Working memory and SI

Simultaneous interpreting (SI) is a highly complex process that places exceptional demands on memory and processing. It is intuitively plausible to think of SI as occurring in a ‘workspace’ in which source language input is temporarily buffered while translation operations are performed. Such a workspace is commonly referred to as “working memory” (WM), a concept which embraces not only short-term storage, but also management and manipulation, of information. Some conceptions of working memory stress storage, proposing separate stores for phonological and visual information, and an ‘episodic buffer’ (a short-term memory system that integrates information across different codes, including semantics) with a focus on rehearsal as a memory management process (Baddeley 2000; Baddeley & Hitch 1974). Others emphasise how the dual demands of storage and concurrent processing drain overall WM ‘capacity’ (WMC) (Daneman & Carpenter 1980), while others emphasise the role of attention and the ‘central executive’ as a general-purpose system for information management and control, with ‘short-term memory’ (STM) becoming merely the active component of long-term memory, as maintained by attention (Cowan 1999; Engle et al. 1999). Throughout there has been an emphasis on variation in WMC between individuals, and how this can be one cause of individual differences in performance in complex tasks. Here we ask whether measures of WMC relate to SI performance, and whether interpreting experience actually enhances WMC or more specific aspects of executive function, either as evident in behavioural tasks, or in direct measures of brain function.

Daneman and Carpenter (1980) developed a ‘reading span’ task to measure WMC as it relates to language comprehension. Participants read a set of unrelated sentences and afterwards have to recall the sentence-final word of each sentence in the correct order. A person’s ‘reading span’ is the maximum number of sentences for which they can correctly recall the sentence-final words. They found that among American college students reading span varied between 2 and 6, and that performance correlated with language comprehension measures such as the distance over which anaphoric reference could be successfully resolved, or in later work, fine-grained measures of the ability to resolve syntactic and lexical ambiguities (Just & Carpenter 1992; Miyake et al. 1994). The majority of SI studies that have measured WMC...
have used a similar task (or a listening variant), rather than WM tasks that do not involve sentence processing (e.g. the Operation Span requiring mathematical calculations). Hence the notion of WMC as referred to here should be regarded as related to language processing, and not necessarily as a domain-general capacity.

Working memory capacity and SI performance

Given that SI places relatively extreme demands on the ability for simultaneous storage and processing, it is natural to ask whether individual variation in WMC relates to SI performance measures. This does appear to be the case, at least for untrained (Christoffels et al. 2003) or trainee interpreters (Lin et al. 2018; Zhang & Yu 2019). But studies that have examined professional interpreters have found either no or weaker relationships. Timarová et al. (2015) noted that the four studies prior to the time of their study had only found a relationship in trainees, whereas their study failed to find a relationship in professionals. And Liu et al. (2004) found the expected superior interpreting performance in professionals than trainees despite the groups being matched for WMC. These findings suggest that in professional-level interpreting WM demands are circumvented by other strategies, making WMC as such a less important factor.

Working memory in interpreters

Given the above, it comes as some surprise that professional interpreters have been shown to have higher WMC than trainee interpreters (Yudes et al. 2013) or other students with similar levels of bilingualism (Yudes et al. 2011). Given that the professional interpreters were significantly older, and would therefore be expected to have lower WMC, this is quite striking. Professional interpreters have also been shown to have higher WMC than language teachers of similar age and level of bilingualism (Christoffels et al. 2006; Stavrakaki et al. 2012) or other age-matched bilinguals (Babcock & Vallesi 2017; Signorelli et al. 2011). At the same time, teachers, trainees and bilinguals did not have superior WMC to monolinguals (Stavrakaki et al. 2012; Yudes et al. 2011; Yudes et al. 2013) or unbalanced bilinguals (Christoffels et al. 2006; Köpke & Nespoulous 2006). Therefore, these studies point to there being something about achieving professional-level SI expertise that enhances WMC (see also recent meta-analyses by Wen & Dong 2019, and Mellinger & Hanson 2019). One may wonder whether this is due to extensive SI experience or the nature of SI training itself. Initial evidence comes from two longitudinal studies which found that trainee interpreters’ WMC significantly improved from measurements taken at the start and end of a two-year (Chmiel 2018) or 18-month (Antonova Ünlü & Sağın Şimşek 2018) SI training programme, by which point it did not differ from that of professionals with 13 years’ experience (Chmiel 2018). Also, Liu et al. (2004) found equivalent WMC in professionals and students at the end of their training, and Timarová et al. (2015) found no correlation between years of SI experience and WMC. Hence, what evidence there is suggests that interpreter training, rather than experience, enhances WMC. It has been suggested that it is the demands of dealing with the novel task of interpreting that enhances WMC (Köpke & Nespoulous 2006) whereas experienced interpreters use other strategies to minimise the load on WM, leading to no correlation between WMC and SI performance. One such strategy might be prediction (see below), but another might be the way input is encoded into memory, as suggested by research on the effect of articulatory suppression.
Articulatory suppression and working memory

An indication of different memory strategies in interpreters comes from studies of random word list recall in which participants are required to say nonsense syllables during presentation, preventing rehearsal of the items to be recalled. Of interest is the effect of this ‘articulatory suppression’ on recall of ‘supra-span’ word lists—lists that are beyond the capacity of STM. Articulatory suppression impairs performance in monolingual controls but has no effect on professional interpreters (Padilla et al. 2005; Yudes et al. 2012). This effect is not found for shorter word lists that can be retained in STM (Köpke & Nespoulous 2006) implying that the interpreter advantage lies in being able to directly store verbal material in memory (perhaps as a semantic code in the episodic buffer) without the benefit of rehearsal in phonological short-term memory. Not only would this be a useful strategy in SI, but also in performing WM span tests. In this regard it is noteworthy that Injoque-Ricle et al. (2015) only found a significant relationship between WMC and interpreting quality when the span test was performed under articulatory suppression, suggesting that it is the ability to deal with interfering phonological information that is critical, not WMC as such.

Executive function

As explained above, the rationale for the reading/listening span task is that it combines the demands on processing and storage in a way that is relevant to the demands of real-time language processing. However, in recent years there has been an explosion of interest in the executive component of WM, following claims that there is a ‘bilingual advantage’ in this aspect of cognition (Bialystok 2011), possibly as a result of switching languages for different interlocutors (Green & Abutalebi 2013). There are reasons to think that executive functions might be particularly enhanced in interpreters. One aspect of executive skill is the ability to maintain the activation of selected items of information in the face of interfering or distracting events. For example, when simultaneously interpreting from German verb-final structures into English (verb-medial) structures, which is further discussed in the next section of this chapter, the source language information has to be buffered while new information unfolds in the auditory input, causing interference in the phonological store (which holds the words we hear). This is related to the notion of suppression, i.e. the ability to ignore irrelevant information, which is particularly important during simultaneous conference interpreting. Interpreters may also have to be selective about what information in the source language they translate, again making demands on the executive system. From this perspective, simultaneous interpreters may become “experts in executive control” (Yudes et al. 2011).

The ‘executive’ system has actually been decomposed into a number of component processes: inhibition (including response inhibition and interference suppression), shifting of mental sets (task switching or cognitive flexibility), and updating information in WM (Miyake et al. 2000). Each of these can be operationalised using specific, non-linguistic, tasks, and a number of studies have used these to compare executive function in interpreters with, variously, monolinguals, proficiency matched bilinguals, or translators. Of these, the translators provide the most stringent test of whether the specific memory and control demands of SI enhance EF.

In tests of response inhibition an automatic, or ‘prepotent’, response has to be inhibited. For example, in the ‘Simon task’ participants simply have to indicate whether a box on the screen is coloured green or red, pressing, say, a right-hand button for red and a left-hand button for green.
When the coloured box appears on the same side of the screen as the appropriate response hand (e.g. a red box on the right) responses are faster than when the position of the box conflicts with the response hand (e.g. a red box on the left still requires a right-hand button response) a ‘congruency’ effect. In this case the automatic tendency to press the button corresponding to screen position has to be suppressed. Two studies have found equivalent congruency effects in bilinguals and professional (Yudes et al. 2011) and trainee (Woumans et al. 2015) interpreters using the Simon task. However, Henrard and Van Daele (2017) report a professional interpreter advantage in a conceptually equivalent task (the ‘antisaccade’ task) compared to translators, who did not differ from monolinguals (note that the sample size of 60 per group was unusually large). On the face of it, Henrard and Van Daele’s results provide good evidence that SI specifically enhances the inhibitory mechanism, but it is not clear why there was no interpreter advantage for the Simon task in previous studies (note that no advantage has been found in the conceptually similar Stroop task either, Dong & Liu 2016; Köpke & Nespoulous 2006).

In tests of interference suppression the participant may simply have to indicate whether a horizontal arrow in the centre of the screen is pointing left or right, and it could either be flanked with arrows pointing in the same (congruent), or opposing (incongruent), directions (referred to as a ‘flanker task’, or ANT). Two studies have found no reduction in the congruency effect in interpreters compared to bilinguals (Morales et al. 2015; Woumans et al. 2015). There was an advantage with respect to monolinguals in one study (Woumans et al. 2015), but not in another (Van der Linden et al. 2018), so there appears to be no specific interpreter advantage.

In tests of memory updating, the participant listens to a continuous stream of stimuli and has to indicate whenever the current stimulus is the same as the one an n number of items back (the ‘N-Back’ task, where n is typically two or three items). Performance depends on constantly updating the contents of a memory buffer. Studies have found superior performance in professional interpreters compared to bilinguals (Morales et al. 2015) and, using a related task, compared to translators, who did not differ from monolinguals (Henrard & Van Daele 2017). But Van der Linden et al. (2018) found no difference between professional interpreters and either bilinguals or monolinguals on the N-Back. Yet, in a longitudinal study of trainees, Dong and Liu (2016) found a greater reduction in reaction times (but not accuracy) for trainee interpreters compared to bilinguals after 4.5 months of training.

Finally, in tests of task switching, participants have to continually revise the rules they use to categorise or respond to stimuli, for example, categorising geometric figures by either their colour or shape. Participants perform the task in blocks of the same task, and then in a block in which the tasks are mixed. The ‘switch cost’ is the slow-down on trials in the mixed block on which the task is different from the preceding trial. The ‘mix cost’ is the difference between response times to non-switch trials in the mixed block compared to the single task blocks. Two studies using this paradigm have found a reduction in mix costs in professional SI compared to translators (Becker et al. 2016) or age-matched bilinguals (Babcock & Vallesi 2017), but a third study only found a difference with respect to monolinguals, not translators (Henrard & Van Daele 2017). In contrast, two longitudinal studies of trainee interpreters found no reduction in mix costs over the course of training compared to translators (Dong & Liu 2016; Van de Putte et al. 2018). Only one of these studies found a reduction in switch cost, and this was in trainee interpreters compared to translators over a 4.5-month training programme (Dong & Liu 2016). But another study following a similar design, though with a much smaller sample size, found no interpreter advantage in switch costs (Keller et al. 2019). Finally, Yudes et al. (2011) used a related task (the Wisconsin Card Sorting Task) and found some evidence for better performance in professional interpreters compared to bilinguals and monolinguals (reduced
Working memory and cognitive processing

intrusion from previous response rules, or ‘perseveration’ errors). Overall, there is some evidence that at least professional interpreters are superior to bilinguals/translators at maintaining focus on the current task, as measured by mix costs (two out of three studies) and perseveration errors (one study).

From the above it is apparent that there is no consistent evidence that professional interpreters perform better than either bilinguals, or even in some cases monolinguals, on tests of individual components of EF. This is particularly the case for tests of response inhibition and interference suppression. Given the general inconsistencies in the burgeoning research field of the bilingual advantage (e.g. Paap & Greenberg 2013), this should come as no surprise. On the other hand, it is surprising on the view that the inhibitory control mechanism is exercised particularly in contexts of rapid, intentional, code switching (Green & Abutalebi 2013). But then it could be argued that conference SI, at least, does not involve rapid code switching in this sense, but rather rapid switching between similar tasks, such as input processing and output monitoring. It is interesting, therefore, that there is some evidence for a professional SI advantage in relation to reduced task mixing costs (see the Nour et al. 2020 meta-analysis for a similar conclusion). There is also evidence from three out of four studies for an SI advantage in the N-Back, which is the only memory-based task, and may reflect interpreters’ superior memory management capabilities that are evident in reading span tests of WMC.

Summary

While behavioural methods tend not to provide clear evidence for EF advantages in interpreters, neuroscientific methods are beginning to reveal differences in brain function even in the absence of behavioural effects (Van de Putte et al. 2018; Vaughn et al. 2019) (see Hervais-Adelman, Chapter 34, in this volume). This highlights the complexity of the relationship between performance on standard laboratory tasks and actual brain functions. In addition, studies have found enhanced connectivity between frontal executive areas and language areas in professional interpreters (Becker et al. 2016; Klein et al. 2018). Hence a test of a discrete function will not necessarily relate directly to the broader context of language processing and interpreting. This is perhaps why the closer a lab task gets to the interpreting situation, the more likely it is that it will be related to interpreting performance or show an interpreter advantage, as we see for the reading/listening span tasks used to measure WMC, and manipulations involving AS. Such tasks engage a broad network of brain systems in a way that is more akin to the SI situation than decontextualised non-linguistic tests of discrete executive functions. But we must also recognise the possibility that interpreters develop particular memory and task-management strategies that may draw on functions that are not picked up by the standard tests, or which, in the case of tests of WMC, may enhance performance compared to non-interpreters (see Riccardi, Chapter 27, in this volume).

Perhaps one way forward is to identify and model particular processes that interpreters do engage in, such as prediction and anticipation, and then see how these may draw on combinations of cognitive abilities that could be enhanced through interpreting experience, or developed directly during interpreter training.

Prediction and SI

Language comprehension proceeds both through bottom-up and top-down processing of information. The former starts from listening and analysing the input that we receive (hear, see) through our senses and matching that input to the wider context and our background or world
knowledge on the topic described. The latter starts from the already built knowledge about the context and our background or world knowledge and applying that to the upcoming sensory input (Marslen-Wilson 1992).

Top-down processing is assumed to allow people to create expectations about the upcoming linguistic input and consequently predict language (Otten & Van Berkum 2008; Van Berkum et al. 2005). A fundamental debate of language processing is when context can take effect during word recognition, before (see TRACE model, McClelland & Elman 1986) or after (see Cohort model, Marslen-Wilson & Tyler 1980) sufficient information on word identity is available in the sensory input. A number of electrophysiological studies recording brain responses called event-related brain potentials (ERPs), as well as eye-tracking studies recording anticipatory looks to the referents of upcoming arguments in visual scenes using the visual world paradigm, have now demonstrated that context information can be used to anticipate features of likely upcoming words at phonological (DeLong et al. 2005), semantic/conceptual (Federmeier & Kutas 1999, 2001), as well as morphosyntactic level (Wicha et al. 2004) (see DeLong et al. 2014 and Huettig 2015 for reviews of findings).

While most studies focus on sentence processing, the same debate exists on the discourse level. Kintsch (1988) proposed a model of comprehension where information that is encountered through bottom-up processing activates abstract knowledge about the phonological, morphosyntactic, or semantic features of a word in an unfolding text. Rather than being used to create expectations about (i.e. predict) the word, such structures, Kintsch claimed, are used to integrate that word in the text more easily. Findings to the contrary show predictions based on the wider context even when these contradict the immediately preceding one (Van Berkum et al. 2005), which have led to the conclusion that language is processed incrementally or in a piecemeal fashion and this helps us make predictions about what will follow in unfolding language.

SI is a complex cognitive task, where multiple efforts like listening and analysis of both the source input and target output, production of the target output, and working memory storage are engaged simultaneously (Gile 2009). Given the incremental nature of language processing, during SI involving languages with asymmetrical sentence structures, such as German, where the verb is often placed in sentence-final position in complex sentences, and English, where the verb comes earlier in the sentence, prediction becomes crucial for relieving cognitive effort. Seeber and Kerzel (2011) found that SI between asymmetrical verb-final German and (verb-medial) English sentences requires higher cognitive load, as measured by the diameter of pupil dilation, than SI between symmetrical verb-medial German and English sentences. However, when anticipation of the sentence-final verb occurs during SI between asymmetrical sentence structures, and the verb is produced in the English output before it becomes available in the German input, cognitive effort seems to be the same (i.e. the same pupil dilation diameter was recorded) as during SI between symmetrical sentences.

**A theory of prediction**

Very recently, a theory was put forward to account for the processes underlying prediction in symmetrical and asymmetrical SI (Amos & Pickering 2019). The authors rely on three-stage monolingual models of speech production, where the initial message planning stage is followed by word order or structure assignment which in turn is followed by articulation. Importantly, prediction during comprehension is thought to follow the same stages as speech production. As language is processed, a covert representation of the speaker’s utterance is constructed using the production mechanism, which is then assigned a structure but not articulated (Gambi & Pickering 2017; Pickering & Garrod 2013).
Amos and Pickering (2019) attribute a higher degree of automaticity to SI between syntactically more symmetrical languages (like English and French) than SI between syntactically less symmetrical languages (like German and English) when it comes to the position of the main verb, as, in the case of the latter, pre-verbal information has to be held in a buffer before the verb is encountered in the input and the sentence can be translated into English. Buffering imposes additional cognitive load, which can be reduced by predicting the sentence final verb and producing it in the output before it becomes available in the input. Following the idea of prediction-by-production, then, the authors claim that the predicted representation serves as input for the planning of speech in the target language. The interpreter uses this representation to derive (but not overtly produce) the speaker intention before it is uttered by the speaker. This prediction-by-production is said to take place in the source language. Given that SI involves simultaneous comprehension and production of speech, it can be considered as an environment particularly conducive to prediction.

**Empirical studies on prediction in SI**

Even though early interpreting studies assume a role for prediction, in particular in the context of simultaneous interpreting (Gerver et al. 1984; Moser-Mercer 2000; Setton 1999), few of them are empirical (Jörg 1997; Riccardi 1996; Seeber 2001). These studies discussed structural prediction during SI between asymmetrical sentence structures. For instance, interpreters were found to use topicalization or placeholders during SI from German verb-final into French verb-medial sentence structures (Van Besien 1999) and placeholders during SI from German into English (Seeber 2001) as a way of postponing the production of the verb. Further studies found instances of verb production in the target output before it becomes available in the source input during SI from German into English (Jörg 1997; Kurz & Färber 2003), from Japanese into English (Gile 1992), and from German into Italian (Riccardi 1996). In the SI literature, the latter is an example of what is referred to more generally as anticipation (Gile 2009).

Two types of anticipation have been identified in this body of literature known as extralinguistic and linguistic anticipation (Lederer 1981). The former is said to primarily rely on general background or situational knowledge, which is of particular importance during SI, given the specific context in which the task is being carried out. So, information about the conference topic, the speakers, the location becomes part of the background knowledge of the interpreter and it can be used top-down to anticipate words, ideas or messages (Gile 1992, 2009; Van Besien 1999). Linguistic anticipation is assumed to rely more on language-specific probabilistic information, or the likelihood of words occurring together in a given language (Gile 2009). In an early study of this topic, Wilss (1978: 348) noted the example of the German word Namens (‘On behalf of’), often introducing the standard expression of thanks Namens ... darf ich ... danken (‘On behalf of ... I would like to thank ...’): hearing Namens thus enables the interpreter to anticipate danken, based on the statistical likelihood of the two words co-occurring in German.

Setton (1999) views frequently co-occurring words or fixed expressions as connecting devices at a discourse level. Along with extralinguistic cues like background knowledge of the topic, they are used incrementally to draw inferences and anticipate what will follow in the unfolding speech. Similarly, Chernov (2004) proposed a model of probability prediction, where prediction depends on the degree of redundancy on every level of processing. The more redundant a syllable, word or utterance in a given language, the more predictable it will be.

Given the importance of anticipation in SI, comparisons have also been made between professional interpreters and other groups, such as trainees and bilinguals, with respect to the rate of anticipations, ratio of exact versus general anticipations, and incorrect anticipations.
Moreover, comparisons have also been made based on directionality or whether the participants are interpreting from or into their native language. While there have been few expertise-based differences in the overall number of anticipations, more instances of exact anticipations have been observed in professional interpreters than student interpreters in their final stage of interpreter training both in SI from German into English (Jörg 1997) and from German into Italian (Riccardi 1996). One possible account for this finding could be that professionals are quicker than students to retrieve specific terms, phrases, and expressions in the target language due to the stronger connections in their brains between specific words or phrases in the source and target languages as a result of experience (Paradis 1994).

Interestingly, both studies also found more instances of anticipation in interpreters whose first language (L1) was German than those who had either English or Italian as their L1. This suggests that (1) predictions are more common when interpreting from than into the interpreter’s L1, and (2) that they are generated in the source language, as discussed in the above model (Amos & Pickering 2019).

**Word order asymmetry and prediction in SI**

In order to look at what causes prediction during SI, an online investigation of the task is needed, i.e. as it happens. This requires breaking down the task into its components, which is difficult given its complexity. While interpreters do produce the anticipated word in the target output before it becomes available in the source input (i.e. the definition of anticipation in the interpreting studies literature), they cannot always afford to do this. Sometimes they postpone production until their hypothesis is confirmed to avoid anticipatory errors. However, this does not mean that they are not creating expectations or pre-activating features on different levels of language processing. It just means that their predictions might not be expressed.

In the more recent predictive processing literature, prediction is viewed less as strategic or all-or-nothing and more as implicit and probabilistic in nature (Huettig 2015). Some researchers have posited a distinction between prediction as a result of higher-order processing of contextual constraint and prediction relying on lower-order processing of transitional probabilities between syllables and words (Frisson et al. 2005; McDonald & Shillcock 2003a, 2003b).

Transitional probability (TP) is the statistical likelihood with which syllables/words appear together in language which is a feature of statistical learning (McDonald & Shillcock 2003a, 2003b). Results on statistical learning (Saffran et al. 1996; Thompson & Newport 2007) have been interpreted as indexing individuals’ prediction of upcoming syllables in speech. In other words, the ability to extract statistical regularities is thought to be linked to an individual’s prediction skills. TP effects have also been found on prediction during reading (McDonald & Shillcock 2003a, 2003b). For instance, collocations like accept defeat, which have a high statistical likelihood of appearing together, i.e. high TP, were read faster than non-collocates such as accept losses, which have a low TP. However, when context was increased, such effects seemed to disappear (Frisson et al. 2005).

Hodzik and Williams (2017) used a latency measurement technique to investigate prediction of the sentence-final verb during SI of sentences from German into English based on two cues that have been found to lead to prediction: contextual constraint and TP. The latency, i.e. time lag, was measured between the onset of the sentence-final verb in the German input sentence and the onset of its translation or version in the English output sentence. The context used was either more or less constraining, depending on the presence or absence of semantic cues preceding the sentence-final verb, whereas TP was computed between the sentence-final verb and the noun preceding it based on frequency and co-occurrence information obtained from...
German and English corpora, and this was either high (e.g. *Unterstützung bekommen* = ‘to receive support’) or low (e.g. *Unterstützung verlangen* = ‘to ask for support’). This resulted in four experimental conditions, following Frisson et al.’s (2005) 2x2 design: sentences with a constraining context and high TP (1a); sentences with a constraining context and low TP (1b); sentences with a neutral context and high TP (1c); sentences with a neutral context and low TP (1d). A significant decrease in interpreting latency as a result of a constraining context and/or high TP was interpreted as prediction.

(1) Sample experimental item across four conditions (with English gloss in italics and English translation):

(1a/b) Obwohl er kein Geld hatte, war er entschlossen, in Oxford zu studieren. Da das Studium zu teuer für ihn war, hatte er von der Universität finanzielle Unterstützung bekommen/verlangen.

German translation: Although he did not have any money he was determined to study in Oxford. Because the studies were too expensive for him, he had received/asked for financial support from the university.

(1c/d) Obwohl er kein Auto hatte, war er entschlossen, uns zu besuchen. Gestern hat er uns einen Brief geschickt, in dem er uns erzählt hat, dass er Unterstützung bekommen/verlangen hatte.

German translation: Although he did not have a car, he was determined to visit us. Yesterday he sent us a letter in which he told us that he had received/asked for financial support.

A main effect of contextual constraint on interpreting latency was obtained both in a group of participants with prior experience in SI (a combination of student and professional interpreters with English (A) and German (B)) as well as a group of English-German bilinguals with no prior experience in SI, although the overall interpreting latency was shorter for the professionals. However, there was no effect of TP on interpreting latency in either group. Even after significantly reducing the length of the sentences (e.g. *Sie hat Unterstützung bekommen* = ‘She *received* support’), no TP effect on latency was observed. A TP effect was only found after converting the verb-final German structures into verb-medial ones (e.g. *Sie bekam Unterstützung* = ‘She *received* support’) in a follow-up study that involved German-English SI by bilingual participants with no prior interpreting experience (Hodzik, 2019). This suggests that TP might affect interpreting latency only when the source and target language structures are symmetrical, i.e. both verb-medial.

These results were obtained during SI of isolated sentences in the lab, so it would be difficult to extend them to the actual SI activity which involves interpreting of speeches in a very specific (conference) setting. Still, some speculations will be made regarding the processing and production mechanisms underlying prediction in SI, which can be taken into account for further investigations involving professional interpreters.
During SI involving asymmetrical sentence structures, the source language word order that was processed as verb-final or OV (object-verb) in the German input had to be converted into VO (verb-object) for the purpose of its production in English. Specifically, this conversion had to take place in the TP region, i.e. the noun followed by verb order in German (Unterstützung bekomen) had to be changed to verb followed by noun order in English (received support), which was initially thought to have resulted in an overall delay in production in the asymmetrical case. But this account was disconfirmed by additional SI latency measurements that actually revealed faster production in the case of asymmetrical structures than symmetrical ones. In fact, interpreters have often been found to intentionally decrease the latency when interpreting between asymmetrical sentence structures as a way of anticipating the target language structure (Setton & Dawrant 2016).

Translation process studies employing measures of eye movements found that during the translation of verb-subject (VS) Dutch sentences into (SV) English, translators gazed significantly longer at the asymmetrical (VS) region in the source language than at the SV region during the translation of subject-verb (SV) Dutch sentences into English (Balling et al. 2014; Jensen et al. 2009). Similarly, longer processing of the asymmetrical region in the source input, i.e. between the noun and verb, could be posited as overriding any possible effect of TP on processing. Thus, SI between asymmetrical sentence structures could be associated with a greater cost in processing (rather than production) compared with SI between symmetrical sentence structures.

Summary

Prediction, both as pre-activation of linguistic features and as anticipation, has been found on multiple levels during language processing per se as well as during SI. Effects of contextual constraint on prediction are evident across studies, and they seem to override any lower-level effects of transitional probabilities between adjacent words. This seems to be the case during SI between asymmetrical sentence structures, which is considered cognitively more demanding than SI involving symmetrical structures.

As an index of individuals’ statistical learning abilities, high TP can be considered as one of the factors contributing towards the automation of the source language processing component in SI. Further research on TP could test the effect of statistical learning on prediction in SI by investigating whether prior occurrences in the wider discourse, i.e. text, may affect TP values.

Conclusion

The findings reviewed in the first part of this chapter suggest a training-related advantage for WMC and improved performance in interpreters compared with non-interpreter groups under AS. On the other hand, findings from tests of discrete executive functions are more conflicting, with some advantages observed for tasks involving memory updating in professionals. It may be that the observed cognitive advantages in interpreters are the result of the continuous practice of the interpreting task (Nour et al. 2020). In the second part of this chapter, experimental findings on prediction and anticipation during SI revealed that the types of cues that will be used to create expectations are, at least partly, dependent on the symmetry in structure between the source and target languages involved in the SI task. Further research could focus on whether and how processes like prediction, which are characteristic of the SI task, might benefit from working memory abilities.

Although the possible link between such abilities and prediction has largely been ignored in the language processing literature, Huettig and Janse (2016) found that the higher an individual’s
WMC, the more they engaged in prediction, as shown by their anticipatory eye movements during spoken language processing. They argue that working memory is a mediating factor in language-based predictions by connecting information in the sensory and linguistic input (in visuospatial memory) to information in long-term memory (including phonological and semantic representations). Variations in WMC within interpreter groups can possibly be used to account for the above-discussed cost in processing asymmetrical versus symmetrical sentence structures during SI. Higher WMC may mean higher portions of long-term memory activated and thus stronger or faster activation of connections, such as those indexed by TP.

Further reading

Chmiel, Agnieszka 2020. Effects of simultaneous interpreting experience and training on anticipation, as measured by word-translation latencies. *Interpreting* 23 (1), 18–44.

References

Becker, Maxi, Schubert, Torsten, Strobach, Tilo, Gallinat, Jürgen & Kuhn, Simone 2016. Simultaneous interpreters vs. professional multilingual controls: Group differences in cognitive control as well as brain structure and function. *Neuroimage* 134, 250–260.


