventional second language (L2) training (43 participants) for the duration of a semester and they were put to test at the beginning and end of their training through the tasks of "n-back" (non-verbal updating), L2 "listening span", and "letter running span" (verbal spans). Consecutive interpreting performance was also analyzed in the terminal evaluation. According to the findings, updating efficiency in both the baseline assessment and terminal evaluation was a predictor of CI performance. Also, CI training improved updating efficiency, whereas, conventional L2 training did not. However, the correlation between CI performance and verbal spans was not strong. The only correlation to be found was between L2 listening span measured in the baseline assessment and CI performance. This measure also forecasted CI performance with borderline significance. Regarding CI training, there was not observed any group difference. The findings show an "interpreter advantage" in updating, which could result from the fact that the effect size of updating was larger in the CI task than the one of WM span tasks. From a theoretical perspective, updating and CI can be strongly related, since they are based on the same primary procedure, or more precisely, recalling and updating process in CI tasks go

through the identical attentional control process, a distinctive association between updating and CI task. On the other hand, comparable associations between WM spans and CI performances were not substantial or no more than borderline significant, which implies a stronger correlation between interpreting performance and WM updating. In this study, there is not any evidence presented for an "interpreter advantage" in WM spans in comparison with the control group and the reason behind this can be the duration of interpreter training, which needs to be investigated in further studies.

In 2020, Serena Ghiselli conducted a study formed at the intersection of working memory, selective attention and interpreting. The study aimed to identify cognitive facets of interpreting and investigate whether selective attention and working memory develop by means of practices in interpreting ultimately. The participants included the two-year master's candidates in the Department of Interpreting and Translation at the University of Bologna. They included 25 interpreting students in study group and 19 translation students in control group. They were Italian L1 speakers. To measure working memory, the researcher used the TOMAL (Tests of memory and learning) (Reynolds & Bigler, 1995) that involves an N-Back Task and five assessments based on verbal memory. In addition, to assess selective attention, three tests including a "dichotic listening test", a "Stroop task" (Stroop, 1935) and a "Flanker task" (Weaver et al., 2013) were applied. The participants were tested both before their master's degree, after one year of training and after they finished their master's courses. A comparison between the results was made to categorize tendencies and evaluate the required program length for interpreting trainees to enhance their cognitive skills. The quantity of available cognitive resources was comparable in two groups. According to data analysis, interpreting students did not have any statistically significant superiority over translation students. This study does not provide any supportive data for "interpreter advantage" concept that was mostly discussed in literature. However, in this study, interpreting and translation students were compared, but they indeed went through similar processes during their training, which might have been effective in the results. For this reason, further studies need to be conducted with a different control group involving students in different departments or bilinguals.

3 years later, another study (Zhao et al., 2023) investigated the impact of working memory, anxiety and language proficiency on speech errors at different levels including syntactic, lexical, conceptual and phonological layers in the course of consecutive interpreting from English (L2) into Chinese (L1) by student interpreters. Fifty-three senior students who received a year of interpreting training participated in this research. The researchers measured interpreters' working memory capacities through a version of "reading span task". According to the findings, there was a negative correlation between speech errors and interpreter's proficiency in their L2, but a positive correlation appeared between speech errors and interpreters' anxiety. Conceptual errors declined under the influences of working memory and language proficiency. Interpreters' inclinations for anxiety resulted in an increasing number of lexical errors. While syntactic errors declined with language proficiency, they expanded in a positive association with anxiety. On the other hand, there was not any association between phonological errors and other variables. Here, due to the absence of any control group and short training duration, there is not any conclusion related to training effect or interpreter advantage.

3.2. Working Memory and Translation

In the literature, it is observable that there exists a limited extent of research focusing on the function of working memory in translation or its effect on translation performance. A considerable number of erstwhile studies centers on working memory within the scope of interpreting. Even three meta-analyses (Mellinger & Hanson, 2019; Wen & Dong, 2019; Ghiselli, 2022) deal with working memory only within the scope of interpreting research. Thus, the present study primarily aims to point to a small amount of studies carried out at the intersection of translation and working memory with special attention to the research tools applied in these studies.

In a study, (Rothe-Neves, 2003), it was focused on the effect of working memory (WM) aspects on translation performance and reported on a study conducted as part of a broader PhD research in which it was aimed to examine the correlation connecting WM, performances in translation, doubling of simple clauses in L1, reading in L2 and writing in L1. Participants were six UFMG (Federal University of Minas Gerais) bachelor's students or apprentice translators (Grouping 1) and six expert translators (Grouping 2). WM was assessed with the tasks including "reading span test", "listening span test" and "digit symbol task". For the process descriptions of performances during translation, the researcher utilized four procedures pertinent to writing effort and time. The procedures related to time were keystroke time, fluency rate, clause time and production time, while the procedure based on writing effort was editing rate. The research emphasized that regression models applied to prove causal relationships did not disclose any substantial effect of WM on translation. Nevertheless, experts and apprentices were different in respect of how their results were associated with each other. It was evident that task coordination among the participants was associated with typing; though, processing speed was relevant to the procedures that use upper processes in translation. There was no verification for the significance of storage space. Therefore, it is possible to assume that translating practice does not entail the acquisition of an entirely different ability, but instead managing a better, more effective, and resourceful way when conducting translation practices. Here, it can be demonstrated that the researcher tried to replicate and apply one of the common perspectives in the studies on working memory and interpreting analyzed in the preceding section. On the other hand, due to the inadequate sample volume, the collected data requires further research to be conducted with more participants.

However, Tokowicz et al. (2004) studied the influences of working-memory capacity (WMC) and study-abroad experience (SAE) on the categories of errors in the course of single-word translation from L1 to L2, comparing absence of response with meaning errors. The participants included 37 persons who were comparatively competent in English and Spanish (15 mother tongue speakers of Spanish and 22 mother tongue speakers of English), and who differed broadly in SAE. The working memory capacities of the participants were assessed through "memory span tasks". In the light of the findings, a correlation between study-abroad experiences of the participants and their working-memory capacities was found. The participants who had more studying experiences abroad and those who had more capacities in working memory made the identical quantity of non-response and meaning errors, while the non-response errors of the rest of the participants were more than their meaning errors quantitatively. According to the findings, it was stated that SAE supported practices of fairly accurate translations to communicate, yet merely the learners whose WMCs were higher were capable of doing so, since this strategy entailed various elements to be retained in memory at the same time. In addition, the participants with higher WMC had active working memory (or could assign resources properly) to use a certain communicative strategy that might result in the improvement of communicative success in a study-abroad setting. Significantly, in this

research, the researchers collected both quantitative and qualitative data and valuable results in relation to individual differences in translation practices. However, in this research that was published in a journal based on bilingualism, cognition and language, it is observable that translation is used as a tool rather than an element to be measured or one of the primary perspectives, and there is not any translator among the participants.

In another study (Li, 2020), on the other hand, it was focused on whether verbal WM in the translator's L1 and/or L2 is associated with quality and speed in written translation. The participants were 33 second- or third-year graduates in Translation and Interpreting departments at nine universities in China. This project depended on two studies. In the first study, storage and processing capabilities of the participants' verbal WM in their L1 and L2 were measured in isolation through a "dual-task paradigm" applied in the e-Prime software. The researchers used "visuo-spatial WM task", "visuo-spatial reasoning task", "verbal span task", "visuo-spatial span task" and "verbal reasoning task" to measure working memory capacity. In the second one, the graduates did translation of a technical text from their L2 to their L1. Their behavioral data were gathered by the means of a keylogger. Four expert translators assessed the quality of their translations. According to the analysis based on correlation, it was stated that the processing mechanism of verbal WM in L2 influenced translation speed data; and that the processing mechanism of verbal WM in L1 was effective in translation quality. For every one of the languages, there was found a positive association between the processing performance and storage span of the verbal working memory in that language. The verbal working memory performances of the participants in the processing capacity and storage span depended on language. Their performances were better in their L1 than in their L2. Moreover, by way of regression analysis, a preliminary model was formed, which displays the exact configuration of the effect of bilingual WM on written translation. From these findings, it is possible to render important implications for training in translation competence. Further training based on verbal working memory for not only L1 but also L2 might improve the students' translation skills. Clearly, in this study, the association between working memory and translation performance was put under the scope as in Rothe-Neves' study (2003).

In 2021, Fuxiang Wang conducted a study to investigate how the difficulty of source text's (ST) translation and participant's working memory capacities influence the amount and extent of translation units (TUs). The data was collected from 38 students who translated two comparatively low- and high-level texts through keylogging. The amount of production translation units (PTU) at every one of the levels and the size of average production translation units (APTU) were analyzed and evaluated. It was unearthed that when translating the high-level text, the participants made use of extra 1-to-6-word TUs, yet their APTU amounts did not obviously decrease. Their working memory capacity was measured through reading span tasks. The quantity of PTUs at every stage did not change with the capacities of WM in translations of both easy and difficult texts. However, APTU size of the participants with WM capacities at a high level was bigger than that of those with WM capacities at a low level. On the other hand, when translating the high-level text, APTU size of the participants with WM capacities at a high level significantly decreased in comparison with those with WM capacities at a low level, which counterbalanced the distinction between the two sub-groups in translation of the rather simple text. As for the results of this study, it can be demonstrated that they only present a broad outline of the correlation between the quantity and size of TUs with WM capacity and translation difficulty of ST.

In another study conducted two years later (Naranjo Ruiz & Giraldo Ospina, 2023), it was aimed to identify the features of translation units (TUs) with respect to the narrow capacity of WM and information storage-processing capacity. The working memory capacities of the participants were not directly assessed. Four translators who received translation training were included in this study. Their native languages were Spanish, and they had one year of experience in English-Spanish translation. The data were collected through *Translog II* and Camtasia software. At the end of the research, it was concluded that translators used a systematic and successive processing method. Their low WM capacities showed signs of lower processing speed and resulted in some effects on the size of the macro TUs. Additionally, it was deduced that WM and attention were active facilitators in retrieving and activating related linguistic and contextual information required for effectual segmentations of texts in translation process.

Overall, it is evident that the studies on working memory and translation deal with translation from different points of view. Because of the small sample size in Rothe-Neves' study (2003), it is not probable to find a common ground between this study and the other study (Li, 2020) regarding their results, even though they both center around working memory and translation performance. On the other hand, the last two studies analyzed in this article (Wang, 2021; Naranjo Ruiz & Giraldo Ospina, 2023) focus on primarily translation units affected by working memory capacity and translation difficulty. In Naranjo Ruiz and Giraldo Ospina's study (2023), only four translators with low working memory capacity are included and their numbers of TUs vary between 1-3 chunks, which is acknowledged as related to the difficulty of the source text. In this regard, it is suggested that the results of these two studies can be discussed on a common ground.

4. Discussion

In this review article, it is focused on two main concepts, namely working memory in interpreting research and working memory in translation research. The first research question is from what perspectives working memory was studied in interpreting and translation research. In the previous part, the relevant studies were analyzed along with their key points and results to some degree. In addition, the information about the studies regarding their focus, date of publication, participants and tools is given in Table 1 and Table 2 in the appendix.

As the studies on working memory and interpreting are examined on a comparative basis, there appear several common points in terms of their focus. In three studies (Bajo et al., 2000; Christoffels et al., 2006; Tzou et al., 2012; Zhao et al., 2023), a focus on language and linguistic points of view can be observed. A large amount of the studies center upon simultaneous interpreting performance and working memory capacity (Chmiel, 2018; Christoffels et al., 2003; Christoffels et al., 2006; Injoque-Ricle et al., 2015; Köpke & Nespoulous, 2006; Liu et al., 2004; Macnamara & Conway, 2016; Padilla et al., 2005; Signorelli et al., 2012; Timarova et al., 2015; Tzou et al., 2012; Wang, 2013; Wang, 2016). A great number of researchers, however, center around interpreter training (Antonova Ünlü & Sağın Şimşek, 2018; Chmiel, 2018; Ghiselli, 2020; Köpke & Nespoulous, 2006; Liu et al., 2004; Macnamara & Conway, 2016; Tzou et al., 2012). Two studies focus on expertise in different contexts (Injoque-Ricle et al., 2015; Liu et al., 2004). On the other hand, it is possible to perceive different perspectives such as age factor (Signorelli et al., 2012), executive control (Hiltunen et al., 2016), experience (Chmiel, 2018), selective attention (Ghiselli, 2020) and

anxiety (Zhao et al., 2023). In addition, in several studies, different modes of interpreting including sign language interpreting (Wang, 2013), consecutive interpreting (Dong et al., 2018; Hiltunen et al., 2016; Zhao et al., 2023) and conference interpreting (Chmiel, 2018; Ghiselli, 2020) are included.

When the studies that focus on working memory and translation are considered, it is not probable to find a pattern due to the limited amount of research in this study field. Still, two studies (Li, 2020; Rothe-Neves, 2003) both concentrate on working memory and translation performance, while two other studies (Wang, 2021; Naranjo Ruiz & Giraldo Ospina, 2023) also focus on translation units. In relation to the results of the latter two studies, it can be suggested that the TU size of the translators with working memory capacity at a high-level decrease significantly in comparison with the ones who have low working memory capacity when translating difficult texts. In the other study (Tokowicz et al., 2004), it is concentrated on study-abroad experience and single-word translation. Regarding the focus of research, there is not any common point to be discovered between the studies on interpreting and working memory and the ones on translation and working memory.

The second question is related to what tools are preferred to assess working memory in these studies. At this point, it is centered on what possible differences between the tools used in interpreting and the ones in translation research were and whether any adaptation(s) of the tools used in interpreting research to the studies on working memory and translation is possible or not. When the studies on working memory and interpreting are taken into consideration, there appear a vast number of the same tools to be used with different combinations. In most of the studies, reading span task is used to measure working memory capacity (Antonova Ünlü & Sağın Şimşek, 2018; Chmiel, 2018; Christoffels et al., 2003; Christoffels et al., 2006; Macnamara & Conway, 2016; Padilla et al., 2005; Signorelli et al., 2012; Tzou et al., 2012; Zhao et al., 2023). The second most used measure, however, is listening span task applied in seven studies (Chmiel, 2018; Dong et al., 2018; Injoque-Ricle et al., 2015; Köpke & Nespoulous, 2006; Wang, 2013; Wang, 2016). Among the tools used to measure working memory capacity, there is digit span task in a great number of studies (Antonova Ünlü & Sağın Şimşek, 2018; Bajo et al., 2000; Christoffels et al., 2003; Injoque-Ricle et al., 2015; Macnamara & Conway, 2016; Tzou et al., 2012). Apart from these, free recall task is also applied by some researchers (Hiltunen et al., 2016; Köpke & Nespoulous, 2006; Padilla et al., 2005). Another tool, memory span task is utilized in both the studies on working memory and interpreting (Wang, 2013; Wang, 2016) and those on working memory and translation (Tokowicz et al., 2004).

In the studies conducted at the intersection of translation and working memory, however, such tools as memory span task (Tokowicz et al., 2004), reading span task (Rothe-Neves, 2003; Wang, 2021) and listening span task (Rothe-Neves, 2003) are applied along with different tasks. In addition, Rothe-Neves (2003) additionally uses digit symbol task to measure working memory capacity. Moreover, in another research, Li (2020) applies visuo-spatial WM task, visuo-spatial reasoning task, verbal span task, visuo-spatial span task and verbal reasoning task for the same purpose. In Naranjo Ruiz and Giraldo Ospina's research (2023), however, the working memory capacities of participants are not directly measured through any tool.

Taken together, it is discernible that reading span tasks, memory span tasks and listening span tasks are used to assess working memory capacity in not only interpreting research but also translation research. In this regard, it can be assumed that different tools used in interpreting research to assess working memory can also be applied in the studies on working memory and

translation. Thus, researchers can obtain concrete and comparable data by means of various tools when assessing working memory capacities of participants in their studies. This also enables researchers to compare the data collected in interpreting research with the one obtained in translation research in terms of the usage of the same tool in different contexts.

5. Conclusion

This review article reveals the dominance of the studies on working memory and interpreting over those concentrated on working memory and translation. Studies based on working memory and interpreting are published every two or three years or even in the same year in some cases, which clearly shows the importance given to their intersection. The substantial amount of research provides us with finding patterns in regards to the common perspectives and tools used in the studies. On the other hand, the limited amount of research on working memory and translation puts us into a situation in which we cannot find any common ground between different perspectives and priorities in the studies. Additionally, the publication history of these studies refers to a trajectory beginning in the 2000s and potential resurrection of focus in the 2020s, which indicates an almost twenty-year gap or non-productive period in literature. In this regard, it can be put forward that working memory is mostly associated with verbal and simultaneous competences and thus, interpreting context. On the other hand, the journals in which the studies were published are based on bilingualism (6), psychology (3), memory (1), cognition (2), interpreting (6), linguistics (1) translation (4) and multidisciplinary issues (1). Many of the studies are published in journals on bilingualism and interpreting. This is followed by the journals on psychology and translation. Additionally, we can observe the journals focusing on memory, cognition and linguistics. When the dates of publication are analyzed, it is possible to see a shift from the journals on bilingualism to those on interpreting and translation. This also can be associated with the cultural turn and the rise of Translation Studies as an autonomous discipline in literature. Moreover, when the recent studies on working memory and translation (Li, 2020; Wang, 2021) are analyzed, it is possible to perceive the importance of working memory for both translation performance and training. As the literature review reveals, it is possible to observe a growing attention directed to working memory in translation research during the recent years (Li, 2020; Wang, 2021; Naranjo Ruiz & Giraldo Ospina, 2023). Thus, in future studies, it needs to be given a special attention to this intersection along with different perspectives. At this point, it can be said that there is still a huge gap in literature in terms of the number and quality of the studies on working memory and translation. As for potential future perspectives, it can be suggested that some studies can be conducted at the intersection of working memory and audio-visual translation, working memory and literary translation or working memory and specialized translation fields.

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