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Simultaneous Interpreting
A Cognitive Perspective

ABSTRACT   Simultaneous interpreting (SI) is one of the most complex language tasks imaginable. During SI, one has to listen to and comprehend the input utterance in one language, keep it in working memory until it has been recoded and can be produced in the other language, and produce the translation of an earlier part of the input, all of this at the same time. Thus, language comprehension and production take place simultaneously in different languages. In this chapter, we discuss SI from a cognitive perspective. The unique characteristics of this task and comparisons with other, similar, tasks illustrate the demanding nature of SI. Several factors influence SI performance, including the listening conditions and the language combination involved. We discuss some processing aspects of SI, such as the control of languages and language recoding. We ask whether experience in interpreting is related to some special capabilities and discuss possible cognitive subskills of SI, such as exceptional memory skills. Finally, we discuss the implications of SI for theories of language production.

When people are faced with a foreign language barrier, the usual way around it is to find someone who speaks both languages to translate for them. Translation involves rephrasing a message expressed in one language (the *source* language) into another language (the *target* language). The term *translation* is often used in a broad sense to refer to any way in which a fragment of source language can be turned into the analogous target language fragment, irrespective of input and output modality. To distinguish explicitly between different types of translation, in this chapter the term is generally used in its narrow sense. It then refers to text-to-text translation and contrasts with *interpreting*, which typically involves the verbal rephrasing of a source language utterance into a target language utterance. From a cognitive perspective, it is important to distinguish between translation and interpreting because they are likely to engage different cognitive processes (De Groot, 1997, 2000; Gile, 1997).

Simultaneous interpreting (SI), sometimes called conference interpreting, can be argued to be one of the most complex language tasks imaginable because many processes take place at the same time. New input is continuously presented while the interpreter is involved simultaneously in comprehending that input and storing segments of it in memory. At the same time, an earlier segment has to be reformulated mentally into the target language, and an even earlier segment has to be articulated (e.g., Gerver, 1976; Lambert, 1992; Padilla, Bajo, Cañas, & Padilla, 1995). This complexity makes the study of SI a challenging enterprise. If we are to understand fully how this task is performed, the separate research areas of language comprehension and language production, bilingualism, discourse processing, memory, attention, expertise, and complex skill performance may all provide relevant insights and should therefore ideally all be taken into account (De Groot, 2000). On the other hand, the process of SI itself may inform theories and models within all these separate research fields (De Groot, 2000; Frauenfelder & Schriefers, 1997; Lonsdale, 1997; MacWhinney, 1997; see also MacWhinney, chapter 3, this volume). Models of bilingualism, for example, need to accommodate the fact that in interpreting

two languages must be activated and controlled simultaneously (Grosjean, 1997), and theories of speech perception that assign articulation a crucial role in comprehension (e.g., Liberman & Mattingly, 1985) should be reconciled with the fact that in SI production and comprehension are performed simultaneously.

The Experimental Study of Simultaneous Interpreting

In trying to understand SI, researchers have generally taken three different approaches. The first approach concerns the detailed study of the output of the interpreting process under varying circumstances. The second approach is to regard SI as a complex *task* and as such to compare it with other tasks to gain more insight about the relevant processing components. For example, interpreting is often compared with *shadowing*, which involves the immediate verbatim repetition of what is heard. Interpreting and shadowing are similar in that both tasks involve simultaneous listening and speaking, but they are different in that shadowing does not require the input to be transformed.

The third approach regards SI as a complex *skill* and compares experienced professional interpreters with students learning SI or with untrained but proficient bilinguals. The hypothesis underlying this approach is that interpreters may possess specific task-relevant subskills. Superior processing in particular cognitive subskills would suggest that the interpreting experience itself may boost these skills, or that interpreters are self-selected on the specific abilities required for performing the task adequately.

Research on interpreting has its own methodological problems (e.g., Massaro & Shlesinger, 1997). A critical issue is that professional interpreters do not abound, so an adequate sample for any given study cannot always be obtained, especially if a specific language combination is required. Many studies are therefore prone to a lack of statistical power, making it hard to draw general conclusions from the data. Other methodological problems concern a lack of ecological validity of the experimental setting and the stimulus materials (e.g., Gile, 2000; but see Frauenfelder & Schriefers, 1997).

In the remainder of this chapter, we first discuss a number of essential characteristics and processing aspects of SI that together illustrate its cognitive complexity. We then examine a set of factors that are known to influence interpreting performance. Next, we review research that compares SI with similar tasks. Finally, we consider SI as a manifestation of expertise and address some issues that need to be resolved before SI can be modeled. But, before beginning our review of SI research, we describe briefly the different forms of interpreting and compare interpreting with translating to show that cognitively they should be regarded as distinct tasks.

Forms of Interpreting

In professional practice, two kinds of interpreting are common: *simultaneous* interpreting and *consecutive* interpreting. The main difference between these two forms of interpreting is the timing between input and output. In consecutive interpreting, an interpreter starts to interpret when the speaker stops speaking, either in breaks in the source speech (discontinuous interpreting) or after the entire speech is finished (continuous interpreting) (see also, Gerver, 1976). The consecutive interpreter usually takes notes while the source speech is delivered. SI contrasts with consecutive interpreting in that the interpreter is required to listen and speak at the same time instead of alternating between listening and speaking. As a consequence, the cognitive demands of SI and consecutive interpreting are likely to be different. Consecutive interpreting puts large demands on long-term memory because it requires reciting a message into another language on the basis of memory and a few notes, whereas in SI constraints in online information processing are likely to constitute the main challenge to acceptable performance.

Mixtures of text-to-text translation and interpreting also exist. For example, in so-called sight interpreting, the interpreter produces a verbal translation of a written text (Moser-Mercer, 1995). SI from or into sign language is especially interesting because the two languages involved are in a different modality.

Interpreting Versus Translating

In many respects, translating and interpreting are very similar tasks. Both are modes of bilingually mediated communication for a third party (see also Neubert, 1997). These forms of language use are unique in the sense that interpreters and translators are not supposed to contribute to the content of the message that they have to transfer. In addition to monitoring what they say or write, as normal

speakers or writers would do, interpreters and translators have to match the content of what they say or write to the content of a source text.

The typical differences between translating and interpreting concern the modes of input and output. These are the visual and written mode in the case of translating and the auditory and verbal mode in the case of interpreting. There are other obvious differences between the two (see Gile, 1995; Padilla & Martin, 1992), some of which are likely to influence the language comprehension process. In SI, the input rate is determined by the speaker of the source text. The rate will usually be comparable to that in normal speech, that is, about 100 to 200 words per min. Speech is transient; any information missed is irretrievable. The clarity of input in interpreting can vary widely because of the variability of the speakers or because of variability of the quality of technical equipment and environmental circumstances. In translating, the source text is static and permanently available. It can be consulted and reread at a rate that suits the translator.

Regarding language production, there is a noticeable difference in the amount of output produced by interpreters and translators within a given time span. Interpreters usually work in pairs, taking turns approximately every 30 min. The speed of delivery is speaking rate. This amounts to up to approximately 4,000 words on average in a 30-min turn. Translators usually produce that amount of translated text in an entire day.

More important, there is only one "go" to produce a good interpretation, whereas iterative improvement of the target text is an essential component of the translation process (Gile, 1995; Moser-Mercer, Künzli, & Korac, 1998). When translating, there is also an opportunity to use dictionaries and to consult experts and colleagues. In contrast, interpreters have to acquire the relevant knowledge in advance. Moreover, unlike translating, interpreting always takes place directly in front of an audience. An advantageous consequence of this is that interpreters usually share the communicative context with the source speaker and the listeners. Also, just as the audience, the interpreter has access to extralinguistic information to aid comprehension (e.g., nonverbal communication and slides). In contrast, in translating, the translated text is typically the only source of information available to its readers.

A translated text is generally of a higher quality than an interpreted text, a fact that relates, in addition to cognitive demand differences between the tasks, to differences in the goals that need to be achieved in the two tasks. The readers of a translation expect a well-written text; therefore, the linguistic acceptability requirements are very high in translating. For interpreters, it is especially important to deliver clear target language, but the stylistic demands are those of ordinary speech, which implies that grammatically less-well-formed utterances are acceptable. A final noteworthy difference is that an interpreted text is usually shorter than the original source text, whereas a translated text is usually longer (Chernov, 1994; Padilla & Martin, 1992). The latter difference implies that interpreting involves a loss of information.

Characteristics of Simultaneous Interpreting

The Simultaneity of Comprehension and Production

One of the most salient features of SI is that two streams of speech have to be processed simultaneously: The input has to be understood, and the output has to be produced. Note that this implies that interpreters have a split conceptual attention (MacWhinney, 1997, and chapter 3, this volume). One conceptual focus is directed to understanding the input; the other focus is on conceptualizing and producing an earlier part of the message. Past research suggests that interpreters exploit natural pauses and hesitations in the source speech to reduce simultaneous processing to a minimum (Barik, 1973; Goldman-Eisler, 1972, 1980).

In an analysis of the temporal characteristics of source and target delivery patterns, Barik (1973) confirmed that interpreters proportionally speak more during pauses in the input than would be expected if the input and output patterns were independent (but see Gerver, 1976). When taking this into account, about 70% of the time that interpreters are speaking, they are simultaneously listening to input (Chernov, 1994). In other words, most of the time interpreters have to cope with simultaneous comprehension and production of language (see also Goldman-Eisler, 1972).

The Lag Between Source and Target Message

The production of the target message usually lags behind that of the source message by a few seconds.

Before being able to produce an adequate interpreting output, a certain amount of input has to be available. This lag, the so-called ear–voice span, is measured as the number of words or seconds between the input and the corresponding output.

Average lags reported for interpreting are longer than for shadowing. For interpreting, the average lag varies between 4 and 5.7 words (Gerver, 1976; Goldman-Eisler, 1972; Treisman, 1965), whereas for shadowing it varies between 2 and 3 words (Gerver, 1976; Treisman, 1965). Consistent with Barik's study (1973), who reported lags of 2 to 3 s for interpreting, in our laboratory we observed average lags of about 2 s for interpreting and 1 s for shadowing. We estimated this to be equivalent to about 5 words for interpreting and between 2 and 3 words for shadowing (Christoffels & De Groot, 2004).

The ear–voice span is likely to be influenced by a number of factors, such as the language of input (Goldman-Eisler, 1972). Even so, the reported average span across the various studies seems consistent. In fact, as discussed in the section on determinants of interpreting output, some input manipulations do not influence the ear–voice span. The span appears to result from an interplay between two contrasting factors. The first is that there is an advantage in waiting as long as possible before starting to produce the translation. The longer the actual production is delayed, the more information about the intended meaning of the input is available (see also Barik, 1975; Kade & Claus, 1971) and the lower the chance of misinterpretation because ambiguities may be resolved.

In support of this, in a study on sign language interpreting Cokely (1986) observed that the number of errors was negatively correlated with time lag. Furthermore, Barik (1975) suggested that specific difficulties observed in SI with function words (e.g., *to*, *for*, *as*) are caused by misinterpretation because of too short an ear–voice span. Because these words are highly ambiguous without sufficient context, they may lead to interpreting errors when translated before the intended meaning is fully resolved.

In contrast, there is also an advantage in keeping the lag as short as possible because a short lag taxes memory less than a long lag. With a long lag, the interpreter runs the risk of loss of information from working memory, with the effect of losing the thread of the input speech. Barik (1975) reported that the longer the interpreter lagged behind, the greater the likelihood that source text content was omitted.

To conclude, there appears to be an optimal ear–voice span that is a compromise between the length of the stretches of input required for full understanding and the limits of working memory. The result of these opposing demands settles on an average lag of four to five words (see also Anderson, 1994; Goldman-Eisler, 1980).

The Unit of Interpreting

Closely related to the issue of an optimal ear–voice span is the question of what constitutes the unit ("chunk") from which SI output is built. The interpreting unit is probably larger than a single word because the span consists of several words on average. Moreover, literal word-by-word translation would render an unintelligible interpretation, if only because languages often differ in word order, and single words do not always have an exact translation equivalent. So, rather than translating each incoming word separately, interpreting usually involves rephrasing at a higher level (Goldman-Eisler, 1980; Schweda-Nicholson, 1987).

In an analysis of a large number of translation chunks, Goldman-Eisler (1972) found that for about 92% of these chunks the ear–voice span consisted of at least a complete noun phrase plus verb phrase, from which she concluded that the verb phrase is an especially crucial part of the input chunk. Apparently, grammatical information is needed before interpreting is possible, and the clause may be the favored unit in interpreting. This is also indicated by the tendency of interpreters to postpone the translation when the verb is uttered late in the input clause. Furthermore, Goldman-Eisler found that in 90% of the cases interpreters started to translate before a natural pause in the source speech occurred, which suggested that interpreters do not merely mirror the input chunking of the speaker but impose their own segmentation of the text. Nevertheless, Barik (1975) found that the more the speaker of the source text paused at grammatical junctions, the better the performance. The usefulness of such input parsing again converges with the idea of the clause as the unit of processing in interpreting.

In an eye-tracking study involving sight interpreting of ambiguous phrases presented in context, McDonald and Carpenter (1981) reported that during the first "pass," parsing was very similar to parsing in ordinary reading. The interpretation was typically produced during a time-consuming second pass of a chunk, when phrases were reread. They concluded that parsing or chunking in (sight)

translation is initially very similar to the analogous processes in reading comprehension.

It thus seems that a good candidate for the preferred unit of interpreting is the clause. Interpreting strategies, which may also influence the size of the chunking unit, are discussed in a later section.

Processing Aspects of Simultaneous Interpreting

Control of Languages

It is a basic requirement of SI to produce "pure" target language, that is, language that does not contain any language switches. Yet, the nature of the task demands that both languages are simultaneously activated while performing the task. Therefore, control of languages is crucial to SI. To explain how languages are kept separate and interference of the nontarget language is prevented in common speech of bilinguals, a number of theories propose a mechanism of external global inhibition or deactivation of activity in the nontarget language system or global activation of the target language (De Bot & Schreuder, 1993; Dijkstra & Van Heuven, 1998; D. W. Green, 1986, 1998, and chapter 25, this volume; Grosjean, 1997; Paradis, 1994). Experiments on language switching provide evidence for a general inhibitory control mechanism (e.g., Meuter & Allport, 1999). That the control of languages may be especially important in SI was suggested by the results of a positron emission tomographic (PET) study by Price, Green, and Von Studnitz (1999). These authors reported that word translation in comparison to reading in the first language (L1) and second language (L2) increased the activity of the areas in the brain believed to control action.

The inhibitory control model proposed by D. W. Green (1986, 1998) addresses the issue of language control most directly. In this model, the bilingual avoids speaking in the unintended language by suppressing activity in the nontarget language system. So-called language task schemas compete to determine the output. Top-down control is achieved by an executive system that boosts the activation of the target task schema (and suppresses activation of the competing task schemas). Translation is given as an example task in which an alternative schema must be suppressed. According to D. W. Green (1998, and chapter 25, this volume), presentation of a word in the L1 that has to

be translated in the L2 will, in addition to a translation schema, also trigger the "naming-in-L1" task. To translate from L1 to L2, an L1 production schema must be inhibited, and the schema for L2 must be activated; that schema in turn inhibits lemmas that are tagged to belong to L1. If word translation is a task that already involves high levels of control, then the control demands imposed by SI on the cognitive system must be very high indeed.

SI may be problematic for any activation-inhibition account because, unlike common language production by bilinguals, SI requires activation of both languages simultaneously. A number of authors have considered ways in which SI might be integrated into existing theoretical frameworks and the implications for language selection and control.

In a framework toward a neurolinguistic theory of SI, Paradis (1994, 2000) proposed the subset and the activation threshold hypotheses (see also Paradis, 1997). The subset hypothesis states that all the elements of one language are strongly associated into a subset that behaves like a separate network that can be separately activated or inhibited. The activation threshold hypothesis holds that an item is selected when its activation exceeds that of its competitors, which are simultaneously inhibited (their activation thresholds are raised). More impulses are required to self-activate a trace (in production) voluntarily than to have it activated by external stimuli (in comprehension). When a bilingual speaks in one language only, the activation threshold of the nonselected language is raised sufficiently to prevent interference during production (cf. the notion of global inhibition). Paradis (1994, 2000) suggested that in SI the threshold of the source language is higher than the threshold of the target language because production requires more activation than comprehension. It is not clear whether such an activation pattern allows for the production of target language only, without interference from the source language, or what the consequences are of higher activation of the target language for comprehension of the source language.

De Bot (2000) discussed a bilingual version of Levelt's model for language production in relation to interpreting (see De Bot & Schreuder, 1993).[1] Like Paradis, De Bot assumed that language-specific subsets develop, that spreading activation is the main mechanism of selection of elements and rules, and that languages can be separately activated as a whole. In the bilingual counterpart of Levelt's model, all linguistic elements are labeled

for language. At the conceptual level (the preverbal message), it is specified what the language of a particular output chunk should be. To prevent the selection of source language elements, De Bot (2000) suggested that in SI the target language cue has a high value, so that only elements from that particular language are selected.

Finally, Grosjean (1997) attempted to integrate SI within the theoretical concept of the language mode continuum, which entails that bilinguals may find themselves on a continuum with the extreme points of being in a completely monolingual mode (complete deactivation of the other language) or in a completely bilingual mode (both languages are activated, and language switches can occur). To allow for SI, Grosjean added input and output components to the continuum and suggested that the activation of these two components, rather than the level of activation of each language, varies. At the input side, both languages are activated to allow for comprehension of input and monitoring of output. At the output side, the source language output mechanism is inhibited (in the monolingual mode). Grosjean acknowledged that, even with the addition of these two components to his model, unanswered questions remain, such as how the interpreter is able to switch occasionally from target to source language while for production the source language should be strongly inhibited.

To our knowledge, no past studies have examined language control in SI. Nevertheless, it should be clear that the control of languages is an important aspect of processing in SI. In the final part of this chapter, this issue, and specifically the issue of selectively producing target language in SI, is discussed further.

Language Recoding

What exactly happens when the source language is recoded in the target language? Theoretically, two interpreting strategies have been distinguished: a *meaning-based* strategy and a *transcoding* strategy (e.g., Anderson, 1994; Fabbro & Gran, 1994; Fabbro, Gran, Basso, & Bava, 1990; Isham, 1994; Isham & Lane, 1994; Massaro & Shlesinger, 1997). These strategies have also been referred to as vertical and horizontal translation (De Groot, 1997, 2000) or Strategy I and Strategy II, respectively (Paradis, 1994).

Meaning-based interpreting is conceptually mediated interpretation. The interpreter is thought to retain the meaning of chunks of information and to recode the meaning of these chunks in the target

language (Fabbro & Gran, 1994). In other words, according to this strategy, interpreting involves full comprehension of the source language in a way similar to common comprehension of speech. From the representation of the inferred meaning, production takes place in the target language.

The transcoding strategy involves the literal transposition of words or multiword units. The interpreter supposedly translates the smallest possible meaningful units of the source language that have an equivalent in the target language. Transcoding is often called a *word-based* or *word-for-word* strategy (e.g., Fabbro et al., 1990), but if this strategy strictly involved replacing single words by their translation equivalents, its role has to be limited because the resulting interpretation would be unintelligible. Paradis (1994) proposed that transcoding can take place at different levels of the language system (phonology, morphology, syntax, and semantics) by automatic application of rules. One linguistic element is directly replaced by its structural equivalent in the target language. Figure 22.1 depicts the two alternative strategies. They are usually not considered mutually exclusive; both strategies can be available to the experienced interpreter.

The important difference between these two strategies is that, in transcoding, small translation units are transposed into the other language without necessarily first being fully comprehended and integrated into the discourse representation, whereas the meaning-based strategy clearly involves full comprehension, including grasping the pragmatic intention of the input, after which the constructed meaning is produced in the target language.

According to Paradis (1994), translation-specific systems subserve the transcoding strategy. Connections between equivalent items in the two languages may function independently of those that subserve each of the separate languages: Patients showing "paradoxical translation" after brain damage were able to translate into a language that was not available for spontaneous production, but comprehension of both languages was normal at all times (Paradis, Goldblum, & Abidi, 1984, in Paradis, 1994; see also D. W. Green, chapter 25, this volume). According to Paradis, this shows that there are four neurofunctionally independent systems: one underlying L1, one underlying L2, and two translation-specific systems involving connections between the two languages, both from L1 to L2 and vice versa. The meaning-based strategy does not appeal to these systems. Meaning-based interpreting depends on implicit linguistic competence,
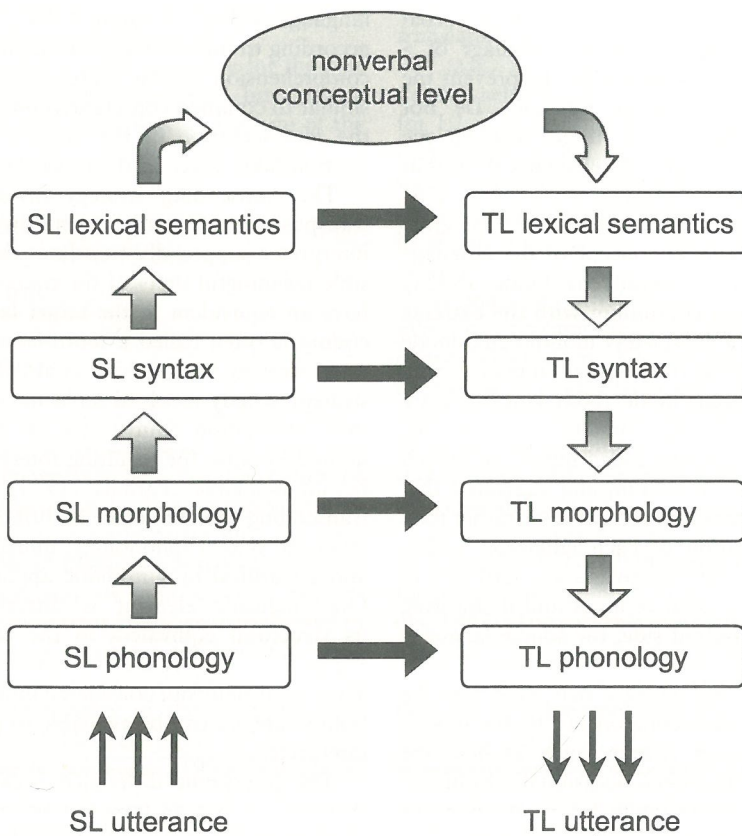
Figure 22.1 Two alternative interpreting strategies (based on Paradis, 1994). The light arrows depict the meaning-based strategy. The source language (SL) utterance is fully comprehended and represented at a nonverbal conceptual level before its meaning is produced as an utterance in the target language (TL). The dark arrows depict the transcoding strategy, according to which particular parts of the utterance (e.g., a certain word or grammatical construction) are directly transcoded into their equivalent in the target language.

acquired incidentally and used automatically, whereas transcoding depends on metalinguistic knowledge that is learned consciously and that is available to conscious recall.

Transcoding, or more specifically, word-based interpreting, is often regarded as an inferior interpreting procedure and is associated with unacceptable output (e.g., Shreve & Diamond, 1997). It is supposedly used relatively often by inexperienced interpreters, in the case of difficult source text (e.g., highly technical text), or under stress (Fabbro & Gran, 1994). In contrast, Paradis (1994) argued that beginning interpreters often employ the meaning-based strategy, whereas skilled interpreters may use transcoding because the rules underlying transcoding presumably have to be learned.

Transcoding at the lexical level does not necessarily imply that words are translated via direct lexical links between the form representations of the corresponding source language and target language words, as in the word association model for word translation (Potter, So, Von Eckardt, & Feldman, 1984). Translation of individual words can be semantically mediated, and there is evidence that even at an early stage of learning an L2, this is indeed what happens (De Groot, 2002; but see Kroll & Stewart, 1994). If the semantic level is distinguished from a conceptual level of representation, with the former storing the lexical meaning of words and the latter containing multimodal, nonlinguistic representation structures (Pavlenko, 1999; see also Francis, chapter 12, this volume) transcoding at the word level can be regarded as

implicating the semantic level of representation, whereas in meaning-based interpreting the non-linguistic conceptual level is involved.

Theoretical Accounts of Recoding   Theoretical accounts of the processes involved in SI seem to assume, albeit implicitly, that all interpreting is meaning-based interpreting. In the bilingual language production model discussed by De Bot (2000), all incoming speech is parsed, delexicalized, and turned into a nonverbal conceptual code that serves as input to the production mechanism. Therefore, input speech and output speech are not connected; consequently, all interpreting is conceptually mediated.

The two earlier models of Gerver (1976) and Moser (1978) were developed as extensions of the information processing models common in the 1970s (see De Bot, 2000, and Moser-Mercer, Lambert, Darò, & Williams, 1997). Gerver's model focuses on how chunks of information are stored temporarily to achieve a continuous stream of input and output. Decoding and storage of source language are represented by one component, which is connected to a component representing encoding and storage of target language. This arrangement suggests that this model considers interpretation to be exclusively conceptually mediated. Similarly, in Moser's (1978) model, the input is fully comprehended before production of the target language is set in motion.

Finally, although Paradis (1994) postulated the existence of transcoding (see above), in the flow-chart of the events in SI that he presented again only meaning-based interpreting seems to be represented: After a phrase has been decoded, the words' forms are discarded from short-term memory, and only their meaning is retained in long-term memory. Subsequently, the chunk is encoded in the target language and produced. The idea that the form of the input is discarded during SI, which is referred to as *deverbalization*, is discussed next.

Deverbalization   It is often assumed that, in meaning-based SI, the source language is completely deverbalized: The linguistic forms are lost, and only the meaning of the message remains. In other words, the message is encoded nonverbally before it is produced in the target language. In fact, Seleskovitch (1976) claimed that skilled interpreting has nothing to do with finding linguistic equivalents of the source language in the target language at all, but only with understanding the meaning of the input. According to this strong view

of deverbalization, interpreting is only possible when the interpreter completely understands what is said; once a fragment of the source language is understood, the form is lost and only the meaning remains (*théorie du sens*).

Both these aspects of the deverbalization view have been questioned. According to Darò (1994), the idea that a good interpretation necessarily implies complete understanding of the input is a "consolidated professional ideology" (p. 265). An interpreter often may not understand the content of a message completely but nevertheless succeed in translating the "surface structure" of the input (Darò, 1994). Gile (1991) stated that there is not much evidence in favor of the idea that the source message form is lost.

Looking at memory for sentence form, Isham (1994) provided evidence against the idea that the form of the input is lost in SI. Isham (1993; as cited in 1994) found similar recall of sentence form in sign language interpreters who interpreted passages from English to American Sign Language as in a control group of noninterpreters who just listened to these passages. In a similar study, Isham (1994) found that spoken language interpreters recalled less of the sentence form than bilingual listeners. However, the interpreters showed two different patterns of recall: One group of interpreters showed form recall similar to that of the listeners, and the other group showed almost no such recall. Nevertheless, systematic deverbalization does not seem to occur; in both of Isham's experiments, most of the interpreters still had some information on the sentence form available. Isham's (1994) results also suggest that the spoken language interpreters' relatively low form recall performance may not be caused by SI as such but by working in two spoken languages. This possibility is discussed further in the next section.

To conclude this section, we are not aware of the existence of any experimental data evidencing the existence of two qualitatively different interpreting strategies, and none of the theoretical accounts of SI discussed have incorporated the transcoding strategy. Nevertheless, it seems plausible that both transcoding and meaning-based interpreting occur, but complete deverbalization seems unlikely. The two strategies may, however, be difficult to disentangle experimentally because they may result in similar output. On the one hand, it is possible that in meaning-based interpreting the exact form of the input still resides in an input buffer. In that case, this form may still influence the target language output, even though no transcoding occurs. On the

other hand, while the input is being transcoded into matched output, it is likely that this input is simultaneously processed further, up to full comprehension, resulting in a level of comprehension that matches comprehension resulting from pure meaning-based interpreting.

Self-Monitoring

Speakers are assumed to monitor their own speech, and the self-monitoring system involved is thought to employ the comprehension system (Levelt, 1989). However, in SI the comprehension system is already occupied with understanding the source text (Frauenfelder & Schriefers, 1997). This raises the question how monitoring in SI comes about. That interpreters indeed monitor whether the produced translation is correct has been suggested by several authors (Gerver, 1976; Isham, 2000; Lonsdale, 1997) and is evident from the self-corrections that we have observed in our own data and that were reported by others (e.g., Gerver, 1976).

Most of the theoretical accounts of SI discussed in previous sections have incorporated some form of output monitoring. In both Gerver's (1976) and Moser's (1978) model, the monitoring of output is performed by comparing the meanings of the source message (retained in the input buffer) and the target message before production takes place. In Paradis's account (1994), it occurs after production has taken place. Paradis himself noted that the comparison between the meaning of the source and target messages is not specified in his model and there is no consideration to what happens when the output is not satisfactory.

The issue of output monitoring in SI is particularly interesting because apparently three speech streams in two languages reside simultaneously in the language system: the comprehension of input, the production of output, and the monitoring of output. Especially for the comprehension system, the situation is complicated because it needs to handle source language input and target language output simultaneously. How these speech streams can all cooccur at the same time and how they are kept separate from one another are questions that still have to be resolved.

Memory Processes

SI poses a great burden on working memory because interpreters simultaneously have to store information and perform all sorts of mental operations to comprehend, translate, and produce speech. In addition, because interpreters monitor their output, it may be necessary to keep some sort of representation of the input phrase available until after production in the target language.

One of the best-known models of working memory is that of Baddeley and colleagues (see e.g., Baddeley & Logie, 1999; Gathercole & Baddeley, 1993). This multiple-component model consists of a *central executive* and two "slave" systems, specialized for the temporary storage of phonologically based material and of visuospatial material. These subsidiary systems are called the *phonological loop* and the *visuospatial sketchpad*, respectively. A fourth component has been proposed, the *episodic buffer*, which is a limited-capacity store capable of integrating information from different sources in a multidimensional code (Baddeley, 2000). The central executive is seen as a mechanism controlling processes in working memory, including the coordination of the subsidiary systems, the manipulation of material held in these systems, and the control of encoding and retrieval strategies. The phonological loop is specialized in maintaining verbally coded information and is therefore the most relevant slave system for SI. It consists of two parts: the phonological store and the subvocal rehearsal process. The phonological store retains material in a phonological code, which decays over time. The subvocal rehearsal process serves to refresh the decaying representations in the store.

Short-term recall for lists of words is disrupted when participants continuously articulate irrelevant syllables during the presentation of these words, a technique called *articulatory suppression* (e.g., Baddeley, Lewis, & Vallar, 1984). Articulatory suppression also leads to reduced recall of auditorily presented short discourse (Christoffels, 2004). The requirement to maintain information during speech production may be an important aspect of the task difficulty of SI because producing speech during SI resembles articulatory suppression. In fact, one may expect reduced recall because of the disruption of the rehearsal process in all tasks in which comprehension and verbal production are involved simultaneously (see also Darò & Fabbro, 1994; Isham, 2000).

After interpreting, text recall is indeed worse than after listening to it (e.g., Christoffels, 2004; Darò & Fabbro, 1994; Gerver, 1974b; Isham, 1994). Two possible causes for the reduced recall after SI can be deduced from the articulatory loop model. First, production of the target speech may prevent subvocal rehearsal. Second, apart from the

incoming source language, the interpreter's own voice enters the phonological store, possibly causing interference.

Isham (2000) found that verbatim recall after articulatory suppression was worse than recall after both common listening and dichotomously listening (listening to two speech streams, one of them presented to each ear). He concluded that reduced recall after SI is mainly caused by the actual production of speech and not by the fact that two speech streams enter the phonological store simultaneously. Another reason for the reduced recall after SI may be the higher cognitive demands of simultaneous comprehension and production.

The pattern of results found when comparing recall following interpreting with recall following other, similar tasks is not consistent, however: Recall after interpreting was found to be better than after shadowing (Gerver, 1974b), but digit span performance was found to be worse in an interpreting condition than in any of the remaining conditions, including shadowing (Darò & Fabbro, 1994). Note however, that shadowing involved verbal repetition of digits presented 1 s apart; these circumstances may actually support recall. Finally, no differences in recall whatsoever were obtained between conditions of SI, shadowing, articulatory suppression (Christoffels, 2004), or paraphrasing (Christoffels & De Groot, 2004). (Paraphrasing in this context involved rephrasing the meaning of a sentence in the same language but in different words or using an alternative grammatical construction; see Moser, 1978.) These inconsistent results are likely to be caused by differences in the relevance of long- and short-term memory in recall performance across these studies.

In conclusion, the relevant studies disagree on whether interpreting and shadowing lead to different memory performance, but clearly memory performance after interpreting is worse than after just listening to a text. Interference from articulatory activity during interpreting forms at least a partial explanation for this differential memory performance. This explanation is supported by the better sentence recall of sign language interpreters in comparison to spoken language interpreters (Isham, 1994).

Working memory is important in ordinary language processing (see Gathercole & Baddeley, 1993). It remains to be seen whether working memory has a role in interpreting beyond its role in ordinary language processing. That such is the case is suggested by studies that indicated that professional interpreters possess outstanding memory

skills (see the section on cognitive skills). Apart from the phonological loop, the central executive and the episodic store are bound to be important. They are presumably involved in the activation of relevant information in long-term memory, the suppression of irrelevant information, the integration of information, and the coordination of the different processes during SI (see also Bajo, 2002).

Determinants of Interpreting Output

Listening Conditions: Input Rate, Information Density, and Sound Quality of Input

Input rate influences the rate at which information has to be processed. Consequently, it also influences interpreting performance. It is not always the case, however, that the faster the input rate is, the harder interpreting becomes. Slow, monotonous delivery of the source message can be as stressful as a speeded presentation (Gerver, 1976). According to Gerver, rates between 100 and 120 words per min are comfortable for the interpreter. When comparing the effect of increasing the input rate in shadowing and interpreting (from 95 up to 164 words per min), he found that the proportion of correctly shadowed text decreased only at the two highest rates, whereas in SI, performance decreased further with each increase in input rate. Moreover, shadowers maintained a steady ear-voice span of 2 to 3 words at all input rates and increased their articulation rates as input rate increased. In contrast, the interpreters' span increased from 5 to 8.5 words, and their output rate remained the same, indicating that they paused more and spoke less the higher the input rate (Gerver, 1969, in Gerver, 1976).

Shadowing performance is more accurate than SI performance, both for bilinguals not trained in SI (Treisman, 1965) and for SI professionals (Gerver, 1974a). Treisman investigated the effect of information density rather than input rate on accuracy of performance. Interpreting suffered more than shadowing from increasing information density. No effect of information density on the ear–voice span was found. The last result, however, was based on six participants only, so this null effect can be caused by lack of statistical power. Gerver manipulated the amount of noise in the input and found that this manipulation had a larger

effect on the number or errors in interpreting than in shadowing. The ear–voice span again remained constant irrespective of the amount of noise. Both findings suggest that interpreters sacrifice accuracy to keep a constant ear–voice span (Gerver, 1976). Alternatively, the participants may already have performed at their maximum lag in the relatively easy conditions and were therefore unable to increase their ear–voice span any further when the amount of noise or the information density increased (see the discussion on the lag between source and target language).

To summarize, these findings indicated that interpreting is more difficult and more sensitive to factors influencing task difficulty than shadowing. Furthermore, they showed that not all factors that increase task difficulty also affect the ear–voice span.

Translation Direction and Language Combination

A recurring question concerns the role of the direction of translation in interpreting. It is often claimed that interpreting is easier into than from one's native language, which is typically the interpreters' dominant language (see Barik, 1975; Gerver, 1976; Gile, 1997; Treisman, 1965). In word translation studies, such a directional effect has been observed by some authors, who have shown that translating from L1 into L2 is slower and more prone to errors than translating from L2 into L1 (e.g., Kroll, Michael, Tokowicz, & Dufour, 2002; Kroll & Stewart, 1994), but others have reported null effects or even the opposite effect (e.g., De Groot & Poot, 1997; La Heij, Hooglander, Kerling, & Van der Velden, 1996; see for discussion, Kroll & De Groot, 1997).

In interpreting studies, there is little experimental evidence in support of any directional effect. Rinne et al. (2000) compared, using PET, interpreting from and into the native language, among other things. They found more extensive activation during translation into L2, possibly reflecting differences in difficulty between the two translation directions. Treisman (1965) found that both French-dominant and English-dominant bilinguals (without interpreting experience) were better when interpreting from English into French than when interpreting in the reverse direction. In a study on allocation of attention and text type, Darò, Lambert, and Fabbro (1996) found no effect of translation direction. Finally, Barik (1973, 1994) provided a detailed analysis of translation direction

data of three professional interpreters and three inexperienced participants. For the professionals, the number of errors and omissions were the same for the two directions. Interestingly, the participants without experience in SI performed better when interpreting from L1 into L2 than vice versa. To conclude, so far no consistent effect of translation direction has been obtained.

It is possible that the particular language combination involved influences the difficulty of interpreting: The more the two languages involved deviate from one another on the lexical, morphological, syntactic, semantic, and pragmatic levels, the more difficult SI is likely to be. For example, Barik (1975) observed that syntactic differences between source and target language might cause problems. If, for instance, certain grammatical constructions specific to a (source) language are transferred into the target language, awkward or ungrammatical target language may result. Note that such an influence of the source language on the target language may indicate a role for the transcoding strategy in SI discussed in the section on language recoding.

Goldman-Eisler (1972) found a longer ear–voice span for interpreting from German to English than from English to French or French to English. The author attributed this finding to the fact that, in German but not in English and French, the verb frequently follows the object (subject-object-verb order). Because the minimal translation unit is likely to be a clause (as discussed earlier), when interpreting from German into English the interpreter may have to wait for the verb in the input, causing lengthening of the ear–voice span. Similar problems may arise when interpreting from languages with occasional verb-subject-object order, such as Arabic (Gile, 1997; MacWhinney, 1997, and chapter 3, this volume). It seems, then, that language combinations differ in the extent to which they pose demands on working memory. As a consequence, they may differ in the ease with which an interpretation can be produced.

The effort model of SI (Gile, 1995, 1997) provides a capacity account of why effects of language combination may arise. This model discusses SI in terms of a limited capacity system. Three basic concurrent, conscious, and deliberate "efforts" are presented: the listening and analysis effort, the production effort, and the memory effort. Each effort represents all the different processes involved in comprehension, production, and memory, respectively. Moreover, a separate coordination effort is postulated. At any point in time, the three

basic efforts are processing different speech segments. The total capacity requirement is the sum of all four efforts. It varies depending on the specific information segments that are processed and therefore fluctuates in accordance with the incoming speech flow. As a consequence, errors may even occur with relatively easy source segments because of a sequential failure originating from an upstream difficulty in the source message.

For example, when capacity needed to produce a difficult chunk is not immediately available, this causes an increased memory load because incoming input has to be stored until production is possible. The additional capacity required for memory may diminish capacity for comprehension, which in turn may lead to problems in the comprehension of the next speech segment. Specific difficulties with certain language combinations can be expected for similar reasons. For example, syntactic differences between source and target language that force an interpreter to wait before formulating the target utterance tend to increase the load on the memory effort.

To summarize, the sparse experimental data suggest that, of the two variables discussed in this section, that is, translation direction and language combination, the latter may be the more important determinant of interpreting performance.

Source Text Characteristics

Redundancy and the Possibility of Anticipation
The characteristics of the source text, especially the degree to which it is redundant, are likely to have an effect on interpreting performance. Chernov (1994) stated that, given the large processing load involved, SI of nonredundant speech (e.g., poetry or legal papers) should be impossible. He assumed that speech redundancy normally enables the anticipation of subsequent input.

Other authors have acknowledged the importance of anticipation in SI as well (e.g., De Bot, 2000; Moser-Mercer, 1997). In Moser's model of SI (1978), a decision point is included that allows for anticipation. On a decision that prediction of input is possible, current input is discarded. That interpreters indeed anticipate subsequent input is evidenced by the fact that they sometimes produce a translation of a part of the source text that has not yet been produced by the speaker (e.g., Besien, 1999; Gernsbacher & Shlesinger, 1997). In fact, a certain amount of anticipation is always involved in interpreting because the interpreter usually does not await the entire sentence before starting to interpret (Moser-Mercer, Frauenfelder, Casado, & Künzli, 2000).

If at discourse level a text is highly structured according to a familiar schema, this may help predict what comes next. In a pilot study, Adamowicz (1989) presented SI students with a prepared, structured text and a spontaneous text. Adamowicz argued that the prepared text was more predictable than a spontaneous text, and that the difference in predictability between the two text types should influence the ear–voice span because anticipation allows for a shorter lag between speaker and interpreter in the case of prepared text. This prediction was substantiated by the data. Note, however, that Adamowicz's line of argument and her data are contrary to the commonly held belief that interpreting is only feasible in the case of spontaneous speech because it is more redundant, has a lower information density, and contains more hesitations than a prepared text (e.g., Anderson, 1994; Chernov, 1994; Gile, 1997).

Finally, the context of a source text and prior knowledge of the topic may make the text more predictable, help activate relevant "registers" in memory, and help select the most salient units of meaning from memory (see De Bot, 2000). Anderson (1994) tested two factors that interpreters traditionally believe to be sources of contextual information that are important for interpreting: the amount of text-relevant knowledge the interpreter has prior to the interpreting event and the presence of visual information while interpreting (e.g., the speaker). She found no difference in quality of SI when professional interpreters received a complete text of the speech beforehand, a summary of the speech, or no information other than its title. Anderson also obtained no difference between conditions with and without visual information of the speaker on video. Similarly, Jesse, Vrignaud, Cohen, and Massaro (2001) found no superior SI performance when presenting visual information on speech lip movements together with auditory speech. Clearly, further research is needed to establish what role these types of contextual information play in SI, if any.

Manipulation of Texts   Darò et al. (1996) studied, among other things, the role of text difficulty in SI. They found that the number of errors was larger for the difficult texts, which were more syntactically complex and contained more low-frequency words than the easy texts.

Barik (1975) observed difficulties not only for function words and grammatical structures that differ between source and target language, but also for some relatively common, notably abstract words. He suggested these words might be problematic because they may have different translation equivalents depending on the context. It would be interesting to determine whether these observations hold up experimentally and whether factors known to influence single-word translation (e.g., word frequency and word concreteness) affect SI performance as well.

Van Hell (1998) found that, for single-word translation in a highly constrained sentence context, the effects of word concreteness and cognate status were attenuated as compared to these effects on word translation in isolation (the variable cognate status is a measure of the orthographic and phonological overlap between the words in a pair of translation equivalents; compare the noncognate word pair *bike* and its Dutch equivalent *fiets* with the cognate word pair *cat* and its equivalent *kat*).

Incidentally, an effect of word manipulations such as cognate status would point at the use of the transcoding strategy in SI because, according to the meaning-based interpreting strategy, the interpreting output is produced from relatively large chunks of input coded in a nonverbal conceptual form. It should therefore not matter whether word equivalents in source and target language are cognates.

Shlesinger (2000b) examined the effect of some of these word-type manipulations on interpreting. She embedded different types of strings containing adjective modifiers (e.g., *delicate, immature, fractured, vulnerable ego*) in six text segments and looked, among other things, at the effect of the length of the input strings and whether they contained true or false cognates. False cognates, or interlingual homographs, are orthographically similar (or identical) words that belong to two different languages but that do not share meaning across these languages (for example, the English word *slim* means clever in Dutch). Suppressing a false cognate presumably requires effort; the interpreter must assess whether a cognate orthographic form involves a true or a false cognate and must then access the appropriate target language replacement (Gernsbacher & Shlesinger, 1997). Therefore, the presence of false cognates was expected to influence performance. However, Shlesinger found better performance for short than for long words in the input strings (i.e., a word length effect), but no effect of false cognates was found. This null effect was qualified by another finding:

Only a surprisingly small part of the manipulated strings was actually interpreted (only one of four modifiers), reducing the chance of a false-cognate effect to materialize. It is likely that the modifiers may have been regarded as redundant information that can be easily skipped, whether automatically or deliberately (Schlesinger, 2000b).

To summarize, text type and text difficulty are likely to influence SI, and there is some evidence that corroborates this suggestion. Although it is not clear which text characteristics play the largest role in SI, an important variable may be whether parts of the input can be easily anticipated. Specific word properties, like word length, may influence interpreting output as well.

Simultaneous Interpretation Versus Similar Tasks

Mental Load and Stress

Several studies have considered the role of mental load and stress in interpreting in comparison to other, similar tasks. A number of these studies used the finger-tapping version of a verbal-manual interference paradigm. Finger tapping is interrupted by the processing demands of another (cognitive) task, and this interference is larger the more demanding this other task is, thus indicating the cognitive load that is involved. A. Green, Sweda-Nicholson, Vaid, White, and Steiner (1990) found that interference on tapping was larger for interpreting (and paraphrasing) than for shadowing, indicating that the former is a cognitively more demanding task.

The finger-tapping paradigm has also been used to infer lateralization of language. Concerning SI, the question posed in this type of research was whether interpreters, bilinguals, and monolinguals showed different lateralization patterns in L1 and L2 (see, e.g., Corina & Vaid, 1994; Fabbro et al., 1990; A. Green et al., 1990). Results have not been consistent across the different studies, but lately the differences in lateralization data have been taken to indicate larger involvement of pragmatic strategies to compensate for low L2 proficiency rather than differential brain representation of language processes (Fabbro, 2001; Fabbro & Gran, 1997; Paradis, 2000).

Hyönä, Tommolo, and Alaja (1995) took pupil dilation as a measure of processing load. Students of interpreting listened to, shadowed, and interpreted

an auditorily presented text. In shadowing, the pupil diameter was larger than in listening, but interpreting yielded an even larger average pupil diameter than shadowing, again suggesting that processing load is largest in interpreting.

Studies using other physiological measures also indicated that mental load during SI is high, and that coping with the difficulties of SI induces stress in interpreters. Klonowicz (1990) found an elevated heart rate for both shadowing and interpreting in comparison to just listening, suggesting an equally large mental effort on these tasks. In a second study, Klonowicz (1994) studied the development of systolic blood pressure, diastolic blood pressure, and heart rate during four successive turns in interpreting. At the beginning of each turn, systolic and diastolic blood pressures increased immediately. During the turn, systolic blood pressure dropped to normal levels, whereas diastolic blood pressure remained elevated. Heart rate only normalized in the first two turns, after which it also remained elevated. According to Klonowicz (1994), these results point to systematically increased arousal in SI that mimics the arousal leading to the development of essential hypertension.

Moser-Mercer et al. (1998) investigated the effect of prolonged interpreting turns (i.e., longer than 30 min) on both the quality of output and psychological and physiological stress experienced by the interpreters. Rather interesting trends occurred, similar to findings for air traffic control, which is known to be an extremely demanding task (Zeier, 1997). After an initial rise of the level of stress hormones, it decreased with further time on task. The decrease may be caused by decreased motivation to perform well. Mental overload caused by increased time on task appears to change the interpreter's attitude to the job: Less effort is expended and carelessness may set in. This interpretation corresponds to the finding that the number of serious meaning errors increases during the second 30 min on task, even though the interpreters were apparently not aware of this performance drop (see also Zeier, 1997). To summarize, these studies indicate that SI involves a high mental load and can induce physiological stress.

Sources of Difficulty in Simultaneous Interpreting

In the studies described in the previous sections, SI and shadowing were often contrasted. Worse performance in SI, larger pupil dilation, longer ear–voice span, and relatively large effects of information density and noise on SI indicate that interpreting is more sensitive than shadowing to factors that increase task difficulty. The combined results of these studies suggest that interpreting is a more demanding and more complex task than shadowing is. Using PET, Rinne et al. (2000) also contrasted SI and shadowing. The brain areas that were selectively activated in SI (i.e., after subtraction of the areas that were activated in shadowing) were those that are typically associated with lexical retrieval, working memory, and semantic processing. This suggests that these cognitive processes play a larger role in interpreting than in shadowing.

Shadowing and interpreting share one source of task difficulty in SI, namely, the simultaneity of comprehension and production. The tasks differ in that interpreting, not shadowing, involves the recoding of source into target language, which may account for the observed differences between the two tasks. Recoding may consist of two subcomponents: First, in SI the message has to be reformulated. Second, SI involves the simultaneous activation of two languages (e.g., Anderson, 1994; De Groot, 1997). It is possible that not all of these task (sub)components contribute equally to task difficulty.

Anderson (1994) compared performance on shadowing, interpreting, and paraphrasing. In contrast to shadowing, in both paraphrasing and interpreting reformulation is required, but only in interpreting two languages are involved. By exploiting these task characteristics, it is possible to disentangle the subcomponent of reformulating a message from the subcomponent of doing so in another language. Twelve professional interpreters performed poorer in interpreting than in shadowing on two quality measures, but interpreting differed from paraphrasing only according to one of the two quality measures. The ear–voice span was smaller in shadowing than in interpreting and paraphrasing, but it did not differ between the last two tasks. In other words, Anderson replicated the difference between shadowing and interpreting, but the results did not clearly indicate that the involvement of two languages instead of just one is an important additional subcomponent in SI on top of the reformulation subcomponent.

In a study mentioned earlier, we attempted to disentangle all three proposed sources of cognitive complexity in SI by comparing the shadowing of sentences with paraphrasing and interpreting them (Christoffels & De Groot, 2004). Bilinguals without interpreting experience performed these tasks

simultaneously and in a delayed condition, that is, immediately after presentation of each sentence. By including this condition, the effect of simultaneity of comprehension and production as a source of difficulty in SI could be tested. The quality of the shadowing output was better in the delayed than in the simultaneous condition, but the difference was small, suggesting that simultaneity of input and output on its own adds somewhat to the complexity of SI but is not a major source of complexity. Also, the difference in output quality between the three tasks in the delayed condition was small, suggesting that having to rephrase a sentence per se—even into a different language—may also not be a major source of difficulty on its own. However, in the simultaneous condition, interpreting and paraphrasing performance were notably poorer than in the delayed condition, whereas shadowing performance was much more similar in these two conditions. These findings showed that especially the combined requirements of simultaneity and rephrasing have a detrimental effect on the quality of performance in SI.

There was no difference between paraphrasing and interpreting in the quality of performance, which may suggest that the additional demand of activating two languages on top of reformulation is not substantial. However, the ear–voice span was significantly larger in paraphrasing than in interpreting. The paraphrasing task has been considered as "unilingual interpreting" or "intralanguage translating" (Anderson, 1994; Malakoff & Hakuta, 1991). For this reason, the task is often used as an exercise or assessment task in the training of interpreters (Moser-Mercer, 1994), and interpreting in bilinguals has been compared directly to paraphrasing by monolinguals (Green et al., 1990). In support of this view, interpreters sometimes accidentally "translate" into the same language (Anderson, 1994; De Bot, 2000).

However, the larger ear–voice span for paraphrasing than for interpreting suggests that paraphrasing is more demanding than interpreting. The reason may be that the vocabulary demands in paraphrasing are likely to be larger than in interpreting because the latter only may require a basic vocabulary in both languages, whereas paraphrasing requires a large vocabulary in the one language concerned (Malakoff & Hakuta, 1991). Moreover, changing the grammatical structure, as is typically required in paraphrasing, may be more demanding than finding a grammatical equivalent of an input segment in the output language, as required in interpreting.

A final, perhaps critical, difficulty in paraphrasing may be that, despite the fact that the input message is already properly formulated, an alternative wording has to be found. In paraphrasing, it may therefore be necessary to inhibit the original sentence form and to monitor output rigidly to avoid literal repetition. All in all, there is reason to believe that paraphrasing may involve higher demands than interpreting.

In conclusion, it seems that both requirements (of simultaneity of comprehension and production and of reformulation) contribute to the complexity of SI, but that especially the combination of these two components taxes the limited mental resources.

Novices Versus Experts

Are Interpreters Special?

Is there anything that distinguishes experienced interpreters from novices? If so, are the differences qualitative or quantitative, and are they caused by a difference in talent or training? Neubert (1997) claimed that untrained or "natural" translation is distinctly different from professional translation and interpreting. Harris and Sherwood (1978), however, argued that translation in general is an innate skill. According to them, translation is co-extensive with bilingualism, and therefore all bilinguals are able to translate (see also Malakoff, 1992; Malakoff & Hakuta, 1991).

Dillinger (1994) compared professional interpreters and balanced bilinguals on comprehension during interpreting, as measured by a wealth of different variables. He found only small quantitative differences and no qualitative differences between the two groups and argued that interpreting is not a special, acquired skill but the application of an existing skill that accompanies bilingualism naturally. Of course, it is still an open question whether any differences may be found for language production.

Studies in which only nonprofessional interpreters participate are sometimes criticized for not being informative about professional interpreting (e.g., Setton, 1999; see also Gile, 1991, 1994). But research with professionals also can have potential drawbacks. As Shlesinger (2000a) pointed out, it may be difficult to distinguish between idiosyncratic strategies applied by the experienced interpreter and other, more general cognitive processes involved in the process. When novices perform the

SI task, presumably no such strategies have developed yet. It is therefore both theoretically and methodologically important to learn whether interpreting in trained professionals and untrained bilinguals involves similar processes or is fundamentally different.

Cognitive Subskills

By comparing novices and professionals on tasks that are supposed to tap into possibly relevant subskills, we can gain more insight into what cognitive subskills are in fact important for SI. In the next section, we discuss memory skills, verbal fluency, basic language processes, and other subskills in relation to SI.

Memory Skills   A number of studies indicated that interpreting is associated with efficient working memory skills. Padilla, Bajo, Cañas, and Padilla (1995) compared experienced interpreters with student interpreters and noninterpreters on a standard digit span test and a reading span test, which is thought to tap into both the processing and storage aspects of working memory (Daneman & Carpenter, 1980). They found that the average performance of the interpreters was higher than that of the other two participant groups (see also Bajo, Padilla, & Padilla, 2000). In our laboratory, we found that, for unbalanced bilinguals, interpreting performance was significantly correlated with both the digit span and the reading span in the two languages concerned, although only marginally so for L1 (Christoffels, De Groot, & Waldorp, 2003), indicating a relation between SI performance and working memory capacity in this group. Moreover, memory performance in L1 and L2 of professional interpreters was superior to that of bilinguals who had no SI experience but were similarly proficient in L2 (Christoffels, De Groot, & Kroll, 2003).

Padilla et al. (1995) compared recall of words in conditions with and without articulatory suppression during presentation. For the articulatory suppression condition, a significant group effect was obtained. This was caused by a decrement in the recall scores of all groups except the experienced interpreters, who apparently were resistant to the effect of articulatory suppression (see also Bajo et al., 2000). This finding suggests that the ability to cope with concurrent articulation is important in SI. This conclusion is also supported by the association that occurs between retention under conditions of articulatory suppression on the one hand and SI performance in bilinguals without previous SI experience on the other hand (Christoffels, 2003).

In contrast, Chincotta and Underwood (1998) did not find a difference in digit span between English-Finish interpreters and Finish students majoring in English, neither in a condition with articulatory suppression nor in one without such suppression. However, consistent with earlier findings, differences in memory processes between the two groups were suggested by the finding that the standard language effect in the digit span task (a larger digit span in the language in which one can articulate faster) disappeared for the students in an articulatory suppression condition, whereas for the interpreters it persisted.

Finally, Bajo (2002) reported that word recall in interpreters, participants with a similarly large reading span, and noninterpreters alike was disrupted by divided attention manipulations that tapped into the visual spatial sketchpad and the central executive components of working memory. The finding that the interpreters did not outperform other groups on these working memory tasks suggests that the ability to cope with simultaneity of verbalization and recall in SI may not reflect a general ability of the executive to coordinate multiple tasks and processes, but instead involves a specific skill to coordinate the verbal processes implicated in SI.

To summarize, findings of superior or qualitatively different performance on several verbal memory tasks for professional interpreters than for other groups of participants suggest the importance of efficient working memory skills for SI.

Verbal Fluency   Fabbro and Darò (1995) observed greater resistance to the detrimental effects of delayed auditory feedback in students of SI than in monolingual controls. In a delayed auditory feedback condition, the speakers' own voice is amplified and delayed for a few hundred milliseconds, a situation that in general causes speech disruption. The student interpreters showed less speech disruption than the controls. Fabbro and Darò suggested that the students were more resistant to the interfering effects of delayed auditory feedback because they had developed a high general verbal fluency as well as an ability to pay less attention to their own verbal output.

Moser-Mercer et al. (2000) reported a number of pilot studies comparing five students of interpreting with five experienced interpreters, all native speakers of French. In line with the results of

Fabbro and Darò (1995), they obtained a smaller detrimental effect of delayed auditory feedback for the professionals than for the students on reading a French text but not on reading an English text. No differences were found between professionals and students on tasks involving semantics, free association, spelling, morphology, and phonology. Finally, in a shadowing task, the interpreters' ear–voice span was similar to that of the students in their native French language, whereas the students were *faster* in shadowing in English. Moreover, in both languages, the interpreters made more errors than the students did. Moser-Mercer et al. (2000) explained these remarkable results by suggesting that professionals are used to processing larger chunks of input than those required in shadowing, which might make it harder for them to respect the instruction of immediate repetition imposed by the shadowing task. If this explanation holds, then we should be cautious in using the shadowing task in studies that test interpreters (see also Frauenfelder & Schriefers, 1997).

To summarize, none of the differences between professionals and students observed by Moser-Mercer et al. (2000) clearly supports the idea that professionals have special verbal fluency skills. Perhaps the two groups compared in this study performed similarly because the students were already enrolled in an SI training program and were therefore possibly (self-) selected on verbal fluency skills. The additional interpreting experience of the professionals may not exert a notable effect on some of the subskills involved in SI. However, given the small sample size, we cannot draw any firm conclusions from the results of this study.

Basic Language Processes   Efficient language processing may be especially important for SI. The more the language processes that are involved in SI are automated, the more processing capacity will be available for other relevant processes and the faster the outcome of these processes will be available for further processing. For example, the ability to access and retrieve words quickly may be an important subskill. Bajo et al. (2000) presented a categorization task to four groups of participants: interpreters, interpreting students, bilinguals, and monolinguals. On each trial, the participants had to decide whether a word was a member of the category to which another word referred. Especially for atypical exemplars of categories, the interpreters were faster than all other groups, indicating faster semantic access. In a lexical decision task, no difference was found between the

groups on the words, but on the nonwords the interpreters were faster than the bilingual participants. The relevance of quick lexical access is also indicated by the positive correlation between interpreting performance on the one hand and word naming and word translation in the two languages involved (English and Dutch) on the other hand, a result that we obtained for unbalanced bilinguals untrained in SI (Christoffels et al., 2003). However, when comparing the performance of interpreters and other highly proficient bilinguals (teachers of L2) on these same tasks, we obtained no differences between groups. This finding suggests that efficient lexical retrieval may not be uniquely related to SI, but to high L2 proficiency instead (Christoffels, De Groot, & Kroll, 2004).

Finally, in a dichotic listening task, Fabbro, Gran, and Gran (1991) compared students of interpreting with professionals in how well they detected errors in translations of sentences. The participants simultaneously received the source sentence to one ear and its translation to the other ear. Professional and student interpreters did not differ from one another in recognizing correct translations. However, an interesting difference between the two groups was that the students recognized more syntactic errors than the professionals, whereas the professionals recognized more semantic errors. This suggests that the groups differed in the level at which they processed the input.

To summarize, although it is not altogether clear which language subprocesses are most critical for skilled SI performance, there is some evidence to suggest that interpreters are relatively efficient in processing meaning.

Other Subskills   A number of other potentially relevant subskills of SI are worth mentioning. Gernsbacher and Shlesinger (1997) pointed out that people differ in how efficiently they can suppress interfering information, such as the inappropriate meanings of homonyms, recently processed (but currently inappropriate) syntactic form, and the literal interpretation of metaphors. They suggested that, in interpreting, resources required for suppression are diminished because the system is already involved in simultaneous comprehension and production. Because, nevertheless, interfering information will have to be suppressed, the ability to do so effectively is likely to be another important subskill of interpreting.

Similarly, Tijus (1997) argued that the most important subskill of SI is to be able to detect inconsistencies resulting from incorrect assignment

of meaning to polysemous phrases and to resolve them immediately. Detecting and quickly resolving such inconsistencies requires a large memory capacity for input processing (Tijus, 1997), which again points to the relevance of efficient memory processes for interpreting.

Training or Selection?

It is not clear whether the differences found between interpreters and other groups of participants concern qualitative or quantitative differences in underlying processes. Another relevant question that needs to be answered is whether the skills required for SI have developed as a consequence of training and experience in SI or whether successful interpreters chose a career in SI because they possess certain talents that make them well suited to the task.

Bajo et al. (2000) presented evidence suggesting that training in interpreting can improve performance on basic language skills. They compared students of interpreting who received a year of training with an untrained control group on three tasks: comprehension, categorization, and lexical decision. Both groups were tested twice, once at the beginning of that year and once at the end. The student interpreters, but not the controls, showed improved performance on the second test.

The most likely answer to the question of what causes differences between novices and experienced interpreters is that both certain language and memory abilities are required for a high performance level, and that certain skills develop with practice. It is, therefore, of great practical interest to find out which aspects of SI can and should be learned on the one hand and what determines aptitude and which tests can predict aptitude on the other hand (Moser-Mercer, 1994).

Gerver, Longley, Long, and Lambert (1984) addressed the latter issues. They developed a set of psychometric tests to select trainees for a course in simultaneous and consecutive interpreting. At the beginning of this course, they administered tests based on text materials (recall, "cloze," and error detection); linguistic subskills (synonym generation, sentence paraphrasing, and comprehension); and a nonlinguistic speed stress test. The tests correlated with final examination ratings, and students passing the course had a higher score on all tests than the students who failed, albeit the difference was not significant for each of the tests. The text-based tests were more predictive for passing the course than the linguistic subskills and speed

tests, suggesting that especially rather general verbal abilities and the processing of text are predictive for SI and consecutive interpreting. Prediction of pass/fail rates was better on the basis of these tests than on the existing selection procedures, showing that aptitude testing can be useful in practice (see Hoffman, 1997, for a discussion of interpreting regarded as a skill from the perspective of the psychology of expertise, and see Arjona-Tseng, 1994; Lambert, 1991; and Moser-Mercer, 1994, for discussions of aptitude tests used in training programs).

Relevant Issues and Concluding Remarks

In this chapter, we presented an overview of experimental research into SI from a cognitive perspective. In the final part of this chapter, we briefly review a number of the most important issues that need to be addressed in developing a complete model of SI.

The Locus of Recoding

An important issue to resolve is where and how in the system actual recoding of language (translation) takes place. Two alternative theoretical views on this issue were discussed: meaning-based interpreting and transcoding. Although little direct experimental data exist to support either of these two recoding strategies, there is some evidence to suggest that, in addition to meaning-based interpreting, transcoding also takes place. This issue of how translation takes place has to be taken into account by models of bilingual processing. For example, if transcoding occurs, it may take place at a number of different levels in the bilingual system: phonological, morphological, syntactic, and semantic (Paradis, 1994). This implies the existence of direct links between representations of the linguistic elements of one language and the corresponding representations in the other language. The existence of such links constrains current models of bilingual memory.

Resource-Consuming Subcomponents of Simultaneous Interpreting

A further question is which subcomponents of the full interpreting task appeal to the limited mental resources of the interpreter and how these

resources are allocated. In fact, it is not yet clear which subcomponents should be distinguished in SI in the first place and whether they share resources. Both Gerver (1976) and Gile (1997) assumed that resources are limited and shared between the various components in their models. As a consequence, the monitoring of output, for instance, might suffer if the listening conditions are suboptimal. It is as yet unclear whether language recoding, the switch of language itself, should be regarded as an additional resource-consuming processing step in SI in addition to the steps required for comprehending and producing language, or whether instead the nonverbal meaning is derived from the source language and the target message is subsequently simply produced from this meaning representation (Anderson, 1994; De Groot, 1997; Isham & Lane, 1994). If only meaning-based translation holds—and not transcoding—it may not be necessary to assume an additional translation stage.

Representation, Selection, Access, and Control

An issue that has received little attention so far is how the language system(s) are represented and specifically whether language comprehension and production are subserved by one and the same system or by two functionally independent systems instead. Yet, to model SI it is necessary to make choices regarding the basic architecture of the language system(s). Considering monolingual language processing, we may ask which parts, representations, or processes are shared between the language comprehension and production systems. Kempen (1999), for example, assumed that grammatical encoding and decoding are performed by the same system, an assumption that may be difficult to reconcile with the simultaneity of comprehension and production in SI, and Frauenfelder and Schriefers (1997) and De Bot (2000) suggested that comprehension and production processes may share the lexical and grammatical knowledge systems (but see Harley, 2001).

With respect to bilingual language processing, common questions are how the two languages are represented in the bilingual mind and how lexical access to bilingual memory comes about. Most of the relevant research on bilingual memory representation focuses on the lexicon and converges on the conclusion that word forms are represented in language-specific memory stores, whereas word meanings are stored in memory representations that are shared between the two languages (for reviews, see De Groot, 2002; Kroll & Dijkstra, 2002). The research on access to bilingual memory mainly supports the idea that lexical access is nonselective, that is, that both during comprehension and during production, words from both languages are initially activated (e.g., Colomé, 2001; Dijkstra, Van Jaarsveld, & Ten Brinke, 1998; Hermans, Bongaerts, De Bot, & Schreuder, 1998; Jared & Kroll, 2001; Van Heuven, Dijkstra, & Grainger, 1998, but see Costa, chapter 15, this volume, for language-specific *selection*).

As mentioned (see The Control of Languages), in a framework in which control of languages is exercised by global inhibition of the nontarget language, presumably two languages must be active simultaneously in SI. The ensuing question is how it is possible that during SI only the target language is produced.

Figure 22.2 illustrates two alternative proposals that allow target language production in SI within a framework of global inhibition of the nontarget language; in addition, it illustrates a third proposal that does not assume global inhibition of a language. To simplify matters, only lexical activation is considered. According to all three solutions, lexical items belonging to the source language must be separated from those of the target language. The items of different languages may form independent subsets, or they are somehow labeled for language (e.g., using language tags or by connections to language nodes; De Bot, 2000; Dijkstra & Van Heuven, 1998; D. W. Green, 1986, 1998; Poulisse, 1997).

The important difference between the first two alternatives (Figs. 22.2[a] and 22.2[b]) is whether separate input and output lexicons exist. If the parsimonious solution is chosen, with just one lexicon for both comprehension and production (Fig. 22.2[a]), the problem is to explain why source language elements are *not* being selected for production even though both languages are activated. One possibility is that, irrespective of activation in the lexicon, the source target elements are not considered for selection at all (e.g., Costa, Miozzo, & Caramazza, 1999) (see Fig. 22.2[a]). In other words, this alternative assumes language-specific selection. Indeed, Costa (chapter 15, this volume) argues that in highly proficient bilinguals (such as interpreters), lexical selection may be language specific. The mechanism for such "filtering" of language is as yet unclear. Perhaps only items with a target language label can be selected when certain language schemas are adopted.
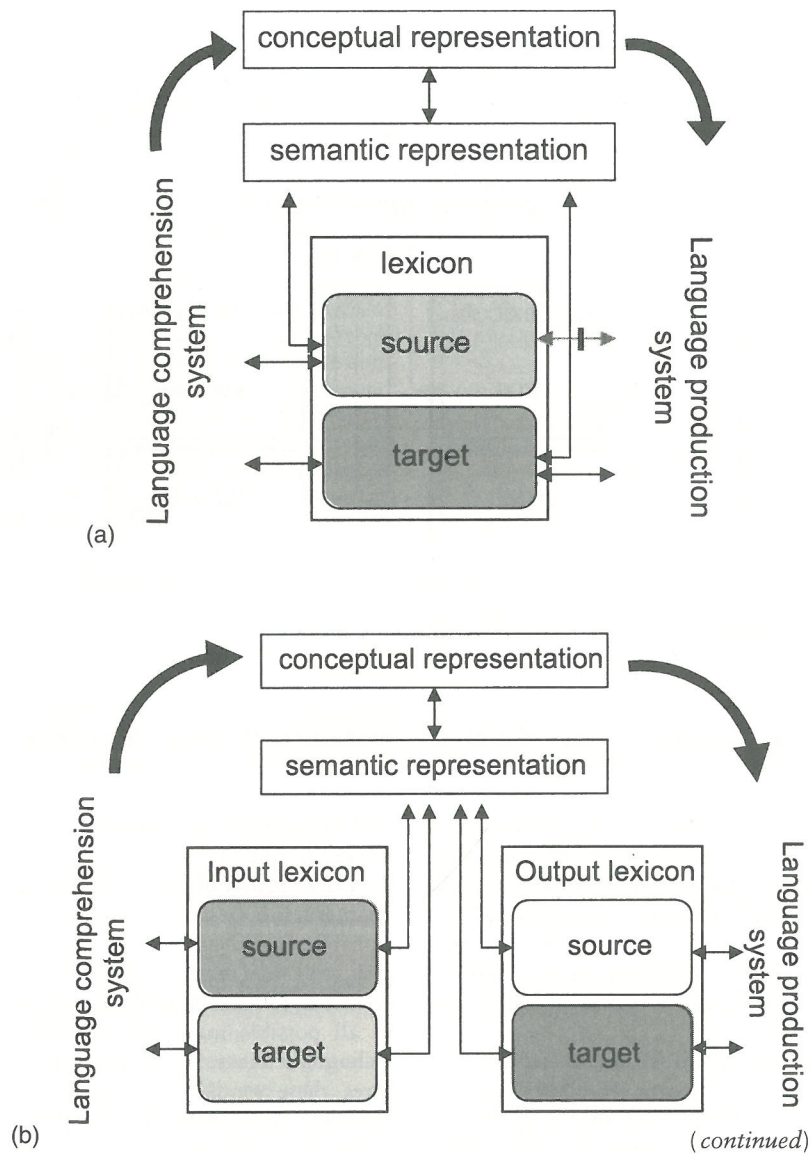
Figure 22.2 The conceptual and semantic levels of representation are separated. Meaning-based translation is illustrated by the route from the language comprehension system via the conceptual level of representation to the language production system. Transcoding at the lexical level takes the shortcut from the source language lexicon via the semantic level to the target language lexicon. (a) The lexicon is integrated for input and output. Both source language and target language lexicons are highly activated (gray in the figure), but selection of source lexicon items for production is not possible. (b) The input and output lexicons are separated. The input lexicons for both languages are activated (gray) to allow for comprehension of the source language and monitoring the produced output. There is (almost) no activation of the source language in the output system, so production only takes place in the target language. Selection of lexical items may be language nonspecific and based solely on the level of activation; source language items are hardly activated and therefore not selected. (c) The input and output lexicons are separated. There is no global activation/inhibition of languages, but a subset of appropriate items is activated instead (gray). Language is one of the elements contained by the conceptual message that determines what lexical items are activated. Selection is language nonspecific and based on the level of activation; the intended item in the target language is selected because it was activated more than semantically related items in both languages.
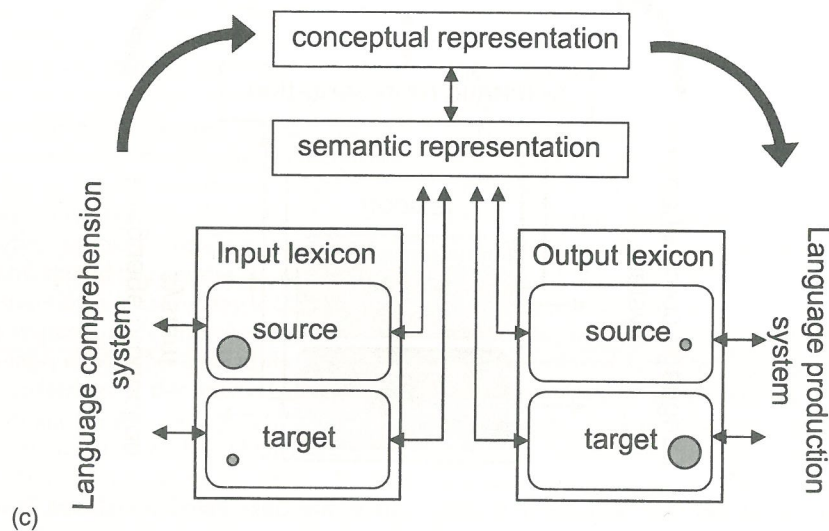
Figure 22.2 Continued.

SI performance may also be explained in terms of an inhibition account by assuming separate input and output lexicons that can be separately activated or inhibited (see Fig. 22.2[b]). According to this scheme, the output lexicon for the source language is strongly inhibited in SI, so that usually only target language elements will be selected. On the input side, both languages are active, but not to the same degree, to allow for comprehension of the input and monitoring of the produced output (see also Grosjean, 1997).

Finally, a third option is not to assume that global activation or inhibition of language systems controls language output, but that only specific activation of the relevant elements in the lexicon occurs. Language is one of the properties embedded in the conceptual message that selectively activates a number of relevant semantically related lexical elements in both languages. However, because of this language cue, the appropriate element in the target language will receive the most activation and will therefore be selected.

Such a proposal, based on a model by Poulisse and Bongaerts (1994, in Poulisse, 1997), is discussed in detail by La Heij (chapter 14, this volume). This option is presented in Fig. 22.2(c) in a model that assumes (functionally) separate input and output lexicons. If integrated input and output lexicons were assumed instead, the elements of the source language that received a lot of activation by the input might be inadvertently selected for

production. Whatever the solution to be chosen, any model of SI, but also models of common bilingual language processing, should ultimately be able to explain the language control that is exercised during SI.

The selection of topics that we addressed in this chapter has been dictated primarily by the available research. It is clear that SI is an extremely complex task, and that many of its intricacies are yet to be resolved. The fact that SI, despite its complexity, is at all possible may help to constrain models of (bilingual) language processing because it requires these models to account for simultaneous language comprehension and production, for the simultaneous use and control of two languages, for translation processes, and for monitoring in SI. Although SI is complex, we hope to have demonstrated that there are ways to study it successfully. This fact, combined with the recognition that no account of the bilingual mind and bilingual language processing can be complete without the inclusion of a satisfactory explanation of SI performance, may challenge other researchers to take up the study of SI as well.

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Note

1. In Levelt's model (Levelt, 1989; Levelt, Roelofs, & Meyer, 1999), three subcomponents are proposed. The first component, the *conceptualizer*, formulates the intended message in a preverbal, nonlinguistic form. This preverbal message contains all the information required for the second component, the *formulator*, to convert the message in a speech plan by applying grammatical and phonological rules and selecting the appropriate lexical items. Lexical items consist of two parts, the *lemma* (representing syntax) and the *lexeme* (representing morphophonological form). The third component, the *articulator*, subsequently converts the speech plan into sounds.

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