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Loraine Obler
CUNY Graduate Center

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Lorraine K. Obler

City University of New York Graduate Center, USA

The articles in this special issue focus on the interactions between cognitive and language processes in conference interpreters. The extreme language demands of their task provide us, as exceptional groups and exceptional performance often do, a useful tool to determine the ways the brain engages cognition to process and produce language.

Consider the language tasks that conference interpreters perform virtually simultaneously: listening to speech in a given language, comprehending it, then speaking the message in a different language. Sometimes the input is fast, mumbled, not loud enough, or, if the speaker is reading a text aloud, the natural intonation variability may be reduced. Often the interpreter must start speaking before a sentence or even clause has ended, in order to keep up with the input. No wonder the International Association of Conference Interpreters (AIIC), when negotiating working conditions with some of the major employers of interpreters (e.g., the European Union and the United Nations) stipulated not only that conference interpreters need working-space with good ventilation and reasonable temperature and allowing direct visual contact with the speakers, but also that they work no more than six hours a day, alternating approximately 30 minutes at the microphone with 30-minute breaks during which a colleague takes over (Agreement 2007–2011 as ratified by AIIC and the Organizations, n.d.). Conference interpreters generally listen in a highly proficient second language and speak in their first language, so their comprehension in the non-first language must be excellent, and their production will be native.¹ A good number of conference interpreters work in both directions, which at first glance might seem to be not much harder than working only in one. In fact, however, interpreters develop strategies at macro and micro levels to deal with the challenges in interpreting from a given language to another, and these strategies are not necessarily commutable. As a result, conference interpreters' proficiency levels in each language they work in must be quite high, and extensive practice with interpretation between the two languages in the direction or directions they will employ professionally is crucial. Indeed, interpreters report that only after approximately 10 years of post-training professional work do they feel they were at the peak of their performance.²

A part of what those years of developing expertise involves is setting up and automating a set of strategies for particular instances of challenging translation moments. On the one hand, there is rarely one-to-one correspondence of lexical items or idioms, or structures, between a given pair of languages; a lexical item or idiomatic usage in a given language may have more than one translation in another one, so the correct translation must be selected based on context. Structural and/or

Corresponding author:

Lorraine K. Obler, Program in Speech-Language-Hearing Sciences, City University of New York Graduate Center, 365 Fifth Ave., New York City, NY 10016, USA

Email: Lorraine.obler@gmail.com

word-order differences between languages can also pose particular difficulty, as Seeber & Kerzel (this issue; see also Seeber, forthcoming) points out in his experiment with conference interpreters working between German with its clause-final verbs in embedded clauses and English with its verbs positioned much earlier in the clause in comparable clauses.

Lack of one-to-one structural and lexical correspondence and not-quite-native proficiency are challenges to the cognitive system underpinning the language abilities stressed in simultaneous interpretation. It is these cognitive underpinnings of interpretation that form the foci of the articles in this issue. Most studied has been working memory (WM, e.g., Moser, 1978), covered here by Köpke and Signorelli, Tzou, Eslame, Chen, and Vaid, and by Signorelli, Haarmann, and Obler. Although different scholars use somewhat different operational definitions of working memory, it is generally understood to be that ability to hold material in mind 'verbatim' in order to 'work' with it as one processes sentences for comprehension and production. For example, if one is listening to a 'garden-path' sentence (A standard example is 'The horse raced past the barn fell'), one needs to be able to pull the beginning of the sentence out from WM to 'relisten' to it in order to correctly comprehend the sentence. In production, one must keep track of whether one has used a singular or plural noun if the verb is separated from it by some distance, so one can correctly have the verb agree in number. This is done via keeping verbatim records of recent speech in WM.

In the current set of articles, Köpke and Signorelli explore why some researchers have found differences in working memory capacity between conference interpreters and controls, while others have not, attributing it to different techniques of measuring and/or scoring WM as well as different populations selected. Most crucially, they conclude, interpreters perform better than non-interpreter controls on free-recall tasks of WM as compared to the more constrained serial-recall tasks. Tzou et al. also consider different types of WM, contrasting performance on lexical and digit span tasks. In addition, their study of student interpreters considers the contributions to interpreting quality of second language (L2) proficiency along with WM. They report no change in reading span WM performance between the first-year and second-year students, thus we may conclude either that WM is enhanced in the first year of simultaneous interpreting courses, or, more likely, that people selected for training have better WM abilities. Signorelli, Haarmann, and Obler report our results of a study of conference interpreter multilinguals carefully matched with control participants for the number of languages mastered. We distinguished phonological WM from semantic WM, via both standard measures of the two types of WM and a well-paired set of tasks differing only in the type of WM called upon that Haarmann had developed (Carter & Haarmann, 2001). Analogous to the Köpke and Signorelli conclusion, we report that interpreters outperformed non-interpreter multilinguals when free-recall was permitted (i.e., in the reading span task) and not when it was prohibited (e.g., in the phonological cued-recall task)

A second notion is important here, that of cognitive load. It overlaps to some extent with WM, since WM is understood to have a limited buffer; in studying cognitive load, however, the focus is on the varying types of materials interpreters may be asked to work with. Shlesinger (2003), for example, designed a clever experiment to stress WM. She did so by loading modificatory clauses with up to four adjectives and observing how interpreters compensated for the overload on WM by eliminating some. Naturally, they wanted to translate as fully and precisely as possible, according to conference interpreters' professional principles, yet their cognitive abilities were overloaded by the task. Liu, Schallert, and Carroll (2004) too set up a demanding Mandarin-to-English interpretation task for professional interpreters and beginning and advanced student interpreters. They concluded that the professionals outperformed the students on such interpretation tasks by successfully selecting the most important ideas. This, then, was the professionals' mode for dealing with cognitive overload. Seeber & Kerzel (this issue), as mentioned earlier, took advantage of the markedly different

word-orders of German and English dependent clauses to measure, via psychophysical changes in pupil size, the effect this has on the amount of cognitive load experience by simultaneous interpreters.

Other cognitive skills engaged by conference interpretation have been less studied. These include concentration (or ability to avoid distraction, but see Darò & Fabbro, 1994; Shlesinger, 2000) and the ability to monitor one's output while one is processing input. Such monitoring is necessary due to the lag between the input that one is processing for comprehension and the translated utterance one is speaking (because conference interpreting is not, strictly speaking, entirely 'simultaneous'). Thus one's attention is split between comprehending one set of words and speaking the translation of a just-prior set of words, and one must self-monitor to assure that the speech produced is correct in content, structure, and word-choice (see Moser, 1978; Moser-Mercer, 2010, for further elaboration on these processes).

Individual differences remain relatively understudied as well. For example, we do not yet know whether, when cognitive differences are evidenced between interpreters and non-interpreters, they arise because people who have the requisite abilities self-select into the field, or whether training and working in the field develop the cognitive skills along with the linguistic ones. A series of articles has compared expert interpreters to those in the early stages of training, sometimes finding differences and sometimes not (see Köpke and Signorelli, this issue, for references). However, there has been insufficient research into the abilities of those who have the language proficiency for entering training programs, but drop out during training or soon after. Anecdotal evidence from faculty who run training programs suggests there is no conclusive cognitive or proficiency test to determine who will become a good interpreter (e.g., J. Tommola and M. Sunnari, personal communication).

Nor have individual differences across the career trajectory been studied. One contributor to individual differences that has not been studied sufficiently is age. Moser-Mercer (2006) has observed differences in the ability to acquire interpretation skills between individuals who are in their twenties and those in their thirties. As well, a number of the professional interpreters interviewed in the AIIC Research Committee study (see note 2) reported changes later in their career consistent with the hypothesis that age-related cognitive changes interact with one's abilities to perform the extreme language task of conference interpreting. One interviewee reported continuing with what he felt was the more automatic task of conference interpreting after he no longer found he could do the consecutive interpretation task to the degree of excellence he expected of himself. Consecutive interpretation is less used today in the high-tech environments generally provided conference interpreters, but it is still often used by court, diplomatic, and healthcare interpreters. In consecutive interpretation, the speaker (ideally) speaks for a unit of several sentences then pauses while the interpreter, who has been taking notes in a type of symbolic shorthand, speaks the content in the target language. Here it is useful to distinguish WM and short-term memory (STM) in a way that neuropsychologists do. STM permits us to remember units of greater length than can be kept verbatim in WM (e.g., something we did 10 minutes ago). Thus one would posit that while both STM and WM are important in both kinds of interpretation, STM is more relied on in consecutive interpreting, while WM is more relied on in simultaneous interpretation.³ We infer that the interviewee felt he could not rely on his STM, even aided by note-taking, as much as he could on his WM. Such rare reports suggest the necessity for further research along the lines of that reported by Signorelli et al. in this special issue, looking at age and changing cognitive skills as a factor in conference interpreters' performance.

Furthermore, this interviewee reported limiting the jobs he agreed to take on, toward the end of his career, to topics he had worked on before, and individuals he had worked with before. It makes sense that conference interpreters regularly report that interpreting sessions on topics they are familiar with is easier than interpreting on unfamiliar topics. This is so even if they have the chance

to prepare by reading materials provided in advance by those hiring them and creating personal lists of technically appropriate lexical correspondences that they are likely to encounter. Such preparation gives interpreters a sense of the general context of what they will be interpreting, thus reducing some high-level comprehension demands so they can focus on the specific linguistic demands of the task while actually performing it.

This interviewee and others mentioned, too, that when possible, late in their careers, they limited the jobs they took on to speakers they are familiar with. This, too, could reduce on-line challenges. For example, in discussions with interpreters, a number have mentioned finding specific speakers' speech hard to interpret due to their speaking with an unfamiliar accent, or irritating vocal ties or voice qualities. Seeber (personal communication) mentions that some employ idiosyncratic discourse structure which can pose difficulties for interpretation. Limiting themselves to speakers they are familiar with, thus, would be similar to selecting to work only on topics they are familiar with, i.e., another way a number report dealing with the subtle cognitive challenges aging brings.

Of course the brain must underlie the cognitive abilities that subserve and interact with the language abilities required for simultaneous interpretation (see Moser-Mercer, 2010, for a review.) A set of laterality studies conducted on simultaneous interpreters in the late 1980s and early 1990s (e.g., Fabbro, Gran, Basso, & Bava, 1990; Fabbro, Gran, & Gran, 1991; Green, Nicholson, Vaid, White, & Steiner, 1990; Lambert, 1989; Petsche, Etlinger, & Filz, 1993) presented conflicting findings vis-a-vis whether there were any differences in lateral dominance for interpreters vs. non-interpreters. Such conflicting findings are similar to those in the literature of the 1970s studying lateral dominance in bilinguals more generally; when differences between groups obtained (and in a number of papers, no differences were seen between the two groups studied), they were in the direction of bilinguals evidencing more bilateral organization for language than matched monolinguals (Obler, Zatorre, Galloway, & Vaid, 1982). *Mutatis mutandis*, when differences obtain in studies of conference interpreters, they are in the direction of greater bilateral dominance for language in interpreters than in non-interpreter multilinguals; in a number of studies, however, no differences in lateral dominance are seen between these two groups.

More recently PET imaging technology was employed by Rinne et al. (2000) to study brain regions involved while professionals interpreted from L1 (Finnish) to L2 (English) and vice versa. Their results confirmed that interpretation into L2 calls on more extensive brain regions than interpretation into L1. Left frontal areas they link to 'lexical search, semantic processing and verbal working memory' showed particular activation during the tasks.

Only one study, to my knowledge, has used imaging techniques to study the effects of interpreter training on structural brain plasticity. Golestani et al. (2010) performed structural MRI imaging on 11 multilingual students in their twenties and thirties before, during and after their 15-month Master's degree training in interpretation. Volume in certain left-hemisphere cortical brain regions (supramarginal gyrus, rostral mid-frontal gyrus, and rostral anterior cingulate) distinguished the interpretation students from control multilinguals even before the program began and increased only in the interpreting student group. Others regions (left mid-temporal gyrus and left pars orbitalis) showed no difference at baseline, but then increased in size over the training period. The authors conclude that plasticity of brain volume is evident in the regions expected in young adults who underwent the intensive training for interpretation. As well, I note, we appear to have in this study – small though the sample is – an indication of differences between interpreters who opt for (and are selected for) training in the field and those who do (and are) not.

These hints of the brain underpinnings of conference interpretation provide signposts to the direction work on cognition in conference interpretation will take. We must be grateful to Signorelli and Seeber for editing the set of articles in this issue to give us a cutting-edge vision of the state of

the field. By doing so, they permit us to understand the cognitive factors implicated in this interesting, exceptional population of multilinguals whose professional lives consist in performing such extreme language tasks. These articles, then, stimulate us to think of further research that should be conducted on conference interpretation and conference interpreters to better understand bilingual sentence-processing and translation abilities.

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Notes

1. Rare cultures – the former Soviet Union among them – predominantly work the opposite way, into a highly proficient second language, thus ensuring native-like comprehension.
2. These comments were made in the course of a series of interviews in an AIIC-funded study of the career trajectory of well-respected senior interpreters who have retired or were approaching retirement that I undertook with members of the AIIC Research Committee headed by Barbara Moser-Mercer with Miriam Shlesinger, Ingrid Kurz, and Minhua Liu. As Moser-Mercer (2010) has observed, this decade of practice to achieve expertise is consistent with reports on development of expertise more generally, e.g., by Ericsson and Faivre (1988).
3. Of course we grant both WM and STM are necessary for both tasks. Study of their relative contributions is problematic due to the multiplicity of operational definitions of WM and STM, which some even use synonymously.

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