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COGNITIVE PROCESSES IN TRANSLATION AND INTERPRETING

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serve as guiding tools in interpreter training. No adequate indicators seem to have been found. Pupil dilation measurements required that the interpreter's head be maintained in a certain posture (Tommola & Hyna, 1990), and EEG measurements imposed "mental interpretation," without TL sound (Kurz, 1992).

Some of the difficulties of empirical testing could be partly offset by increasing sample sizes and by multiplying replications. The sheer effect of large numbers would reduce the effect of random variation and there would be more possibilities for comparing actual interpretation occurrences using specific differences in selected variables (e.g., language combination, speed, previous knowledge of the subject) retrospectively. For professional, psychological, and practical reasons, however, access to subjects and material is difficult, and the use of students as subjects is problematic. Neither their processes nor their strategies can be safely assumed to reflect those of professional interpreters, if only because very few pass their final exams and become interpreters. The large sample size, multiple replication paradigm is therefore not a realistic one.

Conclusion

The concept of processing capacity and the Effort Models have proved useful for explanatory purposes. However, they have to be validated both against state-of-the-art knowledge in the cognitive sciences and with experimental methods before any fine-tuning and further development can be done. One of the main difficulties in such validation lies in the identification of precise, reliable, and sensitive indicators. It is precisely because of these difficulties that the input of researchers from the cognitive sciences is highly desirable.

11

Simultaneous Interpretation and the Competition Model

BRIAN MacWHINNEY

Language processing is a remarkable balancing act. We are all so skilled at these linguistic acrobatics that the complexity of verbal processing is usually hidden from view. Yet, if we look analytically at what goes on beneath this calm exterior, we find a seething cauldron of mental operations working together in complex ways to link sounds into words, words into phrases, and phrases into sentences. All of this processing is smoothly intermingled, so that we can take in new words, even as we are constructing old phrases and interpreting larger textual units. Processing at all of these levels is coordinated so smoothly and seamlessly that we never notice the enormous amount of processing that is completed at every moment, both when we listen and when we speak. We can be driving down the freeway, passing cars, thinking about the day's events while we are listening closely to the report of the day's activities on the radio news. At the same time, we can be carrying on a detailed conversation with our passengers about the upcoming political campaign. It is remarkable that something so complex and multifaceted as sentence processing can be conducted with virtually no apparent effort at all.

Sometimes we do commit errors and go down false linguistic paths. If we ask people to listen to tricky sentences—such as the following: "The horse raced past the barn fell" or "The communist farmers hated died"—we can observe a momentary breakdown of the comprehension system, as people start to think about "barns falling" and "farmers hating to die." Fatigue and distraction can induce speech errors or "slips of the tongue" in production. These errors are testimony to problems that lay in wait under the apparently placid surface of normal language processing. A great deal of what we know about both language production and language comprehension has been based on the study of these situations of processing overload. In fact, one could argue that processing overload is the best window we have on the inner workings of language and thought.

In this chapter, I will explore an additional way in which the processing system can be subjected to overload. This is the activity of simultaneous interpretation in skilled interpreters. Although skilled simultaneous interpreters are among the most linguistically gifted people on this planet, the complexity of the task that they have undertaken eventually takes its toll in terms of errors, omissions, and inappropriate translations. Part of this additional load derives from the fact that the interpreter must engage in both ongoing comprehension and ongoing production simultaneously and continuously. This complete temporal overlapping of comprehension with production can also be found in another difficult linguistic task—the shadowing task in which subjects are asked to listen to an ongoing sequence of input sentences while repeating them immediately in their own voice. Some people find the shadowing task impossible, but even those who manage to do it successfully find it difficult. Simultaneous interpretation places yet another burden on the interpreter's shoulders—the requirement that the input be translated into another language for the output. Because of this further requirement, the simultaneous interpretation task is remarkable not only for the incredible resource and coordination demands that it places on the interpreter but also for the ways in which the interpreter learns to cope with this extreme processing overload.

The contrast between effortless, error-free performance and difficult, overloaded, error-prone production is at the heart of all psycholinguistic theory. Everything that we know about language processing is due to the study of some form of language breakdown or overload. For this reason, the study of processing in simultaneous interpretation could provide information that would be pivotal in the construction of a general psycholinguistic theory.

The Competition Model

The particular version of psycholinguistic theory developed by myself and my colleagues is called the Competition Model (Bates & MacWhinney, 1982; Bates, McNew, MacWhinney, Devescovi, & Smith, 1982; Li, Bates, Liu, & MacWhinney, 1992; Li, Bates, & MacWhinney, 1993; MacWhinney, 1982, 1985, 1987a, 1988; MacWhinney & Bates, 1978; MacWhinney, Bates, & Kliegl, 1984; MacWhinney & Pléh, 1988; McDonald & MacWhinney, 1989, 1995). The model can be understood best in terms of the commitments it makes to four major theoretical issues.

(1) Lexical functionalism. In the debate between functionalist and formalist accounts of language structure and processing, the Competition Model takes the side of functionalist analysis. The basic claim of functionalism is that the forms of language are determined and shaped by the communicative functions in which they are placed. The pressure of communicative function, operating in accord with the constraints of neurolinguistic processing, is considered to be the primary determinant of language development, processing, and evolution.

(2) Connectionism. To model the interactions between lexical mappings, the Competition Model uses connectionist representations. Four important properties of neural network systems are competition, gradience, emergence, and transfer. These effects each have important consequences for simultaneous interpretation.

(3) Input-driven learning. In the debate between nativism and empiricism, the Competition Model emphasizes the role of the input, rather than innate principles or parameters. The role of the input is treated in terms of the constructs of cue validity and cue strength. Connectionist learning algorithms provide the model with ways of extracting emergent linguistic structures from patterns of input cues. The emphasis on cue validity as the major determinant of acquisition allows us, as psychologists, to formulate highly falsifiable hypotheses that can be tested against easily obtained experimental data. In regard to the study of simultaneous interpretation, the cues being studied involve translational structures between languages.

(4) Capacity. Given sufficient time, a competent adult language user can reach optimal decisions about the meanings of sentences. Similarly, given

sufficient time, an interpreter can provide nearly optimal translations. However, simultaneous interpretation occurs on-line in limited time with limited resources. Often these processing limitations are stated in terms of the capacity of lexical or phonological memory (Baddeley, 1986; Gupta & MacWhinney, 1994) or more general notions of central capacity (Just & Carpenter, 1992; Gile, this volume). Because of its functionalist orientation, the Competition Model tends to focus somewhat more on the role of underlying conceptual interpretation in determining processing capacity.

These four commitments constitute a conceptually integrated whole. Given what we know about language processing and learning, it would be difficult to construct a viable model of this type that excluded any one of these four commitments. As an integrated minimalist approach, the model interprets experimental data with the fewest possible theoretical assumptions and without reference to assumptions that cannot be directly related to observed linguistic, neurological, and experimental facts. In the next sections, we will explore these four commitments of the Competition Model with an eye toward understanding what they can tell us about intralingual processing within the simultaneous interpretation task.

Lexical Functionalism

The representational structures used in the Competition Model are simple and traditional. The model takes as its starting point the Saussurean vision of the linguistic sign as a set of mappings between forms and functions. *Forms* are the external phonological and word order patterns that are used in words and syntactic constructions. *Functions* are the communicative intentions or meanings that underlie language usage. In the Competition Model, each lexical item or syntactic construction can be understood as a form-to-function mapping. Take the word *bat* as an example. The functions for this word involve the expression of the various semantic properties of the animal, along with its visual and auditory images. The form of the word is the set of phonological cues contained in the sound sequence /bæt/. In connectionist network diagrams, the association of the sound of /bæt/ to the concept "bat" involves the connection of one set of nodes to another.

The association between /bæt/ and "bat" is an example of the simplest of lexical items. Other types of lexical associations include collocations, idioms, and extended rhetorical patterns (MacWhinney, 1982, 1985). Simultaneous

interpretation uses even more complex mappings between languages (McDonald & Carpenter, 1981), because simple one-to-one lexical mappings between L_1 and L_2 (Kroll & Stewart, 1994) are often inadequate guides to interpretation.

In the version of lexical functionalism developed in MacWhinney (1987a, 1987b, 1988), syntactic and intonational patterns are also controlled by interactions between lexical items. Analyses of this type have also been developed inside Dependency Grammar (Hudson, 1984) and Construction Grammar (Fillmore, Kay, & O'Connor, 1988). The full articulation of a lexical basis for grammar requires the use of connectionist networks to express the syntactic and semantic properties of related lexical items or "gangs" (MacWhinney, 1989). For example, the semantic and phonological properties differentiating verbs taking double object constructions, such as *give* or *throw,* from verbs that take only prepositional datives, such as *recommend* or *donate,* can be controlled through competing cues in lexical connectionist networks.

Much of the cross-linguistic work conducted in the Competition Model framework has focused on the use of cues to agent identification. Figure 11.1 presents a simple connectionist model for the cues to agent identification in English. This network takes as input various combinations of these cues: preverbal positioning, verb agreement morphology, sentence initial positioning, nominative case for pronouns, and use of the article *the.* It produces as output a series of functional interpretations, including actor, topicality, perspective, givenness, and definiteness. For example, if the input sentence is "The dog runs," then the input nodes activated are "pre," "agr," "init," and "the." In this case, all five units of the output are turned on.

When thinking in terms of sentence production, we can simply view the connections in Figure 11.1 as operating in the opposite direction. A model implementing bidirectional associations of this type has been developed by Houghton (1993). Note that Figure 11.1 includes an additional layer of connections called "hidden units." Connectionist models use these additional units to facilitate the learning of nonlinear associations between inputs (functions) and outputs (forms). A good example of a nonlinear association is the marking of the English subject. In the active voice, the positioning of the noun before the verb is a clear and unmistakable marker of agential status. In the passive voice, however, exactly the opposite relation holds with preverbal positioning serving as a cue to the role of semantic patient or theme. This "flip-flop" between two competing interpretations of the same surface cue is mediated by the presence or absence of the additional cue of passive morphol-

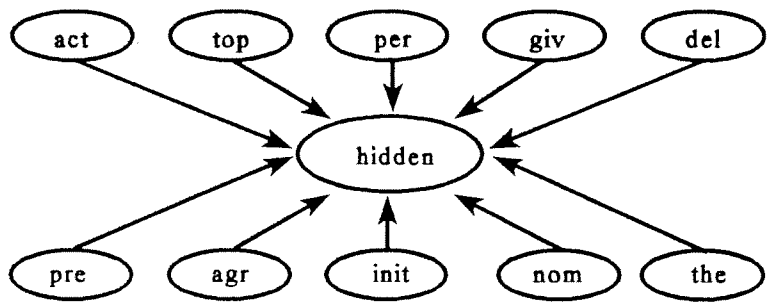

Figure 11.1. Simple connectionist model for the cues to agent identification in English.

ogy on the verb. If the verb has the passive morphology, the normal interpretation is reversed. This relation between the cues involved is a good example of a nonlinear association.

The architecture of connectionist systems of the type diagrammed in Figure 11.1 provides us with several additional ways of thinking about the relations between forms and functions. In a network with a set of hidden units, a group of functions can work in concert to control a set of hidden units, which can, in turn, control a set of forms. In fact, hidden units can pattern in a wide variety of complex ways across various combinations of forms and functions. These patterns give us a way of thinking about four basic ways in which language maps forms onto functions:

1. In natural dialogue, communicative functions tend to co-occur in a state of *peaceful coexistence.* For example, it is often the case that the topic of a sentence is also agential, given, definite, and perspectival. Together, these five functions form a cluster of co-occurring, mutually compatible relations that activate a set of parallel linguistic devices such as preverbal positioning and unmarked stress. These correlations are reflections of real correlations between properties of the world in which we live. Because the functions we choose to talk about are highly correlated in real life, the forms we use to talk about these functions also become highly correlated. This means that no single form expresses any single function and the relation between forms and functions is both fluid and robust. There are also important correlations on

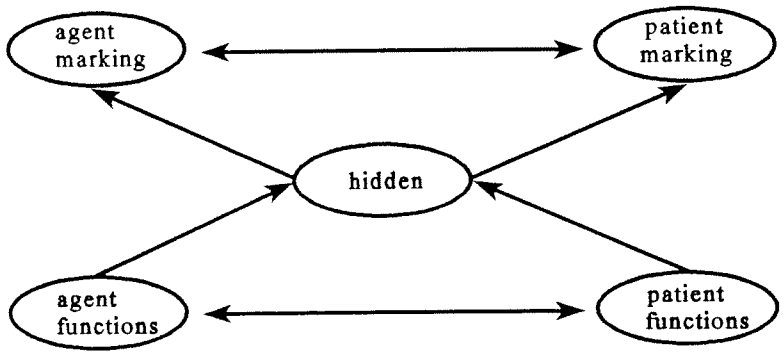

Figure 11.2. Competition between agent marking and patient marking.

the level of forms. For example, words that take the article *the* also are capable of taking the plural suffix, and so on.

2. We can think of a complete set of form-function mappings of this type as a *coalition* of forms and functions. Common grammatical coalitions include "subject," "complement," "subordinate clause," "adverb," and "progressive."

3. The cooperation that exists in coalitions is balanced by the *competition* that exists between major form alternatives. For example, only one noun phrase in a sentence can be the agent and only one can be the patient. This means that there is a direct competition between agent marking and patient marking, as schematized in Figure 11.2.

Competitions of this type exist on all levels of language processing. Words compete for lexical activation, phrases compete for syntactic ordering position, and sounds compete for insertion into syllabic slots. In comprehension, alternative sound forms compete for lexical activation, and alternative interpretations compete for phrase and case role assignments.

4. All of this cooperation and competition works against a background of probabilistic activations that lead to a system rich in *category leakage.* Because of peaceful coexistence, there is often no single function that is uniquely associated with a given form. Over time, the functional weight of a given marking can change so that what was originally a secondary function starts to emerge as the primary function. MacWhinney (1989) examines cases of reinterpretation of this type in the historical development of case-marking in

Hungarian. The fact that a particular suffix can be interpreted as marking definiteness in one century and direct object in the next illustrates the extent to which language can be seen as a slow-moving dynamic system.

Connectionism

One of the oldest debates in psychology and philosophy is the debate between nativism and empiricism. Nativist accounts are linked to complex, untestable theories that make strong claims about biological mechanisms for which no psychological, genetic, or neurological reality has been demonstrated. Among the various assumptions made by nativist systems, the most problematic is the assumption that the brain is a symbol processing device similar to the serial digital computer. In reality, the brain is not a digital computer and it has no method for passing symbols down axons and across synapses. Brain waves cannot be used to transmit phrase structures and there is no evidence that the DNA in neuronal nuclei can encode RAM addresses. Rather, it appears that the brain relies on a type of computation that emphasizes patterns of connectivity and activation. Models based on this type of computation are called "connectionist" models. These models have been used successfully to model the acquisition of a variety of linguistic structures and they appear to offer us the best way of accounting for the facts of language use in simultaneous interpretation.

TRANSFER

When we think about bilingual processing, we first need to consider the degree to which the two languages operate separately. The connectionist view assumes that linguistic processing uses a common, interconnected set of mental structures. This means that the early second language learner should experience a massive amount of transfer from L_1 to L_2. Because connectionist models place such a strong emphasis on pattern generalization, they predict that all aspects of the first language that can possibly transfer to L_2 will transfer.

In regard to lexical processing, connectionist models predict that the initial referent of a new L_2 vocabulary item will be the full conceptual structure of the most closely corresponding L_1 word. The work of Kroll and associates (Kroll & Stewart, 1994; de Groot, this volume) tends to support this prediction. For phonology, these models predict that L_1 phonological features will

be reconfigured and transferred as the initial basis of L_2 segments. This prediction has been supported by work from Hancin-Bhatt (1994) and Flege (1987; Flege & Davidian, 1984).

Input-Driven Learning

CUES AND CUE VALIDITY

The functionalist view of language provides us with a strong, intuitive understanding of many aspects of language structure, and processing and connectionist models provide us with powerful learning mechanisms. But what are the properties of the linguistic input that allow the child to acquire a complex and poorly demarcated system of this type? The basic claim of the Competition Model is that the system of form-function mappings embodied in these networks is acquired in accord with a property we call *cue validity.* This general construct was developed in different ways by different authors, but the single most common interpretation is in terms of the conditional probability that an event X will occur given a cue Y, that, is p(X|Y). If this probability is high, then Y is a good cue to X. The most straightforward prediction from this initial analysis is that forms with a high conditional probability should be acquired early and be the strongest determinants of processing in adults. A more complete treatment of the ways in which cues pattern in the linguistic input distinguishes three cue distribution dimensions: task frequency, cue availability, and cue reliability. I am particularly interested in the ways in which these five dimensions end up contributing to cue strength as measured in our psycholinguistic experiments.

DIMENSIONS OF CUE STRENGTH

Task frequency. The most basic determinant of cue strength is given by the raw frequency of the basic task. Some tasks are incredibly frequent. For example, the task of locating an object in space is something that we routinely do as frequently as once every second. Other tasks may be quite rare. For example, we are seldom called upon to determine the rotational momentum of planetary bodies. Linguistic tasks are often of intermediate frequency. The task of determining the agent of the verb occurs with virtually every transitive

verb. The task of determining anaphoric reference occurs every time a pronoun is encountered. Because most basic linguistic tasks are well above threshold frequency, the dimension of task frequency is seldom an important determinant of relative cue strength.

Availability. Within a given task, cues will vary in their relative availability. I am interested not just in knowing whether a cue is present but also in whether it has any contrastive effect. For example, the cue of subject-verb agreement in English is present in almost all English clauses. However, often the verb agrees with two or more candidate subjects. In a sentence like the following, "The cat chases the dog," the fact that the verb is marked for a singular subject tells us nothing about the status of the subject, because both nouns are singular. Therefore, an available cue is useful only if it is also contrastive. At first, the child picks up cues on the basis of availability. At this early period, the English-speaking child is already paying more attention to word order than his Italian counterpart. And the Hungarian-learning child is making more use of case-marking than his German counterpart. Within a single language, if there are two ways to mark a given function, the child will first start to use the one that is more available. For example, in Hebrew, the child will first use the inflectional reflexive because it is more common. Only later will the child pick up the periphrastic reflexive (Sokolov, 1989).

Reliability. The most important and most basic cue validity dimension is the dimension of reliability. A cue is reliable if it leads to the right functional choice whenever it is present. This is *simple reliability.* In addition to simple reliability, cues can be characterized in terms of their *conflict reliability* vis-à-vis some other particular cue. For example, we can look at just those sentences in which case-marking and word order contrast in Dutch. Typically, the noun phrase before the modal verb is the subject in Dutch, but when that noun phrase is an accusative pronoun, then the case cues dominate over the word order cue. Experiments by McDonald (1989) and Sokolov (1988, 1989) have shown that, up to about age 9, children rely primarily on simple reliability as a determinant of cue strength. However, after this age, conflict reliability becomes more important than simple reliability.

To test the impact of these cue dimensions, we have conducted studies in over a dozen languages, including English, German, Hungarian, Italian, French, Arabic, Hindi, Spanish, Dutch, Russian, Warlpiri, Chinese, Turkish, and Bulgarian. These studies have yielded a remarkably consistent body of

results. The strongest finding is that the order of cue strength found in our experiments with adults always corresponds precisely with the order of cue reliability found in the language. In different languages, we find cue dominance patterns. In English, the dominant cue for subject identification is preverbal positioning. In Spanish, the subject is the noun that is not marked by the prepositional object marker *a.* ln German, subject case is often marked by the definite article. In Hungarian, the object is marked by a case suffix and the subject is unmarked. In Russian, the subject itself may be case-marked. In Arabic, the subject-verb agreement cue is stronger than the case-marking cue.

To evaluate the basic claim of the Competition Model, we need to compare the cue strength estimates from our experiments with text counts in which we measure the availability and reliability of cues to grammatical decisions in various languages. The texts selected for these counts can range from novels to parent-child conversations or foreign language textbooks, depending on the nature of the study involved. Our cue strength measures are computed by fitting the choice data with maximum likelihood estimation (MLE) models. If the MLE model can be fit with a small r.m.s.d. (root mean squared deviation) and if the relative strength hierarchy matches the relative cue validity hierarchy, then we judge the Competition Model predictions to be correct.

Most of our experiments have focused on the measurement of cue strength in comprehension. The interaction of cues such as preverbal positioning, animacy, case-marking, and subject-verb agreement has been modeled mathematically in the Competition Model using maximum likelihood techniques (McDonald & MacWhinney, 1989). The data for these studies come from experiments in many languages and at many age levels using sentences in which the various cues are placed into "competition" with each other in an orthogonalized ANOVA design. The maximum likelihood techniques make it possible to estimate the strengths of particular cues. For example, in our studies of sentence processing in English, Italian, German, French, and Hungarian, we have been able to estimate the relative strengths of preverbal positioning, subject-verb agreement, and animacy as cues to the function of agency. We have found that, in English, the preverbal positioning cue is extremely strong and that the agreement and animacy cues are only of any importance at all when there is no preverbal noun, as in VNN sentences. In Italian, on the other hand, the agreement cue is far stronger than the word order cue. Although both English and Italian are described as SVO languages, the actual strengths of the basic cues to sentence interpretation in these two languages are radically different.

Although most of our experiments have focused on comprehension, the Competition Model provides a similar analysis for sentence production. In production, reliability is defined as the conditional probability of being able to use form X whenever you have idea Y. For example, the preposition *to* would be a reliable marker of the indirect object in English. However, the prepositional dative competes with the double object construction. In this competition, the double object wins when additional cues are present that mark the dative as a pronoun, as in "John ordered her pancakes." In this case, the reliability of the double object dative is measured specifically in cases where the indirect object is pronominal.

The most important empirical claim of the Competition Model is that cue strength in the adult native speaker is determined by cue validity. More specifically, cue strength is determined by a combined weighting of availability and reliability. For cues that compete with each other, the crucial reliability measure is conflict reliability, rather than simple reliability. By using cues in this way, the adult language user makes optimal "rational" use of language. What is crucial about this claim is that these cue validity measures are taken from text counts, rather than from experiments, thereby avoiding the conceptual and empirical circularity involved in some attempts to model psychological phenomena mathematically.

POSITIVE AND NEGATIVE EVIDENCE

In the literature on first language acquisition, generative linguists have argued that the child does not learn language on the basis of corrective feedback. It is interesting to ask exactly how it is that the interpreter learns the specific skills needed during simultaneous interpretation. It is clear that there is little time during the actual activity of interpretation to provide feedback. Interpreters are typically so well skilled in each language that feedback regarding the specific languages would be irrelevant. Instead, the difficulties all arise in regard to the act of translating between languages in real time. For this, it is best to assume that learning is triggered in the following two basic ways.

(1) Error-driven learning. Whenever a particular utterance proves extremely difficult to interpret, the interpreter realizes that there is a need for better interpretation techniques. Possible corrective strategies include increased attention to minor cues, awareness of causes of possible breakdowns, attempts

to acquire new L_2 technical vocabulary, and organization of higher-level discourse structures.

(2) Success-driven learning. Alternatively, learning can also occur when a successful interpretation is made of some complex structure and the forms and strategies used in that interpretation are then recorded for future use.

The detailed psycholinguistic implications of these various experiences have not yet been studied. However, pedagogical approaches (Gommlich, this volume; Kiraly, this volume; Shreve, this volume) already seem to have taken this general analysis into account.

Capacity

Perhaps the best way to begin thinking about the capacity problem in simultaneous interpretation is to think in terms of constraint satisfaction, and the simplest way to deal with constraint satisfaction is to imagine that the interpreter has three basic choices: (a) If the interpretation currently being formulated seems adequate, then it should be passed on to vocal output; (b) if the interpretation is either imperfect or incomplete, and there are resources available to potentially correct it, then the interpreter should hold the interpretation in verbal memory for further work; (c) if the interpretation is imperfect, but there are no resources available to correct it, then it must be produced, even in its imperfect form.

Obviously, a good interpreter seldom encounters situations of the third type. However, situations of the second type arise continually. In most of these cases, the interpreter has sufficient verbal memory capacity to store large chunks of incoming text while working on a fully adequate interpretation.

To understand the nature of some of the problems faced during simultaneous interpretation, we can look at studies of off-line translation of the type presented by Dancette (this volume) and Kiraly (1995). These studies illustrate the extent to which a single source passage can lead to a variety of translations. What characterizes the best translations is the extent to which they are able to satisfy all the multiple lexical and semantic features of the source text in translating to the target language. In simultaneous translation, it often becomes necessary to relax some particular lexical constraint or even to leave out some material altogether to keep up with the real-time processing requirement.

Let us take a simple case to illustrate the problem. Consider a German sentence with a verb in final position. If the German sentence is short, the interpreter will have little problem converting the German SOV order to English SVO. For example, a sentence like the following, *Johannes hat den Mann mit dem dunkelen Mantel noch nicht kennengelernt* (John has not yet met the man with the dark coat), will cause few problems, because the interpreter can lag behind the speaker enough to take in the whole utterance along with the verb before starting to speak. The interpreter prepares an utterance with a subject and an object already in final form. When the verb comes along, it is simply a matter of translating it to the English equivalent, dropping it into the prepared slot, and starting articulatory output. However, if there is additional material piled up before the verb, the problem can get worse. Similar problems can arise when translating from relative clauses in Japanese or from languages with occasional VSO order such as Tagalog or Arabic.

VERBAL MEMORY

If interpreters had access to an unlimited verbal memory capacity, there would be little worry about storing long chunks of verbal material. However, we know that our raw memory for strings of words is not nearly large enough to accommodate the simultaneous interpretation task. In fact, the conventional estimate of the number of items that can be stored in short-term memory is about four. Clearly, the simultaneous interpreter must be supplementing raw verbal memory with additional storage mechanisms. The most likely candidate for this additional storage is some form of conceptual representation. The lexical functionalist analysis of the Competition Model holds that conceptual representations are established through a process of structure building (Gernsbacher, 1990). This process begins with the identification of a starting point (MacWhinney, 1977) or perspective from which the entire clause can be interpreted. In English, this is usually the subject. As new elements come in, they are linked up to this starting point across "valence bridges." For example, if the initial phrase of the utterance is *the black dog,* then the noun *dog* is taken as the perspective and the adjective *black* is linked to *dog* through the modifier valence relation. The formation of the link between *black* and *dog* involves more than the simple positional relation of two words. Instead, the adjective is applied to the noun on the conceptual level and an image of a black dog is activated. The assumption is that, as long as verbal material can successfully access an integrated conceptual representation, it exacts no additional storage cost. In some sentences, a full conceptual

integration is blocked by the ambiguity of syntactic structures. For example, in the doubly center-embedded sentence, "The cat the dog the flea bit chased ran," we find a stack of three nouns in a row without any binding conceptual glue. To relate these nouns to each other, we have to store them in a linear series, wait until we have encountered the string of verbs, and then pull nouns off the series to pair them with the appropriate verbs. This type of positional, nonconceptual processing places heavy demands on raw verbal memory. Even a single center-embedding sentence like this sentence, "The dog the flea bit chased the cat," involves some storage and restructuring when compared with a subject relative like this one: "The cat chased the flea that bit the dog." Studies of Hungarian (MacWhinney & Pléh, 1988) and Japanese (Hakuta, 1981) show that the stacking up of unlinked noun phrases can be even worse in SOV languages.

PERCEPTUAL LOAD FACTORS

It is easy to interfere with normal language processing by imposing additional loads on the listener or speaker. Working within a standard Competition Model experimental framework, Kilborn (1989) has shown that even fully competent bilinguals tend to process sentences more slowly than monolinguals. However, when monolinguals are asked to listen to sentences under conditions of white noise, their reaction times are identical to those of the bilinguals. Similarly, Blackwell and Bates (1994) and Miyake, Carpenter, and Just (1994) have shown that, when subjected to conditions of noise, normals process sentences much like aphasics. Parallel results for the effects of noise on simultaneous interpretation have been reported by Gerver (1974a) and Seleskovitch (1976a). It is important not to interpret these studies as indicating that the locus of capacity is some single, fairly superficial perceptual store. Rather, what these studies show us is that all language processing requires a smooth conversion of phonological information into lexical information. As this conversion is slowed, the subsequent building of conceptual structure is impeded. However, this type of blockage tells us little about the details of the capacity requirements involved in the building and changing of conceptual structure.

EAR-VOICE SPAN

What distinguishes the task of simultaneous interpretation from that of normal monolingual comprehension linked to normal monolingual produc-

tion is the fact that the interpreter must continue to build comprehension structures for incoming material while using established structures as the basis for ongoing articulation. To do this successfully, the interpreter must be able to delineate chunks of comprehended material that are sufficient to motivate full independent output productions. It is this skill that separates the interpreter from the naive bilingual. In effect, the interpreter must maintain two separate conceptual foci centered on two separate points in conceptual space. One attentional focus continues to take in new material from the speaker in terms of new valence and conceptual relations. We can call this the "comprehension focus." The second attentional focus works on the comprehended structure to convert it to a "production structure." The location of the production focus is always lagged after that of the comprehended structure, so that the interpreter always has a split conceptual attention.

The study of simultaneous interpretation offers us a remarkable opportunity to perform controlled investigations of the production process. The great advantage of simultaneous interpretation is that we know a great deal about the nature of the input to the production mechanism. Ignoring for the present the issue of individual differences between interpreters (Moser-Mercer, this volume; Séguinot, this volume; Shreve, this volume), we can imagine studies in which a group of simultaneous interpreters is given the same set of source passages for interpretation. We could then examine the resultant interpretations in terms of lexical forms, timing properties, and completeness of mapping. These indices would allow us to elaborate in detail our notions about constraint satisfaction, transcoding, vertical mapping, and capacity limitations. By further varying the ear-voice span by using compressed or faster input speech as in Adamowicz (1989), we can further delineate the nature of the interpretation process.

TRANSCODING AND COMPETITION

There are two other factors influencing this split attentional focus that are worth mentioning. The first is the occasional availability of direct correspondences between languages. When the interpreter can find clear phrasal or lexical equivalents between the two languages, the task of maintaining a split attentional focus is lightened. In such cases, rather than engaging in full "vertical" interpretation (de Groot, this volume), the interpreter can perform simple horizontal "transcoding." Typically, nouns can be transcoded between languages in a one-for-one fashion without having to pay attention to any

additional grammatical factors. However, this is much less true for verbs, because a good translation of some verbs may require major changes to the grammatical structure of the clause.

The second factor that can influence the success of interpretation in real time is the need to deal with competing interpretations of attachments and role assignments. Consider a German sentence that begins with an initial noun that is ambiguously marked for case, such as the following: *Die Mutter küsst der Vater* (The father kissed the mother). Because a noun like *die Mutter* could be in either the nominative or the accusative case, the listener does not know initially whether to establish the perspective as agent or patient. Because there is a strong tendency for initial nouns to be agents in German, this reading is favored. However, a cautious listener will continue to maintain the alternative assignment in memory until the clause is complete. There are many examples of competing interpretations of this type. The parsing model promoted by Frazier and colleagues (Frazier & Rayner, 1982, 1987, 1990) treats ambiguity resolution in terms of garden-pathing rather than competition. However, a broader survey of phenomena in this area (Altmann, Garnham, & Dennis, 1992; Juliano & Tanenhaus, 1993; MacDonald, 1993; Sedlak & Kurtz, 1981; Simpson & Burgess, 1985; Simpson & Krueger, 1991; Small, Cottrell, & Tanenhaus, 1988; Tanenhaus, Carlson, & Seidenberg, 1985; Tanenhaus & Lucas, 1987; Taraban & McClelland, 1988) indicates that linguistic processing is best viewed in terms of an ongoing competition between alternatives.

BAYESIAN CUE USE

To characterize the costs involved in maintaining alternative interpretations, the Competition Model extends the notion of Bayesian processing to the use of cues in real time. When cues are used in a nontimed sentence interpretation experiment, the subject has time to perform full constraint satisfaction and reach an optimal use of each cue, independent of its linear position in the sentence. However, when processing in real time, cues must be used as they occur. In this case, the model makes these assumptions:

1. Each basic cue to sentence interpretation has a "prediction strength" that is distinct from its final "cue strength." This strength is a function of the likelihood that the use of the cue will be contravened by some other cue that might occur later in the sentence.

2. In adults, each cue's prediction strength is tuned closely to other highly available cues. For example, if a language uses case consistently, then the word order cue will be set to take into account possible reversal by the case cue.

3. Listeners maintain a threshold for selection of an interpretation, based on the summed activation of the cues supporting that interpretation divided by the total activation of all cues.

4. This interpretation selection threshold is variable. When operating under time pressure, the threshold decreases to allow for quick selection of a candidate interpretation.

Conclusion

This chapter has examined the application of a functionalist model of sentence processing to the task of simultaneous interpretation. Because simultaneous interpretation places extreme temporal requirements on the basic language processing system and because it allows us to study production while controlling the target message, there is good reason to think of simultaneous interpretation as an important testing ground for psycholinguistic theories. At the same time, the detailed construction of a psycholinguistic account of simultaneous interpretation could help both interpreters and teachers to think of new, more systematic ways of dealing with the capacity demands exacted by this fascinating activity. The Competition Model can provide a useful framework for these investigations because it emphasizes the role of underlying conceptual structures as the basis for interpretation and because it deals directly with the issues of cue usage, transfer, and capacity use that are so important in understanding simultaneous interpretation.

12

Cognitive Processes in Translation and Interpreting

Critical Issues

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A Heuristic for Research in the Cognitive Processes of Translation and Interpreting

The purpose of this final chapter is to summarize the results of the conference as presented in the preceding chapters. It will focus on the critical issues raised and highlight those areas of research that require further investigation. The authors in this volume have each touched to some extent on most of the critical issues of cognition, translation, and interpreting. We try to address these critical issues and the points the authors raise in the form of a heuristic

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