The neuroscience of simultaneous interpretation

Neuroimaging research shows how the brain responds and adapts to the complex mental training involved in interpreting

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The task of simultaneous interpretation is one of the most complex and demanding linguistic challenges that exist. Interpreters are required to appropriately manage and deploy their cognitive resources in order to be able to monitor an incoming speech stream, buffer it, extract the units of meaning, convert them into a form appropriate for expression in the target language, and monitor their own output simultaneously - all of this in real time.

In a bid to better understand how the process works, the task has historically been examined from various behavioral and, more specifically, psycholinguistic perspectives with the overall task broken down into component tasks so as to understand the cognitive processes involved. The attention of psycholinguists has been focused on component tasks such as auditory speech processing, phonetic disambiguation, word recognition, syntactic parsing, meaning assembly, articulatory suppression, syntactic and semantic anticipation, and many others.

As it has traditionally been assumed that interpreters, especially those working in the consecutive mode, have phenomenal memory skills, interpreters' bilingual and multilingual memory processes, such as encoding, rehearsal and retrieval have been explored in an attempt to explain their superior performance. Cognitive models of the interpreting process have been developed, most notably in the 1970s and 80s, to describe the temporal flow of simultaneous interpreting, to bring structure into the complexity of the process and to identify task overlap.

Patterns of brain activity

Our research has built on this knowledge base and has focused on complementing this level of analysis with data that can help to illuminate the relationships between interpreting and other cognitive tasks by looking at the patterns of brain activity that underlie simultaneous interpretation.

Until recently, very little was known about what the brain of a simultaneous interpreter is doing while on task. The first study to examine this was published in 2000 by a team of researchers based in Finland. J-O Rinne, J. Tommola, M. Laine, B.J. Krause, D. Schmidt, V. Kaasinen, M. Teräs, H. Sipilä, and M. Sunnari[1] employed a brain imaging technique called positron emission tomography (PET) to examine the neural bases of simultaneous interpretation. PET enables us to observe the brain's metabolic activity *in vivo*.

In their study, Rinne and colleagues asked eight experienced interpreters to simultaneously interpret auditorily presented speech, from both English into Finnish and Finnish into English. In order to be able to determine which brain responses were specifically due to the cognitive, multilingual components of interpreting and not just to the relatively more mechanical aspects of the task (hearing and articulating speech), they also recorded brain activity while participants simultaneously repeated speech, without converting it to a different language (shadowing).

They found that interpreting from English to Finnish (i.e. from a foreign to the native language) recruited, over and above those areas recruited by shadowing speech, a portion of the left inferior frontal gyrus involved in the retrieval and maintenance of semantic information, and in the supplementary motor area, which is involved in planning speech output.

When the interpreters were asked to interpret from Finnish into English (which they would not regularly do), two additional areas were found to be involved – the left inferior temporal lobe, which is related to word-finding and semantic processing, and the cerebellum, which is a structure associated with action-pattern storage and refinement.

A large-scale study of novice interpreters

Since then, although there has been an increasing amount of interest in interpretation as a cognitive task, with research groups in Leiden, Granada and Zurich investigating different aspects of interpreters' working memory and cerebral adaptations that occur in experienced interpreters, no new neuroimaging investigation of the task of interpreting itself had been published until publication of a large-scale study of novice interpreters earlier this year, carried out by our team in Geneva [2].

We chose to investigate the cerebral processes that occur in novice rather than professional interpreters, since this allowed us to better identify the neural resources that are engaged when the task is not yet automatized, as might be relatively more the case in experts. With the benefit of a large sample size, we were able to obtain a clear view of those structures that are recruited when interpreters are asked to simultaneously interpret speech into their native language, without the benefit of years of training. This experiment was intended to reveal the brain networks responsible for what we characterize as "extreme language control".

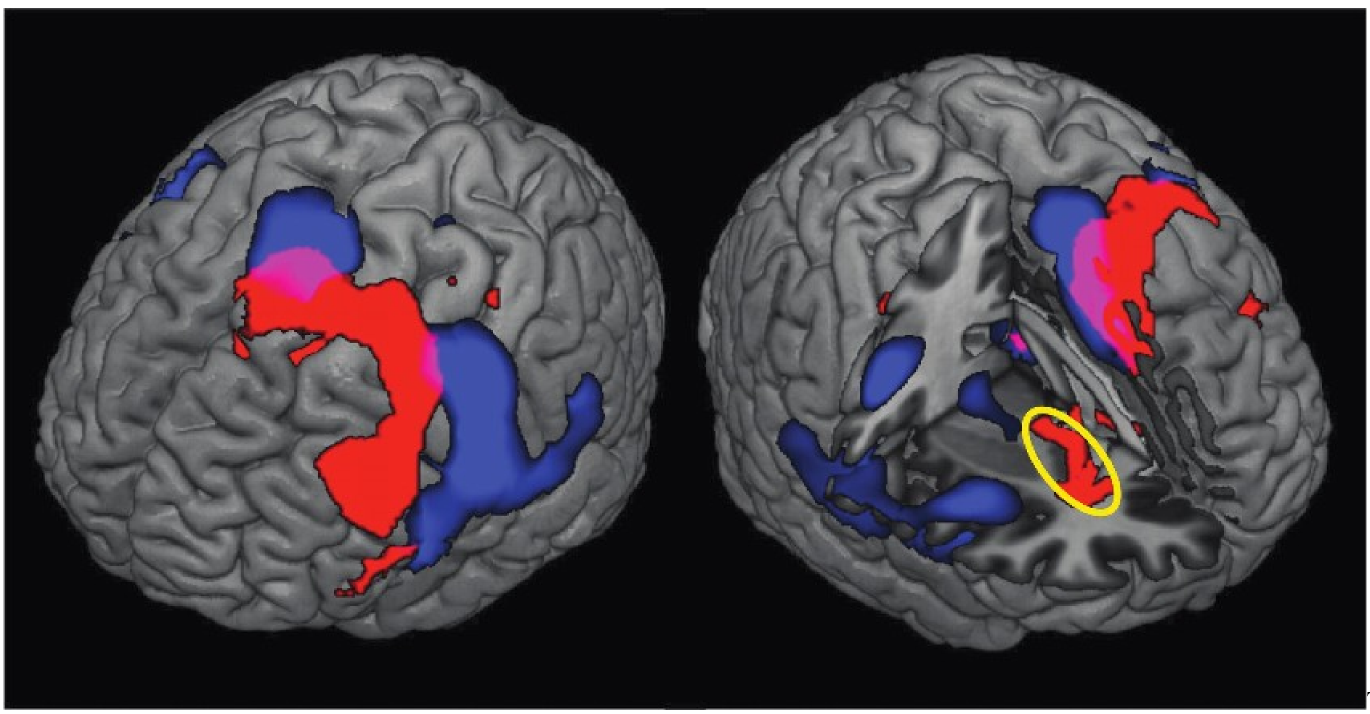
We used functional magnetic resonance imaging, (fMRI) which, like PET enables us to see relative levels of brain activation during task performance. Similarly to Rinne and colleagues we asked participants to both shadow and interpret speech.

The basal ganglia

We discovered that simultaneous interpretation recruits a broad swathe of brain areas; in addition to structures that are well-known to be involved in speech perception, comprehension and production, we also found activity in the basal ganglia. The basal ganglia are subcortical structures that form part of what has sometimes been referred to as "the reptilian brain". This nickname hardly does credit to the complexity and importance of these nuclei for our behaviour.

They are, it is true, structures that are extremely well conserved across many animal species, including those we tend not to consider to be especially complex, from the smallest of rodents to the scaliest of lizards. But this should not distract us from the fact that they are of paramount importance to our survival; these are the structures that form the basis of our ability to select, plan, learn and execute actions. Indeed, disorders of the basal ganglia are responsible for Tourette's syndrome and Parkinson's disease.

But their importance goes well beyond motor functions - they have been found to play a significant role in higher cognitive functions such as motivation and decision-making. Motivation is an integral part of skill acquisition, including the development of skills as challenging as interpretation. Indeed, interpreting requires extremely rapid decision-making since the speaker paces the interpreter, who she/he has no control over the speed of the incoming message.



This figure illustrates the regions of significant cerebral activation elicited by simultaneous interpretation. Regions in blue are those that are equally involved in shadowing and simultaneous interpretation, regions in red are recruited specifically by simultaneous interpretation. These include regions of motor, premotor and supplementary motor cortices, alongside part of Broca's region and portions of the basal ganglia. The right caudate nucleus (it has a homologue in the left hemisphere) is circled in yellow on the right panel.

Cerebral adaptations

Some of our participants subsequently went on to study for a master's degree in conference interpretation. This gave us the opportunity to examine how the brain adapts as a result of extensive and focused training in this discipline. By looking at how their brains responded when performing the same task after the end of their formal training, we were able to see that there was one brain region in which there was a consistent modification of response during interpreting.

In this region, we observed a decrease in activity compared to the pre-training results. We established that this effect did not occur in a control group of participants, whom we scanned at the same interval, but who were engaged in diverse postgraduate studies outside of translation or interpreting, and thus that it is likely to be caused by the acquisition of expertise in interpreting. And what was this brain region? It was the right caudate nucleus, a structure in the basal ganglia, right at the core of the brain, at the centre of our behavioural and cognitive control networks (Hervais-Adelman, Moser-Mercer, & Golestani, 2015)[3].

Simultaneous interpretation is, quite rightly, described as a highly complex cognitive task, and research emphasis has mostly been on the higher-level, not to say "intellectual" aspects of the task, such as linguistic skill, general knowledge and the ability to anticipate. What is most remarkable about our findings is that they provide evidence for the engagement of additional brain mechanisms that underlie another core requirement of the task. Namely, the subcortical involvement that we observe likely underlies the language management and control aspects of interpretation. Indeed, successful interpretation requires an extreme degree of control over lexico-semantic systems in order to juggle comprehension and message extraction in the source language alongside reformulation into a syntactically-valid and semantically-appropriate form in the target language.

So, then, how does the brain deal with this incredibly complex and demanding task? Not by a more intensive use of structures having primarily, or even generally, linguistic roles, but rather by recruitment of resources that are crucial for the management of cerebral and bodily resources.

The implications of this extend well beyond the framework of simultaneous interpretation. As we have already said, these structures are at the core of human behavior, being instrumental in the execution and control of movement, as well as learning, memory and motivation.

The "bilingual advantage"

This becomes particularly intriguing when we consider a phenomenon that has recently garnered considerable interest from researchers and the media – the so-called "bilingual advantage".

When we talk about the bilingual advantage, we are primarily describing the fact that multilingual individuals have repeatedly been shown to have superior cognitive skills compared to their monolingual counterparts. This advantage is not uncontroversial, and the existence of this effect is much debated.

Nevertheless, the current weight of evidence points towards the existence of such an advantage on tasks requiring inhibitory control (e.g. stopping an already initiated or a highly automatized action), and on switching between tasks. There are also strong suggestions that lifelong bilingualism produces a cognitive reserve that is tapped when the brain suffers neurological insult, and that it can protect against the onset of symptoms of dementia, delaying them for several years.

Of profound interest to us is that many of the brain regions we find to be involved in simultaneous interpretation are known to underlie tasks that bilinguals perform better than monolinguals. More specifically, other researchers have shown that switching between languages involves some of these very brain regions, leading us to suspect that regularly exercising control over multiple languages (as is done on a daily basis by bilinguals, and more intensively by simultaneous interpreters) could tune these core brain networks, causing them to become more efficient. Some investigators have indeed reported that simultaneous interpreters display enhanced working memory and cognitive flexibility compared to multilingual non-interpreters.

While we are yet far from being able to recommend the exercise of simultaneous interpretation as a means of enhancing cognition or staving off the effects of cognitive aging, our ongoing research aims to examine the potential benefits of developing expertise in this discipline.

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Notes

[1] Rinne, J. O., Tommola, J., Laine, M., Krause, B. J., Schmidt, D., Kaasinen, V., . . . Sunnari, M. (2000). The translating brain: cerebral activation patterns during simultaneous interpreting. *Neurosci Lett, 294*(2), 85-88. doi: 10.1016/S0304-3940(00)01540-8

[2] Hervais-Adelman, A., Moser-Mercer, B., Michel, C. M., & Golestani, N. (2015). fMRI of Simultaneous Interpretation Reveals the Neural Basis of Extreme Language Control. *Cereb Cortex*. doi: 10.1093/cercor/bhu158

[3] Hervais-Adelman, A., Moser-Mercer, B., & Golestani, N. (2015). Brain functional plasticity associated with the emergence of expertise in extreme language control. Neuroimage, 114, 264-274. doi:10.1016/j.neuroimage.2015.03.072

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