Cognitive research for conference interpreters : making the latest findings accessible and relevant to student interpreters

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COGNITIVE RESEARCH FOR CONFERENCE INTERPRETERS: MAKING THE LATEST FINDINGS ACCESSIBLE AND RELEVANT TO STUDENT INTERPRETERS

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Abstract

Ce mémoire a pour objet d'étudier les contributions les plus récentes dans le domaine des sciences cognitives sur le sujet de l'attention et de la concentration. L'objectif des auteurs est de rendre plus accessibles des travaux qui sont susceptibles d'aider des étudiants en interprétation de conférence ou des interprètes actifs à mieux comprendre les mécanismes qui sous-tendent les fonctions cognitives pendant l'interprétation simultanée. Ces mécanismes sont encore trop souvent mal compris ou mal interprétés alors que pour les étudiants interprètes et les interprètes ils sont un des facteurs clés de leur réussite professionnelle. Les auteurs de cette contribution passent d'abord en revue les principales théories relatives à l'interprétation, ensuite ils présentent les bases de l'approche cognitive. La mémoire et l'attention, des fonctions intégrales, sont analysées en détail en lien avec l'interprétation de conférence.

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Introduction

Simultaneous interpreting (SI) involves listening to input in a source language, analysing and comprehending it and producing the equivalent output in a target language. While outsiders often show curiosity towards SI they lack knowledge of the many aspects involved in this activity. The authors' own experience has revealed that the general take on SI is often limited to the perceived difficulty of the task, yet the few who venture to be more curious may be rewarded with an insight into the complexity of SI. Meanwhile, the interpreter or student interpreter trying to comprehend the processes involved in SI finds this task rather challenging. Making novice student interpreters aware of the multiplicity of tasks involved in their future profession should be amongst the key objectives of training courses.

At present, most practising conference interpreters have been through a formal training period. However, some seem to lack theoretical knowledge about the activity and mainly focus on the practical aspects. Similarly, student interpreters are generally wary of the theoretical issues related to their training and sometimes cast doubts on the relevance of theoretical courses during their training. The explicit aim of this contribution is to challenge this view by showing how theoretical insights into some of the mechanisms of SI can give student and professional interpreters a better understanding of the mechanisms of SI. This knowledge may help professionals to become more aware of their practice and thereby attain a better level of performance in a shorter term.

Furthermore, it is believed that a better scientific understanding of some of the key aspects of the practice, such as attention mechanisms, could have significant repercussions on how student interpreters are trained, which is undoubtedly important for both trainers and trainees. Fortunately, courses on the theory of interpretation play a key part in students' training. This is why the latest scientific findings should be incorporated on subjects that are relevant to the practice of this profession. Sustaining this effort, to quote Viaggio, a practitioner rather then a scholar, in a contribution about research in SI, will help the profession "to come of age" by giving it a scientific definition and studying its objective. It needs to travel "the same distance from experience to awareness as other professions and fully establish and articulate the three indispensable basic components: research of the phenomenon, theoretical grounding of the discipline and practice of the activity" (Viaggio, 1996: page 82).

The authors of the present contribution have observed that theoretical courses taught to conference interpreting students are considered challenging and difficult by students themselves due to a lack of scientific and, in particular, cognitive background knowledge. At the same time student interpreters' interest in research might be heightened when they become aware of the implications of this knowledge for their own practice; they want to know the practical aspect of it. Therefore theoretical knowledge should be imparted in a way that encourages students to reflect on the challenges they face and the best ways to overcome them. One of these challenges, and possibly the most crucial one, is the issue of attention or concentration as it is commonly referred to. We observed that students and professionals alike understand the paramount importance of "good concentration" (Moser-Mercer, 2007), even though few manage to grasp the underlying mechanisms of it. It is a shared awareness and concern that led the authors of this contribution to explore the latest findings on attention related research and to relate them in a way that is easily accessible.

In the present paper the knowledge, concepts and models that are taught in theoretical classes at ETI have been brought together, and further contributions that could be seen as complementary to the former will be explored. It is believed that the information and ideas presented here will help with understanding SI-related scientific discourse, some of which stems from cognitive sciences. This paper may also be of help for those trying to determine a topic for their MA thesis or even serve as initial reading for prospective PhD students looking for directions for their PhD project.

The definition of SI provided in the first paragraph is useful, to a certain extent, in understanding the overall process. It fails however to depict the intricacy of the activity and the reasons why it is such a cognitive challenge. Some SI researchers made significant contributions to the field by putting forward the interpreting models that will be discussed in this contribution.

SI-related studies reached out to many fields of research such as neurophysiology, neurobiology, psychology and cognitive science. The origins of cognitive science will be presented as well as the reasons why they are relevant to interpreting studies.

Attention is probably one of the most popular areas of study for cognitive scientists. The notion of attention needs to be further explored. Giving this notion a clear definition is one of the starting points of the present study. It is believed that clarifying a notion that is often ambiguous or put to wrong use could in itself be of interest.

The objective of this contribution is not to give practical advice to student interpreters. However, one may assume that the present theoretical review will inspire new MA theses intended to create a training module on cognitive sciences' contribution to SI studies, or to elaborate practical techniques to improve cognitive skills that are necessary in SI. It is hoped that in future, conference interpreters or trainees anxious about concentration or memory issues will be given clear-cut guidelines and instructions helping them to enhance the necessary skills in the most efficient way. This is the ultimate goal that inspired the co-authors of this paper.

1. Background

1.1. Approaches in Interpreting Studies.

Before discussing developments of interpreting studies a few comments should be made regarding the methodology of interpretation-related studies.

Scientific approaches to simultaneous interpreting (SI) are numerous due to the complex nature of SI itself. Depending on researchers' main interest, the study may focus on various objects of observation. Practising conference interpreter Viaggio (1996) gives the following list of possibilities: a) SI as a product; b) SI as a function; c) SI as a process; d) The interpreter himself as an object of observation; e) Various objective constraints that affect the interpreter's performance.

At the same time SI may be studied from different angles: a) SI as a natural and social object. Social interactions between all participants of the process are taken into account; b) SI as a linguistic activity. All possible linguistic aspects of SI are discussed under this approach. Given that numerous disciplines study language processing, this approach eventually requires input from different fields, such as general theory of language, psycholinguistics, neurophysiology, general linguistics etc.; c) SI as an analysis of the text, that is, the search for a unit of interpretation; d) SI as inter-lingual mediation. How is the message conveyed into another language? e) SI as a mental and physical activity. This approach will include describing interpreters from different points of view (cognitive, emotional and neurophysiological profile, intellectual capacities, rhetorical ability, physical endurance etc.); f) SI as a mentally and physically taxing activity: working conditions, coping with physical, mental and emotional stress.

From the above list it can be seen that, in theory, interpreting studies may focus on any aspect of interpreters' professional and everyday life, from morning exercise and diet, to what's going on in their head while interpreting, to relaxation techniques and social patterns of their behaviour, etc. Some of these topics may lack scientific rigor while others need a very academic approach to yield any result.

Over recent decades the cognitive approach opened new horizons for researchers and boosted our comprehension of processes involved in SI. Today one may state that many of new interpreting studies are underpinned by this approach and that it is the cognitive take on SI that will prevail in the future (Moser-Mercer, 2000/02; Gile, 1997; Setton, 2003). The next section is an attempt at explaining the cognitive approach, its objects and the kind of issues that it can resolve.

1.2. Cognitive psychology.

Cognitive psychology deals with how people collect information from the world, how such information is represented and transformed into knowledge, how it is stored and how that knowledge is used to direct our attention and behaviour (Solso, 1979).

Here are some of the essential problems of representational knowledge – how ideas, events, things, are stored and schematised in the mind: 1) What are the "internal representations" or "codes"? 2) How is knowledge acquired, stored, transformed and used? 3) What is the nature of perception and memory? 4) What is thought? 5) How do all these abilities develop?

These issues are considered within eight principal research areas of modern cognitive psychology: perception, attention, memory, imagery, language functions, developmental psychology, thinking and problem solving and artificial intelligence.

In the 1950s and 1960s, when computers began to be available and Chomsky's transformational generative grammar provided a rich source of ideas for scientists, traditional borders among disciplines started to come down (Medin et al., 2001). As a result philosophy, linguistics, artificial intelligence, cognitive psychology, anthropology and neuroscience formalised their common interests under the banner of cognitive science (ibid.).

Cognitive studies are often viewed from an information processing standpoint, whereby the information is processed through a series of identifiable stages, each of which perform a unique function and then passes information on to another stage for further processing (Solso, 1979). Such notions are usually represented as models (see next chapter).

Thus, models of cognitive processes play an important role in contemporary cognitive psychology. Nevertheless, it should be kept in mind that models are used as metaphors, which does not reduce their relevance to cognitive studies.

1.3. Modelling in Interpreting Studies.

A crucial stage of any conceptual science, including cognitive science, is modelling. Models of nature, including cognitive models, are abstract organisational ideas derived from inferences based on observations (Solso, 1979). Models are used as metaphors. A model can be described as a representation, usually in symbolic entities and relations, of a process people seek to understand. The properties of the entities and conditions for their action can be specified. Models can serve as a research tool, a graphic aid which may help to see the implications of a theory, draw new inferences and make new hypotheses. Like a theory, models reflect a set of interrelated hypotheses, and as a step in the research process, are destined to be tested and eventually superseded (Setton, 2003).

There are several ways to test the theory that a model tries to illustrate. Models usually start from intuition and are developed by means of deduction and induction. Empirical observation later on can reveal shortcomings in the model. As a result the model is falsified by new contrary evidence and researchers try to come up with a new model that accounts for the new facts and findings. This may result in putting forth a new model and the cycle will repeat itself.

New technologies and revolutionising ways of seeing things can give a sudden boost to this process. In the brief history of SI studies, the breakthroughs were linked to the birth of cognitive science and to the advent of new technologies such as brain imaging techniques and high-resolution methods (electroencephalography, functional magnetic resonance imaging and others) (for the references see: Medin et al., 2001).

There are several SI models that a researcher can find in scientific literature. A simple hypothetical model of SI could be considered to help explain the meaning of modelling. As an act of communication, SI involves three actors: the sender of the message, the interpreter and the receiver of the message. SI may be subdivided in two sub-acts. Firstly, the sender conveys the message to the interpreter; the interpreter plays the role of the receiver. Secondly, the interpreter sends the message in the language of a receiver; the interpreter then plays the role of a sender.

This simple model may be useful in describing social interactions between the three participants of the process. However, it does not imply that both processes – when the interpreter receives and conveys the message – take place simultaneously. In sociological studies this information may not always be relevant. On the other hand this simultaneity is one of the most important features of SI. In this case the relevant research model will inevitably take account of the fact that the interpreter is speaking and listening at the same time. Nevertheless, SI can still be considered as a two-fold process.

All changes when the study focuses on *what* is going on inside his or her head (processes, mechanisms and so on). From this moment onwards, the model must include a mechanism dealing with information processing that is being performed by the interpreter. It is clear that mechanisms of language perception and generation, message decoding and encoding, cognitive mechanisms of memory etc. will be an important consideration in cognitive studies. However, this information will be irrelevant in sociological or purely linguistic studies of SI merely because those fields of research are not concerned with cognitive aspects of SI. This example shows that different models are not necessarily mutually exclusive. Sometimes they approach the same process or phenomena from different angles and aid solving specific problems according to the purpose of study.

Table 1 summarises main SI models relevant to the present study. These models will be discussed in the next chapter.

Table 1. Main models of simultaneous interpreting (relevant to this study)

Author	Year	Main focus
Gerver	1976	Psycholinguistics, information-processing approach
Moser	1978	Psycholinguistics, information-processing approach
Chernov	1978	Psycholinguistics, anticipation
Shiryaev	1979	Psycholinguistics, activity theory approach
Lederer	1981	*Theorie du* sens, SI as an act communication
Gile	1991	Cognitive approach, local cognitive load
Daro and Fabbro	1994	Cognitive approach, language processing
Setton	1999	Cognitive and pragmatic approach

1.4. Early Interpreting Studies.

The term *interpreting studies* was coined as recently as 1993, though researchers have shown an interest in the discipline before that (Salevsky cited in Pöchhacker, 2002).

Interpreting studies are a fairly recent field of research simply because modern day simultaneous interpreting itself only dates back to the 1920s-1930s and the systematic use of this practice only took off after the Second World War (Chernov, 2004). Herbert and Rozan, conference interpreters and teachers at the ETI, are considered pioneers in interpreting studies with their ground-breaking manuals published in the 1950s (Rozan, 1956; Herbert, 1965). Though both works still remain faithful companions to the student interpreters they cannot be considered academic studies *sensu stricto* (Rozan, 1956).

The first such study was published in 1957 by Eva Paneth in her master's thesis on conference interpretation (Paneth, 1957). The theoretical scope, focused on training for future conference interpreters and its constraints, remained modest and it was mainly based on empirical data, such as length of pauses, and observations made during interpreting. However, a new field of science was born.

In the 1960s Pierre Oleron and Herbert Nanpon started to broaden the perspectives of interpreting studies by using a more systematic approach. The measurements however were strictly quantitative (namely time delays in SI) (Oléron & Nanpon, 1965).

David Gerver soon made up for this shortcoming by introducing qualitative criteria (Gerver, 1974, 1976). As it happens, Gerver would then try to build bridges between interpreting studies and associated disciplines by organising a symposium on interpretation in 1978 together with H. Wallace Sinaiko. Further contributions remain rather scarce in the 1960s and can be summed up by the introduction of ear voice span, that is, the lag between the message and its interpretation, studies by Frieda Goldman-Eisler in 1967 and the exploration by Ghelly Chernov of coping strategies for interpreters (Chernov, 2004).

1.5. Interpreting studies from the 1970s to the 1990s.

The 1970s and to some extent the 1980s are characterised by significant advances in research. The interpretive theory of translation put forward by Seleskovitch becomes an incontrovertible postulate and shapes the thinking of a whole generation of researchers. This theory sees interpreting as a means of communication. That is, it focuses on sheer transmission of messages. The whole cognitive process of interpreting thus consists of perception, comprehension, deverbalization, reproduction of the speaker's intended meaning; with deverbalization as the most critical stage of information processing. Based on this understanding, a triangular model of the interpreting process was proposed along with the hypothesis of deverbalization. However, this theory does not provide a detailed explanation of how messages get to lose their linguistic form and are stored and then retrieved. For this school of thought, studies can only take place in an actual interpreting environment, thus rendering the experimental approach irrelevant.

In parallel the 1970s and 1980s are also characterised by the emergence of a series of models that consider SI as a process (see Table 1). Some of these models are still relevant today. Development of the information-processing approach has given rise to the so called information processing models of SI, the first of which was formulated by Gerver (1976) followed by Moser (1978). Both models are linear and examine the sequence of activities involved in understanding a message in one language whilst producing the same message in a different language. As stated by Moser, both models need not conflict with each other and might rather be complementary (Moser-Mercer, 2002). It is interesting to note that both approaches already draw upon developments in domains of cognitive science, such as generative semantics in the case of Moser and attention in the case of Gerver.

Subsequent models elaborated in the 1980s and 1990s followed this trend. For example, Lambert's depth-of-processing model draws a correlation between depth of processing, that is, the depth of analysis, and memorisation (Pöchhacker, Shlesinger, 2002). Dillinger's model (1994) focused on comprehension and is another case in point (discussed in Gile, 1998). The seminal effort models advanced by Gile for the first time in 1983 and subsequently improved, constitute a milestone. These models, or frameworks as Gile calls them, are simple and accessible and are often cited when mechanisms of SI are being discussed. In the next section Gile's frameworks will be explained in more detail.

1.6. Gile’s Effort Models.

A simple interpreting model is needed in order to understand the issue of attention and cognitive control applied to each of the different stages of the interpreting process in this study. For this purpose, the pre-eminence of one of the most popular simultaneous interpreting models should be underlined: Gile's so-called e*ffort model* of SI (Gile, 1983). Gile proposed a cognitive framework that helps to explain mistakes during interpreting and to understand why some speeches (or parts of them) seem to be harder to interpret.

In the early 1980s, cognitive constraints to simultaneous interpreting were formally depicted in Gile’s effort model (Gile, 1983, 2008). According to this model, or “framework” as the author prefers us to refer to it, SI consists of four e*fforts* devoted to different parts of the process.

- ‘Listening Effort’ (or ‘Listening and Analysis Efforts’) are the online operations that are mobilized in order to comprehend the source speech.
- ‘Production Effort’ are the online operations that lead to producing the speech in the target language. Here we can also mention efforts spared for self-monitoring and self-control.
- ‘Memory Effort’ are the online operations that manage the storage and retrieval of the information related to speech in short term memory. (This concept might correspond to working memory models in cognitive psychology, described later in this paper)
- ‘Coordination Effort’ which aims at managing attention allocation and switching among the three core Efforts. This concept is close to the so called ‘Central Executive’ in Baddeley and Hitch’s Working Memory Model (Baddeley and Hitch 1974) discussed in the following chapters.

Given that there is a definite and limited amount of processing capacity that is being distributed among the efforts during the interpreting process, Gile assumes that interpreters usually work at a level close to saturation and have to reallocate quickly the capacity depending on the instant needs (*Tightrope Hypothesis*). If, for example, the speech requires more efforts to comprehend the source (listening and analysis effort), then other efforts will have to spare some extra amount of processing capacity for the listening effort and reduce the amount of cognitive resources available for them.

This kind of analysis is applicable both on a local level (within a sentence or within a clause of the sentence) and on the level of the whole speech. If local difficulties are taken into consideration, then redistribution of cognitive efforts might lead to omissions and mistakes in interpreting the sentences following the one that requires more efforts. In a recent article Gile (2008) calls the phenomenon that underpins these kind of mistakes 'imported cognitive load' and illustrates it with the following example from an extract from Barack Obama's speech in Berlin in July 24, 2008:

"Sixty years ago, the planes that flew over Berlin did not drop bombs; instead they delivered food, and coal, and candy to grateful children. And in that show of solidarity, those pilots won more than a military victory."

Whilst interpreting this speech, it is easy, according to Gile, to anticipate the word 'food' after 'bombs' in the first sentence. On the other hand, words 'coal' and 'candy' may seem a little bit out of place (Gile, 2008). It means that by the end of the first sentence, most of interpreter's cognitive resources will be allotted to the listening effort. On the other hand, the other efforts will be given less resources than they usually need. While the interpreter is striving to comprehend the first sentence, the second sentence has already started. Even if the interpreter could grasp the first sentence and render it in the target language, the cognitive resource deficit generated during interpreting of the first sentence will be passing on to the second one. The listening effort will lack resources when the interpreter hears the speaker pronouncing the second sentence because the interpreter's efforts will be called in to finish the first sentence (production effort). The *current load* connected with the second sentence will thus be heavier due to the *imported load* that was left after the first sentence.

Sometimes, however, the context can make it easier to understand the next sentence. When less efforts are needed for listening, more capacity can be devoted to the production and memory effort.

The consequences of this analysis are the following: if a string of sentences is very dense with information, the processing of previous sentences will add to the current load and the interpreter will be working close to saturation most of the time. Interpreters tend to make more mistakes when interpreting such speeches.

The same problem can happen when the crucial information is unequally distributed within each sentence or when the sentences are very long. It can also be connected to language-specific difficulties (when, for example, the interpreter has to rearrange the sentence structure in the target language such as between German or Oriental languages and English). However, most speakers use intentional and unintentional pauses in their speeches. Pauses between sentences can be very helpful for interpreters as they allow interpreters to finish previous sentences during pauses. Understanding of context is also of help as it increases interpreter's ability to anticipate. Indeed, when the interpreter is aware of the subject and issues of the discourse he or she feels more comfortable dealing with it and can in some cases predict its developments.

Another important source of mistakes, according to Gile's framework, is suboptimal attention management. Inability to recognise a difficult passage or giving too much attention to the least important passages – these and other difficulties may lead to inadequate cognitive resources distribution among the efforts. A closer look at attention management will be given in the following chapters.

In this regard, it is interesting to look at trainee interpreters. Listening efforts, memory efforts or production efforts are not necessarily causing problems as such. The problems arise when the trainee has to learn to juggle all three efforts at the same time – simultaneously. Here the fourth effort introduced by Gile– coordination effort – comes into the spotlight. With practice and experience, the coordination effort mechanism seems to become more efficient and cognitive efforts management tends to improve.

One might support the claim that training simultaneous interpreters can in fact be narrowed down to training their coordination effort mechanism. The possible implementations of this idea will be scrutinised under the following chapters as attention and cognitive control are discussed.

2. Memory and Simultaneous Interpreting

From the very onset of scientific interest in human memory there was a subdivision of memory into “primary” and “secondary” compartments (James, 1890, cited by Cowen, 2000/01). Whilst “primary memory” is characterised by the limited amount of information that can be placed in it, “secondary memory” represents the vast life-long storage containing all sorts of information.

In the 1950s, a new era began for understanding human memory when the concept of primary memory was placed back in the spotlight thanks to a famous article by Miller (1956).

2.1. Miller's “seven plus-minus two”.

In his eminent article, Miller approaches the problem of limits on the information processing capacity from the point of view of communication theory (Miller, 1956).

Using experiments based on absolute judgement dealing with various modalities (sight, hearing, tactition, taste) he maintains that there is a valid channel capacity (i.e. a maximum capacity) for processing information that is close to the magical number 7, plus or minus two. In other words the human brain is able to distinguish (that is, to perform an absolute judgement task without mistakes) among 7, plus or minus two, stimuli of the same kind that differ one from another in only one of their features (loudness, pitch, spatial position etc.).

At the same time, our everyday life experience implies that we are able to discriminate among a much wider range of stimuli. Miller suggests that in this case one deals with multi-dimensional stimuli, contrary to those used in single-dimensional absolute judgement experiments. In real life, we deal with stimuli that differ one from another in many ways or dimensions: size, position, tone, pitch, concentration or any other measurable parameters.

According to the explanation put forward by Miller, when other dimensions, that is, distinctive features, are added to a stimulus our capacity for processing information increases by a certain factor. Thus, using the example of human speech, which can be described by means of 8-10 dimensions such as vowels vs. consonants or nasal vs. oral sounds, it is possible to discriminate among more than 150 stimuli. That is, describing stimuli by 8-10 parameters (or dimensions) we get closer to the order of numbers of stimuli that we can discriminate in real life.

The author argues that there are three ways to get around the rigid span of absolute judgement, that is, discrimination between stimuli. Firstly, it is possible to rely on relative judgement rather than absolute judgement. Secondly, the number of dimensions on which judgements are based can be increased, (relying on more than one parameter). Thirdly, a sequence of several absolute judgements can be performed so that instead of only one operation, a series of operations can be performed, resulting in successful discrimination.

As far as the third option is concerned, one has to take into account our memory capacity as we have to remember the results of several absolute judgements. Miller eloquently writes about it: "Memory as the handmaiden of discrimination" (Miller, 1956. p.91). This way of reasoning is a good example of interconnection between different cognitive functions. It is also noted that in cognition there are no borders between different functions (receiving, processing, storing etc.), everything is interdependent and closely connected.

Miller coined two notions. The first one, *bits of information,* is a constant for absolute judgment; whereas the second one, *chunks of information,* is a constant for immediate memory. That is, *bits* of information are the number of stimuli that we can distinguish with confidence and *chunks* of information is the number of items that can be placed and retained in our immediate memory (Miller, 1956).

Miller then came up with the concept of *recoding*. Recoding allows us to increase the number of bits per chunk of information, thus significantly increasing our capacity for discriminating stimuli and for processing information. He gives the following example: when a student starts to learn radio-telegraphic code he or she can only distinguish dots (.) and dashes (–). Later, the student will learn to see real letters behind the combinations of dots and dashes (first recoding) and even whole words (second recoding). Eventually the student will learn to process those dots and dashes as whole meaningful phrases. At the same time the amount of remembered message is increasing while the capacity itself does not increase.

Another example can illustrate this idea in the context of conference interpreting. The interpreter working for the World Health Organisation, in a conference, comes across a phrase never heard before: "WHO's Global Pandemic Influenza Action Plan to Increase Vaccine Supply". Initially, he will tend to struggle when interpreting this phrase word-by-word (splitting it into several chunks). However, as this phrase is a term that is commonly used in the context of WHO, eventually the interpreter will learn to produce the corresponding translation in his or her target language (by processing the whole phrase as only one chunk of information) or even with the corresponding acronym, if there is a need to catch up with the speaker.

In the same article, Miller then introduces some important ideas that might be interesting for further research of interpreting. Despite the natural limits, due to the nervous system design or due to learning, of our capacity to receive, process and remember information, there are mechanisms that allow us to overcome these limits by organising the stimulus input simultaneously into several dimensions and successively into a sequence of chunks. Furthermore, the process of recoding, in particular linguistic recoding plays an important role in it (Miller, 1956).

2.2. Multi-store model.

Miller introduced the idea of the limited amount of information that the human brain can process at one time, whereas Atkinson & Shiffrin (1969) proposed a structure for human memory that is based on the information-processing paradigm and supported by a mathematical model. Their insight followed the idea of subdivision of processes into several sub-processes. As a result, memory can be represented as a multi-store system consisting of sensory memory, short-term memory and long-term memory.

Sensory memory enables some basic peripheral storage of stimuli at the level of receptors. The traces in this memory die off within a second or so and its mechanisms do not involve the central nervous system.

Short-term memory has been shown to encode acoustic and visuo-spatial information. It is this memory that Miller characterised with the limited capacity estimated at seven plus minus two items. Without rehearsal of the information encoded in short-term memory its traces die off within approximately 15-30 seconds.

Long-term memory can store an unlimited amount of information for an extended period. The information stored in long-term memory subdivided into several categories:

a) Declarative information: facts and events.

b) Procedural information: how to do things.

In addition, Atkinson and Shiffrin pointed out the crucial role played by the control processes bringing information in and out of short-term memory. It strongly affected the succession of studies that was prompted and also linked memory studies with attention. This first multi-store model represented a milestone but was eventually superseded by newer models. Nevertheless, these newer models shared the same modular approach, that is, they regarded memory as a multi-store system.

Baddeley and Hitch, who studied primary memory in humans, popularised the term "working memory" after their first milestone publication (Baddeley & Hitch, 1974).

2.3. Working memory theory.

Baddeley and Hitch proposed their own model of working memory (Baddeley & Hitch, 1974). This model originally consisted of three components: the Phonological Loop, the Visuo-spatial Sketchpad, and the Central Executive.

The Phonological Loop deals with phonological information and consists, in turn, of 1) a short-term phonological store and 2) an articulatory rehearsal component. The first subunit is responsible for processing rapidly decaying auditory memory traces and the second subunit can keep the memory traces prominent. Their role is crucial in language processing (see below).

The Visuo-spatial Sketchpad deals with visual information. This component is used for the temporary storage of spatial information as well as for planning complex spatial movements (the spatial subunit), shapes, colours, speed of objects (the visual subunit).

The Central Executive is a flexible system that manages and regulates cognitive processes between the two 'slave-systems' (the Phonological Loop and the Visuo-Spatial Sketchpad). Baddeley and Hitch bestow four main functions upon the Central Executive: binding the information from a number of sources into coherent episodes; coordinating the 'slave-systems'; shifting between tasks and retrieval strategies; selective attention and inhibition.

Baddeley and Hitch elaborated *dual-task paradigm* experiments, according to which their subjects were asked to perform multiple tasks simultaneously. They found that performing two tasks requiring the use of two different perceptual modalities (a visual vs. a verbal task) was nearly as efficient as performing two tasks separately. This means that the load of information we can deal with in one perceptual domain (hearing) has almost no influence on the load of information that we process in another perceptual domain (sight) and vice versa.

One can reasonably assume that this aspect of the model can be worth considering with respect to teaching and exercising sight-translation and interpreting with text by interpreters. Practising interpreters disagree as to whether they should rely on hearing or on sight whilst interpreting with text. Indeed, two flows of information are dealt with during SI with text (through sight and through hearing). According to the model, written text and oral representation of the same speech should not interfere, at least at the level of working memory. However, it is not yet clear whether the two processes facilitate SI at the level of message generation in the target language. Given the growing volume of SI with text in international organisations, new research intended to answer this question will be needed.

Another interesting finding is that language input, when presented visually, can be transformed into phonological code by silent articulation and then be placed into the phonological store where its persistence is facilitated by the articulatory control process. The phonological store is thus an 'inner ear' remembering sounds in their temporal order, while the articulatory process is an 'inner voice' repeating the sound and speech elements on a loop and preventing them from decaying. These processes imply the important role the phonological loop has to play in vocabulary acquisition of a first language and in the learning of a second language.

In 2000 Baddeley added a third 'slave system' to the original model, the so-called *Episodic buffer*. This component presumably has to link information from different domains to form integrated units of visual, spatial and other types of information in chronological order. The episodic buffer is believed to play a crucial role in building a coherent representation of the outer world. It should also provide links to long-term memory and semantic meaning.

The introduction of the Episodic buffer in the model was intended to resolve contradictions and include sensory stimuli that do not fit phonological and visuo-spatial buffers. That is why this model is sometimes considered as consisting of four units rather than three.

2.4. Long-term working memory.

Considering the numerous tasks that one has to perform on a daily basis, an extensive use of complex memory skills is required. Many tasks require many more than seven chunks of information to be processed. For example, if our memory capacity was limited to only seven chunks, reading would not be possible as after a couple of sentences our memory would become saturated. Moreover, understanding of complex texts and relations between different ideas would not be possible either.

Ericsson and Kintsch argued that one is able to store most of the information relevant to the on-going process in long-term memory (Ericsson & Kintsch, 1995). Different chunks of this information are linked together through special retrieval structures. As a result, a person needs to hold only a few concepts in working memory that help to access all the data associated to these concepts. So the access to this data is underpinned by the concepts-cues and the retrieval mechanisms functioning according to these cues. This was termed “long-term working memory”.

Depending on the domain of expertise, retrieval structures may vary significantly. However, they can be categorised into three groups. Firstly, generic structures that correspond to Ericsson and Kintsch's classic retrieval structure (developed deliberately) that are active when we come across any new body of knowledge. Secondly, domain specific structures corresponding to elaborated memory structures (similar to schemas[1]) that we activate when dealing with familiar concepts and with knowledge from our domains of expertise. Thirdly, episodic text structures that appear only during text comprehension. The episodic text structures are believed to be formed by every reader when he is trying to comprehend a well-written text with a familiar content.

From this model's perspective, learning can be viewed as a process during which more retrieval structures are elaborated. Newer retrieval structures can be more complex; and an expert is someone who has elaborated the most sophisticated and – what is crucial – the most efficient retrieval structures. One may argue that learning from experts under this model is equivalent to acquiring more efficient retrieval structure. That is why acquiring of new skills under the guidance of experts tends to be faster and the transition of skills from a novice to a professional level is swift.

Cowan's model is discussed in the following chapter provides a promising bridge between memory and attention.

1 Structures that organise our knowledge

2.5. Cowan's Model

Information processing models have evolved quickly from the 1950s onwards. If Baddeley and Hitch are still known for having popularised the notion of working memory (Baddeley & Hitch, 1974), no work is more compelling for the purpose of this paper than that of Cowan. He puts the notion of focus of attention at the centre of his definition of working memory (Cowan, 2000, 2000/01, 2005).

Cowan draws upon previous research in order to bring the concept of working memory one step further. He defines working memory as the set of activated representations from long-term memory which are currently in the focus of attention. Long-term memory and short-term memory are thus not separate, they simply correspond to different levels of activation (Figure 1).

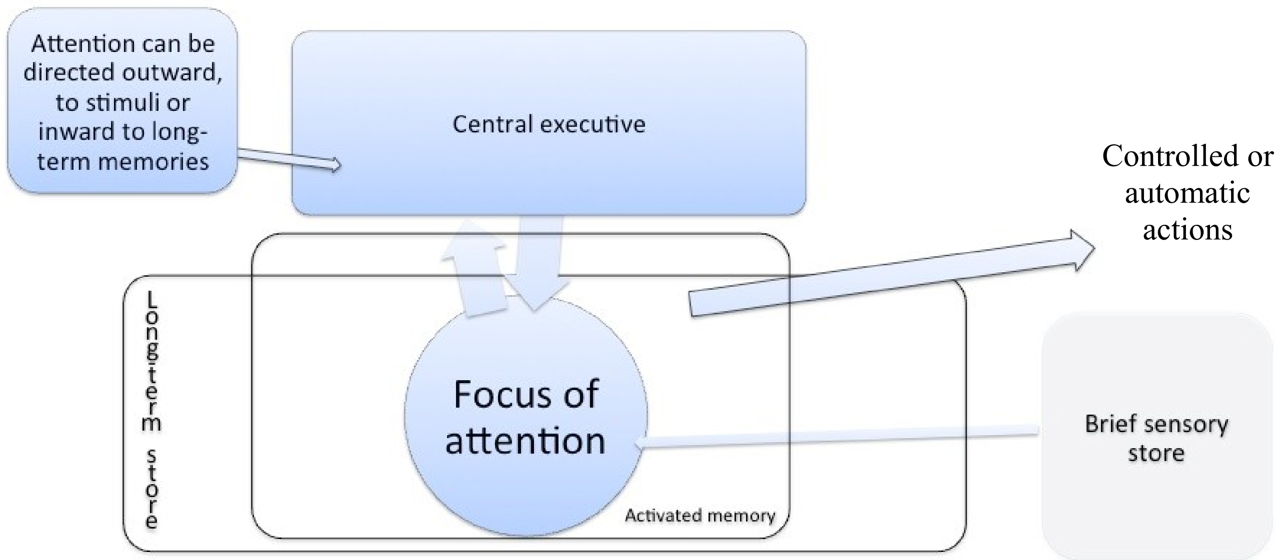

Figure 1: Information processing model adapted from Cowan.

For a more detailed illustration, please see: Cowan, 1988.

In short, working memory according to Cowan, consists of two levels: 1) Activated long-term memory representations, in other words activated memory or short-term store; 2) Focus of attention which is itself a subset of the activated memory.

It seems that there is no limit to the amount of activated long-term memory representations present in working memory. The limitations lie in the second element of working memory, the focus of attention. Researchers generally agree that the focus of attention is limited. However, what the exact limit is and how to define or measure it, is still subject to debate (Cowan 2000/01). Another stimulating aspect of the focus of attention, and probably the key aspect for this study, is that it is controlled both by voluntary and by involuntary processing. According to Cowan, focus control and focus capacity are two distinct limitations and vary from one individual to another (Cowan, 2005).

Ever since Miller's seminal article on the amount of chunks of information the human brain can retain at once (Miller, 1956), cognitive psychologists have endeavoured to explore the limits of the human brain in order to know what the human brain can and cannot achieve. Miller's publication has inspired several major studies, including those of Baddeley & Hitch (1974) and Cowan (2001). This way of interpreting and measuring limits to working memory capacity is not the only one, as Cowan himself acknowledges (Cowan et al., 2008).

This chunk capacity limit can best be compared to a limit in space. It's the amount of chunks that our working memory, considered here as a virtual space, can retain. The two other forms of limits to working memory representations identified by Cowan are limits in time and limits in energy. Information contained in our working memory tends to fade out after a certain time if not rehearsed or replaced by newer elements. This is also something that can be measured (Barouillet et al, 2004). It is also believed that representations require a certain amount of energy per unit of time in order to be in an activated state. Therefore, they compete for resources with other representations or mental processes. This type of limit is often referred to as *resource limit*.

In his study, Cowan has privileged (?) the space aspect of capacity limit and has given new relevance to Miller's findings, albeit by lowering the amount of chunks retained by working memory (Cowan, 2001). His measurements reveal that on average we can only retain between 3 and 5 chunks of information. This difference is due to the fact that the assessment technique used was more thorough than in Miller's case. In fact, Miller's main ambition was not to exactly define the right number of chunks, but rather to focus on how chunking could improve short-term memory performance.

Cowan defined a few basic conditions in order to identify chunks and measure capacity limits. Most importantly information overload should limit chunks to individual stimulus items and steps should be taken to block the recoding of stimulus into larger chunks. Cowan gives details about ten other interpretations of working memory capacity and their respective advantages and drawbacks (Cowan, 2005).

Cowan made a significant contribution to research in interpreting by examining several aspects of working memory and attention while explaining their relevance to simultaneous interpreting (Cowan, 2000/01). Cowan describes the phenomenon of attention filtering as one channel being favoured over another. He notices though that physical changes occur to the unattended channel and concludes that all information is processed in one form or another. He then raises the questions of how interpreters can focus on two channels of information where a layman can only focus on one at a time. One possibility is that they manage to quickly switch from one channel to another, listening and speaking. The unattended channel would still manage to get some information. The second possibility evoked by Cowan is that with extended practice, less attention or less effort if we use Gile's terminology, is needed to perform the same task and it thus becomes possible to focus on both channels at the same time.

The implications of finding out which of these two options best describes what goes on in interpreters' brains are potentially significant for their training. Should the emphasis be put on learning how to switch channels more quickly or should students be encouraged to practice until they can easily speak and listen at the same time? Putting emphasis on the first approach would develop mental agility, whereas favouring the second would train the brain for an unnatural process: paying attention to stimuli whilst producing speech. These two approaches might be compatible to some extent, although evidence for this is still scarce.

As mentioned before, Cowan mentions the possibility of controlled attention, even though this skill is probably also limited and different from one individual to another (for more information on various aspects of attention see next chapter). Research shows that individuals who show a good level of attention control also perform well at tasks measuring intelligence (Conway et al., 2002; Engle et al., 1999).

As far as interpreters are concerned, it could be assumed that individuals with a better attention control are more likely to show better performance at SI. However, there is no certainty as to whether this is an innate ability (or if at least some predisposition can exist), or if it can simply be improved with training. What is clear is that SI students should already have this ability prior to being selected for a program. As the period of future SI students' training before selection is usually not in the scope of research, it would be of practical interest to study what techniques prospective SI students resort to while preparing for entrance tests. Do successful applicants choose better attention/memory training strategies than their less successful colleagues? Or, do the selected ones have different innate capacities? Some light could be shed on these questions by asking applicants about how they prepared themselves for the tests. Later on, when the results of the selection become known, the data obtained might reveal some feature characteristics of successful and unsuccessful candidates. This study could bring us closer to answering the key question as to whether we are born interpreters or if it's more an acquired skill.

If with Cowan one accepts that working memory is in fact activated long term memory content, then the speed at which this content is retrieved is paramount for it determines the aptitude for understanding a message. Again, the implications for interpreters are easy to infer. The faster the retrieval speed, the greater the potential to understand the source message and, therefore the better quality of the interpretation. Retrieval structures are believed to become more complex and more efficient with experience. Thus, all other things being equal, those who have previously trained the cognitive skills discussed above will presumably be better interpreters. On the other hand, it is possible that better interpreters have more efficient retrieval structures elaborated within many fields of knowledge. These would generally take a considerable amount of practice to build up.

3. Attention and Cognitive Control

3.1. Definition of Attention.

In everyday life the word *attention* seems to have many different meanings. Someone might be asked to pay attention whilst doing something, or it can be claimed that a certain issue needs attention, or it can be remarked that someone is trying to attract the audience's attention. However these common usage definitions of attention do not exactly correspond to the meaning attributed to the term in cognitive psychology.

Perhaps the first psychological definition of attention was given by William James in his landmark work on human psychology at the end of XIX century:

> “Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others.”
> (James, 1890, pp. 381–382, cited by Luck &Vecera, 2002)

Although James's definition is still often cited as a starting point for studying the intricacies of attention, it fails to depict the complexity of the notion in the light of subsequent discoveries on the subject. In modern cognitive psychology dictionaries one may find the following definition:

> “Attention is an internal cognitive process by which one actively selects environmental information (i.e. sensation) or actively processes information from internal sources (ie. visceral cues or other thought processes). In more general terms, attention can be defined as an ability to focus and maintain interest in a given task or idea, including managing distractions.” (Dawson & Medler, n.d., para. 4)

As attention entails several psychological mechanisms, a process oriented approach to its study should be given preference over a task oriented study of the subject. This process involves choosing one or several options whilst ignoring other options available. The aim of this selection is to increase the output of the selected option or task.

The process-oriented definition of attention states that attention means, "restricting cognitive processes so that they can operate on a subset of the available information for the purpose of improving the speed or accuracy of the processes"(Luck & Vecera, 2002, p. 238).

Attention is sometimes considered as a core process in cognitive psychology and is thus given a very important place in cognitive processes research (Luck & Vecera, 2002). It is clear then that approaching such a complex activity as SI is impossible without discussing attention. In this paper we are considering higher-level mechanisms of attention without dwelling on perceptual attention issues that are mainly focused on sensory channels and stores.

A few words about aspects of attention may facilitate its understanding in cognitive terms. Whilst psychologists do not agree as to whether all the phenomena united under the banner of *attention* refer to a single underlying basis, all these aspects serve a similar function: reducing the amount of information to a manageable level (Medin et al., 2001).

Thus, in perception, attention helps to focus on a set of otherwise limitless amount of information about the environment. In the representation of objects, attention serves to bring together features of a single object. At the level of action, attention allows us to carry out several tasks without interference among them or select a particular task to carry out rather than some other things we might do (see chapter about central executive functions) (Medin et al., 2001).

Research on attention has largely focused on the visual modality as the most convenient for experimental purposes. This imbalance happened to the detriment of the auditory modality which is of more interest to interpreting research. Although it is hard to allege that observations on one modality are also valid for other modalities, it is also hard to allege the opposite. Now research seems to lend support to the possibility of strong links between attention mechanisms under different modalities (Spence & Driver, 1996). So at the present time it is hard to be entirely sure whether the visual stimulation based research is also partly or wholly relevant to SI studies.

3.2. Modelling of Attention.

The existing models of attention are intended to account for mechanisms of selective attending to information on some channels and for the amount of information being processed on unattended channels (Logan, 2004). Table 2 summarises the main models of attention that will be discussed below.

Table 2. Models of Attention.

Broadbent	1958	Bottleneck theory
Treisman	1960	Attenuation theory
Deutsch, Deutsch	1963	Late selection
Norman	1968	Late selection
Kahneman	1973	Capacity model
Wickens	1984	Multi-dimensional model

Four main groups of research paradigms are frequently used to study attention: cueing paradigms, search paradigms, filtering paradigms and dual task paradigms (Medin et al., 2001). The cueing paradigms imply cueing the location of a target in order to prepare the focus of attention to identify this target. Researchers measure the time it takes subjects to identify the target and then compare this time with that of subjects who have not been cued as to the location of the target. These paradigms mostly involve visual experiments. For example, the subject can be asked to identify an object that will appear in a certain area of the screen (idem.).

The search paradigms are based on experiments in which subjects are requested to search for target stimuli amongst a set of non-target stimuli in order to measure and assess how attention is used to eliminate irrelevant stimuli. These models could be potentially interesting for research on interpretation since interpreters often need to distinguish relevant stimuli (for example while doing chuchotage or working in a noisy environment). Again, existing research mainly focuses on visual search and stimuli. For example, the subjects were asked to spot a certain letter among many other letters scattered throughout display (idem.).

The filtering paradigms experiments usually involve asking subjects to direct their attention to one source of information as opposed to an unattended channel. Researchers then measure how information in the respective channels is processed and how and if irrelevant information is suppressed and at which stage. Much attention has been paid to the so-called *dichotic listening tasks*. In these experiments, individuals are being presented different stimuli on the right and the left ear and are asked to follow only one of the inputs. For example, the subjects can be invited to pay attention to number presented on the left ear while ignoring sets of number presented on the left ear (idem.).

The dual-task paradigms usually operate with two distinct tasks, either involving similar cognitive processes or different ones. Investigators then measure whether any interference can be observed between the performance of the two tasks and if so they try to measure the extent of the interference. Subjects are asked to dedicate different proportions of their attention to either task. It appears that when the tasks involve similar cognitive processes, giving more attention to one of them necessarily entails less attention to the other task. In other words, it is a zero sum operation. Conversely, if the two tasks are relatively independent from each other, then subjects can perform them simultaneously relatively well (Norman, 1976).

One of the first models put forward by Donald Broadbent suggested a selective filter between the external world and the central processor (Broadbent, 1958, cited in Medina et al., 2001). This filter would let through only those stimuli that we want to attend to and exclude the others. It means that only a limited amount of “relevant” information goes through the filter to reach the central processor. Hence, the term *bottleneck model*.

However, it is a well known fact that if people converse in a noisy room, their attention will switch immediately when they hear someone mentioning their name. That is, the information from the unattended channel is in fact processed, albeit in a very limited way. If all the incoming information had to pass through the bottleneck filter then this wouldn't be possible. So another model, proposed by Treisman, was to account for this phenomenon (Treisman, 1960).

In Treisman's model the analysis of the message's content takes place in the early stages of the processing. At the same time items of the incoming information are being prioritised with the aid of memory. This model suggests several stages of analysis: physical properties analysis, permanent priorities analysis, current priorities and, finally, analysis of the meaning.

In addition, analysis at higher level is shifted according to the subject's expectations and aims as low-levels analysis can analyse physical properties of the message almost automatically.

These two models are characterised by the assumption that selection occurs prior to entrance into short-term memory. On the other hand, there exists an array of evidence pointing to the fact that selection occurs after the stimuli have been recognised. From that perspective, Deutsch and Deutsch (1963) and Norman (1968) put forward models according to which information is processed entirely prior to placing the results in short-term memory (cited in Medin et al., 2001). As a consequence limitation of short-term memory appears to be the bottleneck of attention.

Another approach treats attention as a limited resource to be distributed across several tasks being performed. Daniel Kahneman came up with a model according to which attention is limited but can be flexibly allocated depending on task demands (Kahneman, 1973). If, for example, two tasks are not very demanding on attention capacity then one will be able to perform both tasks simultaneously. If one of the tasks becomes more important than the other the attentional resource will be redistributed so that the most important task is dominant. In other words, unattended stimuli can be processed until there is a more important task pulling over more resources. Computation of multiple tasks will be considered in the next chapter.

Resource allocation/limitations models of attention became popular in the 1970s and can often be associated with research on working memory over the same period. Different models of working memory and Cowan's subsequent findings from the late 1980s onwards have already been reviewed. Many researchers working on this subject, such as Cowan, Conway or Baddeley, still assume that people are endowed with a stock of cognitive processing resources that need to be distributed, either among different processes within the same task or among several tasks simultaneously. Some have endeavoured to demonstrate that this resource can be stretched, for example by arousal (Kahneman, 1973).

The main drawback of such models is that they fail to clarify the exact mechanisms of attention. Notions of a *central processor* (Kahneman, 1973) or a *central executive* (Baddeley & Hitch, 1974) in charge of the allocation policy are convenient but have long been blurry. They do not account for what exactly this limited resource is. Other researchers have shown that some results normally attributed to capacity limit could in fact be elucidated with the concept of *decision noise* (Palmer, 1994; cited in Luck & Vecera, 2002). This notion posits that when the number of decisions that need to be taken for a task rise, accuracy to perform the task decreases. This is simply because there is an increased probability of errors. To the knowledge of the authors of this contribution, the notion has not been tested with auditory inputs though it might be assumed that further research in this direction could yield interesting results.

It has been proposed that a different type of attention is perhaps responsible for integrating different modalities' features into a coherent representation of objects, though this might apply only to visual attention (Medin et al., 2001). To summarise, processing of representations of coherent objects demands some way of combining information about the various properties of these objects. Feature integration theory suggests that there is a collection of features, rather than a single representation of an object, that are all indexed to a common location in space. Various features of an object indexed to the same location are brought together thus making the perception of the object possible. This operation requires attention to coordinate the representations of individual features that can, in turn, influence performance on tasks that require consideration of many different features of an object at the same time (Medin et al., 2001).

According to Luck & Vecera, more and more researchers seem to agree that attention does not consist of a single mechanism but rather of an array of mechanisms likely to vary according to the type of task involved. It has been suggested that each of them operates within a different cognitive subsystem and in a manner that reflects the representational structure and processing demands of that cognitive subsystem (Luck & Vecera, 2002). In the light of this largely shared standpoint, several long standing debates on attention (for example: *does attention operate an early or a late selection?*) become partly irrelevant since the key to these questions often lies in the type of task involved.

3.3. Divided Attention and Dual Task Performance.

Our daily life compels us to multi-task. Performance of more than one task at a time has been scrutinised by researchers. Generally speaking, performance of one or both tasks is worse when performed together (the so-called dual-task condition) than when performed separately (single-task condition). What are the mechanisms underlying multi-task performance?

As discussed above, dual-task performance seems to depend on similarity and difficulty of both tasks and on prior experience in performing the two tasks together (practice). Speaking of similarity, it has been noted that if two tasks involve the same input or output modalities then the dual-task performance level will be lower than if the tasks were using different modalities (Eysenck & Keane, 2010). That is, performing two auditory tasks simultaneously will yield much lower results than performing each of them separately. On the other hand, performing an auditory and a visual task simultaneously will affect the separate tasks performance to a lesser degree; sometimes even with no influence at all. However dual-task performance is generally less accurate and rapid than separate single-task performances. How can this be explained?

Two approaches can be explored: the central capacity approach and the multiple resources approach (Medin et al., 2001). Firstly, the central capacity approach assumes that there is a central cognitive operation that determines the general performance. This central operation (central capacity) is characterised by a limited amount of resources that have to be used in a flexible way across the whole range of activities being performed at the same time. Each of these tasks will demand a certain amount of the resources, influencing dual-task performance. This approach stems from Kahneman's ideas of a limited capacity allocated to task demands in a flexible manner (Kahneman, 1973).

It should be noted that two tasks can be performed in parallel (that is, simultaneously) or in a serial manner (one after the other). Subjects usually perform better in dual-tasks when using serial processing although participants using serial processing also found the tasks more difficult (Lehle et al., 2009).

Although this approach is consistent with some experimental evidence (Eysenck & Keane, 2010) the nature of the central capacity mechanism has never been explained within this framework. Brain-imaging studies revealed a distinct activation in the cortex during dual-tasking that was not present in a single-task condition. At the same time, brain activation when two tasks are performed together was less than a sum of the brain activations when they are performed separately (Just et al., 2001). These findings suggest that the need to distribute a limited central capacity (e.g., attention) across two tasks means that the amount that each task could receive was reduced compared to the single-task condition.

Secondly, the multiple resources approach consists of several independent processing mechanisms functioning as multiple resources. Wickens (1984, 2008) proposed a multi-dimensional structure of processing resources (Figure 2). He argues that processing consists of three successive stages and each stage involves different modalities. As a result, encoding (the first stage) involves visual and auditory modalities that can be interpreted in spatial and verbal codes; central processing (the second stage) involves spatial and verbal codes; finally, responding (the third stage) involves manual and vocal responses. If two tasks make use of different pools of resources then subjects will be able to perform both tasks simultaneously without much interference between them.

Despite much evidence in favour of this model some limitations were also noted. For example, the model does not consider other stimulation modalities such as sensory or olfactory. It only focuses on the visual and auditory modalities. Also, it does not take into account that performance seems to vary according to serial or parallel modes of dual-task processing (Lehle et al., 2009).

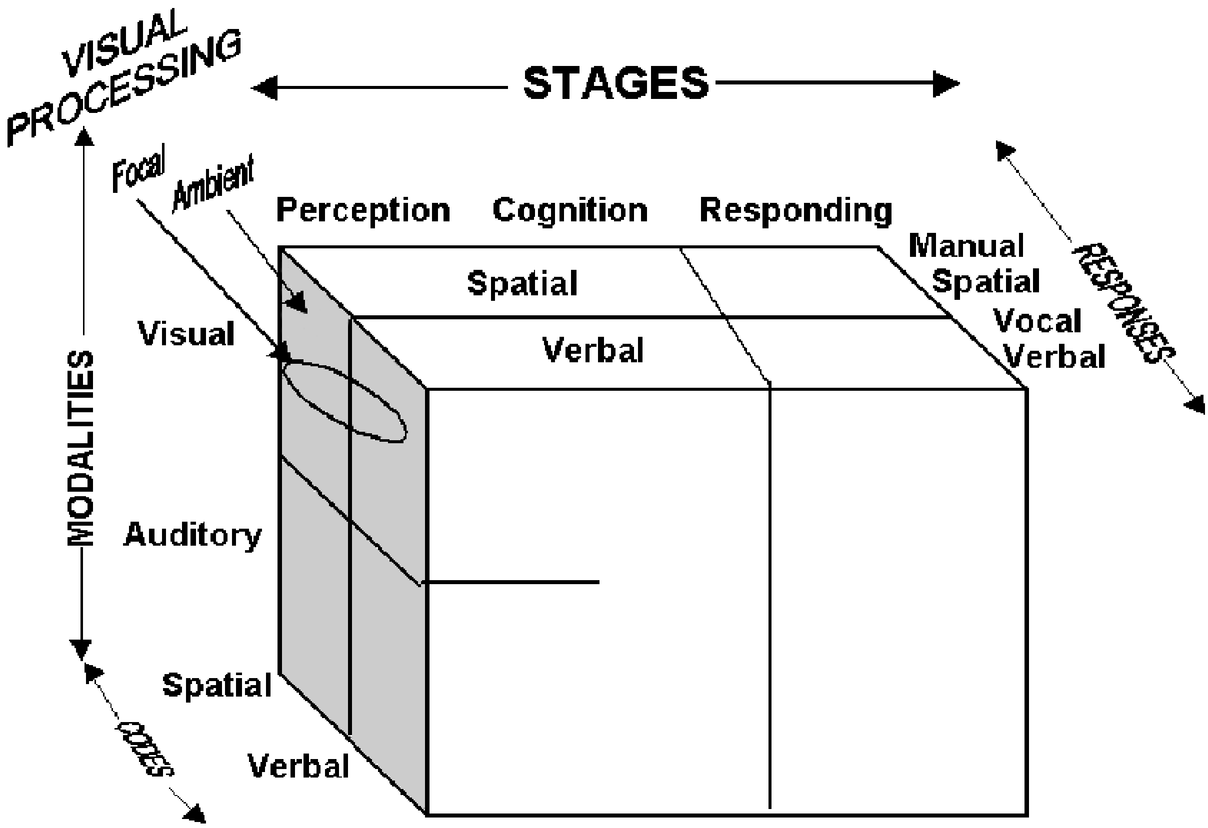

Figure 2. The 4-D multiple resource model (adaptation from: Wickens, 2004).

Interestingly, Baddeley adjusted his and Hitch's working memory model and put forward a form of synthesis of both multiple resources and central capacity approaches. He argues that the processing system is hierarchically organised with the central executive on top and specific processing mechanisms below this level (phonological loop, visuo-spatial sketchpad). Whilst the central executive controls attention, the specific mechanisms can indeed operate relatively independently (Baddeley, 2001).

Interest in the underlying processes of divided attention led to the development of attentional blink studies. The attentional blink is a phenomenon regarding reduced ability to detect a second visual target when it closely follows (within 200-500 ms) the first visual target (Eysenck & Keane, 2010).

Two plausible explanations for this attentional gap in perception were put forward. One explanation is based on the assumption that attentional resources are limited and that if all the resources are allocated to the first stimulus processing then there won't be enough resources for the second stimulus processing. The second explanation implies an active suppression mechanism so that the processing system shouldn't be overwhelmed with distracting information originating from distracting stimuli. Whilst the debate on whether one or the other explanation fits better is still ongoing, most recent data suggests that the attentional blink is a cognitive strategy rather than a resource limitation (Wyble et al., 2009; Olivers et al., 2011). In other words, this explanation implies that it is not possible to engage attention twice in a short time period. The practical implications of this conclusion might be of interest to SI studies, especially since the attentional blink was studied in experiments with serial presentation of visual and auditory stimuli (Vachon & Tremblay, 2005).

Some evidence of processing limitations under dual-tasking is reminiscent of the earlier idea of a bottleneck. When two stimuli are presented very closely one after the other, then the response to the second stimulus will be delayed. This phenomenon has become known as psychological refractory period (PRP). Studies of this phenomenon have shown that selection of an appropriate response occurs in a serial fashion, which leads to slowing of the response to the second stimulus. Given the shortness of PRP, it may be argued that many processes, such as sensory or execution processes, do not occur in a serial fashion. As a result it could be assumed that the bottleneck, responsible for the PRP, should be placed at central processing stage.

However, the PRP effect is not always noticed when two tasks are being performed, which leaves enough room for further exploration and new theories to explain attention and memory performance under dual-tasking (Eysenck & Keane, 2010), which may also lead to new breakthroughs in research of SI.

3.4. Automatic Processing.

Speaking of complex tasks, the question of how learning can decrease the amount of attention attributed to cognitive tasks will also be considered. It could be considered common knowledge that practice makes tasks less demanding on cognitive efforts. For example, learning to write or type is hard and requires considerable application. However, once these tasks are mastered, the required mental efforts become almost negligible and people don't think about how to scribble down different letters – instead, they can focus on their style and the message that is to be conveyed. In this case it may be stated that automaticity has been achieved, as well as a reduction in resource demands.

The so-called *traditional approach* to automatic processes started with classic articles by Shiffrin & Schneider (1977) and Schneider & Shiffrin (1977). They put forward a clear-cut distinction between controlled and automatic processes. Controlled processes are characterised by a limited capacity, by their dependence on attention, and by their flexibility depending on circumstances.

On the other hand, automatic processes are characterised by: an absence of capacity limitations, by the fact that these processes do not require attention, by their rigidity, as once learnt they are hard to modify.

Many experiments supplied data that the Shiffrin & Schneider's classification could not account for – the borderline between automatic and controlled processes turned out to be less clear-cut than expected. This is how Moors & De Houwer came up with four features for automaticity (Moors & De Houwer, 2006): they are goal-unrelated, they are unconscious, they are efficient (they make use of little resources), and they are fast. Such features would allow researchers to claim that a given process may be considered automatic.

However, Moors & De Houwer (2004) argue that it is not necessary that all four features be found at the same time, the dividing line between automatic and non-automatic being fuzzy (some automatic processes can be pretty slow or fast, partially conscious and so on). Instead, they say that most processes are in fact a blend of automaticity and non-automaticity. As a result, it is better to use relative statements, such as, 'this process is more automatic than that process.'

Despite the uncertainty in behavioural data, almost all neuroscientific studies show that cortical activations are lower whilst performing automatic processes or that cortex activations decline with acquisition of automaticity (Eysenck & Keane, 2010). At the same time, automaticity in the brain is strongly associated with activation of certain anatomical structures. Accordingly, it may be asserted that during the acquisition of automaticity people shift from considering degrees of uncertainty in the cortical area to solved, simple and direct solutions through these anatomical structures (for more details see Eysenck & Keane, 2010).

What are the mechanisms underlying this shift from the point of view of attention? Logan proposes an *instance theory* explaining how learning produces automaticity that fits the four features mentioned previously (Logan, 1988). Basically this theory argues that there are two obligatory processes: obligatory encoding (every attended item is to be encoded in memory) and obligatory retrieval (every attended item is a retrieval cue that pulls things associated with it from memory). As a result, each encounter with a stimulus leads it to be encoded, stored, and retrieved separately, even if the stimulus has been encountered before. When a stimulus is encountered many times, the increased storage of information in long-term memory produces automaticity based on a fast-track retrieval of past solutions from memory. Otherwise, retrieval requires rules, is time-consuming and involves multiple steps (Logan, 1988).

The instance theory explains why automatic processes require less attention as the retrieval of well-learned processes is relatively effortless. This kind of retrieval is also faster (direct access to long-term memory items) and unconscious since there is no significant processes involved in the stimulation and the retrieval.

According to the instance theory, people can control automatic processes rather than let them go involuntarily. However, this control cannot be perfect as automatic processes are usually very fast and do not allow much time to act. In any event, the most important part of the instance theory is that automaticity also becomes a memory phenomenon. Although Logan considers automatic processes, it is easy to note some similarities between the instance theory and the ideas on retrieval structures in working memory (Cowan, 2005). When applied to SI, these observations might account for the imminence of mistakes by interpreters (due to imperfect control of automatic processes) and for the noted benefit of memory training for interpreters (since automaticity may be considered as a memory phenomenon).

Generally speaking the bridge between SI-studies and studies of automatic processes may be interesting and fruitful. During SI a lot of subtasks are being dealt with without voluntary control. The number of subtasks that become automatic over time of training and practice is increasing (see above). That is why it is relevant to link automaticity and SI-studies.

3.5. Central Executive Functions

The central executive is perhaps the most important component of the working memory/attention system. Its function is to program the mind. It is involved in understanding instructions, making strategy choices, preparing and adopting a task set, monitoring performance and disengaging task sets. Also, it underpins people's ability to shift rules, to devise and implement strategies and solutions to practical problems and to divide time between tasks in a most efficient way (Logan, 2004). In other words, every time a complex cognitive activity is performed (reading a text, solving a problem, carrying out two tasks, simultaneous interpreting etc.) an extensive use of the central executive occurs.

Initially, the concept of central executive was another “ragbag” for all unanswered questions related to the control of working memory and it was believed to be a unitary system. Over time this topic has become important and popular in cognitive science, neuroscience, clinical science, developmental science and so on. Baddeley (1996) suggested that the central executive was responsible for the following four functions or executive processes: 1) switching of retrieval plans; 2) time-sharing in dual-tasking; 3) selective attention to certain stimuli while neglecting the others; 4) temporary activation of long-term memory.

Miyake et al. (2000) assumed three executive processes overlapping with those of Baddeley (1996): 1) inhibition function (deliberate inhibition of dominant or automatic responses); 2) shifting function (shifting among multiple tasks and operations); 3) updating function (updating of working memory representations).

As stated above, optimisation of performance is an important feature of executive control. Many studies of the central executive focus on the idea that an executive process programs subordinate processes. Neuroimaging studies provide evidence supporting this idea, especially under dual-tasking conditions (see above).

In this respect it is interesting to look at how the subordinate processes can be programmed. Although there are no consistent theories providing clear mechanisms of these processes, there are some interesting ideas that might be helpful in designing future research. One of them is the concept of *cognitive control*.

3.6. Cognitive Control

"A fundamental human cognitive faculty is the capacity for cognitive control: the ability to behave in accord with rules, goals, or intentions, even when this runs counter to reflexive or otherwise highly compelling competing responses (e.g., the ability to keep typing rather than scratch a mosquito bite). A hallmark of cognitive control in humans is its remarkable flexibility: we can perform novel tasks with very little additional experience".
(Rougier et al., 2005, p.7338).

Thus, cognitive control allows us to process information and behave adaptively depending on current goals rather than to remain rigid and inflexible. Cognitive control processes are present in a wide-range of mental operations (goal and context representations and maintenance) and in such strategic processes as attention allocation.

The concept of cognitive control can be traced back as far as 1890 with the work of William James, already mentioned in this contribution (James, 1890). Later, Ach examines the mechanisms behind personal goals and interests in a similar way and attributes them to both attention and will (Ach, 1935). Attention involves the selection of goal-related events in the environment and the priority given to their processing. Will implies organising elements to bring about an intended event (Ach, 1935). In light of these works, most research focused on the description of how the senses and the mind were affected by attention and will rather than on the processes involved. Ach however, anticipated the possibility of conflicts between over-learned habits on the one hand and intentional processes on the other hand (Ach, 1910; cited in Hommel, 2000). Only much later would this idea become one of the centrepieces of studies on cognition.

Cognitive psychology loses interest in the distinction between attention and will until Attkinson & Shiffrin (1968), followed by Shiffrin & Schneider (1977) re-introduce it. What Ach called *over-learned habits* becomes *automated processes* and his *intentional processes* are subsequently called *controlled processes*. The general idea of potentially conflicting processes is maintained. As for attention itself, the notion often remained ill-defined and research amalgamated the notion of attention as a product (i.e. a consequence) and as a cause of goal-oriented behaviour.

Authors such as Baddeley then make a clear distinction between the constitutive elements of cognitive control and its consequences on information processing (Baddeley, 1986; also see chapter on working memory).

A recent trend in research on cognitive control is to see control functions not as basic mental functions, supported by specific systems or neural wiring, but rather as *emergent properties*. According to Hommel, in a contribution on recent trends in cognitive control, these properties are determined by the arrangement and adaptation of pre-existing and less important processes in a way that novel functions emerge (Hommel, 2002). Furthermore, interacting or competing factors in the generation of cognitive control can be distinguished according to two sets of criteria.

A first distinction can be made between endogenous and exogenous factors generating cognitive control. Endogenous factors are conditions from within the mind whereas exogenous factors are related to the external environment. Such a differentiation is the cornerstone of the *biased competition model* used by Desimone & Duncan (1995) according to which attention control is determined by both bottom-up and top-down factors (see below).

A second distinction can be made between perceptual (related to what is perceived by the senses) and response (how reactions are developed) related processes. Perceptual related processes are related to what is perceived by the senses, whereas response related processes are the mechanisms developed as a reaction to a stimulus. Research analyses the ways in which perceptual and response related processes interact. One of the postulates of this trend in research is that it is impossible to isolate pure input (perceptual) selection on one hand and pure output (response) selection on the other hand. This is shown for instance by the works of Cohen who demonstrates that the cognitive processes, needed to generate a response, have a direct effect on singling out some stimulus information for further processing (Cohen et al 1990).

Another trend in research on cognitive control is to consider that control delegates subordinate processes that become autonomous. According to this trend, internal high-level control processes are relatively slow and instead of monitoring task related processes closely, they enable and set the framework for processes to run autonomously, thus more efficiently. From time to time cognitive control readjusts these processes. This is illustrated by Altman & Gray's task-switching model according to which the main function of control is merely to store a task goal into working memory (Altman & Gray, 2008). Once this is achieved the direct effect of control stops and success in performing the task becomes dependent on the processes to which control has been transferred.

As noted before, research has so far focused mainly on the visual modality of attention, to the detriment of the auditory modality which is of more interest to interpreting research. Spence & Driver supported the possibility of strong links between different modalities in attention mechanisms (Spence & Driver, 1996). Apart from these unimodal attention mechanisms (distinct attention mechanisms for each sensory faculty) linked together, it can also reasonably be assumed that there is a supramodal attention mechanism which coordinates attention across different sensory modalities (Luck & Vecera 2002).

Multiple objects and inputs often compete for our attention. This is why some form of control is needed to determine which of these should receive attention and the amount of attention they should receive. Desimone & Duncan's biased *competition model* helps us understand how attention control works (Desimone & Duncan, 1995). They make a distinction between bottom-up control parameters and top-down parameters.

The first category, bottom-up control parameters, is stimulus based and comprises features such as the physical characteristics of the stimulus (shape, colour, intensity) or the suddenness of its appearance in the subject's field of perception (visual, auditory or any other sense). These parameters, or mechanisms, allow people to separate objects from their background. They stem from the inherent or learned biases of the perceptual system towards certain categories of stimuli. The perceptual system is designed to react in a certain way in the presence of determined stimuli. Over time, each individual then also develops responses of his own to the array of stimuli perceived.

Top-down parameters, in other words task or goal driven parameters, vary according to the task that needs to be achieved. They include the mental representation of the goal to achieve and the person's anticipations (Yantis, 2000). These mechanisms select objects that are relevant to current behaviour and ongoing tasks. They play a particularly important role when the subject is instructed to pay attention only to objects in a certain region of a visual display or to a certain category of sounds or objects.

Both bottom-up and top-down parameters strengthen the mental representation of an object. This is why they contribute to giving the object (*object* is used in a generic sense here) a competitive advantage in terms of neural representation and control of behaviour, over other objects in the competition. Research has shown that diverse forms of competition or interference exist in our mental representations of objects. They include modality-specific perceptual competition (for example several objects in our field of vision or in our ears compete for attention), response-specific competition (objects competing because they require a similar response) and competition between analogous internal representations (objects represented in a way that corresponds to other similar representations) (Baddeley, 1986). These distinct facets of competition for representation indicate a different way in which the nervous system selects one set of mental processes over another. In view of this some implications in connection with SI may be found.

Unpredictability and irreproducibility of interpretation may often be explained by diverse forms of competition. For example, perceptual competition (moving delegates, slides, booth partner, other noises), response-specific competition (various options for the output, note-taking when necessary, manipulations with the equipment – 'cough button' etc.) and so on. Every time the speech is being interpreted the context, noise, state of interpreter and other variables are different. This may explain why the same speech is never interpreted in the same way by the same interpreter; let alone by different interpreters.

On the other hand, it might be assumed that certain patterns or sets of mental processes can be trained and imprinted by the nervous system of the interpreter. That is, it might be possible to train interpreters to reproduce the shortest way of processing competing representations while interpreting.

Attention orienting has also often been associated with the notion of *salience* that entails a combination of bottom-up and top-down mechanisms. Attention is oriented to the most salient of available locations or objects. Shipp presents a combination of different salience models in his *physiology of the orienting system* (Shipp, 2004). Other researchers have tried to draw parallels between the notion of salience in the visual modality and salience in the auditory modality. This is how Kayser came up with an auditory saliency map, on the basis of the model of visual saliency maps elaborated from the late 1980s onwards.

The views expressed above challenge the more traditional notion of attention as a high-speed mental spotlight that repeatedly scans items in the perception field. According to Desimone & Duncan (1995), attention is rather "an emerging property of slow, competitive interactions that work in parallel across the visual field". This is further substantiated in subsequent positron emission tomography (PET) studies (see Corbetta et al., 1993).

Research has also often shown that repeated and extended practice in judging any given relevant stimulus will favour its selection over other stimuli. In other words, it increases the competitive advantage of certain stimuli over others (Moray, 1959; Moser-Mercer, 2000).

In respect of discriminating amongst stimuli when people have to attend to both relevant and distracting stimuli, a theory put forward by Lavie seems quite interesting. Distracting stimuli are often more disruptive of task performance than salient or distinctive distractors (Lavie, 2005). Lavie developed a theory according to which two assumptions were made. Firstly, susceptibility to distraction is greater when the task involves low perceptual load than when it involves high perceptual load. Perceptual load depends on factors such as the number of task stimuli. In other words, the processing demands of each stimulus that needs to be perceived. The argument is that, “high perceptual load that engages full capacity in relevant processing would leave no spare capacity for perception of task-irrelevant stimuli" (Lavie, 2005). This coincides with remarks by Shlesinger (2000) on higher quality of SI when the number of words per minute in the original speech is relatively high. A dense flow of words increases the number of task stimuli and, thus, perceptual load. This explains why speeches with lower number of words per minute are prone to more mistakes. There is an optimal number of words per minute that is neither low, nor high (the exact number would apparently depend on other parameters of message).

Secondly, susceptibility to distraction is greater when there is a high load on executive cognitive control functions (for example, working memory) than when there is a low load. The reason for this assumption is that, "cognitive control is needed for actively maintaining the distinction between targets and distractors". This is especially likely when it is hard to discriminate between target and distractor stimuli (Lavie, 2005; Eysenck & Keane, 2010). This observation is also relevant to the interpreting process. Training and extended experience will gradually increase the interpreter's capacity to distinguish between relevant and irrelevant stimuli and to crack complex ideas (Moser-Mercer, 2000). As a result, we may claim that increasing expertise in SI enables interpreters to use executive cognitive control functions more efficiently. This should enable interpreters to attribute cognitive resources to processes in a way that leads to the highest possible quality of SI.

4. Conclusion

Theoretical courses taught to conference interpreting students intend to get them acquainted with a scientific approach to SI. However, many active conference interpreters are not aware of the whole cognitive dimension of the profession they exercise. A clear understanding of issues connected with those cognitive functions, intensely used by conference interpreters, may lead to improved training techniques (as well as better candidate selection). A well-defined scientific basis of SI may also favour the consolidation of the profession. In this regard, a new generation of interpreters aware of the cognitive aspects of the profession, will surely generate common benefits for all professional conference interpreters.

The problem of understanding cognitive research applied to SI might stem from a lack of scientific training among most SI students. A crash course of scientific methods and approaches, paradigms formulation and other SI-relevant basic scientific knowledge is certainly needed. To bridge these gaps it might be useful to suggest that students read a selection of articles covering more general methodological issues (such as Padilla et al., 1998).

Some cognitive science concepts, such as *attention* for example, need to be dissociated from their common usage meanings. Definitions in this regard are very important, although the scientific community often fails to work with commonly accepted definitions.

Regarding topics covered in this paper, a lot of work has been done concerning visual stimulation and processing of visual information. This is due to objective reasons related to experimental design and the restraints connected with it. As already mentioned, it is not clear whether these results and studies are relevant to SI or not. It seems likely that there is at least some overlap. Yet there is strong evidence to suggest that supramodal attention mechanisms exist and that they are applicable across all modalities (Medin et al., 2001). In future, some studies might emulate previous experiments by redesigning them for auditory rather than visual stimuli, or even by adapting them to the conditions of SI practice. Apart from answering specific SI-related questions, these experiments might bring answer to some cognitive questions of general importance, such as the existence of supramodal mechanisms and others.

Considering the whole range of models mentioned in this study, it should be noted that the issue of *central mechanisms for coordination* is used time and again. In different models, those mechanisms go by different names but they always play an important integrative role and contribute to shaping coherent representations. The idea of central mechanisms for coordination is now generally accepted even though the nature of such mechanisms does not always seem clearly defined. Nevertheless, a modular approach to cognitive functions, that is breaking complex cognitive functions down into simpler tasks, is largely believed to be artificial. This is because it involves singling out modules in order to study and model processes, whilst in reality all cognitive functions are interconnected.

SI is prone to mistakes; hence the search for the weakest link in SI-associated processes. While Gile's tightrope analogy is very illustrative it does not suggest a detailed explanation of the origin of mistakes, processing capacity being the weakest link in the Gile’s model.

Another approach to tracing the source of mistakes involves looking for a bottleneck in SI processes. Classical selective attention theories would place the bottleneck at the stage of input information flow, whilst working memory theories would say that limitations are due to the finite volume of working memory. However, according to Cowan, the limitations lie within the focus of attention rather than within activated memory structures. Thus, he resolves the problem of where the bottleneck is to be located. Furthermore, Cowan argues that both voluntary and involuntary processes can control the focus of attention. That is, automatic and non-automatic processes can be controlled (maybe no to the same degree, but still be controlled). It may well be that most people never try to control the focus of attention in the way that conference interpreters do. Nevertheless, it does not mean that laymen cannot do this at all. After all, limitations here vary from person to person.

Speaking about cognitive limitations in SI, there are two possible ways to circumvent them. The first one consists of switching quickly between listening and speaking. The unattended channel in this case will still manage to get some information. However, attentional blink studies and PRP studies seem to imply that the human brain is not able to engage attention twice in a short period of time, this may stem from a cognitive strategy or from a limited amount of resources (Vachon, Tremblay, 2005). Thus, the ability to quickly switch between tasks should in turn be limited.

Another possible way to overcome cognitive limitations stems from the idea that practice and training will take interpreters to the point where less attention is needed to perform SI (that is, less *effort* is needed in Gile's terms). This idea allows us to consider processes in a parallel rather than in a serial mode. Different approaches may be linked to this idea. The central capacity approach stemming from Kahneman's works claims that the resources of that central capacity can be distributed among multiple tasks. The amount of resources that each task receives is less than under single-tasking. That may account for mistakes that interpreters make (the listening and speaking performance during SI are never as good as during normal listening or speaking). However, the nature of that central capacity mechanism is not explained in this framework. From this point of view, Wickens's multi-dimensional model looks more attractive as it suggests a good explanation for SI processing. This model, however, also has its limitations.

Finally, Baddeley's synthetic approach reunites the central capacity and multiple resources approach. He believes that the central executive coordinates, whereas specific processes are dealt with by slave systems relatively independently.

Sometimes SI-skills acquisition is associated with establishing automaticity for certain cognitive operations. The instance theory argues that automaticity is in fact a memory phenomenon and that control is, to a certain extent, an automatic processes. The question is to determine the limit beyond which people cannot control well-learned processes due to their speed or complexity, much like when people learn to play musical instruments. It takes time to learn to play with both hands but at a certain level of skills, the piano player begins to solve more complex artistic tasks. At the creative level the piano player is not thinking about how to play with both hands simultaneously. In other words, despite the enormous complexity of a task, automaticity can sometimes be achieved for the whole process or for certain sub-processes. This enables voluntary control to solve more complex and abstract tasks.

SI is an example of the remarkable flexibility of cognitive control in humans (interpreters pay attention, choose appropriate reactions, engage in competitive activities etc.). A new trend in cognitive control research considers control functions as emergent properties defined by multiple factors (exogenous and endogenous factors, linked with response or perception, etc.) Reverting to the cognitive limitations of SI discussed above, it could be argued that under certain circumstances emerging control establishes a direct “fast-track” link between certain inputs and outputs. This direct link might persist over time and with practice, as there is evidence that attention control is relatively slow. Whereas, subordinate functions dealing directly with sub-processes operate fast and autonomously.

One might speculate that in the head of conference interpreters there is a special kind of attention control emerging in association with distinct retrieval structures highly efficient under SI conditions. This mechanism is not necessarily very fast. It can instead be slow but overwhelming, harnessing resources of multiple sub-processes, giving a competitive advantage to certain stimuli and output reactions over others. It remains to be seen how this data could be used to improve conference interpreters' training. If a special type of attention control does emerge during SI (and during other demanding cognitive activities), it could be argued that teaching SI may boil down to elaborating and training a special type of cognitive control. This could potentially have a strong impact on teaching SI.

How is focus maintained on what is important, how are primary ideas chosen and how can the message be compressed? These and many more questions have yet to be investigated. Some issues and unanswered questions raised in this study may become interesting topics for future research by MA students in conference interpreting. This contribution may also lay the foundations for a PhD project aiming at a further study of attention and cognitive control.

As several researchers (Shlesinger amongst others) of SI have pointed out, studying the cognitive mechanisms of SI could potentially disclose hitherto unascertained mechanisms of cognition and of the human brain in general (Shlesinger 2000). Simultaneous interpreting is a highly taxing activity as far as cognitive functions are concerned and it pushes the human brain to the extreme limits of its capacities. In this regard, the advent of a cognitive approach to SI has ushered in a new era of brain research.

Nevertheless, as freshly trained conference interpreters, the co-authors of this contribution would like to believe that despite the scientific contributions to unveiling some of the SI secrets it will always keep its touch of magic. After all, it is the artistic component of SI that thrills and attracts us the most.

5. Bibliography

- Ach, N. (1935). *Analyse des Willens [analysis of the will]*. In E. Abderhalden (Ed.), *Handbuch der biologischen Arbeitsmethoden (Vol. VI)*. Berlin, Germany: Urban & Schwarzenberg.
- Altmann, E. M., & Gray, W. D. (2008). An integrated model of cognitive control in task switching. *Psychological Review, 115*, 602-639.
- Atkinson, R.C., & Shiffrin, R.M. (1968). *Human memory: A proposed system and its control processes.* In K.W. Spence & J.T. Spence (Eds.), *The psychology of learning and motivation: Advances in research and theory, Vol. 2* (pp.89–195). New York: Academic Press.
- Baddeley, A. D., & Hitch, G. (1974). Working memory. In G. A. Bower (Ed.), *Recent Advances in Learning and Motivation, Vol. 8* (pp. 47-90). New York: Academic Press.
- Baddeley, A. D. (1986). *Working memory. Oxford Psychology Series #11*. Oxford: Clarendon Press.
- Baddeley, A.D. (1996). Exploring the Central Executive. *Quarterly Journal of Experimental Psychology, 49A,* 5-28.
- Baddeley, A.D. (2001). Is working memory still working? *American Psychologist, 56,* 851-864.
- Barrouillet, P., Bernardin, S., & Camos, V. (2004). Time constraints and resource sharing in adults' working memory spans. *Journal of Experimental Psychology: General, 133,* 83–100.
- Broadbent, D. (1958). *Perception and Communication.* London: Pergamon Press.
- Chernov, G. V. (2004). *Inference and anticipation in simultaneous intepreting : a probalility-prediction model.* Amsterdam/Philadelphia: J. Benjamins.
- Cowan, N. (1988). Evolving conceptions of memory storage, selective attention, and their mutual constraints within the human information processing system. *Psychological Bulletin*,

104, 163–191.

- Cowan, N. (2000/01). Processing limits of selective attention and working memory: Potential implications for interpreting. *Interpreting 5:2*, 117–146.
- Cowan, N. (2001). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences, 24,* 87–185.
- Conway, Cowan, N., Bunting, M.F., Therriault, D.J., & Minkoff, S.R.B. (2002). A latent variable analysis of working memory capacity, short-term memory capacity, processing speed, and general fluid intelligence. *Intelligence, 30,* 163–183.
- Cowan, N. (*2005*). *Working memory capacity.* Hove, United Kingdom: Psychology Press.
- Cowan, N., Morey, C.C., Chen, Z., Gilchrist, A.L., & Saults, J.S. (2008). *Theory and measurement of working memory capacity limits.* In B.H. Ross (Ed.), *The Psychology of Learning and Motivation, Vol. 49* (pp. 49-104). Amsterdam: Elsevier B.V.
- Conway, R.A., Cowan, N., & Bunting, M.F. (2001). The cocktail party phenomenon revisited: The importance of working memory capacity. *Psychonomic Bulletin & Review, 8,* 331–335.
- Corbetta, M., Miezin, F. M., Shulman, G. L., & Petersen, S. E. (1993). A PET study of visu-ospatial attention. *Journal of Neuroscience, 13,* 1202–1226.
- Darò, V., & Franco F. (1994). Verbal Memory During Simultaneous Interpretation: Effects of Phonological Interference. *Applied Linguistics 15(4),* 365-381.
- Dawson, Michael R.W. & Medler, David. A. *Dictionary of Cognitive Science.* Retrieved May 2011 from www.bcp.psych.ualberta.ca/~mike/Pearl_Street/Dictionary/dictionary.html
- Desimone, R., & Duncan, J. (1995). Neural mechanisms of selective visual attention. *Annual Review of Neuroscience, 18,* 193–222.
- Deutsch, J.A., & Deutsch, D. (1963). Attention: some theoretical considerations. *Psychological Review, 94,* 283-321. (Cited in *Medin et al., 2001*).
- Engle, R.W., Kane, M.J., & Tuholski, S.W. (1999). *Individual differences in working*

memory capacity and what they tell us about controlled attention, general fluid intelligence and functions of the prefrontal cortex. In A. Miyake & P. Shah (Eds.), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 102–134). Cambridge, UK: Cambridge University Press.

- Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review, 102,* 211-245.
- Gerver, D. (1974). Simultaneous listening and speaking and retention of prose. *Quarterly Journal of Experimental Psychology, 26*, 337–341.
- Gerver, D. (1976). *Empirical studies of simultaneous interpretation: A review and a model.* In R. Brislin (Ed.), *Translation: Applications and research* (pp. 165-207). New York: Gardner Press.
- Gile, D. (1994). *Opening up in interpretation studies.* In M. Snell-Hornby, F. Pöchhacker, & K. Kaindl (Eds.), *Translation studies an interdiscipline* (pp. 149–158). Amsterdam: Benjamins
- Gile, D. (1997). *Conference interpreting as a cognitive management problem.* In J. Danks, M. Gregory, B. Shreve, S. Fountain, & M. McBeath (Eds.) *Cognitive processes in translation and interpretation* (pp. 196-214). London: Sage.
- Gile, D. (2008). Local Cognitive Load in Simultaneous Interpreting and its implications for Empirical Research. *Forum, 6(2),* 59-77.
- Herbert, J. (1965). Manuel de l'interprete. Geneve: Georg.
- Hommel, B. (2000). *Intentional control of automatic stimulus- response translation.* In Y. Rossetti & A. Revonsuo (Eds.), *Interaction between dissociable conscious and nonconscious pro- cesses* (pp. 223–244). Amsterdam: John Benjamins Publishing Company.
- Hommel, B., Ridderinkhof, K. R., & Theeuwes, J. (2002). Cognitive control of attention and action: Issues and trends. *Psychological Research, 66*, 215-219.
- Hugdahl, K., Westerhausen, R., Alho, K., Medvedev, S., Laine, M., & Häcmäläinen, H.

(2009). Attention and cognitive control: Unfolding the dichotic listening story. *Scandinavian Journal of Psychology, 50,* 11-21.

- James, W. (1890). *Principles of psychology*. New York: Holt. (Cited in *Cowan, 2000/01* and in *Luck & Vecera, 2002*).
- Just, M. A., Carpenter, P.A., Keller T.A., Emery L., Zajac H., & Thulborn K. R. (2001). Interdependence of Nonoverlapping Cortical Systems in Dual Cognitive Tasks. *NeuroImage, 14,* 417–426.
- Kahneman, D. (1973). *Attention and effort*. Englewood Cliffs, NJ: Prentice Hall.
- Koch, C., & Ullman, S. (1985). Shifts in selective visual attention: towards the underlying neural circuitry. *Human Neurobiology, 4,* 219-227.
- Lavie, N. (2005). Distracted and confused? Selective attention under load. *Trends in Cognitive Sciences, 9,* 75-82.
- Lehle, C., Steihauser, M., & Huebner, R. (2009). Serial or parallel processing in dual tasks: What is more effortful? *Psychophysiology, 46,* 502–509.
- Logan, G.D. (1988). Toward an instance theory of automatisation. *Psychological Review, 95,* 492-527.
- Logan, G.D. (2004). Cumulative progress in formal theories of attention. *Annual Riview of Psychology, 55*, 207-234.
- Lu, Z., & Dosher, B. A. (1998). External noise distinguishes attention mechanisms. *Vision Research, 38,* 1183–1198.
- Luck, S.J., & Vecera, S.P. (2002). *Attention.* In Pashler, H., & Yantis, S. (Eds.), *Steven's handbook of experimental psychology. Third Edition* (pp. 235–286). New York: Wiley.
- Massaro, D.W., & Shlesinger, M. (1997). Information processing and a computational approach to the study of simultaneous interpretation. *Interpreting, 2,* 13–53.
- Medin D.L., Ross B. H., Markman A. B. (2001). *Cognitive psychology. Third edition*. New York: John Wiley and Sons, Publishers.

- Meyer, D. E., & Kieras, E. D. (1997). A computational theory of executive cognitive processes and multiple task performance. Part 1: Basic mechanisms. *Psychological Review, 104,* 3–75.
- Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review* 63(*2),* 343–355.
- Miyake, A., Friedman, N.P., Emerson, M.J., Witzki, A.H., Howerster, A., & Wager, T. (2000). The Unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41*, 49-100.
- Moors, A., & De Houwer, J. (2006). Automaticity: A theoretical and conceptual analysis. *Psychological Bulletin, 132,* 297-326.
- Moray, N. (1959). Attention in dichotic listening: affective cues and the influence of instructions. *Quarterly Journal of Experimental Psychology, 11,* 56–60.
- Moser, B. (1978). *Simultaneous interpretation: A hypothetical model and its practical application.* In D. Gerver, & H. W. Sinaiko (Eds), *Language Interpretation and Communication* (pp.353-368). New York: Plenum Press.
- Moser-Mercer, B. (2000). *The rocky road to expertise in interpreting: Eliciting knowledge from learners*. In M. Kadric, K. Kaindl, & F. Pochhacker (Eds.). *Translations-wissenshaft* (pp. 339-352). Tubingen, Germany: Stauffenburg Verlag.
- Moser-Mercer, B. (2002). *Process models in simultaneous interpretation.* In F. Poechhacker & M. Shlesinger (Eds), *The Interpreting Studies Reader* (pp. 148-161). London : Routledge .
- Moser-Mercer, B. (2000/01). Simultaneous interpreting: Cognitive potential and limitations. *Interpreting 5(2)*, 83–94.
- Norman, D. A., & Bobrow, D. G. (1976). On the analysis of performance operating characteristics. *Psychological Review, 83,* 508–510.
- Oléron, P., & Nanpon, H. (1965). Recherches sur la traduction simultanée. *Journal de psychologie normale et pathologique, 62*, 73-94.

- Olivers, C.N. L., Hulleman, J., Spalek, T., Kawahara, J., & Di Lollo, V. (2011) The sparing is far from spurious: Reevaluating within-trial contingency effects in the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance, Vol 37(2)*, 396-408.
- Palmer, J. (1994). Set-size effects in visual search: The effect of attention is independent of the stimulus for simple tasks. *Vision Research, 34,* 1703–1721.
- Paneth, E. (1957). *An investigation into Conference Interpretation.* M.A. Thesis, University of London.
- Pöchhacker, F. and Shlesinger, M. (eds) (2002) The Interpreting Studies Reader, London and New York: Routledge
- Rozan, J.-F. (1956). *La prise de notes en interprétation consécutive.* Geneva: Georg, trans.
- Rougier, N. P., Noelle, D.C., Braver, T.S., Cohen, J.D., & O'Reilly, R.C. (2005). Prefrontal cortex and flexible cognitive control: rules without symbols. *Proceedings of the National Academy of Sciences of the United States of America*, *102(20),* 7338-43.
- Setton, R. (1999). *Simultaneous Interpretation: A cognitive-pragmatic analysis*. Amsterdam/ Philadelphia: John Benjamins.
- Setton, R. (2003). *Models of the interpreting process.* In A.C. Aís, & J. A.S. Panilla (Eds.) *Avances en la investigación sobre la interpretación [Advances in research on interpreting] (*pp. 29-91). Granada: Editorial Comares.
- Shlesinger, Miriam. 2000. *Strategic allocation of working memory and other attentional resources in simultaneous interpreting*. Doctoral dissertation, Bar Ilan University, Israel.
- Simon, H. A., & Kaplan,C. A. (1989). *Foundations of cognitive science.* In Posner, M.I. (Ed.) *Foundations of Cognitive Science.* MIT Press, Cambridge MA.
- Schneider, W., & Shiffrin, R.M. (1977). Controlled and automatic human information processing: 1. Detection, search, and attention. *Psychological review, 84*, 1-66.

- Shiffrin, R.M., & Schneider, W. (1977). Controlled and automatic human information processing II: Perceptual learning, automatic attending, and a general theory. *Psychological review, 84,*127-190.
- Shipp, S. (2004). The brain circuitry of attention. *Trends in Cognitive Sciences, 8,* 223-230.
- Solso, R.L. (1979). *Cognitive psychology.* New York: Harcourt, Brace, Jovanovich.
- Spence, C., & Driver, J. (1996). Audiovisual links in endogenous covert spatial attention. *Journal of Experimental Psychology: Human Perception & Performance, 22,* 1005–1030.
- Treisman, A. (1960). Contextual cues in selective listening. *Quarterly journal of experimental psychology, 12,* 242-248.
- Vachon, F., & Tremblay, S. (2005). Auditory attentional blink: Masking the second target is necessary, delayed masking is sufficient. *Canadian journal of experimental psychology, 59(4),* 279-286.
- Viagio, S. (1996). Research in simultaneous interpretation. An outsider's overview. *Interpreters' Newsletter, 7,* 73-84.
- Wickens, C.D. (1984). *Processing resources in attention.* In R. Parasuramen, & D.R. Davies (Eds.) *Varieties of attention* (pp.63-101). Orlando: Academic.
- Wood, N., & Cowan, N. (1995). The cocktail party phenomenon revisited: Attention and memory in the classic selective listening procedure of Cherry (1953). *Journal of experimental psychology: General, 124*, 243-262.
- Wyble, B., Bowman, H., & Nieuwenstein, M. (2009). The attentional blink provides episodic distinctiveness: Sparing at a cost. J*ournal of experimental psychology: Human perception and performance, 35(3)*, 787-807.
- Yantis, S. (2000). *Goal-directed and stimulus- driven determinants of attentional control.* In S. Monsell, & J. Driver (Eds.), *Attention and performance (Vol. 18): Control of cognitive pro- cesses* (pp. 73–103). Cambridge: MIT Press.