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Information processing and a computational approach to the study of simultaneous interpretation

DOMINIC W. MASSARO AND MIRIAM SHLESINGER

We begin by describing some challenges to psychological inquiry and to the understanding of simultaneous interpretation. We then articulate the computational and hypothesis-testing approach to inquiry, and illustrate a general information-processing model. We discuss some experimental and theoretical studies of language processing carried out within the information-processing approach. We analyze not only behavioral measures of language processing but also its phenomenal experience. We close with a review of two current hypotheses about simultaneous interpreting and consider some methodological hurdles in the study of this fascinating skill.

Even at its finest, the human brain does not seem to have been programmed to process a text of any level of complexity between any two languages at any speed. When it comes to the composite skill of simultaneous interpreting (SI), there are inherent limitations to the capacity of the interpreter — no matter how expert and versatile — to perform this online interlingual conversion. Not surprisingly, much of the literature on interpreting deals with just that: the limitations on our processing capacity and the compensatory strategies which we tend to adopt as a means of producing a piece of running discourse which will be as “dynamically equivalent” to the original as possible. Thus, the discussion centers on speed of comprehension, attention splitting, control over activation thresholds in an interpreters’ two languages, and the role of memory (especially short-term and working memory) in determining the extent to which an interpreter can “afford” to lag behind the speaker. As noted

by de Groot (1997):

Only in SI does attention constantly have to be divided between comprehension of the input and production of the output. The proportions of attentional capacity required for the comprehension, on the one hand, and production, on the other, must continuously fluctuate [...] This unremitting and fluctuating capacity-sharing will heavily tax the limited processing resources of the simultaneous interpreter. Orchestrating the portions of attention that must be assigned to the various ongoing activities may be the vulnerable spot in simultaneous interpretation." (1997:27).

Thus, simultaneous interpreting offers a challenging domain for inquiry within the emerging field of cognitive science. No description could be considered complete without an understanding at psychological, linguistic, neurological, sociological, and applied levels. A psychologist's focus is necessarily on a psychological level of explanation, whereas an interpreter's concern is with practice. Before articulating a psychological framework for the research and application of SI, we will make a few observations about the challenges researchers and practitioners face when involved with scientific inquiry.

Then we will describe hypothesis testing, computational modeling, and an information-processing framework that could be useful in the study of SI. We illustrate the value of this approach in the study of language processing more generally. We will touch on the limitations on explanation, strategies of inquiry and introspective reports. We will review two current hypotheses from the SI literature, and conclude with a description of two methodological hurdles in the study of SI.

Challenges to psychological inquiry

One reason why progress in the understanding of SI has been slow is that SI behavior is complex, complexity being the hallmark of causes of behavior. Each of us has a unique history, and often behaves differently in any given set of circumstances. The fact that behavior is so dependent on many influences and on our distant pasts makes it difficult to uncover simple behavioral laws. This is all the more true of complex behaviors such as SI, and one wonders whether we will ever be able to achieve a full understanding or a predictive theory. What is more, theories of SI are likely to have predictive power only in the laboratory, where the complexity of the task can be simplified, mea-

sured and controlled. In fact, in line with the dictum that "data without theory are meaningless," even laboratory data on SI might exceed the constraints of any adequate theory; thus, our contention is that experiments on SI only infrequently inform us about theoretical alternatives (Massaro, 1975a, 1975b, 1987), one reason being the large number of variables.

Moreover, because of the probably high degree of interaction between the processes occurring in SI, it is difficult to isolate them in an experimental setup. Thus, while we advocate the integration of research findings taken from cognitive psychology and psycholinguistics into the study of SI, we also realize that conclusions based on the study of single processes in isolation in non-interpreting environments may not be fully applicable (cf. Gile, 1997: 213).

Several recent developments in philosophy and science inform our question, among them the "New Realist" view of science, which allows for predictability in the laboratory, but not in the naturally varying environment (Manicas & Sécord, 1983). Jenkins (1979) has given a similar view of memory research, because of the context sensitivity of any finding: the "law" of memory that is observed necessarily depends on four classes of variables — subjects, acquisition conditions, memory materials, and memory tasks — and will differ under different choices within these four classes. By the same token we might expect the laws of SI to have an analogous context sensitivity, the four classes of variables being the interpreter, his or her training and performance history, the interpreting situation, and the interpreting requirements. In short, given the multitude of processes contributing to it, context-independent laws of SI are probably beyond our reach.

A second difficulty in devising truly reliable corroborative methods of psychological research is that we all tend to interpret the world as more orderly than it actually is. Suppose we tell you that we have in mind a rule for producing a sequence of numbers, and we ask you to try to guess the rule. If you are told that the sequence 2, 4, 6 was generated by this rule, you will probably guess that the rule is one in which the numbers increase by two. In fact, this guess would be much more specific than the rule we have in mind, i.e. counting by twos or whatever. You naturally tend to see the rule as more specialized than necessary. As scientists, this bias to interpret situations too simplistically can impede understanding and accurate prediction.

A third difficulty is that people have a bias to validate their beliefs, a "confirmation bias." Once a researcher develops a hypothesis, it is only

natural that s/he will be motivated to test the accuracy of this hypothesis. It is well documented that scientists, even very seasoned ones, actively search for evidence to support their own beliefs, often ignoring alternative hypotheses. Leo Tolstoy rationalizes the human nature of confirmation bias as follows:

I know that most men, including those at ease with problems of the greatest complexity, can seldom accept even the simplest and most obvious truth if it be such to oblige them to admit the falsity of conclusions which they have delighted in explaining to colleagues, which they have proudly taught to others, and which they have woven, thread by thread, into the fabric of their lives.

A fourth difficulty in psychological inquiry, which may be understandable, given the first three, is that there are several alternative theories to describe most phenomena. For example, there is currently a great deal of controversy concerning language acquisition and use. At issue is whether a child's productive ability requires an internalization of rules of grammar, or whether associative and generalization mechanisms are sufficient. In a classic experiment, young children were able to generate plurals of pseudo-words they had never heard before. The obvious interpretation at that time was that the child used a rule to achieve the "correct" outcome. There is a rule for forming plurals and children may use this rule to guide their behavior.

On the other hand, the child might have performed correctly simply by using analogies to specific words that they already knew. In this case, the child knowing the plurals of rug, bug, and tug, could induce from these instances that a good guess for wug might be wugs. In fact, even though generating wugs based on analogs might be regarded as a good example of inductive rule generation, it need not be a grammatical rule.

In summary, as we face the complexity of behavior, we tend to impose more order than may actually exist, we display a confirmation bias in testing hypotheses, and we are overwhelmed with several conflicting theoretical explanations.

The computational approach

Four features of the computational approach can help to address these problems. First, it is necessary to develop highly specific, precise, and simplified experimental studies in order to reveal fundamental regularities or laws

related to the phenomena of interest. The idea is that these regularities or laws cannot be revealed or reliably tested in highly complex situations. A complex experiment or natural situation is influenced by multiple causes, and the regularities of each of them will not be easily disentangled. A valuable theory might be capable of predicting behavior in the laboratory where the complexity of everyday life can be simplified, measured and controlled, but not in the naturally varying environment. In fact, complexity of the natural setting might far exceed what any scientific theory could hope to predict.

A theory often provides a given prediction under a constrained set of circumstances, which cannot be maintained in a complex experiment. By dissecting complex behaviors into simpler component processes, the computational approach may offer the parsimony that is critical within any scientific inquiry.

Second, the computational approach enables the investigator to perform a fine-grained analysis of the results to distinguish among competing models. Only by thorough, systematic, and even anxiety-ridden (there's always another possible explanation lurking in the wings) analyses can an investigator eliminate alternative models, thus reducing the set of models consistent with the observations of human performance. It also behooves us to remember that small deviations between predictions and observations must be taken seriously: Johannes Kepler was convinced that the tiny, but systematic, 8' of arc deviation between the actual orbit of Mars and that predicted by Ptolemaic theory was meaningful. Taking this result seriously perhaps contributed to Kepler's patience during 30 years of inquiry to arrive at his three laws of planetary motion.

The third remedy afforded by the computational approach is the ability to test between alternative models of performance using the research strategy of falsification and strong inference. Falsification has the goal of actually falsifying a model, and strong inference seeks to distinguish between two or more different models. Within the computational framework, the investigator should develop opposing models and devise an experimental situation that allows a test between their respective predictions. Simply accumulating evidence that is consistent with a given model is not an ideal strategy because the data might be equally consistent with one that is diametrically opposed. When results are indiscriminately confirmatory, they support a variety of hypotheses; yet progress is made only when alternatives are eliminated — which may happen even if it is consistent with many other findings. The idea of

"whole word shape" being functional in reading is a good example. Although this old idea was consistent with an abundance of research findings, it was disqualified only when experiments were motivated by falsification and strong inference. For example, the advantage of recognizing letters in words also occurs when the words are written in mixed upper and lower case, which should eliminate any benefit from word shape.

Although good scientific inquiry dictates that we actively attempt to eliminate alternative models, it is difficult to do so with models that have enough flexibility to predict a wide range of alternative results. This appears to be the case for the Physical Symbol Systems and Connectionism, for example (Massaro & Cowan, 1993).

In both of these theoretical frameworks, the time course of the component processes of the model does not usually match the processes that occur in human beings, so that the observed data will often be insufficient to decide among alternative models. Furthermore, although specific models within both of these theoretical approaches can be falsified, others can be devised to reproduce any possible result which would render these theories nonfalsifiable. To guard against an unfalsifiable theory, there is a fourth aspect of the computational approach that might be employed beneficially; namely, its ability to ensure that only models with "discriminating taste" would be permitted to survive. Discriminating taste means that a model predicts only actual results, not the universe of possible results.

The investigator therefore tests the theory not only against observed results but also against a range of hypothetical ones that are known not to occur. We keep these implications in mind in our discussion of a framework for inquiry in the study of SI.

Hypothesis testing

Experiments are usually developed and conducted within general scientific frameworks, whether these frameworks are explicitly defined or only implicitly assumed by the experimenter; hypotheses must be testable, and must be as parsimonious as possible. One framework for scientific endeavor has been expressed most succinctly by Popper (1959) — that hypothesis testing must follow deductive rather than inductive methods; i.e. a conclusion follows logically from given assumptions, hypotheses, or premises, and should con-

tain no more information than that which is contained in the given assumptions. All humans are animals; I am a human; therefore, I am an animal. The conclusion that "I am an animal" was directly deduced from the given information that all humans are animals, and I am a human. No new information is presupposed, for instance, by concluding that humans are a unique type of animal. Everything follows from what is given. This is in contrast to inductive reasoning in which the conclusion contains more information than is contained in the observations and experience on which it is based. Every cat we have ever seen has hated being given a bath; therefore, all cats hate being given baths. There is no certainty that a dirty cat will not come to our door sooner or later begging for a bath.

Following Hume, Popper claims that we are not justified in inferring universal or general statements from specific ones; any conclusion drawn inductively might turn out to be false, so that no experimental observation can verify a hypothesis. If a theory survives the experimental tests, we should not discard it. On the other hand, if the experimental tests falsify conclusions drawn from the theory, then the theory should be rejected or modified accordingly. A critical feature of Popper's scientific framework is that verifiability and falsifiability do not have a symmetrical relationship. Although theories can be falsified, they cannot be truly verified; positive results only corroborate, but do not verify, a particular theory.

As we know only too well, models could be modified indefinitely to incorporate inconsistent results (Popper, 1976). This prolongation of falsification is called "immunization." Successive modification of a model keeps it alive and holds off its eventual rejection. In this case, a better contribution is an alternative model rather than another inconsistent experimental result. As observed by Conant: "A theory is only overthrown by a better theory, never merely by contradictory facts" (1947:36). Surviving a particular experimental test only temporarily supports a theory since another investigator could soon provide a test that falsifies it.

In a slightly different approach to scientific endeavor, Platt (1962; 1964) encourages scientists to employ a strong inference strategy for testing hypotheses. In contrast to generating a single hypothesis, Platt would have the scientist generate multiple hypotheses relevant to a particular phenomenon of interest. The experimental test would be designed to eliminate (or in Popper's words, falsify) as many of these hypotheses as possible. The results of the experimentation would allow the generation of new hypotheses which could be subjected to further tests.

Both Platt and Popper adhere to Hume's axiom prohibiting inductive arguments. The message is that the scientist should not attempt to confirm a single pet hypothesis. However, Platt's solution seems more productive in that at least one of the multiple hypotheses under test should fail and can, therefore, be rejected. Strong inference has the potential of providing more information than falsification. If an experiment can be designed to falsify one hypothesis with one outcome and another hypothesis with another outcome, then there is a greater likelihood of rejecting a hypothesis.

By making two hypotheses mutually exclusive then, the experiment should be able to falsify one of them. However, other outcomes might be possible; for example, neither or both of the outcomes could be obtained.

Computational modeling

One of the goals of cognitive science is to understand how we perform the myriad sets of behaviors that characterize us. We promote the value of computational models in this enterprise of understanding how humans accomplish these feats. Models are usually considered to be a somewhat more constrained and specific form of a theory. Computational usually refers to a system that makes specific operations or computations. The most familiar computational system is the computer although a computational model is not necessarily a computer model. A computational model might consist of a set of operations that are described in quantitative form. Thus, computational modeling is the formal, quantitative description of behavior by the interaction of a set of simpler component processes. We attempt to help understand the complexity of everyday behavior in terms of simpler mechanisms working in combination. Computational modeling necessarily describes the processes causing behavior and not just the behavior itself. Computational modeling is a valuable approach because it helps to overcome difficult problems in psychological inquiry.

Science is a precise discipline and computational models constrain our theorizing to be more precise. They are developed specifically to be tested against empirical results of humans since they describe how humans perform. Of course, in order for predictions to be made, the model must be comprehensive. In many cases, the model builder will discover that some important component was not specified or that it was not specified sufficiently. Thus,

computational modeling usually leads to greater detail and completeness. One result is that the model is more easily tested in a broader range of situations; if the results are not consistent with its predictions, modification will be required. Having a completely specified model will usually reveal possible alternative ones, leading to experimental tests of specific assumptions. Computational modeling, therefore, represents an enterprise of a continual interplay between experimentation and modeling.

The study of SI can be roughly partitioned into language understanding and language production processes. We have described language understanding as a prototypical pattern recognition problem (Massaro, 1998). One of the themes of our theoretical framework is that perceivers use multiple sources of information to make sense of the message. Both bottom-up (stimulus-driven) and top-down (knowledge- or context-driven) sources are used to arrive at the most appropriate interpretation. Although this type of processing has been well documented in speech perception and comprehension tasks, it has not often been used as a point of departure for the study of SI. There are far fewer studies of the conveyance of emotional information and other paralinguistic information via the face and the voice. It seems essential to understand how the interpreter arrives at the emotional state of the speaker and to what extent he or she transmits the same emotional content. We and others have found that similar processes occur in speech perception and sentence understanding across a broad range of different languages (MacWhinney & Bates, 1989; Massaro, 1998). Thus we expect similar language understanding processes in the SI situation, although this type of investigation remains to be done.

On the speech production side, much less is known although this is fully half the equation. Some studies have shown that a variety of cues are provided by the speaker and he or she exploits the tradeoff in these cues to render a clear message. Other studies have looked at the role of speech errors such as false starts and hesitations in sentence processing and comprehension (Fox Tree, 1995). Should interpreters somehow simulate these characteristics in their interpretations? In 1977, Gerver and Sinaiko (1978) assembled a group of researchers and interpreters to initiate the scientific study of SI. About two decades later, we have gained some significant insights into the perception and production of language, but the application of this knowledge and its scientific study within the SI situation remains at its infancy (Lambert & Moser-Mercer, 1994). It is hoped that the issues discussed here will facilitate a successful transfer of this knowledge.

The information processing approach

Notwithstanding its complexity, the useful heuristic of information-processing models allows us to take advantage of the strategies mentioned above, and offers the potential for some progress in the study of SI. Like democracy — to cite Winston Churchill's famous formulation — information processing is not perfect but it's the best approach we have for the time being. "Information," though difficult to define precisely, refers to representations derived by environmental stimulation or from processing that influences selections among alternative choices for belief or action. "Information processing" (IP) refers to how the information is modified so that it eventually has its observed influence. Five properties of IP have been described (Palmer & Kimchi, 1986). First, an informational description: the environment and mental processing can be described in terms of the amount and types of information. Recursive decomposition, also described as hierarchical decomposition indicates how one stage of processing can be broken down into substages. For example, a memory stage can be broken down into acquisition, retention, and retrieval stages; retrieval can be further broken down into memory search and decision; and memory search can be further broken down into access and comparison stages. The flow continuity principle: information is transmitted forward in time. All inputs necessary to complete one operation are available from the outputs that flow into it. Also central to the IP approach is the principle of flow dynamics: each stage or operation takes some time (i.e., a mental process cannot be instantaneous). Finally, the physical embodiment principle means that information processing occurs in a physical system. Information is embedded in states of the system called representations, and operations used to transform these representations are called processes.

In IP, the progression of information is traced through the system from stimuli to responses. Although an IP analysis usually describes the mapping from one stage to another, it is generally the case that several different stages can operate at once. In SI, it is necessary to be perceiving and understanding the spoken text while producing a translation of it. Several stages can operate at once, but if a particular input were followed through the system, the operations carried out on it might occur in sequential order (hence the term "stage"). In this case, the IP model lends itself to powerful analytic devices, such as Donders' subtraction method, Sternberg's additive factor method, backward masking, and mathematical models (see Massaro & Cowan, 1993).

As illustrated in Table 1, at least six stages of processing between the presentation of a stimulus and the subject's response have been identified. It should be noted that there is a transition from physiological terms to psychological terms between stage 1 and 2 and back to physiological ones in stage 6. This terminology is as it should be in that an algorithmic mental level has proven more appropriate for more central functions and the neural/physiological level more appropriate for more peripheral ones.

Table 1. Six stages of processing and one variable influencing each stage

Stages	Variables
1. Sensory Transduction	Signal Intensity and Duration
2. Evaluation and Integration	Stimulus Quality
3. Pattern Classification	Similarity of Alternatives
4. Percept/Act Translation	Percept-Act Compatibility
5. Motor Programming	Complexity of Movement
6. Motor Execution	Physical Components of Movement

The first measurable stage, sensory transduction, occurs more rapidly with greater signal intensity. The second, featural registration, evaluation, and integration, is influenced by the quality of the featural information, the nature of the evaluation, and the type of integration required. The third stage is pattern classification or the perceptual encoding of a stimulus event relative to various alternatives in memory. If the output of this stage were discrete rather than continuous, we would say that the pattern is categorized as a given alternative. However, this stage of processing makes available the degree to which the signal represents one pattern relative to the degree to which it matches all others. The time necessary for this stage is influenced by the family of alternatives that are relevant to the task at hand.

Research has shown that well-learned patterns are recognized in accordance with a general algorithm, regardless of the modality or particular nature of the patterns (Massaro, 1987). An IP model has received support in a wide variety of domains and consists of three operations: feature evaluation, feature integration, and decision. Continuously valued features are evaluated, integrated, and matched against prototype descriptions in memory. The evaluation stage gives continuous information about the degree to which each feature is present in the stimulus. The integration stage combines or integrates the outputs of the evaluation stage in an optimal fashion. Finally, a continuous

or discrete identification decision is made on the basis of the relative goodness of match between stimulus information and the relevant prototype descriptions.

The fourth stage is referred to as percept/action translation (more traditionally known as response selection). It is influenced primarily by what often comes under the blanket term, stimulus-response compatibility, though a more realistic description would be percept-act compatibility, since it concerns the mapping of a crucial factor in performance. An important contribution to performance is how readily perception maps into action. Thus, for example, reacting in the direction of a signal is usually easier than reacting away from a signal, and it would be a feat of effort to look away from rather than toward the location of overhearing your name at a cocktail party. Once the action is selected, it has to be programmed before it can be executed.

The representation and processes involved in reading words and naming pictures has been described by Theios and Amrhein (1989), using an IP model to account for the slower naming of pictures relative to the reading of words. Picture (and color) naming involves additional time for two processes relative to word naming: determining the meaning and mapping this meaning into a response (stages 3 and 4 in Table 1). These two stages are also central to SI because a direct mapping between the input text and the target translation is seldom possible.

An obvious variable influencing the fifth stage, motor programming, is complexity of the action that is required. Complexity and programming time increase with the number of discrete actions required. The time to initiate a response sequence increases with the number of key presses required, and is independent of whether subjects responded in the direction of or away from the test signal (percept-act compatibility). The specificity of the percept also appears to be important for motor programming. Programming time is longer to the extent that advance preparation and the percept do not specify the required action. Thus, for literate adults, the reaction time (RT) of a naming response to pictures will be longer than the same response to words (all other things constant, Theios & Amrhein, 1989).

The motor execution stage involves moving the appropriate effectors for the desired action. The physical requirement of the action influences this stage of processing, as does muscle tension. All public speakers and interpreters are aware of the importance of emotional and physiological state in executing a good presentation.

As indicated by this short review, IP offers a productive understanding of the processing dynamics of how we work. In many respects, we can envision the IP approach as providing a microscope of the mind (Massaro & Cowan, 1993). Within the information processing framework, moreover, it is important to develop theories and hypotheses in the form of computational models.

Information processing analysis of language

Having described the information processing approach, we illustrate in more detail how it is applied to language perception and comprehension. There are at least four stages of processing a language pattern: sensory transduction, sensory cues, perceived attributes, and conceptual understanding. Our sensory systems transduce linguistic input and make available a configuration of sensory cues. Perceived attributes correspond to the outcome of processing these cues. As in other domains of pattern recognition, there is a many-to-one relationship between sensory cues and perceived attributes. For example, information about the syntactic structure of a spoken utterance is conveyed by not only pitch but also duration and the actual words being used. In SI, such cues are essential because the segmental information is often degraded by the simultaneous auditory masking from the interpreter's own output. In turn, there is a one-to-many relationship between some sensory cue and the resulting perceived attributes. The pitch of the speaker's voice provides segmental information and information about the syntactic structure of the utterance as well as the age, gender, and affective state of the speaker. In an analogous fashion, perceived attributes and conceptual understanding are not necessarily uniquely associated. Identical percepts can take on different meanings, making it difficult for the interpreter to select the appropriate translation in the short time required for a smooth translation. Similarly, the same meaning can be created by entirely different percepts. The plethora of homophones in English, such as /see/ and /sea/, produce different meanings with the same phonological form, while the different phonological forms /ocean/ and /sea/, can produce more or less the same meaning. Given the assumption that language processing is best conceptualized as pattern recognition, it is worthwhile to consider the most appropriate definition of language recognition.

Language recognition

What does it mean to recognize a linguistic pattern such as a word? We assume that word recognition is a part of the broader concept of language comprehension. Given the popular riddle, How many animals did Moses bring on the ark? most people find this a perfectly acceptable question and give some quantitative reply. They do not notice or understand at the time of the question that the lead character in this biblical event is not Moses but Noah (Erickson & Mattson, 1981; Reder & Kusbit, 1991). Aspects of the appropriate biblical event are quickly called to mind even if the main player or other details are incorrect. Comprehension appears to be a matter of degree (graded); there are different degrees of understanding of our example riddle. In addition, understanding is dynamic in that it fluctuates across time — for example, the change in understanding when we become aware of the misplaced biblical character. Similarly, sentence interpretation is more ambiguous than the discrete interpretations usually given by students of language processing.

Our view is that the outcome of word recognition is graded in the same way that comprehension is graded. Most investigators, on the other hand, have assumed that the outcome of word recognition either occurs or doesn't. This all-or-none property is also reflected in our models of word recognition, beginning with Morton's (1969) seminal logogen model with a threshold for each word and Forster's (1985) search model of lexical access to the more recent cohort (Marslen-Wilson, 1984) and activation-verification models (Paap, Newsome, McDonald, & Schvaneveldt, 1982). Much of contemporary research also reflects the implicit assumption of discrete word recognition. There is a good deal of debate about the number of activated meanings given presentation of a polysemous word, but the all-or-none property of a given meaning is not usually questioned.

However, there are hints of evidence for graded word recognition. Abrams and Balota (1991) for example, found that the strength of a key press was related to the frequency of the test word. Connine, Blasko, and Wong (1994) demonstrated that word recognition might be graded. An ambiguous prime was made by modifying the initial phoneme before /ent/ to be ambiguous between /d/ and /t/. In this case, the prime is an ambiguous word between dent and tent. Ambiguous primes of this type facilitated lexical decisions for both meanings of the prime, indicating perhaps multiple and graded activation. Thus, we

should keep in mind the caveat that word recognition is unlikely to be all-or-none (and that interpreters usually go with less than complete information, thus creating even more ambiguity).

In SI, it is well-known that the interpreter's degree of understanding builds gradually as the source message evolves. Many of the comprehension processes typical of the monolingual, visual task of reading — such as the interplay between immediate, online decoding of units as they appear, on the one hand, and the chunking of units into constituent phrases or clauses, on the other — have been shown to apply to the bilingual, auditory task of interpreting. Evidence of these similarities has drawn mainly on studies of sight translation (e.g. McDonald & Carpenter, 1981) and of think-aloud protocols (e.g. Gerloff, 1987; Krings, 1987; Séguinot, 1992; Dancette, 1997). (But see: Danks & Griffin (1997) on the task-specific cognitive demands of interpreting, as compared with other "linguaging" tasks).

To comprehend a text is, among other things, to build a meaningful and coherent representation of its conceptual content, or text world, and to actualize links between textual and extratextual information (Dancette, 1997; Hatim & Mason, 1997). It stands to reason, then, that the less information one has about the text at any given point, the more tenuous one's comprehension of it. The linearity of the simultaneous interpreting process — the fact that the interpreter cannot access those parts of the text which have not yet been uttered by the speaker — has important implications in this regard. To begin with, the interpreter is but an intermediary, who does not necessarily share the extralinguistic knowledge available to the speaker and to the intended addressee. Furthermore, the interpreter's knowledge of the setting (event-specific background, the participants, the topic(s), and the schemata typical of the particular discourse) is usually limited, especially at the outset; indeed the number of omissions and of incorrect inferences in simultaneous interpreting has been shown to be highest at the beginning of the discourse (Shlesinger, 1995). By the same token, Kohn and Kalina (1996) note that top-down hypotheses are liable to be weaker at the outset of the discourse, so that the interpreter may have to wait longer to obtain additional information, based on special bottom-up effort.

Operating within these limitations, the interpreter must continually adjust his/her ear-voice span (EVS) — the interval between the moment a given component of the input is perceived and the moment its target-language counterpart is produced — and engage in an ongoing trade-off between the risk of forgetting parts of the input (by extending the EVS beyond the limits of

working memory), and the risk of error (due to production based on incomplete utterances; i.e. on anticipation). Given the key role of anticipatory planning in monolingual processing — in both comprehension (Bruce, 1958) and production (Goldman-Eisler, 1958) — its role in simultaneous interpreting, in which comprehension and production practically coincide, is bound to be all the more crucial. By studying interpreters' specific anticipatory strategies, then, one may hope to learn about trade-offs between cognitive skills, and about other aspects of online processing. At the same time, it must be remembered that these strategies too are a function of many variables.

Thus, for example, text type and structural characteristics of the discourse may play a vital role in determining textual predictability (Kopczynski, 1982; Chernov, 1994; Jörg, 1995; Hatim & Mason, 1997). Adamowicz (1989) has shown that when it comes to hypotheses formed by interpreters about yet-to-be-revealed segments of discourse, the EVS in the case of prepared and structured texts is shorter than with extemporaneous ones.

Another factor known to affect the EVS is the interpreter's level of expertise: expert interpreters generally tend to opt for a longer EVS — a strategy which may be accounted for by their having developed more global and more efficiently organized knowledge structures than those of novices (Moser-Mercer, 1997), as interpreters make effective use of the text-schematic knowledge typically available for processing the former. Novices' tendency to opt for an EVS which is too short to allow for effective reorganization of the input has frequently been cited as accounting for their higher error rate (as compared with that of professionals). Davidson (1992) refers to this as a "panic reaction" stemming from novices' concern over their possible inability to remember a segment of the incoming message if it becomes too long. In a comparative study of the outputs of several signed-language interpreters, Cokely (1986) found an inverse relationship between interpreters' EVS and their error rate. Interpreters with a 2-second lag time exhibited more than twice as many miscues (particularly lexical omissions) as interpreters with a 4-second lag, who had almost twice as many miscues as those with a 6-second lag. Cokely concludes that "[...] the primary reason for this is the quantity of the source language message available to the interpreter. The greater the lag time, the more information available; the more information available, the greater the level of comprehension" (1986:373).

The extent of structural and morpho-syntactic (dis)similarity between the source and target languages is another determinant of the EVS (Gile 1991).

Take, for example, the task of interpreting from a head-final language like English (i.e., one in which modifiers precede the noun) into a similarly head-final language like German. By contrast, take the task of interpreting from English into a head-initial language like Hebrew. In the former case, the interpreter will be able to follow, more or less, the left-to-right sequence of the source language. In the case of Hebrew, on the other hand, any string of modifiers + noun will require the modifiers to be stored in working memory until the noun has been either anticipated or sounded by the speaker. Among the language combinations often mentioned as posing particular difficulties because of their syntactic anisomorphism are German-English (Moser, 1978; Wilss, 1978; Jörg, 1995), German-Italian (Riccardi, 1995) and Japanese-English (Davidson, 1992; Gile, 1992).

The interpreter's own language combination has also been shown to affect both speed and accuracy of perception. In a study of speech perception errors among non-native listeners, Voss (1984) found an underlying perception strategy of processing the input somewhat independently of the acoustic information. The subjects "seem to have 'heard' words that were not even present in the acoustic information [...] When one takes the rest of the context into consideration one finds that this would have ruled them out" (p. 99-100). Since most of the work done in simultaneous interpreting entails listening to one's second language, the chances of such misperceptions are somewhat higher to begin with (cf. Bond & Ganes, 1980; de Groot, 1992; 1993).

The mitigating effect of redundancy in natural language allows the interpreter to extend the EVS. Goldman-Eisler and Cohen suggest that interpreting would not be possible were it not for the fact that "a large part of the context of normal language consists of highly automatic overlearned sequences and redundancies" (1974:9). Chernov (1973) presented subjects with "surprise ending" sentences, and found an overriding tendency to interpret in keeping with expectations rather than with actual input. In other words, by the time the subjects had perceived, decoded and processed the sentence endings they had applied their own linguistic and extralinguistic knowledge towards anticipating them. Chernov (1979; 1994) goes so far as to describe this redundancy as an indispensable feature of the input: "[...] not all verbal messages, but only messages with an adequate degree of redundancy, can be interpreted simultaneously" (1994:140).

This is in keeping with the "Moses and the Ark" example above, and is supported by day-to-day observations of trainee interpreters. In one class of

advanced trainees, a small-scale study was conducted, which required students to listen to the sentence: "The gross domestic product has not grown over the past year; the gross national palate, however, keeps growing." Eight of the eleven students produced the following output, including the self-correction (back-translated from the target language): "The gross domestic product has not grown over the past year; the gross national product... gross national palate, however, keeps growing." Even though the subjects did not begin their output of this sentence before hearing the word palate, they seem to have been "primed" to expect that the second noun phrase would be gross national product, patterned on the preceding gross domestic product. Their subsequent monitoring and self-correction of the error indicates that anticipatory strategies, rather than misperception, were responsible for the initial error. No less important, as in the observations of Voss (1984) cited above, and as in the Moses example, they "heard" what they expected to hear. We now address an important issue in language processing and attempt to show how the debate was resolved using the principles of inquiry developed in this chapter.

Autonomous versus integration models

A major distinction between autonomous and integration models of language processing has to do with how several linguistic variables influence performance. Early strictly modular views proposed that some linguistic process such as phoneme recognition was triggered by a primary source of information (e.g., auditory speech in terms of phonetic features) and was not perturbed by other sources such as lexical, syntactic, and semantic context (Fodor, 1983). Integration models, on the other hand, proposed that these multiple sources of information are combined during linguistic processing (Massaro, 1975b; Oden, 1977). Thus much of the debate has centered on how bottom-up and top-down sources are processed. Bottom-up sources correspond to those sources that have a direct mapping between the sensory input and the representational unit in question. Top-down sources or contextual information comes from constraints that are not directly mapped onto the unit in question. As an example, a bottom-up source would be the stimulus presentation of a test word after the presentation of a top-down source, a sentence context. A critical question for both integration and autonomous

(modularity) models is how bottom-up and top-down sources of information work together to achieve word recognition. For example, an important question is how early can contextual information be integrated with acoustic-phonetic information. A large body of research shows that several bottom-up sources are evaluated in parallel and integrated to achieve recognition (Massaro, 1987; 1994). An important question is whether top-down and bottom-up sources are processed in the same manner, and whether this processing is similar in typical communication and in the interpreting task.

We take the critical characteristic of autonomous models to be the language user's inability to integrate bottom-up and top-down information. To attempt to add some order to the plethora of possibilities, we consider integration of top-down and bottom-up information as the keystone distinguishing between autonomous and nonautonomous models. In our view, the autonomous model must necessarily predict no perceptual integration of top-down with bottom-up information.

As is perhaps apparent in the unresolved debate between autonomous and integration viewpoints, specific predictions and tests are not easy. Massaro (1996) formalized and tested two prototypical autonomous models, as well as an integration model. The integration model was the fuzzy logical model of perception (FLMP), which had already been tested extensively in a broad number of domains. The autonomous models were a horse race model and a post-perceptual guessing model, which were new formalizations of existing autonomous views. Several research findings were shown to falsify these autonomous models of language processing. The FLMP, on the other hand, was very successful in describing these same experimental results, and we focus on this model as a prototypical information processing model, and on its implications for SI.

Fuzzy Logical Model of Perception (FLMP)

The results from a wide variety of experiments have been described within the framework of the FLMP. Within the present framework shown in Figure 1, language processing is robust because there are usually multiple sources of information that the perceiver evaluates and integrates to achieve perceptual recognition. According to the FLMP, patterns are recognized in accordance with a general algorithm, regardless of the modality or particular nature of the

patterns. The assumptions central to the model are (1) each source of information is evaluated to give the degree to which that source supports the relevant alternatives, (2) the sources of information are evaluated independently of one another, (3) the sources are integrated to provide an overall degree of support for each alternative, and (4) perceptual identification follows the relative degree of support among the alternatives.

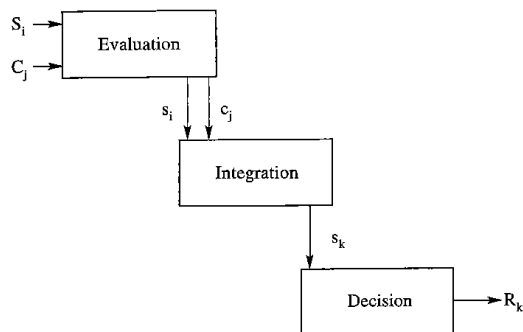


Figure 1. Schematic representation of the three stages involved in perceptual recognition. The three stages are shown to proceed left to right in time to illustrate their necessarily successive but overlapping processing. The sources of information are represented by uppercase letters. Sensory information is represented by S_i and context information by C_j . The evaluation process transforms these sources of information into psychological values (indicated by lowercase letters s_i and c_j). These sources are then integrated to give an overall degree of support for a given alternative s_k . The decision operation maps this value into some response, R_k , such as a discrete decision or a rating.

FLMP account of lexical context

In a seminal experiment that has been replicated several times, Ganong (1980) found that lexical identity could influence phonetic judgments. A continuum of test items was made by varying the voice onset time (VOT) of the initial stop consonant of CVC syllables. The VC was also varied. For example, subjects identified the initial consonant as /d/ or /t/ in the context

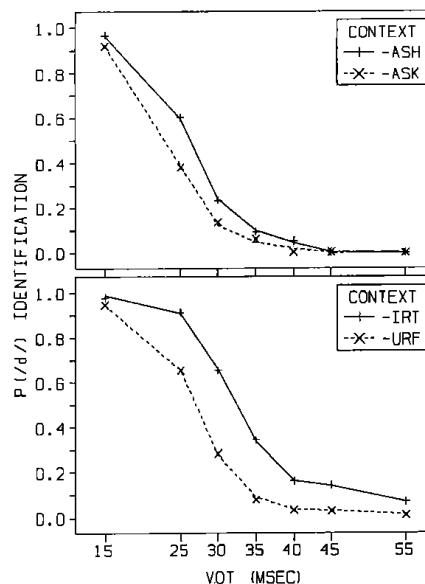


Figure 2. Observed (points) and predicted (lines) proportion of /d/ identification for -ash and -ask contexts (top panel) and -irt and -urf contexts (bottom panel) as a function of VOT. (Observed data from Ganong, 1980). Predictions of the FLMP.

/ash/ (where /d/ makes a word dash and /t/ does not), or in the context /ask/ (where /t/ makes a word task and /d/ does not). Both the segmental information of the initial phoneme and the lexical context influenced performance. The top panel of Figure 2 shows that the percentage of voiced judgments decreased as the initial segment was changed from /t/ to /d/. A lexical context effect was also observed because there were more voiced judgments /d/ in the context -ask than in the context -ash. The bottom panel of Figure 2 shows similar results for the contexts supporting the words dirt and turf. An important result was that this lexical effect was largest at the intermediate levels of

VOT that were most ambiguous. This result is consistent with the general principle that the least ambiguous source has the most influence on perception.

According to the FLMP, there are two sources of information in the Ganong task: the bottom-up information from the initial speech segment and the following top-down context. It is assumed that both of the sources are evaluated and integrated to achieve perceptual identification. The evaluation process provides continuous information indicating the degree to which each source of information supports each alternative. This continuous information is represented in terms of fuzzy truth values that lie between zero (no support) and one (complete support). With two response alternatives, as in the Ganong task, .5 is completely ambiguous support. Furthermore, with just two response alternatives, the support of a source of information for one alternative is one minus its support for the other alternative. At the integration operation, the total support for a given alternative is given by the multiplicative combination of the two separate sources of support. Finally, the decision operation follows a relative goodness rule (RGR): A response is based on the total support for that alternative relative to the total support for both alternatives. As can be seen from the close match between the observed points and predicted lines in Figure 2, the FLMP gave a good description of the results. Thus, the model captures the observed interaction between segmental information and lexical context: the effect of context was greater to the extent that the segmental information was ambiguous. This yields two curves in the shape of an American football, which is a trademark of the FLMP. We now turn to the interesting question of how the perceiver integrates word information and sentence context in language processing.

Integrating word information and sentence context

Psycholinguists have studied this problem in the gating task (Grosjean, 1980; 1985). As indicated by the name of the task, portions of the spoken message are eliminated or gated out. Successive presentations involve longer and longer portions of the word. Subjects attempt to name the word after each presentation. Warren and Marslen-Wilson (1987), for example, presented words such as *school* or *scoop*. The probability of correct recognition of a test word increases as additional word information is presented in the gating task.

The gating task appears to have promise for the investigation of speech perception and spoken language understanding. Investigators have shown that two features of the gating task do not limit its external validity. Multiple presentations of the test word on a given trial (Cotton & Grosjean, 1984; Salasoo & Pisoni, 1985) and unlimited time to respond in the task (Tyler & Wessels, 1985) are not essential for the results. Thus, the results appear to be generalizable to the on-line recognition of continuous speech.

Tyler and Wessels (1983) used the gating paradigm to assess the contribution of various forms of sentence context to word recognition. Subjects heard a sentence with its final word gated out. This test word was increased in duration by adding small segments of the word until correct recognition was achieved. The sentence contexts varied in syntactic and semantic constraints. Some sentence contexts had minimal semantic and weak syntactic constraints in that the target word was not predictable in a test given the sentence context and the first 100 ms of the target word. Performance in this condition can be compared to a control condition in which no semantic and weak syntactic constraints were present. If sentential context contributes to recognition of the test word, then accuracy should be better for the sentence context with minimum semantic constraints.

Figure 3 gives the probability of correct word recognition as a function of the number of segments in the test word and the context condition. Both variables had a significant influence on performance. In addition, the interaction between the two variables reveals how word information and context jointly influence word recognition. Sentence context influences performance most at intermediate levels of word information. The contribution of context is most apparent when there is some but not complete information about the test word. The lines in Figure 3 give the predictions of the FLMP (see Massaro, 1994). As can be seen in the figure, the FLMP captures the exact form of the improvement in performance as a function of segmental information and sentential context. It remains to be determined whether this result holds for SI as well. According to the information-processing analysis of successive pattern classification and percept/act translation stages, we expect that it would.

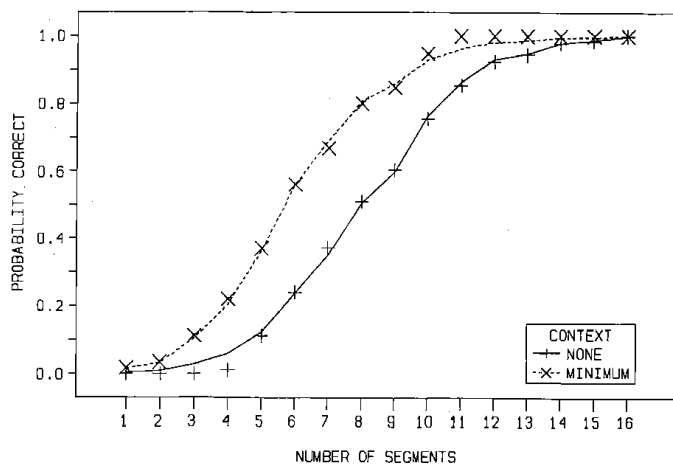


Figure 3. Observed (points) and predicted (lines) probability of identifying the test word correctly as a function of the sentential context and the number of segments of the test word. The minimum context refers to minimum semantic and weak syntactic constraints. The none context refers to no semantic and weak syntactic constraints (results of Tyler & Wessels, 1983; predictions of the FLMP).

Bottom-up and top-down processes in SI

Although they differ crucially in the circumstances in which they are performed, interpreting and (written) translation are two related tasks which may share certain processing strategies. Thus, concepts which have emerged from research into translation as a process (Lörscher, 1986; Séguinot, 1989; Fraser, 1996) are potentially relevant to the study of interpreting. Chief among these has been the Minimax Principle (derived from Game Theory) (Levy, 1967) which states that translators will try to keep the cognitive load as light as possible and will not proceed to a deeper, top-down level of processing unless a more shallow, bottom-up level has proven unsuccessful. This is often associated with a sign- (rather than sense-) oriented mode of processing,

based on (near-)automatic lexical pairings.

Toury (1986) describes segmentation as "one of the basic operations that a translator [i.e. in the written as well as the oral medium] has to perform" and regards it as "highly indicative, not only of the mere occurrence of discourse transfer, but also of the linguistic level(s) at which it occurs" (1986:83). Referring to written translation, Lörscher notes that

when a TL [target-language] text segment is produced immediately after the reception of an SL [source-language] one, the subject has probably translated in a sign-oriented way. By means of an automatic association process, the corresponding TL text segment becomes available within a very short period of time and can be verbalized. Sense-oriented translating is dependent on and controlled by mental processes which bring about a separation of SL forms/signs from their sense which is in turn combined with TL forms/signs. However, these processes of separation and combination require much longer periods of time than automatic association processes [...]. Sign-oriented translations are brought about by automatic association processes, and employ an inventory of stored surface-structure equations of lexemes (1991:272-274).

By the same token, when the word order of the target language parallels that of the source language, the interpreter will probably prefer to proceed in a more or less left-to-right sequence; i.e. to use the least demanding strategy for the task. Differences in canonical word order, however, tend to rule out such a strategy as leading to a deviant word order in the target language.

The balance between bottom-up and top-down strategies, and the manner in which they interact in actual performance is partly a matter of expertise. As demonstrated by Pahl and Petzolt (1997), novices differ from experts in their integration of contextual information. When faced with insufficient or ambiguous input, the former rely largely on lexical standard assumptions, whereas the latter try to hold back until more information is available to ensure correct disambiguation and idiomatic collocations.

Le Ny (1978) too hypothesized that "the forgetting of the non-semantic information of the input text is more rapid in an expert interpreter than in the normal unilingual subject during the phase of comprehension" and that "this rapid decline of the non-semantic information is essential to carry out the task of simultaneous interpretation because it facilitates better processing of semantic information" (1978:292). Isham and Lane (1993) found (signed language) interpreters' performance on cloze tests requiring recall-based inferences to be superior to those of transliterators (who, by definition, follow

an essentially sign-oriented pattern), and concluded that interpreters, like listeners, but unlike transliterators, process sentences to represent their propositions rather than their form.

Alongside the growing body of knowledge based on empirical studies are several theories, hypotheses and models which have yet to be put to the test. While some which seem intuitively correct may well withstand experimental scrutiny, their acceptance at face value would have done little to further the scientific study of interpreting. One of the best known theories or hypotheses on the workings of SI to be advanced in the relevant literature will serve to illustrate this point. The theory of deverbalization — whereby only the meaning remains in the interpreter's mind without any trace of its linguistic vehicle — was first suggested by Seleskovitch (1968). It rests on apparently valid insights, backed by firsthand experience and observation. However, as Jensen (1985) notes: "It cannot be proved that Seleskovitch is wrong, just as she cannot prove that she is right [...]" (1985:107).

Much of the relevant literature builds on an intuitive assertion that interpreting is not performed in a word-by-word sequence, but is rather based on semantic-syntactic structures in the source language which are first converted into deverbalized concepts and only then recoded and articulated in the target language. This theory, also known as the "théorie du sens", was based on the premise that the words are evanescent, but their meaning remains, determined as it is by the identity and intention of the generator of the message. Once the interpreter has understood and assimilated the meaning of an utterance, s/he dissociates it from the words in which it was conveyed, distances herself/himself from them and seizes their sense.

Expanding on this theory, Lederer (1983:144) posits a three-stage process: the first in which information is committed to working memory, the second in which cognitive integration takes place in long-term memory, and the third in which the output is formulated. Here too, however, no attempt is made to test either the theory or the model. Seleskovitch and Lederer base their conclusions on professional experience, introspection, intuition and chance observation rather than on empirical evidence.

The notion of deverbalization is frequently mirrored in the writings of interpreter trainers as well, as a strategy which is appealing in terms of its cognitive efficiency as well as its communicative effectiveness. In psychological terms, it appears to be a form of conceptual mediation in which the interpreter accesses a shared store — a kind of code that is common to all his

or her languages. It not only obviates the search for word-based equivalents but also produces a more fluent and cohesive output. One implication is that interpreters process individual stimuli (bottom-up) only long enough to arrive at an underlying knowledge-base, and that in doing so, they make recourse to the linguistic and extralinguistic knowledge (top-down) required to arrive at the "sense" of the utterance. As noted by Kohn and Kalina (1996), top-down processing in SI encompasses not only world knowledge but a complex interaction between different types of knowledge — of grammatical dependencies, of collocational links, of text types, etc.: "While for analytical purposes, it is certainly necessary to distinguish between these two dimensions [top-down and bottom-up processing], this must not obscure the fact that they are indeed inseparable" (Kohn & Kalina, 1996:19).

As noted above, however, there appear to be situations in which form-based interpreting (horizontal "transcoding") supersedes deverbalization (Isham, 1994). For one thing, as the rate of input increases, processing is likely to become more and more bottom-up, and more data-driven; the interpreter does not have the time, as it were, to process fuller, meaning-based units of text, and may adopt a more-or-less sign-oriented strategy. This is especially true of inexperienced interpreters and of languages which are markedly different in terms of syntax; it may also be more common with some parts of speech (e.g. nouns) than with others (MacWhinney, 1997). Even experienced interpreters may "short circuit" deeper level processing (Nida, 1969) if there is a well-rehearsed stock equivalent or cognate available. Along the same lines, Gile (1986) notes that for written translation "cette compréhension ne doit pas nécessairement être aussi approfondie que celle du destinataire [...]" En général, les relations logiques et fonctionnelles entre les différents termes spécialisés doivent être clairement identifiées afin que le traducteur puisse remanier librement la structure de l'énoncé de manière qu'il puisse rédiger une traduction claire" (pp. 363-366).

Attempts to assess the relative weight of vertical and horizontal processing are complicated by the subtle interaction between cognitive skills, *per se*, and acquired strategies. Kohn and Kalina (1996) define interpreting as "strategic discourse processing geared to the interlingual transfer of mental world modeling from a source discourse to a target discourse platform," and note that "the strategic orientation of interpreting is all-pervasive [...]. Automation of strategic processes also plays an important role, for only if routine decision processes are performed more or less automatically will the interpreter have

enough capacity and attention to solve the more intricate and complex problems" (1996:127).

One of the main methodological problems immanent to this all-pervasiveness of the strategic orientation lies in the difficulty of teasing apart the role played by strategies internalized by interpreters from the cognitive workings and constraints imposed by the task. (Schjoldager, 1995). It is as though the interpreter's behavior is directed by cognitive constraints, on the one hand, and by a set of strategic heuristics for task performance, on the other: Try to get the gist, don't worry if you have to leave out or compress things which seem to be redundant; try to sound fluent and coherent; and make sure to keep talking.

The complex interactions between the crucial processes — alternatively referred to in the literature in terms of such partly overlapping dichotomies as top-down/bottom-up processes, sense-/sign-oriented transfer, vertical/horizontal transcoding — seem to offer the most meaningful, if daunting, object of collaborative study. Thus, for example, if stimulus-driven interpreting plays a greater role than has been acknowledged by deverbalization theory, it would seem that "a cognitive psychologist's opinion that all we need to know about this skill could be inferred from our knowledge of comprehension and production in L1 and L2 would obviously be flawed" (de Groot, 1997: 31), and that more ought to be done to define the relative weight of these two types of processes, as a function of the parameters which typically affect cognitive load.

Phenomenal experience in language processing

One phenomenal experience in speech perception is that of categorical perception. Listening to a synthetic speech continuum between /ba/ and /pa/ provides an impressive demonstration: students and colleagues usually agree that their percept changes qualitatively from one category to the other in a single step or two with very little fuzziness in between. Another misleading impression is that we have substantial silent periods between the words of an utterance, when in fact very little silence exists. We also wonder, regardless of our native language, why foreign languages don't have these silences whereas our language does. Our phenomenal experience, however, may reveal very little of the hidden processes supporting perception and under-

standing. As noted by Marcel (1983), phenomenal experience might be dependent on linking current hypotheses with sensory information. If the sensory information is lost very quickly, continuous information could participate in the perceptual process but might not be readily accessible to introspection.

Not only can we be misled by our perceptual experience, we also are fallible with respect to our understanding of language. The illusion of knowing has been well-documented (Glenberg, Sanocki, Epstein, & Morris, 1987). Students are asked to read a passage and indicate if they understand it. They read it and then claim it is perfectly clear — even though the passage contains a blatant contradiction. They presume knowledge and coherence when in fact there is very little. The same might be said of our reaction to political speeches. We too often nod our heads in agreement in circumstances in which we don't know what we are agreeing with. This takes our interpretation of the Japanese "yes" or nod of agreement one step farther. Westerners have learned that "yes" from a Japanese person does not mean he or she agrees — only that they understand. We must also realize that "yes" or even an apparently informed answer from any listener might not signify understanding, as in our illusory understanding of the Moses question. Given the tenuous state of our experience, it is not surprising that the introspective method has substantive limitations in the study of SI.

The introspective method

Simultaneous interpretation and even psycholinguistics are perhaps too wedded to our phenomenal experience and to the introspective method in seeking explanations. The introspective method has been part of psychological inquiry since its inception over a century ago, and is also characteristic of many studies of SI. Although sometimes proving valuable as an adjunct to the experimental method, it does not, by itself, lead to precise and quantitative knowledge. In an interesting adaptation of the think-aloud protocol technique, Kalina (1993) confronted interpreters with their recorded product immediately after the task had been completed, and prompted them to reactivate and verbalize whatever had gone through their minds at particular points in their interpretation. Notwithstanding the innovativeness of this type of introspection, it cannot be expected to provide a full, or even a fully reliable picture.

More or less conscious amending or manipulating of what has really taken place in the process may occur, or else, the interpreter may simply have forgotten what factors motivated a particular choice. Indeed "self-observation may be an additional instrument but its results are subject to the same reservations as those set out above" (p. 228).

Recently, psychologists have documented the limitations of the introspective method by showing that many of the causes of our behavior remain opaque to us. In one study, for example, subjects were asked to memorize word pairs, such as ocean-moon (Nisbett & Wilson, 1977). After this task, they were asked to name a detergent. Studying ocean-moon increased the likelihood of giving Tide as an answer but, when asked, subjects almost never mentioned the words in the memorization test as an influencing factor. In another task, subjects choose an article of clothing of the best quality from several arranged in a row (Nisbett & Wilson, 1977). After choosing among four nightgowns, for example, the subject is asked why that particular one was preferred. Subjects revealed a strong position effect in that there was a strong bias to pick the nightgown that was on the right. Subjects were four times as likely to choose the one on the right regardless of the actual nightgown in that position. These same subjects never mentioned position as an influencing factor in their decision and virtually all the subjects adamantly denied the experimenter's proposition that position had an influence. Clearly, then, the introspective method falls short of providing an understanding of behavior in these domains.

Ericsson and Simon (1993) defend the use of the introspective method, but remind us that the verbal reports elicited by this method are data. It is also worth remembering that previous uses of the introspective method did not determine which psychological processes were responsible for the reports, nor how these processes might change with instructions and tasks. Understanding the results goes hand in hand with understanding the measuring instrument (how the results were obtained); in this case, understanding the processes responsible for an introspective report will help account for the actual outcomes of that report. On the basis of a review of many studies, the authors claim that subjects are capable of giving reliable verbal reports of conscious experience, but cannot be expected to give reliable accounts of processes outside of consciousness or of events no longer available in memory. Thus, we cannot expect introspective reports to inform us about most of the fundamental processes involved in SI. Still, the early writings on

simultaneous interpreting were also based, in the main, on introspection. Distinguished interpreters and trailblazers of the profession tended to formulate their teachings more as dicta ("do as I do and you shall succeed") than as tentative observations to be corroborated or refuted. Thus, we find practitioners who, while undoubtedly conversant with the object of their research and deeply committed to gaining an ever-better understanding of their field, are sometimes prone to a certain lack of detachment, which surfaces in their writings in the form of a sense of awe at an impossible job incredibly done. Also characteristic is the frequent lack of delineation between descriptive writings (whether or not based on empirical research) and prescriptive or normative ones.

Another example of a theory derived in part from experience and introspection, which remains to be tested is Gile's Efforts Model (1988; 1991; 1997; cf. Shreve & Diamond, 1997). This theory posits three concurrent conscious and deliberate "Efforts" — listening to and analyzing the source-language speech; producing a target-language speech; storage and retrieval. In an ongoing tradeoff, processing capacity is strategically shared among these Efforts, since priorities must be established with attention allocation strategies. At each point in time, each of these Efforts has particular Processing Capacity requirements that depend on the task(s) they are tackling. These tasks determine how much information must be stored, how many storage and retrieval operations take place, how much processing needs to be performed in order to reach sufficient understanding of a particular speech segment, what target language words are looked for, what syntactic choices have to be made, etc. [...] The Efforts Model is basically a conceptual model, built intuitively but untested experimentally as yet (Gile, 1991:17-18).

In other words, in the ten years which have elapsed since this model was suggested by Gile, little has been done to subject it to systematic testing. Precisely because the Efforts Model is a pre-theoretical, largely intuitive formulation of notions which are based on extensive experience and thoughtful insights, as Gile himself recognizes (Gile, 1997), we hold that these notions ought to be subjected to empirical testing, using our information-processing approach, for example, where the dynamic nature of simultaneous interpreting can better be studied. Much of the research carried out to date on simultaneous interpreting has focused on cognitive overload and processing breakdowns—using errors, omissions etc. as dependent variables. It is intuitions and insights such as the ones which generated the Efforts Model that can

point to potential avenues of research, but the precise methods to be applied must first be worked out through ongoing collaboration between interpreter-researchers and information-processing researchers.

Methodological hurdles in the study of SI

When it comes to interpreting, it is all the more true that "the great mass of translation has left no records" (Steiner, 1975: 273-274); it is only through the rather laborious task of recording, transcribing and analyzing that one can create a tangible record of the input and output products. As for the process, hypothesis-testing within the framework of an information-processing paradigm is apt to bring SI research closer to understanding how it works, but the road is strewn with methodological hurdles. To begin with, as in any complex cognitive task, the object of study had best be broken down into observable and controllable units, yet without losing sight of the interactions among them. Balancing the holistic and the atomistic approaches has generated controversy not unlike that which has proliferated in relation to psychological processing in general (e.g. Neisser, 1976; Bruce, 1985, 1991; Banaji and Crowder, 1989; Naveh-Benjamin, 1993; cf. Conway, 1993). In the context of SI research, it has centered on the validity of materials and the dearth and variability of subjects.

Non-authentic materials, and the decoupling of experimental procedures from genuine settings, have often been cited as undermining ecological validity. Gile (1994) comments on the texts used by Dillinger (1989) in an experimental study of comprehension in interpreting: "[...] although interpreting sentences read out of context or written material not intended for oral communication may deepen insight on aspects of language comprehension and production or on other aspects of language-related skills, both processes and results may be quite different from those that occur in actual interpretation" (p. 45). To which Dillinger (1990) replies: "The hypothesis that the texts are different and the processes involved in comprehending and interpreting them are qualitatively different because one text was presented to an audience and the other was not is not only unsupported by any evidence, but also seems entirely implausible" (p. 43). The discussion does not rest there, however: "[...] interpreters report reacting to factors that have not yet been quantified or even specifically identified. Those [interpreters] who engage in research

themselves have stressed time and time again the need to use experimental materials and conditions as close as possible to field conditions because of this. In Dillinger's case, since the whole validity of the experiment relies on the speeches, we feel that starting out with the assumption that there is no difference constitutes a methodological error." (Gile, 1994:46).

Whatever their position in the debate over "unnatural" texts, SI researchers tend to agree that the use of decontextualized materials — words, phrases or even sentence-length utterances in isolation — would defeat the purpose; nothing less than complete units of discourse may serve as a basis for inferences about the nature of cognitive processes involved in interpreting (but see Spiller-Bosatra et al., 1990; de Groot, 1997). Herein lies one of the major difficulties: clearly, text-length units of discourse are liable to introduce far greater variability than the syllables, words or sentences often used in psychological and psycholinguistic studies, but there appears to be little chance of fully controlling for potential confounds, particularly when several texts must be used for any given study.

Most of the research questions which feature centrally in information-processing-oriented SI research require the manipulation of one or more features of the discourse (e.g., syntactic density), of its delivery (e.g., speaker visibility) or of the interpreter (e.g., experience). The design generally entails the use of several texts and an analysis of the outputs. This in turn has raised the issue of the comparability of texts. While "authentic" texts may not differ, in principle, from "artificial" ones, as Dillinger (1989) maintains, every text is in some ways unique, marked by a set of linguistic, stylistic and structural parameters and by the particular circumstances of its delivery. The early literature on SI research abounds with conclusions based on outputs for texts which are grouped together on the tenuous grounds of being "six prerecorded excerpts from articles in the French edition of ..." (Gerver, 1976), "two short stories" (Darò & Fabbro 1994); "four types of materials offering differing grammatical and structural characteristics [...] with which an interpreter might come into contact" (Barik, 1972; 1973; 1975); or "two 'easy' and two 'difficult' texts" (Tommola & Hyönä, 1996). Notwithstanding the important contribution of such studies, their tendency to overlook subtle differences among ostensibly "same" or "matched" texts is liable to produce misleading results. Researchers face an immense challenge in devising materials that preserve experimental rigor while not compromising ecological validity.

The availability and suitability of subjects is another methodological

difficulty in SI research. As in the study of any highly skilled behavior, differences between novices and experienced performers must be taken into account. Thus, the subject population for most studies of the information-processing aspects of interpreting is inherently small since:

- professional interpreters have been shown to differ significantly from non-interpreter bilinguals (Esser, 1990; Darò, 1989; 1994; Spiller-Bosatra et al., 1990; Padilla, 1995; Kohn & Kalina, 1996; cf. Dillinger 1989), so that the two subject-groups cannot be indiscriminately mixed;
- the number of professional interpreters for any given language combination is small;
- the variability among professional subjects with respect to potentially relevant parameters (extent of experience, personality, language history, gender, handedness, prior knowledge etc.) is considerable, and is bound to encumber the process of hypothesis testing and scientific investigation. It remains to be determined to what extent other seemingly less central characteristics play a role.

Retrospective

It remains to be determined to what extent an information-processing approach will increase our understanding of SI and improve training and practice. We endorse a collaborative relationship among researchers and practitioners, as illustrated by the Ascona workshops and several papers in this issue. Intuitions which lead to the formation of hypotheses are likely to evolve in the process of interpreting or observing the work of colleagues. It is in such circumstances that one notices the unique (some might say anomalous) features of interpreting, develops one's own intuitions about the process or formulates one's own hypotheses. It is in such circumstances too that "practisearchers" have been led to speculate on whether, for example, speaker visibility really facilitates task performance (e.g. Anderson, 1994; Tommola & Lindholm, 1995); whether interpreters' intonation is really unlike any other (Shlesinger, 1994); or whether it is consistently easier to translate from (or into?) one's native language (Pinhas, 1972; Barik, 1975; Gile, 1991; 1995; Schweda Nicholson, 1992). These intuitions can be mapped onto specific hypotheses and subjected to rigorous experimental tests. These tests in turn can inform researchers and practitioners alike and lead to gradual but significant progress in our understanding of one of the most challenging arenas of human communication.

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References

- Abrams R. A., & Balota, D. A. (1991). Mental chronometry: Beyond reaction time. *Psychological Science*, 2, 153-157.
- Adamowicz, A. (1989). The role of anticipation in discourse: Text processing in simultaneous interpreting. *Polish Psychological Review*, 20(2), 153-160.
- Anderson, L. (1994). Simultaneous interpretation. Contextual and translation aspects. In S. Lambert & B. Moser-Mercer (Eds.), 1994. *Bridging the gap: Empirical research in simultaneous interpretation* (pp. 101-120). Amsterdam/ Philadelphia: John Benjamins.
- Banaji, M., & Crowder, R. G. (1989). The bankruptcy of everyday memory. *American Psychologist*, 44(9), 1185-1193.
- Barik, H. (1972). Interpreters talk a lot, among other things. *Babel*, 18(1), 3-10.
- Barik, H. (1973). Simultaneous interpretation: Temporal and quantitative data. *Language and Speech*, 16(3), 237-270.
- Barik, H. (1975). Simultaneous interpretation: Qualitative and linguistic data. *Language and Speech*, 18(2), 272-298.
- Bond, Z. S., & Ganes, S. (1984). Misperceptions of fluent speech. In R. A. Cole (Ed.), *Perception and production of fluent speech* (pp. 115-132). Hillsdale, NJ: Lawrence Erlbaum.
- Bruce, J. (1958). Some tests of the decay theory of immediate memory. *Quarterly Journal of Experimental Psychology*, 10, 12-21.
- Bruce, D. (1985). The how and why of ecological memory. *Journal of Experimental Psychology: General*, 114(1), 78-90.
- Bruce, D. (1991). Mechanistic and functional explanations of memory. *American Psychologist*, 46 (1), 46-48.
- Chernov, G. (1973). Towards a psycholinguistic model of simultaneous interpretation. *Linguistische Arbeitsberichte*, 7, 717-726.
- Chernov, G. (1979). Semantic aspects of psycholinguistic research in simultaneous interpretation. *Language and Speech*, 22(3), 277-295.
- Chernov, G. (1994). Message redundancy and message anticipation in simultaneous interpretation. In S. Lambert & B. Moser-Mercer (Eds.), *Bridging the gap: Empirical research in simultaneous interpretation* (pp. 139-153). Amsterdam/Philadelphia: John Benjamins.

- Cokely, D. (1986). The effects of lag time on interpreter errors. *Sign Language Studies*, 53, 341-376.
- Conant, J. B. (1947). *On understanding science*. New Haven, CT: Yale University Press.
- Conway, M. A. (1993). Method and meaning in memory research. In G. M. Davies & R. H. Logie (Eds.), *Memory in everyday life* (pp. 499-536). Amsterdam/London/New York/Tokyo: North-Holland.
- Connine, C. M., Blasko, D. G., & Wong, J. (1994). Vertical similarity in spoken word recognition: Multiple lexical activation, individual differences, and the role of sentence context. *Perception and Psychophysics*, 56, 624-636.
- Cotton, S., & Grosjean, F. (1984). The gating paradigm: A comparison of successive and individual presentation formats. *Perception & Psychophysics*, 35, 41-48.
- Dancette, J. (1997). Mapping meaning and comprehension in translation: Theoretical and experimental issues. In J. H. Danks, G. M. Shreve, S. B. Fountain, & M. K. McBeath (Eds.), 1997. *Cognitive processes in translation and interpreting*. (pp. 77-103). Thousand Oaks/London/New Delhi: Sage Publications.
- Danks, J.H., Griffin, J. (1997). Reading and translation: A psycholinguistic perspective. In J. H. Danks, G. M. Shreve, S. B. Fountain, & M.K. McBeath (Eds.), *Cognitive processes in translation and interpreting*. (pp. 161-175). Thousand Oaks/London/New Delhi: Sage Publications.
- Darò, V. (1989). The role of memory and attention in simultaneous interpretation: A neurolinguistic approach. *The Interpreters' Newsletter*, 2, 50-56.
- Darò, V. (1994). Non-linguistic factors influencing simultaneous interpretation. In S. Lambert & B. Moser-Mercer (Eds.), *Bridging the gap: Empirical research in simultaneous interpretation* (pp. 249-271). Amsterdam/Philadelphia: John Ben-jamins.
- Darò, V., & Fabbro, F. (1994). Verbal memory during simultaneous interpretation: Effects of phonological interference. *Applied Linguistics*, 15(4), 365-381.
- Davidson, P. M. (1992). Segmentation of Japanese source language discourse in simultaneous interpretation. *The Interpreters' Newsletter, Special Issue*, 1, 2-11.
- Dillinger, M. L. (1989). *Component processes of simultaneous interpreting*. Unpublished doctoral dissertation, McGill University, Montreal.
- Dillinger, M. L. (1990). Comprehension during interpreting: What do interpreters know that bilinguals don't? *The Interpreters' Newsletter*, 3, 41-58.
- Erickson, T. D., & Mattson, M. E. (1981). From words to meaning: A semantic illusion. *Journal of Memory and Language*, 20, 540-551.
- Ericsson, K. A., & Simon, H. A. (1993). *Protocol analysis: Verbal reports as data*. (Rev. ed.) Cambridge, MA: MIT Press.
- Esser, U. (1990). Gedächtnis - Interdisziplinäre Schnittstelle zwischen Psychologie und Übersetzungswissenschaft. In H. Salevsky (Ed.), *Probleme des Simultandol-metschens: Eine Studie zur Handlungsspezifität*. Linguistische Studien. Reihe A. Arbeitsberichte 154 (pp. 83-87). Akademie der Wissenschaften der DDR, Zentralinstitut für Sprachwissenschaft.
- Forster, K. I. (1985). Lexical acquisition and the modular lexicon. *Language and Cognitive Processes*, 1, 87-108.
- Fox Tree, J. E. (1995). The effects of false starts and repetitions on the processing of subsequent words in spontaneous speech. *Journal of Memory and Language*, 34, 709-738.
- Fraser, J. (1996). The translator investigated. *The Translator*, 1(2), 65-79.
- Ganong, W. F. III. (1980). Phonetic categorization in auditory word recognition. *Journal of Experimental Psychology: Human Perception and Performance*, 6, 110-125.
- Gerloff, P. (1987). Identifying the unit of analysis in translation: Some uses of think-aloud protocol data. In C. Faerch & G. Kasper (Eds.), *Introspection in second language research* (pp. 245-262). Clevedon, England: Multilingual Matters.
- Gerver, D. (1976). Empirical studies of simultaneous interpretation: A review and a model. In R. M. Brislin (Ed.), *Translation: Applications and research* (pp. 165-207). New York: Gardner Press.
- Gerver, D., & Sinaiko, H.W. (Eds.). (1978). *Language, interpretation and communication*. New York: Plenum Press.
- Gile, D. (1986). La compréhension des énoncés spécialisés chez le traducteur - quelques réflexions. *Meta*, 31(4), 363-369.
- Gile, D. (1988). Le partage de l'attention et le modèle d'efforts en interprétation simultanée. *The Interpreters' Newsletter*, 1, 27-33.
- Gile, D. (1991). The processing capacity issue in conference interpretation. *Babel*, 37, 15-27.
- Gile, D. (1992). Predictable sentence endings in Japanese and conference interpretation. *The Interpreters' Newsletter*, 1, 12-23.
- Gile, D. (1994). Methodological aspects of interpretation and translation research. In S. Lambert & B. Moser-Mercer (Eds.), *Bridging the gap: Empirical research in simultaneous interpretation* (pp. 39-56). Amsterdam/Philadelphia: John Benjamins.
- Gile, D. (1995). *Basic concepts and models for interpreter and translator training*. Amsterdam/Philadelphia: John Benjamins.
- Gile, D. (1997). Conference interpreting as a cognitive management problem. In J. H. Danks, G. M. Shreve, S. B. Fountain, M. K. McBeath (Eds.), *Cognitive processes in translation and interpreting* (pp. 196-214). Thousand Oaks/London/New Delhi: Sage Publications.
- Glenberg, A. M., Sanocki, T., Epstein, W., & Morris, C. (1987). Enhancing calibration of comprehension. *Journal of Experimental Psychology: General*, 116, 119-136.
- de Groot, A. M. B. (1992). Determinants of word translation. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 18, 1001-1018.
- de Groot, A. M. B. (1993). Word-type effects in bilingual processing tasks: Support for a mixed representational system. In R. Schreuder & B. Weltens (Eds.), *The bilingual lexicon* (pp. 27-51). Amsterdam: John Benjamins.
- de Groot, A. M. B. (1997). The cognitive study of translation and interpretation: Three approaches. In J. H. Danks, G. M. Shreve, S. B. Fountain, & M. K. McBeath (Eds.), *Cognitive processes in translation and interpreting* (pp. 25-56). Thousand Oaks/London/New Delhi: Sage Publications.
- Goldman-Eisler, F. (1958). The predictability of words in context and the length of pauses in speech. *Language and Speech*, 1(4), 226-231.
- Goldman-Eisler, F., & Cohen, M. (1974). An experimental study of interference between receptive and productive processes relating to simultaneous translation. *Language and Speech*, 17, 1-10.
- Grosjean, F. (1980). Spoken word recognition processes and the gating paradigm. *Perception & Psychophysics*, 28, 267-283.

- Grosjean, F. (1985). The recognition of words after their acoustic offset: Evidence and implications. *Perception & Psychophysics*, 38, 299-310.
- Hatim, B., & Mason, I. (1997). *The translator as communicator*. London/New York: Routledge.
- Hibbard, H. (1965). *Bernini*. Baltimore, MD: Penguin Books.
- Isham, W. P. (1994). Memory for sentence form after simultaneous interpretation: Evidence both for and against deverbalization. In S. Lambert & B. Moser-Mercer, (Eds.), *Bridging the gap: Empirical research in simultaneous interpretation* (pp. 191-211). Amsterdam: John Benjamins.
- Isham, W. P., & Lane, H. (1993). Simultaneous interpretation and the recall of source-language sentences. *Language and Cognitive Processes*, 8(3), 241-264.
- Jenkins, J. J. (1979). Four points to remember: A tetrahedral model of memory experiments. In L. S. Cermak & F.I.M. Craik (Eds.), *Levels of processing in human memory* (pp. 429-446). Hillsdale, NJ: Lawrence Erlbaum.
- Jörg, J. (1995). *Verb anticipation in German-English simultaneous interpreting*. Unpublished master's thesis, University of Bradford, England.
- Kalina, S. (1993). Analysing interpreters' performance: Methods and problems. In C. Dollerup & A. Lindegaard (Eds.), *Teaching translation and interpreting. Insights, aims, visions* (pp. 225-232). Amsterdam: John Benjamins.
- Kohn, K., & Kalina, S. (1996). The strategic dimension of interpreting. *Meta*, 41 (1), 118-138.
- Kopczynski, A. (1982). Effects of some characteristics of impromptu speech on conference interpreting. In N. E. Enkvist (Ed.), *Impromptu speech: A symposium*. (pp. 255-266). Åbo: Åbo Akademi.
- Krings, H. P. (1987). The use of introspective data in translation. In C. Faerch & G. Kasper (Eds.), *Introspection in second language research* (pp. 159-176). Clevedon, England: Multilingual Matters.
- Latane, B., & Darley, J. M. (1970). *The unresponsive bystander: Why doesn't he help?* New York: Appleton-Century-Crofts.
- Lederer, M. (1983). La traduction simultanée. In D. Seleskovitch & M. Lederer (Eds.), *Interpréter pour traduire* (pp. 136-162). Paris: Didier Érudition.
- Le Ny, J. Psychosemantics and simultaneous interpretation. In D. Gerver & H. W. Sinaiko (Eds.), *Language, interpretation and communication* (pp. 289-298). New York: Plenum.
- Levý, J. (1967). Translation as a decision process. In *To honor Roman Jakobson II* (pp. 1171-1182). The Hague: Mouton de Gruyter.
- Lörscher, W. (1986). Linguistic aspects of translation processes. In J. House & S. Blum-Kulka (Eds.), *Interlingual and intercultural communication* (pp. 277-292). Narr: Tübingen.
- Lörscher, W. (1991). *Translation performance, translation process and translation strategies*. Tübingen: Narr.
- MacWhinney, B. (1997). Simultaneous interpretation and the competition Model. In J. H. Danks, G. M. Shreve, S. B. Fountain, & M. K. McBeath (Eds.), *Cognitive processes in translation and interpreting* (pp. 215-232). Thousand Oaks/London/New Delhi: Sage Publications.
- MacWhinney, B., & Bates, E. (1989). *The crosslinguistic study of sentence processing*. New York: Cambridge University Press.
- Manicas, P. T., & Secord, P.F. (1983). Implication for psychology of the new philosophy of science. *American Psychologist*, 38, 399-413.
- Marcel, A. J. (1983). Conscious and unconscious perception: An approach to the relations between phenomenal experience and perceptual processes. *Cognitive Psychology*, 15, 238-300.
- Marslen-Wilson, W. D. (1984). Function and process in spoken word recognition: A tutorial review. In H. Bouma & D. G. Bouwhuis (Eds.), *Attention and performance X: Control of language processes* (pp. 125-150). Hillsdale, NJ: Lawrence Erlbaum.
- Massaro, D. W. (1975a). *Experimental psychology and information processing*. Chicago: Rand McNally.
- Massaro, D. W. (Ed.), (1975b). *Understanding language: An information processing analysis of speech perception, reading, and psycholinguistics*. New York: Academic Press.
- Massaro, D. W. (1987). *Speech perception by ear and eye: A paradigm for psychological inquiry*. Hillsdale, NJ: Lawrence Erlbaum.
- Massaro, D. W. (1994). Psychological aspects of speech perception: Implications for research and theory. In M. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 219-263). New York: Academic Press.
- Massaro, D. W. (1996) Integration of multiple sources of information in language processing. In T. Inui & J. L. McClelland (Eds.), *Attention and performance XVI: Information integration in perception and communication* (pp. 397-432). Cambridge, MA: MIT Press.
- Massaro, D. W. (1998). *Perceiving talking faces: From speech perception to a behavioral principle*. Cambridge, MA: MIT Press.
- Massaro, D. W., & Cowan, N. (1993). Information processing models: Microscopes of the mind. In L. W. Porter & M. R. Rosenzweig (Eds.), *Annual Review of Psychology*, 44, 383-425.
- McDonald, J.L., & Carpenter, P. A. (1981). Simultaneous translation: Idiom interpretation and parsing heuristics. *Journal of Verbal Learning and Verbal Behavior*, 20, 231-247.
- Morton, J. (1969). Interaction of information in word recognition. *Psychological Review*, 76, 165-178.
- Moser, B. (1976). *Simultaneous translation: Linguistic, psycholinguistic and human information processing aspects*. Unpublished doctoral dissertation, University of Innsbruck, Austria.
- Moser, B. (1978). Simultaneous interpretation: A hypothetical model and its practical applications. In D. Gerver & H. W. Sinaiko (Eds.), *Language, interpretation and communication* (pp. 353-368). New York: Plenum.
- Moser-Mercer, B. (1997) Beyond curiosity: Can Interpreting research meet the challenge? In J. H. Danks, G. M. Shreve, S. B. Fountain, & M.K. McBeath (Eds.), *cognitive processes in translation and interpreting* (pp. 176-195). Thousand Oaks/London/New Delhi: Sage Publications.
- Naveh-Benjamin, M. (1993). Commentary: Ecological perspectives of working memory.

- In G. M. Davies & R. H. Logie (Eds.), *Memory in everyday life* (pp. 231-239). Amsterdam/London/New York/Tokyo: North-Holland.
- Neisser, U. (1976). *Cognition and reality*. San Francisco: W. H. Freeman.
- Nida, E. (1969). Science of translation. *Language*, 45(3), 483-498.
- Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review*, 84, 231-259.
- Oden, G. C. (1977). Integration of fuzzy logical information. *Journal of Experimental Psychology: Human Perception and Performance*, 3, 565-575.
- Paap, K. R., Newsome, S. L., McDonald, J. E., & Schvaneveldt, R. W. (1982). The activation-verification model for letter and word recognition: The word-superiority effect. *Psychological Review*, 89, 573-594.
- Padilla, P., Bajo M. T., Cañas J. J., & Padilla, F. (1995). Cognitive processes of memory in simultaneous interpretation. In J. Tömmola (Ed.), *Topics in interpreting research* (pp. 61-71). Turku: University of Turku, Center for Translation and Interpretation.
- Palmer, S. E., & Kimchi, R. (1986). The information processing approach to cognition. In F. J. Knappe & L. C. Robertson (Eds.), *Approaches to cognition: Contrasts and controversies* (pp. 37-77). Hillsdale, NJ: Lawrence Erlbaum.
- Pinhas, R. (1972). Les retombés scientifiques des opérations Apollo sur l'interprétation simultanée. *La linguistique*, 8 (1), 143-147.
- Platt, J. R. (1962). *The excitement of science*. Boston: Houghton Mifflin.
- Platt, J. R. (1964). Strong inference. *Science*, 146, 347-353.
- Popper, K. (1959). *The logic of scientific discovery*. New York: Basic Books.
- Popper, K. R. (1976). *Unended quest*. London: Fontana/Collins.
- Prahl, B., & Petzolt, S. (1997). Translation problems and translation strategies involved in human and machine translation: Empirical studies. In C. Hauenschild & S. Heizmann (Eds.), *Machine translation and translation theory* (pp. 123-144). Berlin/New York: Mouton de Gruyter.
- Reder, L. M., & Kusbit, G. W. (1991). Locus of the Moses illusion: Imperfect encoding, retrieval, or match? *Journal of Memory and Language*, 30, 385-406.
- Riccardi, A. (1995). Language-specific strategies in simultaneous interpreting. C. Dollerup & A. Lindegaard (Eds.), *Teaching translation and interpreting: Insights, aims, visions* (pp. 213-222). John Benjamins: Amsterdam.
- Salasoo, A., & Pisoni, D. (1985). Interaction of knowledge sources in spoken word identification. *Journal of Memory and Cognition*, 2, 210-231.
- Schjoldager, A. (1995). An exploratory study of translational norms in simultaneous interpreting: Methodological reflections. *Hermes*, 14, 65-87.
- Schweda-Nicholson, N. (1992). Linguistic theory and simultaneous interpretation: Semantic and pragmatic considerations. *Babel* 38(2), 90-100.
- Séguinot, C. (1989). *The translation process*. Toronto: School of Translation, York University.
- Séguinot, C. (1992) Review of translation performance, translation process, and translation strategies: A psycholinguistic investigation by W. Lörscher. *TTR*, 1, 271-275.
- Seleskovitch, D. (1968). *L'Interprète dans les conférences internationales: Problèmes de langage et de communication*. Paris: Minard Lettres Modernes.
- Shlesinger, M. (1994). Intonation in the production and perception of simultaneous interpretation. In S. Lambert & B. Moser-Mercer (Eds.), 1994. *Bridging the gap: Empirical research in simultaneous interpretation* (pp. 101-120). Amsterdam/Philadelphia: John Benjamins.
- Shlesinger, M. (1995) Shifts in cohesion in simultaneous interpreting. *The Translator*, 1(2), 193-214.
- Shreve, G. M., & Diamond, B. J. (1997). Cognitive processes in translation and interpreting: Critical issues. In J. H. Danks, G. M. Shreve, S. B. Fountain, & M. K. McBeath (Eds.), *Cognitive processes in translation and interpreting* (pp. 233-251). Thousand Oaks/London/New Delhi: Sage Publications.
- Spiller-Bosatra, E., Darò, V., Fabbro, F., & Bosatra, A. (1990). Audio-phonological and neuropsychological aspects of simultaneous interpretation. *Scandinavian Audiology*, 19, 81-87.
- Steiner, G. (1977). *After Babel: Aspects of language and translation*. Oxford: Oxford University Press.
- Theios, J., & Amrhein, P. C. (1989). Theoretical analysis of the cognitive processing of lexical and pictorial stimuli: Naming, and visual and conceptual comparisons. *Psychological Review*, 96, 5-24.
- Tömmola, J., & Lindholm, J. (1995). Experimental research on interpreting: Which dependent variable? In J. Tömmola, (Ed.), *Topics in interpreting research* (pp. 121-133). Turku: University of Turku, Center for Translation and Interpreting.
- Tömmola, J., & Hyönä, J. (1996). The effect of training on cognitive load during simultaneous interpreting. *Proceedings of the XIVth Conference of the International Federation of Translators* (pp. 946-951). Melbourne, Australia.
- Toury, G. (1986). Monitoring discourse transfer: A test-case for a developmental model of translation. In J. House & S. Blum-Kulka (Eds.), *Interlingual and intercultural communication: Discourse and cognition in translation and second language acquisition studies* (pp. 79-94). Tübingen: Narr.
- Tyler, L. K., & Wessels, J. (1983). Quantifying contextual contributions to word-recognition processes. *Perception & Psychophysics*, 34, 409-420.
- Tyler, L. K., & Wessels, J. (1985). Is gating an on-line task? Evidence from naming latency data. *Perception & Psychophysics*, 38, 217-222.
- Voss, B. (1984). *Slips of the ear: Investigations into the speech perception behaviour of German speakers of English*. Tübingen: Narr.
- Warren, P., & Marslen-Wilson, W. D. (1987). Continuous uptake of acoustic cues in spoken word recognition. *Perception & Psychophysics*, 41, 262-275.
- Wilss, W. (1978). Syntactic anticipation in German-English simultaneous interpreting. In D. Gerver & H. W. Sinaiko (Eds.), *Language, interpretation and communication* (pp. 343-352). New York: Plenum.

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— Books

Edwards, A.B. (1995). *The practice of court interpreting*. Amsterdam/Philadelphia: John Benjamins.
Morris, M. (Ed.). (1995). *Translation and the law*. [ATA Scholarly Monograph Series VIII.] Amsterdam/Philadelphia: John Benjamins.

— Article in book/journal

Kurz, I. (1995). Interdisciplinary research: Difficulties and benefits. In Daniel Gile (Ed.), *Interpreting Research* [Special issue]. *Target* 7/1, 165-179.

Darö, V. (1994). Non-linguistic factors influencing simultaneous interpretation. In S. Lambert & B. Moser-Mercer (Eds.), *Bridging the gap. Empirical research in simultaneous interpretation* (249-272). Amsterdam/Philadelphia: John Benjamins.

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