Component Processes of Simultaneous Interpreting

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Gracias a la vida,
que me ha dado tanto.
V. Parra

Abstract

The component processes specific to simultaneous interpreting and common to interpreting and listening were investigated. Experienced conference interpreters and inexperienced bilinguals performed aural-to-oral simultaneous interpreting of a narrative and a procedure from English into French and then gave a free recall of each immediately afterwards. A comparison group of bilinguals performed a simple listening task with the same materials. The texts were on an unfamiliar topic (positron emission tomography) and differed only with respect to frame type.

Experience showed a main effect on interpreting measures, (experienced interpreters performed more accurately), and interacted with text-structure variables that indexed proposition generation, but did not affect recall. Task did not have a main effect on recall and interacted weakly with text-structure variables. Text and Text-structure variables had very strong effects both for the interpreting and the recall measures.

The results were viewed as evidence that interpreting involves the same component processes as normal listening comprehension rather than constituting a specialized comprehension skill. Analyses of text-structure variables provided evidence for influence of high-level conceptual processing and other component processes both on line and off line. Since there was no evidence that interpreting interfered with comprehension, the qualitative on-line measures possible in the interpreting task appear to be generalizable to comprehension under more usual circumstances.

Resumé

Les processus spécifiques à la traduction simultanée et ceux qu'il y a en commun entre la traduction et la compréhension auditive ont été étudiés. Des interprètes de conférence expérimentés ainsi que des sujets bilingues n'ayant aucune expérience de l'interprétation ont fait la traduction simultanée du français à l'anglais de deux textes: un narratif et une procedurale, ayant donné un rappel libre des mêmes textes immédiatement après l'interprétation. À titre de comparaison, un groupe de sujets bilingues a executé une tâche de compréhension avec les mêmes textes. Les textes traitaient d'un sujet peu familier (la tomographie par émission de positrons) et différaient seulement par rapport à ses cadres conceptuels.

L'expérience a affecté isolément, aussi qu'en interaction avec les variables structurelles indiquant la génération des propositions, la précision des interprétations (les interprètes plus experimentés ont fait des traductions plus exactes), mais n'a pas affecté le rappel des textes. Il n'y avait pas de différences significatives entre les tâches; seulement des interactions faibles ont été trovées entre tâche et structure textuel. Les variables dérivées de la structure du texte ont exercé des effets très marquants sur l'interpretation et sur le rappel.

Les résultats es analyses indiquent que l'interprétation implique les mêmes processus qui constituent la compréhension normale, au lieu d'impliquer une compétence spéciale. Étant donné qu'il n'avait aucune indice d'interférence de l'interprétation sur la compréhension, les mesures qualitatives disponibles en temps réel lors de l'interprétation pourront être aussi characteristiques de la compréhension dans des circonstances plus usuels.

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Chapter One

Introduction

Simultaneous translation — the continuous, nearly simultaneous, usually aural-to-oral, meaning-preserving, rendering of a source-language input text in a target language — is, to most, a surprising and somewhat mysterious phenomenon. It is surprising in that it is possible at all, given the number and complexity of subtasks that have to be managed at the same time, and mysterious in that the mechanisms and processes by which it is carried out are unknown.

Its practitioners prefer to call it *simultaneous interpreting*, the term used here, because they associate *translation* (Fr. *transcodage*) with either the activity of written translation or that of producing a literal, word-for-word (hence less adequate) oral target-language version.

In a normal conference setting, interpreters work in a sound-isolated booth with a window on the proceedings to follow them visually, and with headphones that enable them to follow them auditorilly. They work in pairs, alternately interpreting for 20 minutes and resting for 20 minutes, although during the rest period they usually continue to accompany what is happening or assist their partner with the occasional question. Their work consists in listening to what the speaker says in the source language and providing an accurate translation of it into the target language. However, they must do this *while the speaker continues* to deliver his text, and nearly simultaneously. They can neither stay too close to the speaker or they will have difficulty understanding, nor can they lag too far behind or they will have difficulty remembering what they have understood. Interpreting, then, is conceived of as a process which includes normal comprehending of a source-language input text, translating it, and re-producing it in the target language, rather than some sort of unthinking word-for-word transposition (Seleskovitch, 1984).

An important and salient characteristic of the simultaneous interpreting task is its complexity. At any given point in time, interpreters have to comprehend and translate the source-language text, as well as formulate, produce and monitor their target-language text, all while keeping track of the coherence of the original, the accuracy of their translation, the smoothness of their delivery, and the non-linguistic events in the setting (see e.g., Barik, 1969; Gerver, 1976; Lederer, 1981). Moreover, all of the subprocesses of interpreting are themselves quite complex. For example, comprehension involves a large number of different subprocesses, each with its own representations of the source-language text and its own operations to be performed on them. The task is even further complicated in practice by several other factors:

(a) Interpreters are often called upon to interpret texts on technical topics about which they have little or no prior knowledge. Comprehension of technical texts under much more favorable circumstances is already quite difficult in the absence of specialized knowledge.

(b) Languages differ very widely in their structure and in the factors that determine the meaning of a given utterance and the appropriateness of each of the many possible translations of it.

(c) Interpreting is paced by the speaker rather than by the interpreter. Interpreters thus cannot translate at a rate that is comfortable for them; rather they are subject to the pace that the speaker sets.

(d) Interpreting often occurs in (diplomatic or mediational) settings in which interpreters' errors can be very costly (see Thiéry, 1985). Even in less stressful situations, interpreters are evaluated principally in terms of the precision of their interpreting, so accuracy has to be maximized.

In spite of the enormous complexity of the interpreting task, however, it is a commonplace to see or hear interpreters doing it routinely: during debates or speeches in the House of Commons or the United Nations, international conferences, legal proceedings, trade negotiations, visits of heads of State, classroom teaching for the deaf (using the simultaneous communication or *Sim-Com* method — see e.g., Stewart, Akamatsu & Bonkowski, 1988) or even regular television programs (as with the sign interpreters on close-captioned programs). Interpreters in fact perform very well at speeds somewhat slower than spontaneous speech: at source-language presentation rates of up to 120 words per minute, interpreters can perform with 90% accuracy (under favorable listening conditions; Gerver, 1971a,b), while speaking and listening simultaneously 65% to 75% of the time (Barik, 1969; Chernov, 1978, 1979; Gerver, 1972, 1974a).

The fact that interpreting is so routinely carried out in spite of its complexity raises a question with important theoretical and practical implications: How do expert interpreters carry out the subprocesses of discourse comprehension and production to perform simultaneous interpreting smoothly and efficiently? That is, what constitutes interpreting skill and what subprocesses are specific to the interpreting task? In other words:

> "The crucial question for simultaneous interpreting is [...] how syntactic (language-specific) and semantic (language-independent) information may be organized in a [...] bilingual, such as the interpreter, and how this information is accessed and becomes available during the process [of interpreting]". (Moser, 1978: 356)

An understanding of only the processes specific to the interpreting task, however, would still provide an incomplete characterization of the phenomenon. Equally important is an account of the processes that interpreting shares with normal discourse comprehension. Thus, interpreting is also an important phenomenon for the information it can provide about comprehension under more normal circumstances, and it offers several advantages as a task environment for studying comprehension on line.

First, one important way of corroborating any complex psychological model is to provide evidence that particular component processes specified by the model can be affected by some experimental manipulation independently of the others. Simultaneous interpreting is interesting in this respect because the extraordinary complexity of the task may enable us to study more subtle disruptions of processing than would be possible, for example, by using brain damaged patients, and more natural disruptions than would be possible with deviant texts, for example those containing center-embedded or garden-path sentences. To demonstrate this, very subtle, but naturally occurring, variations of processing complexity are examined here.

Second, the interpreters' nearly-simultaneous production of their translations provides us with a continuous, on-line measure of some (at present undefined) stage of their comprehension. If they manage to fully understand the text on line, then the translation will be a useful on-line measure of the comprehension process that is free from the influences of post-comprehension memory processes and that reflects more immediately the processing of a given segment. If interpreters are forced by task demands to curtail or truncate processing, it may be an even more useful task environment, since it would, by the method sketched below, be possible to bisect the comprehension process and study each part separately and more accurately.

Consider the hypothesis that interpreters go no further than recovering propositions from the source text. In this case, the interpreting protocol can be compared to the source text to provide a more direct measure of the functioning of the linguistic processor (see e.g., Hoover, Deffner & Ericsson, 1989), a measure that is unobscured by overlaid higher-level semantic operations carried out by the general cognitive processor. By the same token, the interpreting protocol can be taken as a more direct measure of the *input* to these same higher-level semantic operations and by comparing the interpreting protocol with a free recall protocol, for example, it will be possible to study these higher-level semantic processes more precisely. The same reasoning holds for whatever level interpreters reach in their processing. To assess the kinds of information that can be obtained in this task environment, one objective of the present study is to identify if, where, and the extent to which interpreters' processing is curtailed.

Third, the protocol of the interpreter's performance provides an on-line measure that can be subjected to the same kinds of qualitative analyses as are used with recall protocols. Currently used measures of on-line processing raise a series of problems (Renaud, 1989). Eye movement data and word or sentence reading times have suffered from the use of models that do not adequately specify the connection between the reading or gaze-duration times and the processes they are supposed to measure (Danks, 1986). Reaction times also have the inherent limitation of providing only quantitative information that is interpreted as an index of *how much* processing, rather than *what kind* of processing is occurring.

One method used to circumvent this limitation consists in asking subjects to verbalize all and any ideas, thoughts or associations that occur to them while reading a text or solving some problem (Ericsson & Simon, 1984; Olson, Duffy & Mack, 1984). The *think-aloud* protocols obtained by this procedure provide qualitative information about which parts of the input are important at which time and about which processes may be going on. This information, however, is difficult to interpret for several reasons (Ericsson & Simon, 1984; Renaud, 1989). First, thinking aloud may interfere with the processes being measured. Second, the results can vary with the specific instructions given and may be more informative with some kinds of tasks and texts than with others. Third, subjects talk about what occurs to them, rather than responding systematically to each part of the source text.

Thus, the sampling rate of this measurement procedure is irregular and, for many purposes, simply inadequate. Finally, it is notoriously difficult to identify and analyze the relevant information in the protocols (Breuleux, 1987).

Simultaneous interpreting protocols, however, seem to have none of these problems, and have some other advantages as well. The sampling rate is regular and of high frequency, and the task is so automatic that it is apparently not sensitive to instructions or to extraneous elaborations. The relevant information in the protocols is the nature of the differences from the original text and can be analyzed with the same useful methods and theoretical assumptions that have been developed for the analysis both of recall and think-aloud protocols. The fact that subjects perform, rather than talk about how they perform, the task being studied (comprehension) suggests that interpreting will provide a very direct measure of processing. Protocols of interpreting performance also have the advantage of providing temporal/quantitative and qualitative information simultaneously: lag times can provide the same detailed temporal information about *how much* processing is going on, while the differences between the translation and the original provide qualitative information about *which* processes are occurring, at the same time.

Fourth, examining exactly how interpreters adapt their processing to overcome constant or transient interference with particular subprocesses can provide important information about the nature of the interactions among component processes, as well as about the strategies and control structures used to manage complex processing. The potential of this type of task for the study of hypotheses about attention and allocation of processing resources was recognized in the 50s, and is reflected by the fact that simultaneous interpreting was first studied together with shadowing by psychologists interested in the single-channel hypothesis of attention (see Swets & Kristofferson (1970) for a review).

Fifth, by comparing interpreters with listeners on a recall task, it is possible to assess the extent to which comprehension in simultaneous interpreting is different from the normal processes of a listening task. If the two tasks are found to be different, their differences can be explored in more detail. If performance on recall is the same for both tasks, then the interpreting task becomes an important methodological tool for modelling normal comprehension, while permitting more direct on-line measurements not possible with a simple listening task.

Finally, among yet other advantages are that simultaneous interpreting can be used to study speech production in the same ways (Flores d'Arcais, 1978), and that it has an interesting same-language control task (shadowing) which can be used either to factor out the effects of using two languages or to study the effects of having to translate vs. repeat the source text.

Simultaneous interpreting also has some disadvantages as a task environment, due principally to the current lack of information available about the task. Two languages are involved, and little is known about the differences, if any, in the comprehension of bilinguals vs. monolinguals. It is not known whether the other processes that make up simultaneous interpreting interfere with the comprehension processes being measured, for example, whether there are effects of simultaneous speaking in one language on comprehension in another. Some investigators have postulated a translation or language-switching phase, a discrete processing step in interpreting that comes between comprehension and production (Kade & Cartellieri, 1971; McDonald & Carpenter, 1981); its possible effects on comprehension are also unknown.

Perhaps the most serious problem is that practically nothing at all is known about the processes that constitute simultaneous interpreting. There is little reliable research on simultaneous processing (Gile, 1988), and none at all on its component processes and the effects of text-structure variables on them. Without some knowledge of how the task is carried out, principled selection, training and evaluation of interpreters is not feasible, principled accounts of interpreting performance are beyond reach, and even a careful analysis of its potential as a task environment is impossible.

The research reported here was carried out in an attempt to remedy this problem, and differs from previous research in several ways. One important difference is that here well articulated models and methods from the study of text comprehension in Cognitive Science are used. These models and methods provide the tools necessary both to develop a more adequate understanding of simultaneous interpreting and to provide basic information about the on-line processing of natural language discourse.

A second important difference is the goal of arriving at a *process* model. That is, rather than study the interpreter's translation as an autonomous product, here it is analyzed as a detailed indicator of the cognitive processes that have produced it. In other words, interpreters' translations are used as the basis for inferences about the component processes which have been executed to perform the task, that is, those which constitute skill in interpreting.

A few examples should make this inferential process clearer. The deviations from the original text that appear in examples (1) and (2), for instance, provide evidence of problems of lexical access: in (1), the interpreters misperceived the source text (hearing *red* for *lead* and *psychotron* for *cyclotron*) and translated accordingly; in (2) the interpreters do not recognize the English *annihilation* and simply try to render it with French pronunciation.

(1)	Original	... a *lead* bucket...
	Translation	... un sceau *rouge*... (Subject 25)
	Original	... the old *cyclotron*...
	Translation	... les vieux *psychotrons*... (Subject 6)
(2)	Original	... this is called *annihilation*...
	Translation	... ça s'appelle de l'*annihilisation*... (Subject 25)
	Translation	... ceci est appelé *yanilation*... (Subject 16)

In examples (3) to (5), there is evidence of complex morpho-syntactic processing. In (3), there are various manipulations of aspect and tense. In example (4), the subject inserts an obligatory relative pronoun (*qui*), changes tense and reflexivizes the verb. Example (5) shows meaning-preserving paraphrase, suggesting some semantic processing, as well.

(3)	Original	... I *visited* Alex...
	Translation	... je *suis allé rendre visite* à Alex... (Subject 25)
	Translation	... je *viens de lui rendre visite*... (Subject 29)
(4)	Original	... a friend named Alex...
	Translation	... un ami qui s'appelle Alex... (Subject 16)
(5)	Original	... I have a friend named Alex...
	Recall	... my friend Alex... (Subject 13)

Examples (6) to (10) below provide evidence of semantic processing and the influence of prior knowledge on comprehension. In (6), the interpreter substitutes the whole (*il*) for a part (*his head*), and adds further information to specify how the patient went into the machine (he was *slid* in, rather than merely *placed*). (7) provides evidence for even more complex semantic manipulations: there was no explicit mention in the original of metabolic states, but the interpreter drew on his own prior knowledge to draw his conclusion. (8) shows that interpreters can integrate previously presented text information (*mon ami*) into the translation of subsequent portions of the source text. Finally, (9) and (10) provide examples of less successful use of prior knowledge.

(6)	Original Translation	... his *head* is *placed* inside a donut-shaped machine... ... *il* est ensuite *glissé* dans l'interieur d'une machine... (Subject 10)
(7)	Original Recall	... the different colors represent different amounts of gamma rays... ... chaque couleur correspond à des rayons gamma et *reflète des états métaboliques*... (Subject 9)
(8)	Original Translation	... I visited Alex... ... j'ai visité *mon ami* Alex... (Subject 20)
(9)	Original Translation	... this is called *annihilation*... ... il y a *une corrélation*... (Subject 27)
(10)	Original Translation	... the patient has a *brain* tumor... ... le patient peut avoir une tumeur *cervicale*... (Subject 30)

Based on systematic analyses of this type, it has been possible to identify the cognitive processes that constitute normal comprehension, and in this study simultaneous interpreting is characterized using these same methods.

This investigation also used other methods that are different from those used in previous research. They involved extending existing methods used to study text processing to fit the requirements of studying interpreting, in particular extending methods for coding response protocols and combining methods of text analysis for controlling experimental materials.

Lastly, because there has been almost no experimental research on the nature of expertise in interpreting, another difference is that the comparison of expert interpreters and novice bilinguals included here provides an empirical basis for identifying processes that characterize interpreting expertise. By manipulating the linguistic properties of the input texts, and by analyzing their effects on accuracy of interpreting and recall, effects of text characteristics on interpreting performance can be precisely assessed and compared to their effects on normal listening comprehension. In this way, what is unique about expertise in simultaneous interpreting and what it has in common with listening comprehension were investigated.

To summarize, the present research arose from an interest in the cognitive processes and representations that constitute text comprehension, and it was specifically concerned with the ways in which current cognitive models of discourse processing can shed light on the nature of simultaneous interpreting. The main goal of the present study was to advance understanding of the task of simultaneous interpreting, within the context of current theories of text processing, by using it as a task environment for the study of comprehension. With this in mind, two broad questions about the nature of simultaneous interpreting were investigated. On the one hand, the nature of expertise in interpreting was studied to identify the processes specific to the interpreting task itself. On the other, interpreting was contrasted with listening to characterize the processes which they have in common. Consequently, two main areas of research were important here: the research on simultaneous interpreting itself, and that on normal text comprehension. The next chapter provides a necessarily selective review of the relevant results from these areas.

Chapter Two

Review of Previous Research

Research on Interpreting

The literature on simultaneous interpreting can be seen as coming from three sources:

(a) the work, which is unfortunately not available in translation, of several investigators, particularly in the Soviet Union (see Chernov, 1969, 1973, 1975, 1977, 1978; Gofman, 1963; Hromasová, 1972; Krušina, 1971; Pinter, 1968; Romer, 1968; Roothaer, 1976; Sheryaev, 1979; Tsvilling, 1966 — see, however, Chernov, 1979, 1985),

(b) the work of interpreters and teachers of interpreting, which deals with pedagogical and methodological questions as well as intuitive views of the interpreting process (see Hebert, 1968; Henderson, 1982; Kade & Cartellieri, 1971; Lederer, 1981; Paneth, 1957; Schweda-Nicholson, 1987; Seleskovitch & Lederer, 1984; Seleskovitch, 1968, 1976; van Hoof, 1962) which are sometimes theoretically motivated (see Kopczyński, 1980; Le Ny, 1978; Moser, 1976, 1978; de Souza, 1982), and

(c) the work of a few experimenters in Europe and North America, i.e., basically the work of Barik, Gerver and Lambert (Anderson, 1979; Barik, 1969, 1970, 1971, 1972, 1973, 1974, 1975, 1976; Gerver, 1971a, 1971b, 1974a, 1974b, 1975, 1976; Gran & Fabbro, 1987; Kraushaar & Lambert, 1987; Lambert, 1983, 1989; Lawson, 1967). Anderson, Barik, and Lawson's work, however, were theses that did not lead to further research. Since the untimely death of David Gerver in 1981, and apart from sporadic uses of the simultaneous translation task (e.g., McDonald & Carpenter, 1981), the only current experimental research on simultaneous interpreting appears to be that carried out at the Universities of Ottawa (Lambert) and Trieste (Gran and Fabbro).

Experimental Research on Interpreting

Gerver (1976) provides an excellent review of the work done until then, and the general outline of his review is followed here, since few experiments have appeared since its publication. The first issues Gerver raises are those of input and its segmentation.

Input rate. The effects of input rate have been studied in most detail by Gerver (1971a): when professional interpreters were asked to interpret texts presented at 95, 112, 120, 145 and 164 words per minute (wpm), the proportion of the text that was correctly interpreted decreased with each increase in rate (see Figure 4.1, p. 49), and ear-voice span (EVS) increased (see discussion of EVS below). As well, interpreters maintained a steady output rate, paused more, and spoke less as rate increased. Accuracy of translation was optimal when the rate of presentation was between 95 and 120 words per minute. In comparing these results to the significantly better performance of subjects shadowing the same texts (i.e., concurrently listening to the text and repeating it in the same language), Gerver interprets the differences as accountable by Foulke and Sticht's (1969) finding that increased presentation rate poses problems for higher-level processing rather than for perception. Treisman (1965a), using rates of 100 and 150 wpm and statistical approximations of English and French texts, found a similarly significant effect of information rate on efficiency of interpreting.

Noise (Gerver, 1974a) had predictably similar negative effects on interpreting: the proportion correctly interpreted was significantly lower and the incidence of errors was significantly higher under noisy conditions. The translations produced in this experiment were also judged for intelligibility and informativeness with respect to the original and found to be significantly worse by these measures as well. EVS also increased as signal-to-noise ratio decreased (i.e., as noise increased).

Segmentation of input. Another important question about the nature of the input is how the interpreter segments it. Barik (1969) suggested, drawing on Goldman-Eisler's (1968) work, that the interpreter might use pauses in the input text to divide it into meaningful segments. Goldman-Eisler (1972) found that 48% of the time interpreters started speaking before the input chunk (utterance between pauses) had finished, 41% of the time they waited for two or more chunks, and only 11% of the time did they wait for a pause after a chunk to begin encoding. Gerver (1971b), based on Suci's (1967) finding that pauses in spontaneous speech tend to delimit well-formed syntactic units, had subjects interpret texts with normal stress and pausing vs. texts with minimal stress, intonation and no pauses of more than 250 msec. In the texts that Gerver's interpreters produced, 55% (pause condition) vs. 32% (no pause condition) of the pauses occurred at major constituent boundaries, 30% vs. 42% occurred between minor constituents and 15% vs. 26% occurred within minor constituents. As well, significantly more words were correctly interpreted in the pause condition, so he concluded that pauses do assist the interpreter to segment the input text. Also with respect to segmenting, Golman-Eisler (1972: 131) found that in 90% to 95% of the cases in her study, the interpreter's segment consisted of "at least a complete predicative expression".

Some authors have suggested that interpreters try to optimize their use of input text pauses so as to reduce the strain of listening and speaking simultaneously (Barik, 1969, 1973; Goldman-Eisler, 1968; van Hoof, 1962). In favor of this view, Barik (1973) offers data from a study in which he calculated the proportion of input text pause time that interpreters would be expected to use for speaking if their speaking was independent of input text pauses. Barik's obtained values were greater than those expected (no inferential statistics were reported), and he concluded that interpreters indeed make use of input text pauses as much as they can. As well, he cites the coincidence of values for mean chunk length and mean EVS in favor of this hypothesis. However, Goldman-Eisler (1968) found that the majority of pauses were of one second or less, and Gerver (1975) found that 83% of speakers' pauses in a conference setting were of less than one second in length. Gerver argued that since he found interpreters to have an articulation rate of between 96 and 110 wpm, there was not in fact very much that the interpreter could put into such pauses: only about four or five syllables. In another study, Gerver (cited in Gerver, 1976: 183) measured the amount of time interpreters actually spent speaking during the presentation of the source-language text, and found that speaking and presentation were simultaneous between 64% and 75% of the time. Goldman-Eisler and Cohen (1974) and other authors also found similarly high values for this measure of simultaneity of listening and speaking.

Several authors (e.g., Gerver, 1971a,b, 1976) have defended the view that the original segment of input text is held in memory and compared with the corresponding segment of the output text as it is produced. The evidence they offer comes from three sources: introspective statements by interpreters, the fact that interpreters may correct themselves after having produced a mistranslation, and Treisman's (1964b) finding that it took subjects between 1.3 s and 4.3 s to recognize that messages on different channels were identical. On the other hand, Welford (1968) held that interpreters learn to ignore the sound of their own voice, which is amply supported by findings using shadowing (see Levelt, 1983), and therefore do not monitor their speech output. The interference generated by attempting to monitor one's own voice when the message is the same is sufficient to cause a significant disruption in the shadowing or interpreting task (Lawson, 1967; Treisman, 1959, 1964a,b, 1965a,b; Salter, 1973). However, none of these authors have provided evidence sufficient to distinguish between these claims and many others, such as that corrections are made not based on a stored *copy* of the input text segment, but on some semantic representation of its content.

There are two further areas of investigation into simultaneous interpreting that have used data more similar to those used in studies of discourse processing: recall measures and the ear-voice span (EVS). Very little has been studied about the effects of interpreting on recall, but what has been done has usually compared it to shadowing. This is of importance for the present study because shadowing can be used to tease out the translation-related effects, and possibly the effects of high-level semantic processes in recall as well.

Recall. Shadowing is the continuous, nearly simultaneous repetition of an aurally presented text (i.e., it is the same as interpreting except that the text is repeated back rather than translated), and was originally developed in the 50s (Broadbent, 1952; Cherry, 1953; Cherry & Taylor, 1954) as a technique for attention research. Until recently, almost all of the studies using it have been concerned with attention. The interest in the shadowing task lies in the fact that for most of the time, the subject is listening and speaking simultaneously, and the question arises of how subjects allocate their cognitive resources or attention in order to do so, even in the presence of a third (unattended) stimulus whose characteristics can vary from clicks to foreign language prose (see Swets & Kristofferson, 1970 and Norman, 1976 for reviews). The experimental technique usually involved measuring the number of shadowing errors as a function of the characteristics of the stimuli presented to the unattended ear (e.g., Treisman, 1964b). The number of errors was found to be inversely correlated with the order of approximation of the shadowed text to English, both in shadowing (Moray & Taylor, 1959), and in interpreting (Lawson, 1967). Reversing ear of presentation (Treisman, 1959), and presenting two or more messages in the unattended ear (Treisman, 1964a) resulted in little further decrement of performance. Sex of speaker, similarity of content between attended and unattended texts, additional messages presented to the attended ear, and a text in a second language known to the subject have been found to interfere greatly with shadowing performance even when presented to the unattended ear (Salter, 1973; Treisman, 1964b, 1965a,b). More recent studies using shadowing (Marslen-Wilson & Tyler, 1980, 1981; Marslen-Wilson, Tyler & Seidenberg, 1978; Marslen-Wilson & Welsh, 1978) have measured repetition latency to explore the interaction of semantic and syntactic cues in word recognition and sentence processing. Finally, Gerver (1974a) and Lambert (1983) have shown that shadowing has significantly detrimental effects on recall, which we shall consider in some more detail below (see also Leahey & Holtzman, 1979).

Carey (1971) compared recognition of words, syntactic structures and content after shadowing and listening to texts presented at three rates (60, 120, 180 wpm) to test the hypothesis that shadowing will have a facilitating effect on retention to the extent that it is accurate. He found, however, no significant differences between listening and shadowing, and suggested that larger differences might have been found with more sensitive tests of retention. As well, he did not control text characteristics explicitly; his passages were of "literary prose" of "similar content and length".

Gerver (1974a) performed a study of content-question answering after listening, shadowing and interpreting texts. He found significantly more errors after interpreting than after shadowing, and significantly impaired recall after both, with recall after shadowing significantly worse than after interpreting. He concluded (see also Seleskovitch, 1976) that "simultaneous speaking impairs recall, and that simultaneous interpretation involves a compulsory analysis of source language deep structure and its transformation into the surface structure of the target language" (p. 340), which accounts for superior recall in the interpreting condition. (Gerver uses *deep structure* in the sense of semantic structure.) On the other hand, he believes that although some semantic analysis may be carried out in shadowing (as Carey, 1971 found), it is "an incidental rather than an integral part of the process" (Gerver, 1974a: 341). This leads to one of the questions addressed in the present study: which kinds of semantic processing occur during interpreting?

Finally, Lambert (1983) compared subjects' performance on recall and recognition tasks after shadowing, interpreting simultaneously, interpreting consecutively*, and listening to passages of French prose of equal length. Using a more refined measure of recall (based on the propositional analysis of Kintsch, 1974) than Gerver's (1974a) previous study, she found

* In consecutive mode, the interpreter reproduces, from notes and from memory, the speaker's text in the target language only *after* the speaker has completed delivery.

significant task differences, and post-hoc tests of multiple comparisons revealed significant differences in which recall after listening was greater than after shadowing and recall after consecutive interpreting was greater than after shadowing. Long and Harding-Esch (1978) found a parallel deficit of second language recall vis-à-vis first language. Lambert's recognition data thus replicated Gerver's (1974a) results: recognition after listening was significantly more accurate than after interpreting, which in turn was significantly more accurate than after shadowing. Performance after consecutive interpreting was not significantly different from that after listening, nor after simultaneous interpreting. These results showed interference of simultaneous listening and speaking on both recall and recognition measures, and Lambert hypothesized that, in terms of the Craik and Lockhart (1972) model, listening and consecutive interpretation involve deeper (semantic) processing than simultaneous translation which in turn is deeper than shadowing.

To summarize, recall studies reveal interference of concurrent speaking and listening on comprehension which seems to be partially counterbalanced by the deeper processing of interpreting.

Ear-voice span. The final set of studies considered here has provided data about the ear-voice span (EVS), which, like gaze duration (Just & Carpenter, 1980) and eye-voice span (Levin & Addis, 1979), can be interpreted as an index of amount of processing. Some of these studies have also compared interpreting with shadowing.

Oléron and Nanpon (1965), in the first and in many ways most interesting study of simultaneous interpreting, emphasized the importance of studying EVS, the factors that determine it, and its evolution in interpreting extended discourse. Their data indicate mean EVSs of between 2 s and 3 s for interpreting paragraphs between English and French, whereas EVS for shadowing (Carey, 1971) or translating isolated words were both between 1.0 s and 1.2 s. Treisman (1965a) found similar values for prose passages, but found no effect of order of approximation to English or French on EVS (using first, second, and eighth order approximations as well as syntactic prose). Barik (1969) also obtained similar mean EVS values (2.53 s for French texts, 2.62 s for English texts), and in addition found no significant differences for direction of interpreting (weaker to dominant language or vice versa), or for experience (professionals vs. students vs. amateurs). Moreover, he found a positive correlation ($r > .65$) between input rate and EVS for trained interpreters, but a much weaker one for amateurs. A similar correlation ($r > .65$) held between EVS and amount of material omitted. It would be interesting to compare more detailed EVS data to studies of gaze duration in sight interpreting from written source texts (e.g., McDonald & Carpenter, 1981).

Accuracy. Since accuracy of translation is the principal measure used here, it will be convenient to summarize the factors that have been found or asserted to affect it:

(a) anxiety (Gerver, 1976): higher anxiety is an advantage under good listening conditions but a liability under high-stress listening conditions;

(b) contextual clues (Anderson, 1979; Chernov, 1979; Lederer, 1981; Oléron & Nanpon, 1965) are important particularly in disambiguating conversation;

(c) décalage (Barik, 1969): lag time cannot be either too short (because of ambiguities) or too long (because of the limits of working memory);

(d) direction of translation (into or out of the dominant language — Barik, 1969; Gerver, 1976; Lawson, 1967; Pinhas, 1968; Treisman, 1965a): interpreting *from* the dominant language has been found to be more accurate (Lawson, 1967), especially for novices (Barik, 1969), in spite of the opposite opinion widely held by United Nations interpreters and European teachers of interpreting (see Gerver, 1976);

(e) interference from a competing message (Lawson, 1967) or noise (Gerver, 1974a);

(f) use of pauses (Barik, 1969; Goldman-Eisler, 1968; Kade & Cartellieri, 1971);

(g) prior knowledge of domain and social setting (Anderson, 1979; Chernov, 1979; Giles, 1988; Lederer, 1981) facilitates translation;

(h) rate (Gerver, 1971a,b): exponential decay in accuracy after 112 wpm;

(i) redundancy of information (Chernov, 1979, 1985; Kade & Cartellieri, 1971; Moser, 1978; Nida & Taber, 1969; Treisman, 1965): expectations facilitate translation;

(j) similarity of languages (Krušina, 1971): similarity of syntax facilitates interpreting (see Gile, 1988 for the opposite view), and

(k) size of the unit interpreted (Oléron & Nanpon, 1965): phrases were more accurately translated than paragraphs.

Expert-novice differences. There is very little about expert-novice differences in interpreting available in the literature. In most studies, it is assumed and/or asserted (without evidence) that the skills of interpreters are not characteristic of bilinguals in general (e.g., Gerver, 1976: 167), and that the models developed of skilled interpreting do not apply to novice bilingual interpreters (e.g., Moser, 1978: 361). Harris (Harris & Sherwood, 1978), however, argues that translation ability is a natural consequence of bilingualism. If this argument can be extended to interpreting as well, then it will suggest the existence of few or small expert-novice differences, as does the once-current view among interpreters that "no special training was required [for interpreting] and that it all depended on an innate special skill" (Longley, 1978: 47).

More specifically, Nida (1969, cited in Gerver, 1976: 198) predicts that "experienced simultaneous translators may often short circuit the deeper [semantic] level of analysis", although there is no evidence either for or against the hypothesis. Experts have, however, been found to add more information and delete less (Barik, 1969), process larger chunks, and give less literal translations (McDonald & Carpenter, 1981).

Non-experimental Literature on Interpreting

Based only tangentially on this limited experimental literature, and mostly on professional experience, introspection or observation, interpreters themselves have produced a voluminous literature on interpreting and its teaching, as indicated by Henry & Henry's (1987) 140-page *International Bibliography of Interpretation.* Gile (1988: 364), in a recent appraisal of this research, observed that "most of these [studies on interpreting] formulated general theories and models and did not test particular hypotheses by experimental methods. [...] The majority of authors reiterated and developed ideas formulated previously, but did not engage in any proper research". Although this expert-generated literature often offers interesting insights (e.g., Lederer, 1981; Seleskovitch & Lederer, 1984), it is not clear how to treat the information experts provide in the absence of a body of experimentally-based theory, and thus it extrapolates the limits of the present review.

The results reviewed here are of general interest in that they provide a parametric description of interpreting performance. However, since qualitative analyses were not done of the effects of the treatments (for example, analysis of the variance of EVS as reflecting text-structure variables), no information is available about which treatment affected which component processes in which ways. Few of the experiments have been replicated and only intuitive judgements were used in controlling the texts for density of information, coherence, syntactic complexity, etc. Given the importance of these and other text-structure variables in comprehension, many of the results reviewed here may be confounded with uncontrolled-for text characteristics.

Current theory and research on text comprehension suggest that understanding of skill in interpreting will be best furthered by information of two specific kinds:

On the one hand, existing information about the parameters of interpreting performance needs to be complemented with an understanding cf the nature of the cognitive processes, as well as of the representations on which they operate, that are specific to expertise in interpreting.

On the other, this information would still be incomplete without an account of the cognitive processes and representations that interpreting shares with normal text comprehension, as well. The review of comprehension research that follows is limited to the the parts of the literature that bear most directly on the present study.

Research on Text Comprehension

Text comprehension is conceptualized in contemporary Cognitive Science as composed of a set of quasi-independent component processes which are said to construct and transform in different ways multiple mental representations of the input text, based both on text properties and on different types of prior knowledge. The processes are interdependent only with respect their input-output relations, and the prior knowledge involved can be either linguistic or encyclopedic. The central problem is seen as one of specifying how and when different text properties and aspects of prior knowledge interact during processing. Text comprehension is commonly subdivided into the component processes (sets of operations defined over classes of representations) belonging to the *language processor* and those of the *general cognitive* (or conceptual-processing) *system* (e.g., Fodor, J. A., 1983; Seidenberg & Tanenhaus, 1986).

The subprocesses of the language processor [i.e., up to and including semantic interpretation (Forster, 1979: 36)] are considered to form one or more modules that operate in parallel (on different segments of the input). They will always compute the same output irrespective of the states or operations of other modules or the general cognitive system (Tanenhaus, Carlson & Seidenberg, 1986: 365), although interaction is permitted at certain points in processing; this is the essence of the *modularity hypothesis* (Altman & Steedman, 1988; Fodor, J. A., 1983; Garfield, 1987). The module(s) of the linguistic processor are to be thought of as highly limited and totally dedicated microprocessors (Forster, 1979: 33). They include: lexical processing, syntactic processing, and proposition generation or semantic interpretation (Danks & Glucksberg, 1980; Forster, 1979: Figure 2.1; Foss, 1988).

The subprocesses of the general cognitive system, which act on the semantic output of the language processor, are assumed to function inferentially to enhance the coherence of the output of the language processor in several ways: (a) by filling in missing elements (deep anaphora (Hankamer & Sag, 1976), bridging inferences (Clark, 1977a,b), etc.), (b) by organizing it in terms of macrostructures, schemas, frames, etc. (Schank & Abelson, 1978; Frederiksen, 1986), and (c) by integrating it with existing prior knowledge (Hayes-Roth, 19/7; Kubeš, 1989). For some researchers, the general cognitive system has access to the outputs of all of the component processes of the linguistic processor (e.g., Forster, 1979; Tanenhaus, Carlson & Seidenberg, 1986). Finally, these models include the assumption that "input will always be represented at the maximal level of representation to which its analysis can be taken [by the processor]" (Marslen-Wilson & Tyler, 1980: 66).

It should be noted that this is a composite model of text comprehension, since the psycholinguists who study the language processor generally pay little attention to the role of the general cognitive system in comprehension (indeed, for some it has no special role to play in the analysis of linguistic stimuli — Forster, 1979: 33), and the cognitive psychologists interested in the higher-level semantic processing of the general cognitive system generally focus on the phenomena beginning with the propositions generated by the linguistic processor (e.g., Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983). The current trend toward encompassing all of this research under the umbrella of Cognitive Science underscores the artificiality of this distinction, and has led to the development of models which attempt to include all of these processes (Kintsch, 1988; Frederiksen, Bracewell, Breuleux & Renaud, 1989; Figure 2.1 below).

The class of modular comprehension models that constitute the theoretical underpinnings of the present research are sometimes opposed to interactive (parallel, non-modular) or strategic comprehension models such as those of Marslen-Wilson & Tyler (1980) and van Dijk & Kintsch (1983). These classes of models differ most importantly in that the interaction between component processes is severely restricted in modular models: in the linguistic processor, a given process has access only to the output of the previous process, and perhaps to the information in the lexicon. In interactive models, on the other hand, component processes have access to an indeterminate number of sources of information.

With regard to the general cognitive processor, a similar difference is found: whereas Frederiksen et al. (1989), for example, look for more algorithmic, structured interactions between information sources, van Dijk & Kintsch (1983) consider all processing to be unstructured and heuristic. The modular processing hypothesis thus constitutes a much stronger, more directive theoretical stance.

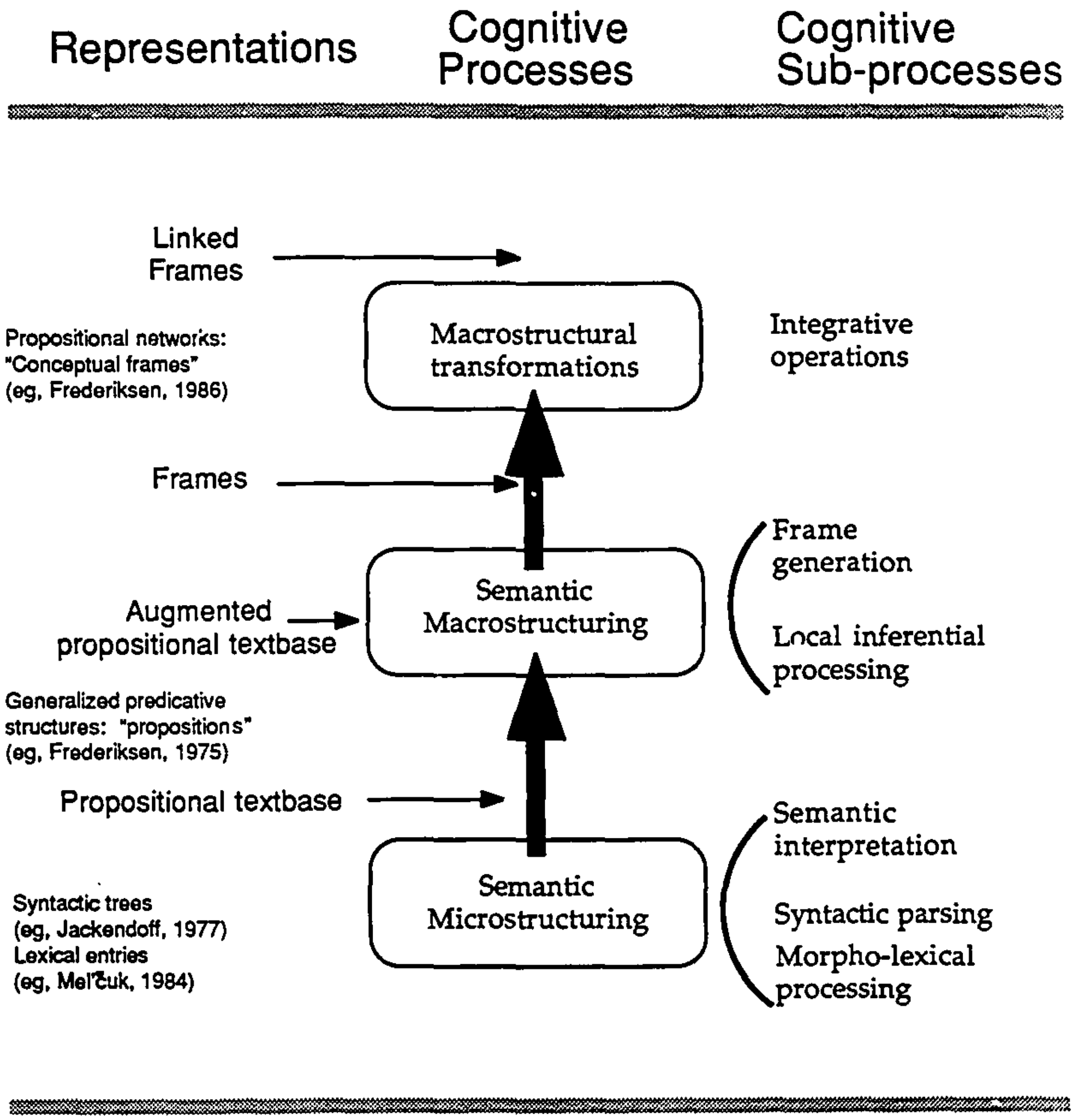


Figure 2.1. Component processes of text comprehension (adapted from Frederiksen, et al., 1989).

Relatively recent enhancements to such modular models include: (a) the resolution of semantic processing into several well-defined levels: semantic interpretation or proposition generation, inferencing to enhance local coherence of the textbase, frame construction, and knowledge integration (Frederiksen et al., 1989), (b) more refined techniques for description at each level (Frederiksen, 1975, 1986), (c) computational implementations of such models (Décary et al., 1987; Frederiksen, Décary & Hoover, 1988), and (d) models of plans and strategies for the control of processing (cf. Breuleux, 1987). A summary of the assumptions that characterize one such modular model of comprehension (that of Frederiksen et al., 1989) follows (see also Figure 2.1).

The Linguistic Processor

Lexical access. "The lexicon is important because it is the place in the language processing system where disparate information types (or codes) come together" (Foss, 1988: 303), and for this reason it has received a great deal of attention from psycholinguists. Three aspects of lexical processing are usually recognized (Seidenberg, Waters, Sanders & Langer, 1984; see also Frauenfelder & Tyler, 1987; Marslen-Wilson, 1987):

•Pre-lexical processes, in particular automatic propagation of activation through the lexicon (Collins & Loftus, 1975; Yantis & Meyer, 1988), can account for the associative and semantic priming context effects on word recognition widely cited in the literature, while maintaining the modularity and context-independence of lexical access itself (Seidenberg, 1984; Seidenberg et al., 1984). In keeping with this, there is evidence that access to semantic information can occur even when a word has not been consciously recognized (see e.g., Greenwald, Klinger & Liu, 1989; review and discussion in Holender, 1986).

•Lexical access is the activation of information associated with a given lexical item. It is currently viewed as proceeding in a strictly bottom-up, context-independent fashion (cf. Forster, 1979; Seidenberg et al., 1984), producing, if necessary, more than one possible lexical item as being recognized (Marslen-Wilson, 1987; Kintsch, 1988). In general, "the syntactic and semantic complexity of a word does not affect the time to access it in the mental lexicon" (Foss, 1988: 308). On the other hand, an important determinant of lexical access is the experiential variable of frequency of occurrence: the more frequently occurring the lexical item, the more facilitated is its access (Bradley & Forster, 1987; see also Gernsbacher, 1984). Spreading activation and facilitation with frequency of use in semantic nets have clear parallels with activation and plasticity in neural nets (cf. Ramón y Cajal, 1895; Hebb, 1949), and have led to connectionist models which emphasize these parallels (e.g., Small, 1983; McClelland & Elman, 1986).

The representations produced by lexical processes are lexical *entries* containing phonetic/phonological, syntactic, semantic and other information (see Mel'čuk, 1984 for a discussion of what information appears to be necessary in lexical entries, from a linguistic point of view).

•Post-lexical processes, also independent of access itself, involve "selection, elaboration and integration of lexical information for the purpose of comprehending a text..." (Seidenberg et al., 1984: 315), that is, the syntactic and semantic processes described below. By establishing semantic and inferential links with new concepts, presumably these newly linked or inferred concepts can by lexicon-internal propagation be found to prime or facilitate recognition of subsequent words, thus accounting for another class of context effects. This characteristic of lexical processing is most likely also closely related to the memory phenomenon referred to as the generation effect, in which words generated as responses to a target by some rule are recalled better than the targets themselves (Slamecka & Graff, 1978; Gardiner, Gregg & Hampton, 1988; Nairne & Widner, 1988). Further research is necessary to clarify the possible role of the generation effect in discourse comprehension.

Syntactic parsing. Syntactic processes presumably buffer the lexical items recognized until such a time as a whole sentence, clause (Fodor, J. D., 1988; Ferreira & Clifton, 1986) or phrase (NP, VP, etc; Tyler & Warren, 1987) can be constructed, independently from any semantic information (e.g., Ferreira & Clifton, 1986: 365). [See Altman & Steedman (1988) for a discussion of modularity and the fineness of grain of the units proposed by syntax for semantic evaluation.] In the case of syntactic indeterminacies such as PP or reduced-relative attachment, either incomplete or multiple syntactic trees are produced for subsequent assessment based on semantic information. The representations produced are syntactic parse trees, most often represented using standard phrase structure grammar (see Jackendoff, 1977; Radford, 1981; Sells, 1985).

Frederiksen et al. (1989) also include in syntactic processing a process of generating representations of interclausal syntactic dependency relations such as cohesive ties (Halliday & Hasan, 1976) and patterns of topicalization (Grimes, 1975; Clements, 1979). The representations produced are linked syntactic parse trees (see also Plante, 1985).

Proposition generation. Proposition generation, or semantic interpretation, operates on the syntactic trees (or sub-trees) provided at this point. Ritchie (1983) identifies three computational approaches to proposition construction: homogenous or non-syntactic, clause- or sentence-final, and interleaved syntactic and semantic processing.

(a) So-called non-syntactic proposition construction systems [e.g., Riesbeck's (1974, 1975; Riesbeck & Schank, 1978) ELI parser; Wilks' (1975a,b) preference semantics; the semantic grammar in Hendrix, Sacerdoti, Sagalowitcz and Slocum's (1978) LIFER system] claimed to bypass entirely the need for traditional syntactic analysis, using expectations generated from the proposition-components already identified to constrain the analysis of the whole, and to facilitate the analysis of subsequent words. This approach seems to find no counterpart in the psychological literature.

(b) The serial, sentence-final approach leaves proposition construction to the end of syntactic constituents (clauses or sentences). Woods, Kaplan and Nash-Webber's (1972) LUNAR system is the computational counterpart to the clause-processing hypothesis in psycholinguistics (e.g., Hurtig, 1978; Fodor, J. A., Bever & Garrett, 1974). Proposition generation, given this assumption, can proceed, in general, by either frame instantiation or by semantic parsing (Frederiksen et al., 1989). In frame instantiation, propositions are constructed by finding some canonical frame that can be matched to an input sentence. This approach places great emphasis on the information in the lexicon, usually about verb-based sentence frames, so that proposition construction becomes a process of mapping syntactic to semantic variables. In the second approach, proposition construction involves a 'top-down' semantic analysis of clausal segments through the application of a propositional grammar (Frederiksen, 1989a; see grammar in Frederiksen, 1986, Appendix A). The interpretation rules, then, are productions with lexico-syntactic tests that generate nodes in a semantic parse tree (Frederiksen, Décary & Hoover, 1983). Note that such interpretation rules explicitly capture generalizations about interpretation that are multiply represented and distributed throughout the lexicon in lexically-based systems such as current connectionist models and their precursors.

(c) Interleaved syntactic and semantic analysis only differs from the clause- or sentence-final serial approach in fineness of grain (see Altman & Steedman (1988) for discussion, and Tyler & Warren (1987) for an experimental investigation): the syntactic units passed on to semantic processing are smaller, usually phrases (e.g., Winograd's (1972)

SHRDLU and Frederiksen et al.'s (1988) CODA). Recent psycholinguistic research seems to favor this approach of assuming parallel construction of syntactic and propositional representations in phrase-sized increments (Frazier, 1987; Fodor, J. D. & Frazier, 1980; Ferreira & Clifton, 1986; Frazier, Clifton & Randall, 1983). Particularly important computational work on semantic interpretation is Hirst (1987), and a very useful and comprehensive introduction is found in Allen (1987, chaps. 7 to 10).

The semantic representations produced are *propositions*, predicate-argument structures (or a class of semantic networks) which serve both as representations of conceptual information in text and as units of information for logical reasoning and problem solving (Frederiksen, 1975, 1986; van Dijk & Kintsch, 1983; Sowa, 1984). Although the use of propositional representations has been widespread since the early 70s (Frederiksen, 1975; Kintsch, 1974; Schank, 1973), Frederiksen (1986: 232-233) has recently observed that a semantic network does not in itself constitute a theory of representation, and that to make semantic networks systematic representations requires: "(a) defining all relations in the network (...), (b) specifying the entities (...) assigned to nodes in the network, and (c) specifying rules (procedures) by which all structures in the network can be defined". In Palmer's (1978) terms, the representing system, the represented system and the mappings between them all have to be systematically and explicitly defined. This leads one to doubt the efficacy of using incompletely defined representational systems such as that proposed by Kintsch (1974; Turner, 1987), and buttresses the choice in the present research of the more rigorously defined system proposed by Frederiksen (1975, 1986).

The General Cognitive Processor

Inference generation. Local inference generation operates on the proposition set thus generated, enhancing its internal coherence (Frederiksen, Frederiksen, Humphrey & Ottesen, 1978; Trabasso & Nicholas, 1978; Frederiksen, 1981). Some of these operations are text-based: cohesive links in the text, for example, suggest how to fill in missing elements (Hankamer & Sag, 1976), recover anaphoric antecedents, or how to make some links between concepts or propositions more explicit (Clark, 1977a,b). Other inferential operations are based on prior knowledge, and involve the addition of new information to an incomplete text, the most important of which are frame-generating inferences (Mandler & Johnson, 1977; Frederiksen, 1986). The representations produced are new proposition components, propositions or relations between propositions.

Frame generation. The set of propositions or textbase, once augmented or enhanced in this way, is further reorganized and structured by the generation of new links (new groups or new propositions, as well) between propositions and/or groups of propositions to form larger conceptual structures: episodes, procedures, plans, etc. which are the components of different frames or schemas (Schank & Abelson, 1978; van Dijk & Kintsch, 1983; Sowa, 1984; Frederiksen, 1986, 1989b).

Frame construction may proceed by text-based linking, knowledge-based instantiation or by rule-based generation (Frederiksen, 1985). In text-based frame construction, propositions are linked into a frame structure based on the interpropositional relations made explicit in the text. This approach, however, does not account for the role of prior knowledge or of specialized knowledge of different text types (genre knowledge). In instantiation, a frame or schema is retrieved from memory and the in-coming propositions are matched to existing slots in the frame (Rumelhart, 1980). This is a plausible model under the assumption that the comprehender has the appropriate prior knowledge to draw upon, but is difficult to apply to tasks in which subjects have to acquire new information from text. In generation, no prior content knowledge is assumed, only genre knowledge, that is, of what narratives, procedures, descriptions, etc. are. This genre knowledge consists of sets of rules for identifying and combining frame components independently of the domain of text content (Frederiksen, 1977, 1986, 1989b).

Frederiksen (1989a) reports a series of results consistent with the rule-based approach to frame generation which suggest that individuals have specialized competences for the comprehension of different text types. In particular, proficiency in comprehending different frame types shows different patterns of development and is independent of content knowledge. With age, subjects were found to become increasingly able to generate multiple frames for the same text.

The representations produced by frame-generation processes are what Sowa (1984) calls *conceptual graphs*, that is, semantic networks with propositions as nodes and dependency relations as links or relations with other, relevant, knowledge. A frame, in the abstract sense used here, is a class of such semantic networks defined by the type(s) of proposition which are the nodes and the type(s) of relations which can link them (see

Frederiksen, 1986). Frederiksen (1986) has made this representation particularly explicit by providing frame grammars couched in Backus-Naur Form (BNF) notation.

The two frame types of interest here are the narrative and the procedure. Although both are structures of events, they differ in that narratives usually appear in the form of chains of episodes, whereas procedures are represented hierarchically as trees of subprocedures.

A narrative is a conceptual structure in which events are structured primarily in terms of their temporal relations, that is, it is essentially a set of events linked by relations of order and equivalence in time (Frederiksen, 1986), although causal and spatial relations are also often included (Trabasso, Secco, & van den Broek, 1984; Trabasso & Sperry, 1985; Trabasso & van den Broek, 1985).

A procedure is a conceptual structure in which (resultive or goal-directed) events are structured principally in terms of the part-whole relations between them, that is, hierarchically (Frederiksen, 1986), although more complete models of procedures also include structures of goals and conditions (Frederiksen, 1989b).

These frame models were found to provide strong predictors of selective recall and inference for text-based information (Frederiksen, 1989a,b), as well as of on-line interpretation and sentence reading times (Frederiksen & Renaud, 1987; Renaud, 1989).

Most important to present concerns are a series of studies by Frederiksen and Renaud (Frederiksen & Renaud, 1987; Renaud & Frederiksen, 1988; Renaud, 1989) in which they demonstrate the effects of frame structure variables on reading times, on-line interpretation and recall. They had subjects read a procedural text on an unfamiliar topic, and either allowed subjects to stop where they wished to give an interpretation of the text or prompted them to do so after every third sentence. They analyzed three measures (subjects' reading times per segment, the accuracy of the interpretations they provided while reading the text, and the accuracy of the free recall protocols they gave after having finished reading the text) as affected by a variety of text structure variables. The text structure variables indexed syntactic processing, proposition generation, and frame processing. They found strong effects on reading time of all of the variables that indexed semantic processing, and strong effects of all types of processing on recall. In particular, distinctions between frame and non-frame information, between types of information within the frame, between frame components, between levels in the procedure, and between positions within subprocedures all yielded significant effects on reading time. There was also a strong effect of propositional density, but no effect, however, of clause density or clause complexity (number of clause embeddings) on reading times. Finally, they found a facilitation effect of frame processing on reading: reading times decreased when frame-linked inferential processes increased.

These results show very clearly that on-line text processing is heavily weighted toward semantic processing in reading. Subjects appear in fact to be able to perform the necessary frame-construction operations on line while they are reading. This suggests that interpreters, too, will be able to construct frames as they understand, and that an absence of frame-related effects will be a specific consequence of curtailment of processing.

Frederiksen and Renaud's results also make particularly clear that information about processing as it occurs on line is of special importance for the development of theories of discourse processing. Such concurrent measures as gaze durations, reading times and simultaneous interpreting protocols can provide the information about the timecourse and qualitative nature of inferential processes that recall and sentence-processing studies have not been able to.

Knowledge integration. The propositional information enhanced with local inferences and restructured with frame-generating inferences can then be integrated with prior knowledge (Kubeš, 1989), through the generation of further inferential links, leading to the production of systems of linked frames (see Hayes-Roth, 1977; Walker & Meyer, 1980).

The results reviewed here are consistent with a view of text comprehension in which text properties are processed simultaneously at multiple levels, with semantic or conceptual processing being emphasized over formal or syntactic processing. On the one hand, the review makes clearer the magnitude of the complexity that characterizes the simultaneous interpreting task: during comprehension many complex operations must be performed on a variety of representations, implicating both perceived text characteristics as well as prior knowledge, and one would expect production to be no less complex (see e.g., Frederiksen, Donin-Frederiksen & Bracewell, 1987). This suggests that interpreters should acquire a specific skill or skills to deal with this complexity. However, precise information about the nature of the skills or component processes specific to interpreting is not available.

On the other hand, in particular the Frederiksen and Renaud studies make clear that the complexity inherent in normal comprehension is transparent to the comprehender: many cognitive operations are performed on several representations, automatically and in real time during a more normal comprehension task than interpreting. This suggests that interpreting and normal comprehension have more in common than might initially seem to be the case. However, the on-line information about inferential processing of higher-level semantic structures in normal comprehension that is necessary to characterize important component processes is scarce and only beginning to become available.

Chapter Three

Rationale

To recapitulate, this study lies at the convergence of two lines of research. One, not very active and based on little experimentation, seeks to characterize the complex process of simultaneous interpreting. The second, currently very active and highly developed, seeks to account for normal text comprehension. On the one hand, there is little research on the component processes of interpreting, little integration with current theories of comprehension, and no research at all on the effects of text structure on interpreting performance. On the other, text comprehension research has evolved to the point where it may (although it has not) make an important contribution to the study of interpreting and where it needs to develop task environments that permit more refined measurement of higher-level inferential processes on line. Since the interpreting task may provide this kind of information, the situation seems very clearly to call for experimental research using the highly developed techniques of current text comprehension research to assess the characteristics of interpreting as both an important real-world task and as an experimental task environment.

In the context of this situation, the present study addressed two general questions:

1) What are the processes that constitute the skills specific to expertise in interpreting?, and

2) What is the relation between skill in interpreting and normal text comprehension?

Expertise in Simultaneous Interpreting

From a practical point of view, an account of interpreting expertise can provide the principles on which to base assessment of proficiency and aptitude, planning of programs of training, improvement of professional performance, and computer-based simulation of interpreters' performance. Judging from the fact that the cost of interpreters' services alone (i.e., not including equipment, travel, lodging and other arrangements) is in the range of US$100 per hour, and given the enormous demand for their services, improvements in assessment, training and performance will have considerable economic consequences, as well.

From a theoretical viewpoint, expertise in simultaneous interpreting serves as a benchmark phenomenon, one complex enough, yet informative enough, to serve as a testing ground for theories of comprehension as work on on-line models progresses. The current reliance of text processing theory on information from after-the-fact measures such as recall and from concurrent measures of *amount* of processing has led to models of comprehension that can be significantly extended by bringing to bear the sort of qualitative on-line information that is made available by studying simultaneous interpreting. For this to happen, however, it is necessary to complement the currently available parametric descriptions of interpreting performance with an account of the types and relative importance of the processes involved in the task.

To address this problem, the present study was constructed around an expert-novice contrast (Experience) in which the *experts* had an average of more than 3800 hours' (or 8.5 years') experience with the task and the *novices* no experience at all. Contrasting these two groups directly (rather than studying the experts alone and comparing the results with data on listening available in the literature) provides more reliable information by eliminating the possibility of confounds due to the textual materials or testing conditions and provides more specific information because of the particular set of analyses performed. In particular, the general question about interpreting skill was broken down into more specific questions about the component processes of comprehension during interpreting, to wit:

(i) Is syntactic processing of the source text going on?

(ii) Is proposition generation occurring?

(iii) Is the frame structure of the source text being processed?

(iv) What is the relative importance of each type of processing in interpreting?

In an effort to provide converging evidence about these questions, component processes were assessed in two ways: (a) by using text-structure variables to predict interpreting and recall responses, and (b) by classifying each response on the basis of its relation to a unit of input information (a component of a proposition).

Text-structure effects. Within each text, propositions varied with respect to the properties of the syntactic units they were found in, with respect to their their internal characteristics, and with respect to the properties of their organization into larger conceptual structures.

For example, proposition 1.0 below (of the narrative text) might be found in a simple declarative clause such as example (1), or in a more complex clause, such as (2).

```
1.Ø    visit    PAT: I, OBJ: FRIEND(TOK NUM: SING)) ≡TNS: PAST;
```

(1) *I visited a friend named Alex.*

(2) *Dave told Guy I visited a friend who's name was Alex ...*

It might also be a root proposition (as 1.0 above) or be embedded within another proposition, as in 1.1:

```
1.Ø    tell     PAT: Dave, REC: Guy, THM: 1.1 ≡TNS: PAST;
1.1    visit    PAT: I, OBJ: FRIEND(TOK NUM: SING)) ≡TNS: PAST;
```

Moreover, the proposition may or may not be a part of the principal text frame structure or one of its component episodes, subprocedures, etc.

If variation in each of these *text-structure variables* affects the accuracy of interpreting performance, then it suggests that corresponding component processes are involved in the interpreting process, as summarized in Table 3.1 below. The variable is thus said to *index* processing of the corresponding type. Note that processing at each successive level implies processing at the previous level(s), as reflected in Table 3.1. The magnitude of an effect would be related to the relative importance of the component process in determining accuracy of performance.

Table 3.1

Predicted effects of text structure variables under different processing hypotheses

	Type of processing performed during interpreting							
	Pre-semantic processing		Propositional processing		Frame processing			
	Syntactic parsing		Proposition generation		Frame construction		Knowledge integration	
Predictors	Main	Inter*	Main	Inter	Main	Inter	Main	Inter
Text-structure variables								
Syntactic variables								
Clause density	yes	yes	yes	yes	yes	yes	yes	yes
Clause embedding	yes	yes	yes	yes	yes	yes	yes	yes
Propositional variables								
Proposition density	-	-	yes	yes	yes	yes	yes	yes
Directness of mapping	-	-	yes	yes	yes	yes	yes	yes
Text Frame variables								
Frame/non-frame propositions	-	-	-	-	yes	yes	yes	yes
Frame components	-	-	-	-	yes	yes	yes	yes
Text Frame type	-	-	-	-	yes	yes	yes	yes
Text Order	-	-	-	-	-	-	yes	yes

* Main (Main effect of predictor), Inter (Effect of interaction of predictor with another variable).

To assess syntactic processing, propositions were classified according to the syntactic complexity of the segment in which they are found (Clause density (Cls), in clauses per segment) or according to the level of clausal embedding (Clause embedding (Mtx), matrix or non-matrix clause) at which they are found. To assess proposition generation, propositions were classified by both syntactic and proposition-semantic properties. For one variable, they were classified by the propositional complexity of the segment in which the proposition was found (Proposition density (Den), in propositions per segment) or according to the directness of the mapping from syntactic to semantic representations (RtMtx). For the directness of mapping variable, propositions were cross-classified by the correspondence of level of syntactic to level of propositional embedding (root or embedded proposition in a matrix clause; root or embedded proposition in an embedded clause). Finally, to assess frame processing, propositions were classified by whether or not they were part of the principal frame (Frame/non-frame propositions (FNF)), and by the frame component they belonged to. These variables are summarized in Figure 3.1 and described in more detail in the section on the linguistic properties of the text materials, in the next chapter.

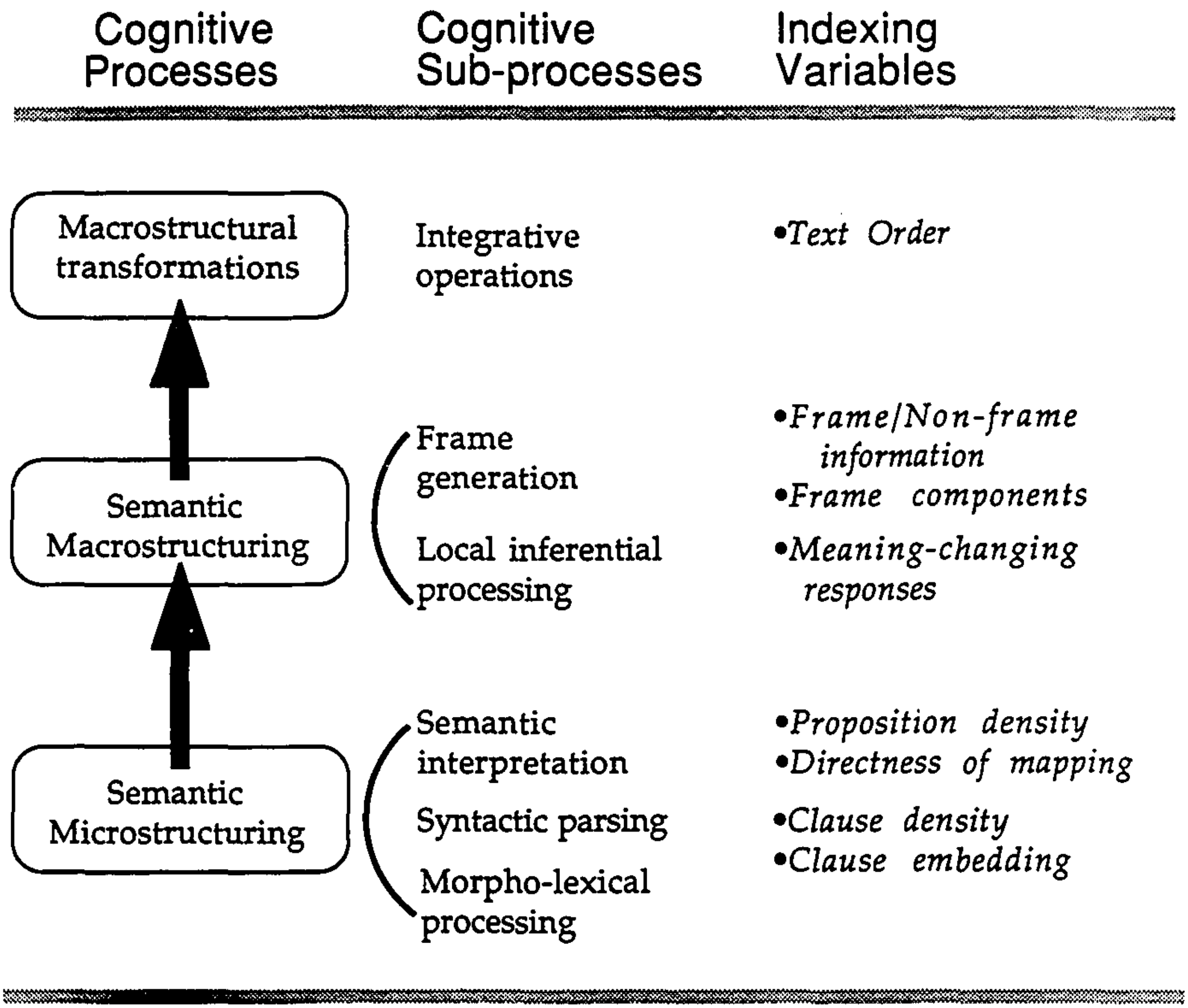


Figure 3.1 Variables indexing component processes of text comprehension.

In addition to using the text structure variables cited above, frame processing was also assessed by a *text-frame-type* contrast across texts. Frame processing is a central issue in comprehension since in communicating the main goal is to create in the hearer a reasonable facsimile of the speaker's conceptual structure usually called the message. This conceptual structure is not an unorganized set of propositions, but a structured system of them, so communication is successful only to the extent that frame information, as well as the propositional information, is understood correctly. Thus, the cross-text frame manipulation is necessary to provide information about how well interpreters organize the propositional information they understand. In the present study, narrative and procedural frames were contrasted. Since both are constructed principally around events, this particular contrast provided information specifically about how events are structured, without the possible confound due to proposition type that would have arisen had the contrast been between narrative and descriptive frames, for example. To assure the validity of the Text contrast as a difference due to frame-related information, the texts were controlled in great detail for equivalence of their non-frame (lexical, syntactic, cohesive, and propositional) characteristics.

Finally, to permit the interpretation of Text Order effects as indicative of the use of information from one text in the comprehension of the next, rather than a practice effect, subjects were given a practice text on a related topic before responding to the experimental texts. Thus, if Text Order affects performance, it provides evidence that subjects are integrating knowledge acquired from the first text with the information in the second text. Also supporting this interpretation is the fact that it seems unlikely that interpreting for four to eight minutes will be sufficient to lead to a practice effect in such a complex task.

Response-type effects. In addition, subjects' responses to each proposition, indeed to each element of each proposition, were classified in terms of the relation of the response information to the source-text information. These response-type measures reflect the kind of processing going on. Consequently, these *response-type variables* were used to assess the type of operation that was being applied to the propositional elements in question. Thus, subjects' responses to propositional elements were coded as: (a) meaning changing (RT1), (b) paraphrased (RT2), (c) verbatim (RT3) or (d) absent, and this information was represented as the proportion of each source-text proposition that was responded to in each of these ways. These response-type variables are associated with different types of processing, as summarized in Table 3.2 below. The meaning-changing responses were indicators of semantic processing, in particular of inferential substitutions or additions to the original based on the subjects' prior knowledge. The paraphrased responses were indicators of syntactic processing, but also provide evidence of proposition generation, since these responses are, by definition, meaning preserving. The verbatim responses provided evidence of syntactic processing and were indicators of overall processing difficulty, and absent responses were not analyzed.

Table 3.2

Association of response-type variables with type of processing

	Type of processing		
	Pre-semantic processing	Propositional processing	
	Syntactic processing	Proposition generation	Local inferencing
Response-type variables			
Meaning-changing responses (RT1)	yes	yes	yes
Paraphrased responses (RT2)	yes	yes	-
Verbatim responses (RT3)	yes	-	-

Individually and through their interactions, these two sets of text-structure and response-type variables provide information both about what kinds of information are being processed (text structure variables) and about the sorts of operations which are being applied to that information (response-type variables). For example, if more meaning-changing responses are found for frame propositions than for non-frame propositions, it suggests that subjects are selectively generating additional semantic links between the frame information provided in the text and prior knowledge or other parts of the text.

To assess these processes both in real time and in post-input comprehension, the variables above were analyzed for two sets of measures: a more immediate, on-line measure of interpreting performance (an interpreting protocol) which provides information about the interaction of these processes with working memory, and a delayed, post-facto measure of retention (a free recall protocol) which provides information about the additional processing associated with retrieval from long-term memory. Comparison of the patterns of results for these two sets of measures provides complimentary information about what sorts of processing are occurring at what point during comprehension.

Effects due to experience. The use of text-structure, response-type and frame-type contrasts *within* subjects made it possible to contrast all of these variables indexing type and level of processing across groups and thus compare expert interpreters and inexperienced bilinguals for each of the types of processing assessed, as well as to see the relative importance of each type of processing within groups. The mixed between- and within-subjects design thus made it possible to construct a profile of processing for each group. Moreover, if the differences due to expertise lie in a more general skill or efficiency in allocating processing resources, then one would expect that interpreting would interfere more with recall for the novices than for the experts. The between-subjects effects provide global information about differences due to experience and order of text presentation. The within-subjects effects give evidence of general comprehension processing, independently of experience or order. The between-by-within interactions are important as indicators of the specific processing differences that characterize the global differences in expertise or the different processing strategies applied as a function of text order.

Comprehension in Listening and in Interpreting

In theoretical terms, an analysis of the similarities between comprehension in listening and in interpreting would provide a principled basis for examining the extent to which the results about interpreters generalize to the comprehension of bilinguals under more usual circumstances. It yields information about whether the component processes, or the particular *weighting* of component processes, involved in the interpreting task are specific to interpreting or generalizable to other tasks involving comprehension, particularly normal listening comprehension. In practical terms, such an account can provide useful information about how the task interferes with interpreters' comprehension. Since efficient comprehension is central to interpreting performance, this information can be used to design programs of training that will enhance interpreting ability to circumvent task-specific interference with comprehension. In methodological terms, an account of the relation between listening and interpreting would provide a basis for assessing the adequacy of simultaneous interpreting as a task environment for studying normal comprehension processes. It would permit the assessment of the extent to which the on-line data provided by interpreting are representative of listening performance as well.

To address this problem, the present study also investigated a Task contrast (listening vs. interpreting) in which bilinguals were given either an interpreting or a listening comprehension task for the same texts. Again, contrasting these two groups directly avoids problems of confounds of materials or testing conditions, as well as of comparability of particular sets of analyses. This general question about the task-related differences in comprehension was broken down into the more specific questions that follow:

(i) Is syntactic processing the same in both tasks?

(ii) Is proposition generation the same across tasks?

(iii) Is processing of the frame structure of the text the same across tasks?

(iv) Is the relative importance of each type of processing the same across tasks?

To provide evidence pertaining to these questions, the same text-structure, frame-type and response-type variables described above were used to provide information about both what kinds of information are being processed (text-structure variables) and what sorts of operations are being applied to that information (response-type variables) in comprehension. In order to compare the tasks directly, the analyses were performed on the free recall measure only, since no comparable on-line measure was available for the listening task.

The use of text-structure, response-type and frame-type contrasts within subjects made it possible to contrast all of these measures across task conditions. This was done by comparing the inexperienced interpreters and listeners for each of the types of processing assessed, as well as to see the relative importance of each type of processing within groups. The mixed between- and within-subjects design again made it possible to construct a profile of processing for each group. The between-subjects effects provide global information about differences due to task and order of text presentation. The within-subjects effects give evidence of general comprehension processing, independently of task or order. The between-by-within interactions are important as indicators of the specific processing differences that characterize the global differences in task or the different processing strategies applied as a function of text order.

To summarize, the processes specific to interpreting skill were investigated by contrasting experienced with inexperienced interpreters performing simultaneous interpreting of a narrative and a procedure and then doing a free recall of each immediately afterwards. Text-structure and response-type variables provided information about component processes of both groups, as did the factors Text and Text Order. The processes common to comprehension in listening and in simultaneous interpreting were studied by contrasting inexperienced interpreters' recall after listening and after interpreting. The same variables were used in analyzing task differences as were used to assess differences due to experience.

Chapter Four

Method

Subjects

Subjects were sampled from two populations: experienced interpreters (n=8) and inexperienced interpreters (n=16). The two groups are compared in Table 4.1.

Table 4.1

Comparison of Groups of Subjects

	Group	
	Experienced interpreters	Inexperienced interpreters
n	8	16
% Females/Males	75/25	31/69
Mean age	≈45	29
% English better	25	6
% French better	50	69
% Same	25	25
Mean hours interpreting experience	3830	0

The experienced interpreters were professional conference interpreters from the Montreal area with an average of 3830 hours of active interpreting experience. Given that under normal conditions professional interpreters work 20 minutes on, 20 minutes off during a six-hour working day, that is 3 hours of interpreting per day, and an active interpreter might work some 150 days per year, the subjects who participated here had an average of 8.5 years' interpreting experience. 25% of these subjects gave English as their better language, 50% gave French, and 25% said they were equally fluent in both. The responses were the same for the language they preferred to translate into. The group was predominantly female (75%), and the average age was estimated at 45 years.

The inexperienced interpreters were bilingual graduate students attending one of the two English-language universities in Montreal (McGill and Concordia). These subjects had never attempted simultaneous interpreting before; 69% of them gave French as their better language, 6% gave English, and 25% responded that they were equally fluent in both. Note that even the subject who considered himself English dominant uses French at home and both languages at work, and reports using each language 50% of the time; the French-dominant subjects estimated they used English (an average of) 49% of the time. Males were more numerous in this sample (69%), and the average age was 29 years.

All subjects appeared to be very proficient in both languages (i.e., balanced bilinguals), and all used both languages on a day-to-day basis (overall, English 53% and French 47% of the time). This even division of language use corroborates the assessment that they are balanced bilinguals. Subjects' self-evaluations of dominance of one language over another thus clearly reflect small differences in their functional language skills, especially comprehension. No further evaluation of subjects' bilingualism was attempted, since in several studies self-rating proved most highly predictive of performance, especially among highly educated subjects (see Albert & Obler, 1978: 45).

Materials

Two texts (Tables 4.2 and 4.3) were used in order to assess component processes dealing with high-level semantic (frame) information. It was thus very important to isolate frame-level properties as the only important difference between texts, so as to permit the interpretation that text differences were due primarily to differences in these properties. To assure the reliability of this contrast, a multidimensional profile of lexical, syntactic, and semantic properties was constructed and the two texts were equated along each dimension. (See Appendices A and B for analyses of the experimental texts).

To access rule-based frame generation processes rather than those of frame instantiation from prior knowledge (see Frederiksen, 1985), texts on a topic unfamiliar to the subjects were used. Although about 15% of subjects in each group reported some prior knowledge of positron emission tomography (the content common to the two texts), and most had at least heard of the PET scanner, it was often not clear if they were confusing it with the more widely-known computerized axial tomography scanning technique (the CAT scan).

Table 4.2

Experimental Text: Narrative

I have a friend named Alex who is a nuclear physicist, but he works in a public hospital instead of at some big university's reactor. He spends a lot of his time shooting protons at glucose and other things. Alex makes several different isotopes with the old cyclotron which is in his lab, and he often helps one of the computer programmers who works in the hospital's brain scanning center. Yesterday I visited Alex at the hospital.

When I found the right office, it was already 10 o'clock. Alex was reading a collection of technical articles, but he put his book on a nearby shelf when I arrived and he showed me all around the lab. He turned on the small cyclotron which was in one corner and made some fluorine isotope to demonstrate how simply it worked. The small machine made noises while Alex explained what it was doing. Afterwards, Alex made some terrible coffee. We talked about the local news for a little while, until a staff doctor asked for some carbon-eleven glucose in a hurry. He said he would call as soon as he was ready for it. Then he prepared the next patient for her scan. Alex explained that since the glucose isotope was only hot (or radioactive) for about a half an hour, he could just set up what was in the lab. He would only start to make the isotope itself when the doctor called again. Not long after Alex was all ready, the doctor called back to confirm his previous request and Alex began to prepare his magic potion right away. When he had finished it, he checked whether it was hot (or radioactive) enough for the scanner. Then we ran up to the scanner room on the third floor, with the solution in a lead bucket.

The scanner was a big aluminum ring with millions of wires connecting it to a big computer in the next room. The patient was waiting nervously for an injection on a long table, with her head inside the ring. As we walked back down the stairs together, Alex explained that scanners detect gamma rays coming from inside the patient's brain. I didn't really understand very much of what he was talking about. It sounded really crazy to me.

After lunch, Alex checked in at the lab. Then we visited his friend Yoshio who ran the brain scanner's computer system. Even before he greeted us, Yoshio pointed at the two TV screens on a large desk and then asked which image was clearer. Yoshio was working on a new program to make the images sharper. Then he pointed at another screen with the same brain image, but it had two handles connected to it, like a video game. He suggested how we should play around with the handles, and when we moved them, the image changed in color and brightness. Yoshio explained that it was better for the doctors to manipulate the color and brightness of the important parts of the image.

The telephone rang, interrupting him. The call was for Alex. He had to go back to the lab, and it was time I left, too. We thanked Yoshio for his explanation of the new program, and walked to the main entrance together. Then Alex went to make some other kind of isotope and I went to the bank to pay some bills. It was a very interesting visit.

Table 4.3

Experimental Text: Procedure

A man goes to visit his doctor. He complains that his head often aches. He feels weakness in his arms and nausea. The symptoms make the doctor suspect that the patient has a brain tumor. He cannot be sure, though, without finding out what's happening inside the patient's skull. How is it possible to discover, causing no damage, what's going on inside someone's brain? Technology has provided us with a safe way of getting this information: the PET scanner. Let me explain how it works.

First, the patient is prepared: he lies on his back, his eyes and his ears are covered by wrapping them with gauze, and his head is secured with plastic pins so it can't move at all. Finally, his head is placed inside a donut-shaped machine and he is given an injection of a radioactive solution. This is made from a kind of glucose with a radioactive marker attached to some of its molecules. The marker is usually a carbon isotope produced in a cyclotron. This apparatus shoots protons into the nuclei of carbon atoms so they end up with an extra proton. This makes the atoms unstable, but only for a while: after half an hour most of them are normal again. These unstable atoms are attached to the glucose and injected into the patient's neck.

After the injection, scanning begins. The scanner has gamma ray detectors around the patient's head. That's why it's shaped like a donut: so his head can fit in the middle. The unstable atoms eject positrons to become stable again. The positrons each emit two gamma rays when they hit electrons in the patient's tissue, and this is called annihilation. The gamma rays leave the annihilation site in opposite directions and they have enough energy to leave the brain through the skull. When they hit two detectors simultaneously, a signal is sent to a computer. Because each of the detectors has a tube in front of it, it can only see straight ahead. Thus each pair of these detectors only gives information about a small area of tissue. The scanner then collects these signals and registers which of the detectors they came from.

When the scanner finishes its job, the computer starts reconstructing an image of the region that was scanned. A program compares the number of signals sent by each pair of detectors and those sent by all the others, and then it calculates the number of gamma rays emitted by each of the regions of the brain. The image appears on a screen as some colored squares that represent a cross-section of the brain, and this image is what the doctor interprets to perform his diagnosis.

Since the different colors represent different amounts of gamma rays and the rays are produced by the radioactive glucose, he can see where the glucose concentrated. Doctors already know that tumors consume more energy than normal tissue, and that they get this energy from glucose, so the doctor can spot the tumor because it will have a brighter color. Other disorders also show typical patterns on the image, and with different isotopes we can get information about the processes happening in the brain. The isotopes are safe, since they're only radioactive for a short while. The doctor doesn't have to open the skull, so he doesn't cause any damage. Thus, this technique allows him to see what's happening inside the brain easily and safely.

Rate of presentation was controlled at 145 words per minute, for all subjects.

Linguistic Properties of the Experimental Texts

The texts were contrasted using a multidimensional profile of lexical, syntactic and semantic properties. This strategy yields a finer-grained, more reliable comparison across texts than the similar-length-and-content comparison usually found in comprehension studies using more than one text. Moreover, all text variables are within-subjects factors (i.e., text-variable effects are assessed for each individual), so that sensitive measures can be made of the contribution of any of these factors to group differences on dependent measures. Finally, the statistical power lost with the use of a relatively small number of subjects is partially offset by the level of detail of the analyses used to control text sources of within-group variance, as seems most appropriate for this type of research, and by the use of the within-subjects design for text variables.

Control of lexical equivalence. Lexical equivalence of the two texts was assured by equating them with respect to the number of words (types and tokens), and the proportion of closed-class words (types and tokens), as summarized in Table 4.4 below with columns for each text and a difference score (Δ):

Table 4.4

Summary of Data on Lexical Equivalence of the Experimental Texts

	Text Type		
Text Property	Narrative	Procedural	Δ
Total words (tokens)	574	579	5
Total words (types)	231	232	1
Type-token ratio	.40	.40	0
Proportion of closed-class tokens	.49	.49	0
Proportion of closed-class types	.26	.29	.03
Mean lexical density (words/segment)	10.1	10.2	.1
Mean word type frequency (per million)	1631	1728	103
Proportion of infrequent words (types)	.38	.44	.06
Proportion of words (types) in both texts	.42		

The number of word-types refers to the number of different words (i.e., not including repetitions), whereas word-tokens refer to the number of strings of letters delimited by blanks (i.e., including repetitions). The type-token ratio is a measure of lexical repetitiveness or variety. Since closed-class words are much more frequent and play a special role in syntactic parsing and semantic interpretation, their occurrence in the texts was also verified. As was discussed above, frequency is a major determinant of efficiency of lexical access, so mean word-type frequency (in occurrences per million) was estimated for each text. Those word-types with a frequency of 100 or more occurrences (the ≈1000 most frequently occurring words) in the Kučera & Francis (1967) corpus were assigned the frequencies found by Kučera & Francis. The word-types with a frequency of less than 100 per million were assigned an estimated frequency of 10 per million. Mean word-type frequency was then the arithmetic mean of these frequency scores for each text.

Table 4.4, then, constitutes a profile of the lexical complexity and diversity of the texts used, showing that the texts were constructed to give them nearly identical profiles. Because of this similarity, we can conclude that the two texts are, for our purposes, equivalent in difficulty of lexical processing.

Control of syntactic equivalence. Syntactic equivalence of the two texts was assured by equating them with respect to clause density, the number of segments, clauses, clause embeddings, and different clause types, as summarized in Table 4.5 below, with columns for each text and a difference score (Δ).

Table 4.5

Summary of Data on Syntactic Equivalence of the Experimental Texts

	Text Type		
Text Property	Narrative	Procedural	Δ
Total segments	57	57	0
Total clauses	98	98	0
Mean clause density (clauses/segment)	1.7	1.7	0
Total clause embeddings	31	35	4
Total major clauses	52	51	1
Total bound adjuncts	12	12	0
Total other adjuncts	7	8	1
Total rank-shifted qualifiers	12	11	1
Total rank-shifted noun groups	15	16	1

Segments are syntactic units derived from Winograd's (1972, 1983) description of clause types. A segment is generally a clause with a finite (tensed, conjugated) main verb group along with any non-finite clauses attached to it. The segment thus allows for a more exact definition than the sentence, as well as providing units of a more homogeneous size (see Dillinger, 1987). The subjects' interpreting and recall protocols were also segmented using the same method to provide uniform and comparable units of analysis.

Clauses are traditional units of grammatical analysis and can be identified in a straightforward manner. To classify them, a set of clause types was defined based on Winograd (1983 — see Dillinger, 1987). Clause density is measured in units of clauses per segment, i.e., it is a measure of syntactic complexity.

Table 4.5, then, constitutes a profile of the syntactic complexity and diversity of the texts used, showing that the texts were constructed to give them nearly identical profiles. Because of this similarity, we can conclude that the two texts are, for our purposes, equivalent in parsing complexity, or more precisely in the difficulty of constructing syntactic representations of their units.

Control of directness of semantic interpretation. Formally, semantic interpretation is a family of functions that maps between syntactic trees and semantic (propositional) nets. The texts were equivalent with respect to the transparency or *directness* of this mapping, using a global measure. This was assured by equating them with respect to the proportion of direct to indirect surface-to-propositional maps (Narrative: 149 to 49 (3.09); Procedure: 150 to 48 (3.13)). *Direct* mappings were between unembedded clauses and unembedded propositions or between embedded clauses and embedded propositions; the elements were at the same level of embedding in both representations. *Indirect* mappings were those that required a change in level of embedding during interpretation: embedded clauses mapped onto unembedded propositions or unembedded clauses mapped onto embedded propositions.

It was hypothesized that, when added to the mapping process, the complication of having to adjust the level of embedding would increase processing difficulty, and that the cross-classification would make it possible to explore the nature of the difficulties associated with recovering surface-embedded information. This variable was included to investigate further the well known effects due to topicalization or *staging* (Clements, 1979; Marshall & Glock, 1978).

Control of propositional equivalence. Proposition-semantic equivalence of the two texts was guaranteed by equating them with respect to propositional density and the total number of propositions, event propositions, stative propositions, and relational propositions, as summarized in Table 4.6 below, with columns for each text and a difference score (Δ).

Table 4.6

Summary of Data on Propositional Equivalence of the Experimental Texts

	Text Type		
Text Property	Narrative	Procedural	Δ
Total propositions	198	198	0
Mean propositional density (per segment)	3.5	3.5	0
Total events	84	84	0
Total statives	72	74	2
Total relationals	42	40	2

The list of propositions for each text (see Appendices A and E) constitutes a description (in a specialized metalanguage for propositions) of the concepts and conceptual relations that are made explicit in the text. The resulting description is a representation of the shallow or (nearly) literal interpretation of text content. The propositional metalanguage used here is that described in Frederiksen (1975, 1986).

Events are propositions in which the head element or *predicator* is an action or process, and the arguments are objects involved in the event or its attributes; *statives* are those in which the head element is an object and the arguments are its attributes or other objects it is related to; *relational propositions* are those with an algebraic or dependency relation as head and propositions as arguments (Frederiksen, 1975).

Table 4.6, then, constitutes a profile of the proposition-semantic complexity and diversity of the texts used, showing that the texts were constructed to give them nearly identical profiles. Because of this similarity, we can conclude that the two texts are, for our purposes, equivalent in propositional density and types of proposition.

Control of cohesion. Cohesion designates a class of textual devices that signal some of the explicit semantic relations between some of the concepts which the text designates. These devices thus serve as specific markers of the coherence of text content (Halliday & Hasan, 1976; Dillinger, Bracewell & Fine, 1987). These markers, therefore, play an important role in constructing inferential links between the elements of the propositional representation of text content. Cohesive equivalence of the two texts was assured by equating them with respect to the number and types of cohesive elements, as summarized in Table 4.7 below, with columns for each text and a difference score (Δ):

Table 4.7

Summary of data on cohesive equivalence of the experimental texts

	Text Type		
Text Property	Narrative	Procedural	Δ
Total cohesive elements	239	241	2
Proportion cohesives of total words	.42	.42	0
Mean cohesion density (per segment)	4.2	4.2	0
Total referentials	100	100	0
Total conjunctives	34	34	0
Total lexicals	104	105	1
Total other cohesives	1	2	1

The types of cohesive elements are those of Halliday & Hasan (1976): *referentials* include pronouns, deictics, etc., *conjunctives* include conjunctions and conjoining expressions, and *lexicals* include synonyms, antonyms, super- and subordinate terms, etc.

Table 4.7, then, constitutes a profile of the cohesive complexity and diversity of the texts used, showing that the texts were constructed to give them nearly identical profiles, while maintaining, of course, the same lexical, syntactic and propositional profiles. Because of this similarity, we can conclude that the two texts are, for our purposes, equivalent with respect to cohesion.

Tables 4.5-4.8 document the strict equivalence of the two texts for non-frame characteristics. The differences between the texts are all frame related, and are specified below.

Frame types. The difference between the experimental texts which is of interest here is that of the principal frame which the text exemplifies. The two frame types contrasted here are the narrative and the procedure. Two important aspects of frame structure are (a) how particular types of propositions are linked together, and (b) how these types and links are instantiated and distributed among embedded and unembedded clauses and propositions. The first is specified for the experimental texts by the frame diagrams in Appendices C and D, as well as the upper panel of Table 4.8. The second is characterized in the lower panel of Table 4.8 and in Table 4.9 below.

Frame analysis consists in identifying the propositions of the appropriate type or types, and the relations between these propositions expressed in the text, in order to construct a semantic network with propositions as nodes and semantic relations (as defined in Frederiksen, 1975) as links between them. A frame, in the abstract sense used here, is a class of such semantic networks defined by the type or types of propositions which are the nodes and the type or types of relations which can link them (see Frederiksen, 1986).

A *narrative* is a conceptual structure in which events are organized primarily in terms of their temporal relations, that is, it is essentially a set of events linked by relations of order and equivalence in time (Frederiksen, 1986). In the frame network (see Appendix C), the X axis corresponds to equivalence in time and the Y axis to order in time (higher before lower).

A *procedure* is a conceptual structure in which (resultive or goal-directed) events are organized principally in terms of the part-whole relations between them, that is, hierarchically (Frederiksen, 1986, 1989b). In the frame network (see Appendix D), the X axis corresponds to the part-whole relation (parts to the right of wholes) and the Y axis to order in time (higher before lower).

Directness of mapping, although equivalent overall (as discussed above), varies considerably across text type. The Narrative text, for example, contained twice as much information in root propositions as the Procedure (3.21-to-1 vs. 1.57-to-1 root-to-non-root propositions), and had four times more information presented in matrix clauses than the Procedure (1.91-to-1 vs. 0.45-to-1 matrix-to-non-matrix clauses). The two texts are, then, equivalent in semantic parsing complexity overall, but differ on how the information is distributed by proposition and clause types (see Table 4.8).

Table 4.9 displays a breakdown of the information in Table 4.8 by the frame/non-frame distinction. In the Narrative, there was a large difference in the distribution of frame information across clauses, but a much smaller difference in the distribution of non-frame information. Moreover, frame information appeared much more frequently in matrix clauses. In the Procedure, on the other hand, the distribution of frame and non-frame information across clauses was nearly the same, and there was much more information in embedded clauses.

Table 4.8

Summary of Data on Frame Characteristics of the Experimental Texts

Text Property	Text Type: Narrative	Text Type: Procedural	Δ
Frame/Non-frame propositions	82/116 (0.71)	102/96 (1.06)	-0.35
Frame Components	Episode*	Subprocedure*	
Component 1 (Fr/NFr propositions)	18/14	39/0	
Component 2 (Fr/NFr propositions)	32/38	30/0	
Component 3 (Fr/NFr propositions)	22/34	33/0	
Other propositions (Fr/NFr propositions)	10/30	0/96	
Directness of mapping**			
Root-Matrix propositions (RM1)	116	45	71
NonRoot-Matrix propositions (RM2)	14	16	-2
Root-NonMatrix propositions (RM3)	35	32	3
NonRoot-NonMatrix propositions (RM4)	33	105	-72
Root/NonRoot propositions	151/47 (3.21)	121/77 (1.57)	1.64
Matrix/NonMatrix propositions	130/68 (1.91)	61/137 (0.45)	1.46

* The number of propositions constituting frame components was calculated differently for the two texts. For the Narrative, both frame (Fr) and non-frame (NFr) propositions were counted for each component; for the Procedure, only frame propositions were counted for each component.

** Root-Matrix propositions are root (unembedded) propositions which appear in matrix (unembedded) clauses. NonRoot-Matrix propositions are embedded propositions in matrix (unembedded) clauses. Root-NonMatrix propositions are root propositions in embedded clauses. NonRoot-NonMatrix propositions are embedded propositions in embedded clauses.

Table 4.9

Distribution of Frame Information over Matrix and Embedded Clauses

	Text Type: Narrative	Text Type: Procedure	Δ
Frame propositions			
in matrix clauses	65	29	36
in embedded clauses	17	67	-50
Non-frame propositions			
in matrix clauses	65	32	33
in embedded clauses	51	70	-19
Total propositions			
in matrix clauses	130	61	69
in embedded clauses	68	137	-69

Rate of presentation. The texts were presented at 145 words per minute (wpm) to all subjects, i.e., subjects had 414 msec mean processing time per word. This speed is slower than the normal rate of spontaneous speaking (160-180 wpm; Foulke & Sticht, 1969), but is fast enough to cause professional interpreters some difficulty. Gerver (1971a,b) reports data showing that about 75% of the words in his texts were correctly translated at 145 wpm compared to 98% at 112 wpm (see Figure 4.1 below). Gerver concluded using this criterion that 112 wpm was the optimal rate of presentation for professional interpreters. In the present study the faster rate was chosen to increase deviations from the original text, since they are the clues from which processing is inferred.

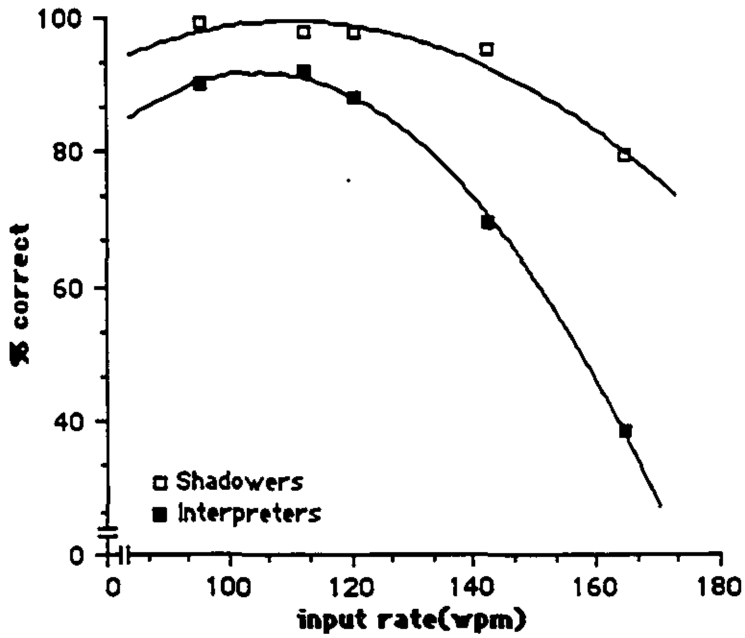


Figure 4.1 Percent correctly translated or shadowed by professional interpreters, by rate of presentation (data from Gerver, 1971a).

Rate was measured in mean words per minute to permit comparison with Gerver's (1971a,b) study and other discussions of interpreting. However, syllables per second is a much more precise measure, simply because syllables are much less variable in length (±50 msec) than words (±500 msec). Even by this more refined measure, control of rate was good: the procedural text was less than 5% faster, because it had more syllables (869 vs. 823) than the narrative text (see Table 4.10).

Table 4.10

Rate of input, by text

	Text Type		
	Narrative	Procedure	Δ
Total syllables	823	869	46
syllables/second	3.47	3.67	.20
msec/syllable	289	273	16
words/minute	145	145	0
propositions/minute	49.5	49.5	0

A uniform text-internal rate of delivery was assured by marking the text at 10 s intervals and practicing reading while monitoring a timer until delivery was smooth (there was only one false start per text) and at the desired rate.

Although the theoretical interest of having such carefully controlled materials is obvious, producing them is tedious, time consuming, and anything but practical. These two texts, for example, took approximately nine months for one person to produce by hand. However, the recent development of computer-based tools for text analysis has begun to make it much more practical to produce such materials. Specialized high-level programming languages such as Déredec (Plante, 1985) and sophisticated systems such as CODA-X (Frederiksen, Décary & Hoover, 1988) can be used to generate complex databases of information about the texts being used. It may even be possible to automate some of the analyses or use statistical methods to compensate for text differences. Comparisons of texts of "similar length and content" are clearly inadequate when theory generates precise questions and methods of analysis permit ever more detailed comparisons.

Tasks and procedure

Tasks. Subjects were instructed either to listen to or interpret, and afterwards to recall, each experimental text. They were explicitly instructed *not* to worry about remembering the text but to concentrate on understanding or interpreting it (see Appendix E for instructions). Both texts were presented and recalled in English. Interpreting was from English into French. Presentation of each text lasted approximately four minutes. A short practice text on a related topic was also presented to all subjects for warm-up (see Appendix E).

Procedure. Subjects were seated individually in a small, quiet room which was very similar in appearance to an interpreter's booth, equipped with a Fostex X-15 series II four-track cassette tape recorder and full-sized enclosed headphones with an unobtrusive Radio Shack 33-1063 miniature lapel microphone clipped to the headphone wire. After a short introduction presented on tape, subjects listened to or interpreted a two-minute warm-up text, then the first experimental text. After the first experimental text, they were asked to provide a recall of it, and took a short break while the experimenter readied the equipment for the second text. Finally, they listened to or interpreted the second experimental text and provided a recall. All instructions and stimuli were presented binaurally from the left channel (channel 1) of the stimulus tape. Subjects' interpreting performance, as well as their recalls, were recorded on the right channel (channel 2). After the task was completed subjects were given a short debriefing session to get information on their training, experience and reactions to the experiment.

Deviations from standard practice. The experimental task in a laboratory setting seemed to deviate from standard interpreting practice in several ways:

1) The task was decontextualized. That is, the text interpreted was not presented in the context of a particular audience, on a particular social occasion such as a conference of specialists. These communicative parameters were left undefined, and constitute the major difference between laboratory and natural conditions. The extent to which this may affect actual interpreting performance has not been studied in any detail, although its importance has been repeatedly emphasized by Seleskovitch (1984) and colleagues. It is important to bear in mind, however, that their theorizing is based heavily on the interpretation of spontaneous speech, in particular dialogue. In a conversational situation, context is obviously much more important than in interpreting prepared text.

2) It was not possible to see the speaker. This is a particular instance of the difference pointed out in (1), and subject to the same caveats. Note that all of the examples used by Seleskovitch & Lederer (1984) to emphasize the importance of contextual variables are cases in which either deictic reference to the immediate physical situation or speaker/addressee identity are important, and that neither of these is important in the presentation of a prepared text. Thus, the kind of text chosen and type of social situation (lecture) that was presupposed both acted to reduce the importance of contextual variables, thus making the

laboratory task much more similar to one kind of natural setting than would initially seem to be the case.

3) The interpreters were not allowed to prepare for the task, nor were they allowed to choose the topic. Interpreters sometimes specialize in, or develop a preference for, given topics, and in most cases are given the opportunity to do some preparation before interpreting about a given topic. This difference refers to the role of prior knowledge in interpreting performance, a clearly important, although entirely uninvestigated, factor. This does not, however, make the experimental task very different from normal practice, for the following reasons.

On the one hand, interpreters rarely have technical knowledge of topics they are called upon to interpret; at best they have some general awareness of the area under discussion, at least in Canada where the market does not make great demands on technical specialization. On the other hand, it is unlikely that in a few days' time an interpreter untrained in physics, math or chemistry (i.e., the majority) will be able to understand very much of any technical topic. Moreover, preparation time is used to become familiar with the vocabulary of the area (according to experienced subjects) rather than attempting to understand theory. This emphasis on the lexical characteristics of a given type of technical text is also reflected in the widespread use of terminology databases and specialized dictionaries. The difference, then, between preparing and not preparing for an interpreting session seems to be one of increasing the subjective frequency of rare words — presumably with a consequent facilitation of access to them, rather than increasing prior knowledge.

4) There was no audience. Some subjects reported that an important difference of the laboratory setting was the absence of an audience. They found the tension and pressure to perform an important stimulus that was missing in the laboratory. The consequences for processing are unknown, but one might expect little more than a slight decrement in overall performance because of this difference.

5) Subjects were not paid. The consequences of this difference are, unfortunately, quite unpredictable.

The main deviations from standard interpreting practice bear on context and prior preparation. The setting and type of text used here (pre-prepared material read in a lecture or radio broadcast setting) reduced the importance of contextual variables. Preparation would have emphasized correct terminology, rather than increasing prior theoretical knowledge.

Since the translations produced were analyzed for content, correct or incorrect terminology (*cycloscope* for *cyclotron*, for example) made little difference in coding. Thus, the differences between the experimental task and normal practice have been minimized.

Data manipulation

Preparation of protocols. The steps described above yielded 16 interpreting protocols and 24 free recall protocols for each text. All 80 protocols were transcribed including false starts, hesitations, etc. and were divided into numbered syntactic units (segments) to facilitate subsequent analyses. French-language protocols were transcribed by a French-native-language linguist.

Match/Mismatch analysis. In all comprehension research some assessment is made of the degree to which the response protocol matches/mismatches the input text (Ericsson & Simon, 1984); this is the fundamental step of generating data from the observations. One typical, but more detailed than usual, form of this analysis (*recall/inference coding*, see Bracewell, Frederiksen & Frederiksen, 1982) proceeds by categorizing the propositions of the original text as *absent*, *recalled*, *inferred*, or *recalled with inference* in the response protocol. This coding technique has proved to be very useful, and is in fact more detailed and reliable than many more widely used techniques (e.g., simple presence vs. absence of propositions judged without reference to explicit criteria). However, the attempt in the present study to measure subtle processing differences using a small number of subjects made a more refined adaptation of this method necessary.

Rather than matching entire propositions, here the units of comparison were the *slot-filler pairs* that constitute each proposition. That is, each slot-filler pair of each proposition in the input text received a score according to the degree of similarity between it and the segment in question, using the following ordinal scale of similarity:

0 if the slot-filler pair was not present in the segment (*absent*); least similar.

1 if there was a change of meaning in either the slot or the filler (*semantic change*).

2 if there was a change in surface form of either the slot or the filler, without a change in meaning (*paraphrase*).

3 if the slot-filler pair appeared in the segment verbatim (*verbatim*); most similar.

For each proposition, the *distance* between the response protocol and the propositions of the input text was represented with three measures: (a) the proportion of the original proposition's slot-filler pairs reproduced with semantic changes, (b) the proportion paraphrased, and (c) the proportion reproduced verbatim.

The response type called *verbatim* merits some comment in dealing with translation protocols. Obviously, translations are never verbatim, but are paraphrases in another language. However, in this study, *verbatim* was used to indicate that in translation the same sentence structure and direct translation-equivalent lexical items were used. *Paraphrased* responses were those in which there were meaning-preserving surface changes. Perhaps more accurate names for these response types might be *strictly meaning preserving* and *loosely meaning preserving;* the relative proportions of each type, however, show that this is not an important difference in the present data.

The technique of assessing text similarity introduced here includes the following refinements of the Bracewell et al. (1982) method:

(a) the basic units of comparison are smaller, yielding a finer-grained comparison;

(b) the units are compared with respect to syntactic as well as semantic differences, providing more information about the relation between the two texts;

(c) the units are compared using an ordinal rather than nominal scale of similarity, which is more appropriate for assessing distance;

(d) the measures for similarity at the level of proposition units are derived from measures of the similarity of their components, making the proposition measure more precise and detailed as well as reducing the error variance introduced by miscoding;

(e) similarity of propositions is assessed along three quasi-continuous dimensions, rather than along a single discrete dimension.

(f) the use of an approximately continuous measure (proportion of proposition *p*), rather than a small set of discrete categories, makes error variance more evenly distributed along the scale, damping any possible effects of coding bias.

The goal of these refinements to the coding method is clear: they reduce error variance introduced by variability in the application of the coding methods, and thereby contribute to increasing the power of the statistical tests used.

Databases. The raw data matrices generated by these methods were composed of vectors of three values associated with each proposition, for each text, for each subject.

For each of the experimental texts a database was constructed, using Microsoft® Excel, in which each record (row) corresponded to a text proposition, and each field (column) to information about the linguistic properties of the text, as summarized in the tables above. This made it simple to generate information about propositions with a given property (e.g., those found in matrix or non-matrix clauses, that were root or non-root propositions, those found in a segment with *n* clauses, etc.), as well as classify propositions by these properties. Once the raw data matrices were appended to these databases as new fields, generating dependent measures by performing calculations on classes of propositions became simple with the database calculation functions built into Microsoft® Excel. A relational database management program and improvements to the database design, however, would have made the process much more efficient.

Using these databases, a set of nine matrices of dependent measures (see Table 4.12 below) were generated for each set of measures (interpreting and recall), and used as input to the analyses of variance described below.

Design and analyses

Between-subjects Design

The major between-subjects contrasts in the present study, as cited above, are *Experience* and *Task*. The use of two texts also entailed *Text Order* as a between-subjects factor.

Experience refers to difference in experience with the interpreting task. One group of subjects, the High-experience interpreters, had an average of 8.5 years' experience interpreting, whereas the other groups had none.

The Task factor contrasts the two tasks studied: two groups of subjects interpreted, and another listened to the experimental texts.

The Task x Experience interaction is not of interest here: the model of comprehension underlying the study does not predict transfer of experience with the interpreting task to performance on a listening task. Thus, comparing subjects with and without interpreting experience on a listening task makes little sense in this theoretical context. Moreover, because the high-experience subjects are drawn from a very specialized population with limited availability, it was important to optimize the time spent with them by avoiding the condition in which experienced interpreters would simply perform a listening task. Consequently, rather than crossing Task and Experience, three experimental groups were used: High-experience interpreters (n = 8), Low-experience interpreters (n = 8), and Low-experience listeners (n = 8). The analyses were set up with a between-subjects factor called Group. Two contrasts involving Group were of interest: (a) the planned comparison of Experience (High-experience interpreters vs. Low-experience interpreters) on both the interpreting and recall measures, and (b) the contrast of Task (Low-experience interpreters vs. Low-experience listeners) for the recall measures only.

Text Order was the last between-subjects factor, contrasting the two orders of text presentation (narrative-procedure vs. procedure-narrative). The resulting between-subjects design is shown in Figure 4.2.

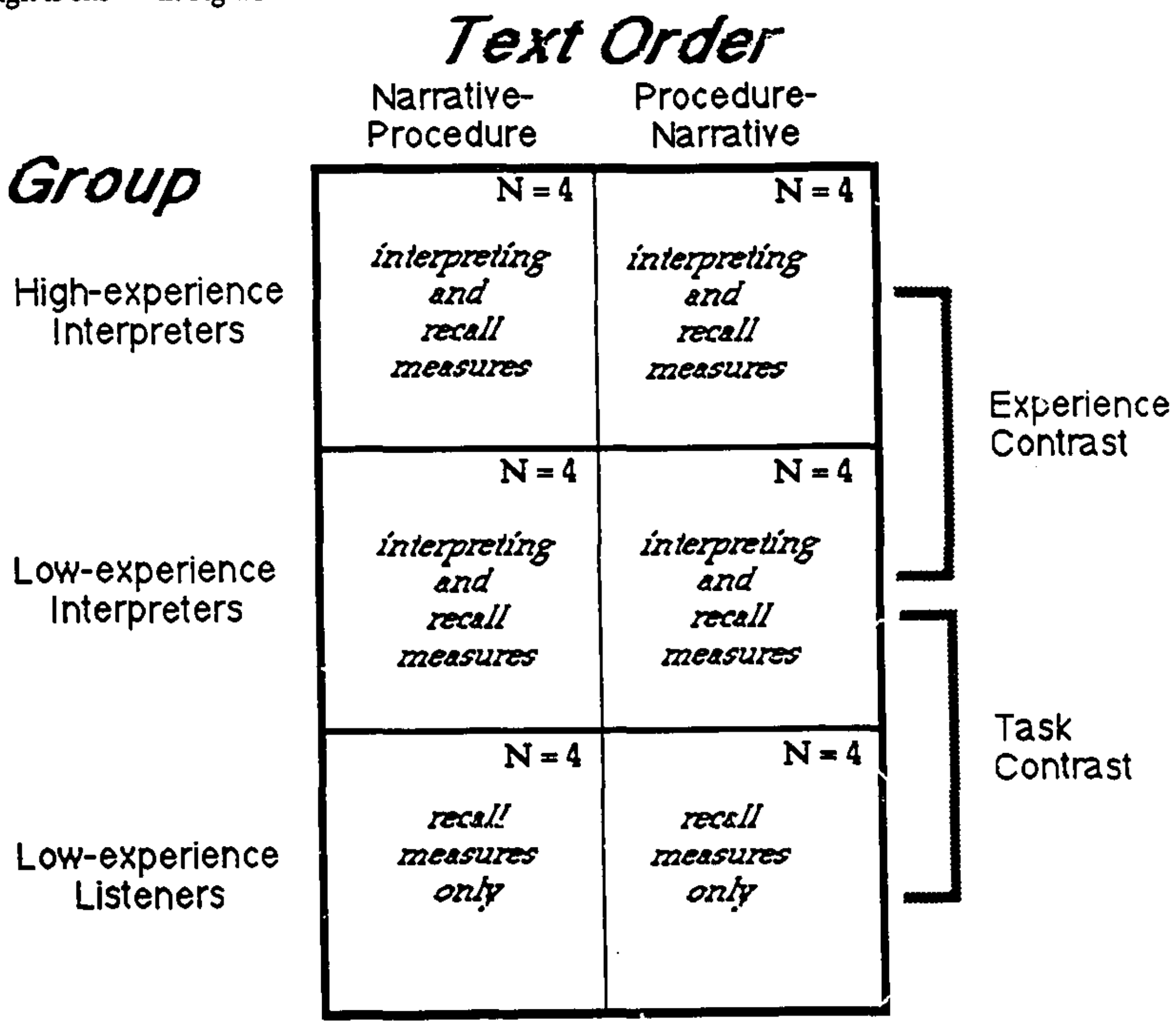


Figure 4.2 The between-subjects design for the experiment.

Within-subjects Models

A series of different within-subjects variables were studied by means of different within-subjects models.

Text (narrative vs. procedure) was introduced to permit assessment of frame-level processing and was made a within-subjects factor to increase the sensitivity of the statistical tests. There was a single narrative/procedure contrast.

Response type (meaning-changing (RT1), paraphrased (RT2), verbatim (RT3) responses) variables were introduced to assess the class of processing operations applied in responding to the input. Two contrasts were tested in all analyses: meaning-preserving (verbatim plus paraphrased responses) vs. meaning changing responses (RT2+3-1) and verbatim vs. paraphrased responses (RT3-2).

Text-structure variables were manipulated within texts and controlled across texts. A separate within-subjects model was used to test the contribution of each in a separate analysis, as summarized in Table 4.11 below.

Table 4.11

Within-subjects models used in the repeated-measures analyses of variance

Analysis	Classification of propositions	Within-subjects model
1	Pooled over all propositions	Text x Response type
2	Clause density (Cls)	Text x Response type x Cls
3	Clause embedding (Mtx)	Text x Response type x Mtx
4	Proposition density (Den)	Text x Response type x Den
5	Directness of mapping (RtMtx)	Text x Response type x RtMtx
6	Narrative/Non-narrative (FNF(Narr))	Response type x FNF
7	Procedural/Non-procedural (FNF(Proc))	Response type x FNF
8	Episodes (Frco(Narr))	Response type x Frco
9	Subprocedures (Frco(Proc))	Response type x Frco

Clause density. Dependent measures were devised by categorizing propositions as to the number of clauses contained in the segment where the proposition was found: 1 clause per segment vs. 2 clauses per segment vs. 3 or 4 clauses per segment (low (Cls1), medium

(Cls2) and high (Cls3) clausal density, respectively), on the assumption that recovery of information from syntactically more complex segments, especially given the exacting demands of concurrent tasks on processing resources, would demand greater processing and hence be associated with decrements in accuracy of performance. Two contrasts were tested: Mid-Low clause density (Cls2-1) and High-Mid clause density (Cls3-2).

Clause embedding. Dependent measures were devised by categorizing propositions as to the level of embedding of the clause in which the proposition was expressed: matrix (unembedded) vs. non-matrix (embedded) clause, on the assumption that it would require more processing to recover syntactically embedded, detopicalized information. One contrast was tested: matrix (Mtx) vs. non-matrix (NMtx) clauses (Mtx-NMtx).

Propositional density. Dependent measures were devised by categorizing propositions as to the number of propositions expressed by the segment including them: 1 to 3 propositions per segment vs. 4 propositions per segment vs. 5 to 7 propositions per segment (low (DenLo), medium (DenMid) and high (DenHi) propositional density, respectively), on the assumption that it would be more difficult to recover information from semantically more complex segments. Two contrasts were tested: Mid-Low proposition density (DenMid-Lo) and High-Mid clause density (DenHi-Mid).

Directness of mapping. Dependent measures were devised by cross-categorizing propositions as to both the level of syntactic embedding of the clause in which the proposition was expressed (matrix vs. non-matrix clauses) and the level of semantic embedding of the proposition in the corresponding semantic representation (root (unembedded) vs. non-root (embedded) propositions), on the assumption that direct maps or matches (unembedded clause to unembedded proposition (RM1) or embedded clause to embedded proposition (RM4)) would be easier to process than indirect maps or mismatches (matrix clause to embedded proposition (RM2) or embedded clause to root proposition (RM3)). The two contrasts examined were: (a) between non-root and root propositions within *matrix* clauses (RM2-1 contrast) and (b) non-root and root propositions within *non-matrix* clauses (RM4-3 contrast).

Frame vs. non-frame information. Dependent measures were devised by categorizing propositions by whether or not they were part of the principal frame instantiated by the text. The same frame/non-frame contrast was examined in each text separately, yielding two contrasts: Narrative vs. non-narrative (FNF(Narr)) and Procedural vs. non-procedural information (FNF(Proc)).

Frame components. Dependent measures were devised by categorizing propositions by the frame component they belonged to. Frame components of the narrative were episodes; of the procedure, subprocedures. The same frame component contrasts were examined in each text separately, yielding four contrasts: Episode2-Episode1 (Frco2-1(Narr)), Episode3-Episode2 (Frco3-2(Narr)), Procedure2-Procedure1 (Frco2-1(Proc)), and Procedure3-Procedure2 (Frco3-2(Proc)).

To summarize the design, Table 4.12 displays the major variables controlled and manipulated in the present study.

Analyses. The matrices of dependent variables generated by the methods described above were subjected to mixed between and within repeated-measures multivariate analyses of variance using the *Multivariance VII* statistical analysis package (Finn & Bock, 1985). The interpreting data were analyzed using a between-subjects model of Experience (low, high) x Order (narrative-procedure, procedure-narrative). The recall data were analyzed using two between-subjects models: Task (listening, interpreting) x Order (narrative-procedure, procedure-narrative) and Experience (low, high) x Order (narrative-procedure, procedure-narrative). The dependent measures were the proportion of each proposition reproduced: (a) with a change in meaning, (b) with paraphrase or (c) verbatim. For all analyses, there were 4 subjects in each cell of the between-subjects model, for an N of 16. Each between-subjects model was tested in conjunction with a series of nine within-subjects models (see Table 4.12), for a total of 660 tests of significance. Finally, the criterion for significance was set at α=.05.

Table 4.12

Variables Controlled and Manipulated within and between Subjects

	Locus: Within subjects	Locus: Between subjects
Controlled Variables	rate of presentation task text order text properties across texts	all text properties text frame type rate of presentation
Manipulated Variables	text frame type text properties within texts	experience task text order

Chapter Five

Results

Two main sets of analyses were carried out: (a) an assessment of the effects of Experience and Text structure on interpreting and recall to investigate the nature of interpreting skill, and (b) a second of the effects of Task and Text structure on recall to investigate the relationship between comprehension in listening and in interpreting. The results are presented as follows: (a) first the effects of Experience (as well as of text-structure variables, Text Frame type and Text Order) on interpreting are reported; then (b) the effects of these variables on recall are reported; finally (c) the effects of Task (as well as text-structure variables, Text Frame type, Text Order and Task by Text Order) on recall are reported. Significant *F* values are given in tables that are referred to in the text; complete results of all analyses are provided in Appendix F.

In the mixed between- and within-subjects design used here, main effects of between-subjects factors indicate quantitative differences in processing across groups, and main effects of within-subjects factors indicate general qualitative differences in processing of text structure. Interactions of between and within factors indicate qualitative differences in processing that were associated with between-subjects factors. For example, an interaction of Experience with variables indexing proposition generation would indicate that the qualitative differences between the experience groups lie, more specifically, in the component process of proposition generation. As well, interactions of Text Frame type and text-structure variables would indicate that component processes are differentially important in the context of a particular frame type and could be interpreted as suggesting that processing of frame information interacts with processing involving other aspects of text structure. Note that because the paraphrased responses appeared in very small numbers (approximately 4% of each text) and showed little variance, the effects of the response type contrast RT3-2 between verbatim and paraphrased responses were due to variation in verbatim responses alone;

hence in plotting the effects of response type, the verbatim and paraphrased responses (RT3 and RT2) were pooled and labelled "meaning-preserving responses".

The nature of interpreting skill

The Effects of Experience on Accuracy of Interpreting

Experience had only weak effects on interpreting performance. Overall, high-experience subjects performed more accurately and gave more verbatim responses, and significantly so. This seems to be related to more efficient proposition generation involving matrix clauses, as indicated by three weak effects and one strong one involving interactions of experience with Directness of mapping (RM2-1; Table 5.1). There were no effects of Experience x Order on interpreting performance.

Table 5.1

Summary of Effects of Experience on Interpreting

Contrast name	$F(1,12)$	p
Experience	6.9911	.0215
Exp x RT3-2	5.7652	.0335
Exp x Text x RT2+3-1	5.3876	.0387
Exp x RM2-1	7.9886	.0153
Exp x RM2-1x Text	6.1834	.0287
Exp x RM2-1 x RT3-2	5.6753	.0347
Exp x RM2-1 x RT2+3-1x Text	12.3588	.0043

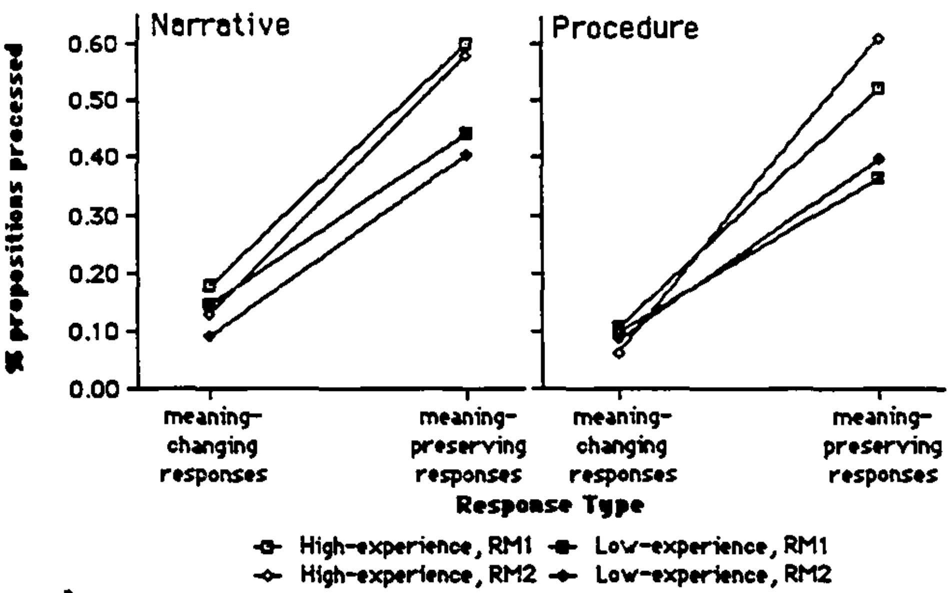


Figure 5.1* Interactions of Experience, Text, Directness of mapping and Response type.

* Note: In this and subsequent figures, "%" symbolizes "proportion" rather than "percent".

Figure 5.1 summarizes graphically the effects of Experience on interpreting performance, and some of its interactions. In general, high-experience subjects (white symbols) produced more meaning-preserving responses than low-experience subjects (black symbols), and slightly more meaning-changing responses for the narrative as well. Overall, more of the narrative text was responded to. The root propositions in matrix clauses (RM1 — square symbols) were processed more than the non-root propositions in matrix clauses (RM2 — diamond-shaped symbols) for the narrative but the opposite was true for the procedure, and Experience tended to exaggerate the differences.

Figure 5.2 illustrates the similarities between the Experience groups. Again the high-experience subjects (white symbols) produced more responses overall than the low-experience subjects (black symbols). There were differences between texts, in particular the procedure, for root propositions in matrix clauses (RM1), but no differences for non-root propositions (RM2). Quantitatively there was an overall difference of approximately 16%, but qualitatively, the pattern of subjects' responses was nearly identical.

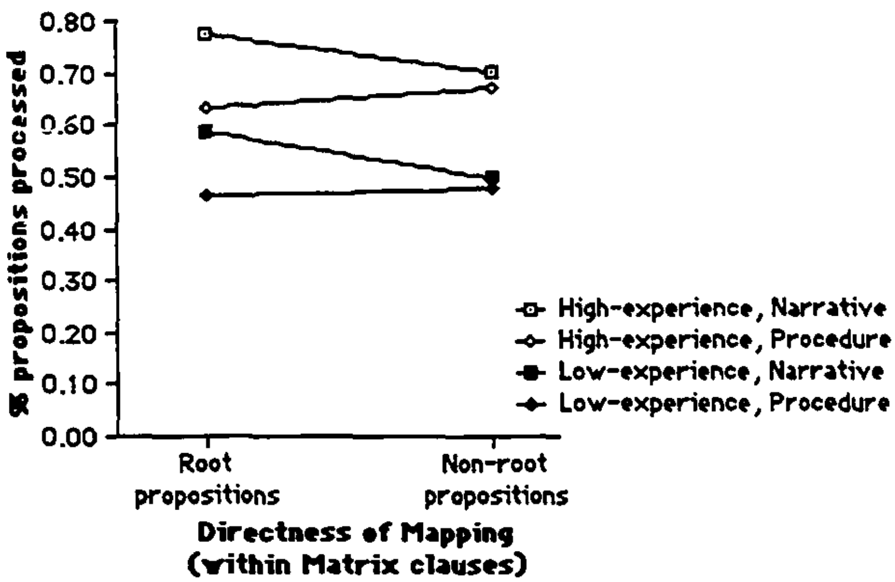


Figure 5.2 Interactions of Experience, Text and Directness of mapping.

The weak effects of between-subjects factors indicate small quantitative differences in processing across the Experience groups, whereas the relative absence of interactions of between and within factors indicates few qualitative differences, except for the subprocess of proposition generation. Note that no other between-by-within interactions were significant, suggesting that high- and low-experience subjects were processing the texts in the same way, although the high-experience subjects were performing more accurately.

The Effects of Text-structure Variables on Accuracy of Interpreting

Syntactic processing. Text structure generally had strong effects on interpreting accuracy, independently of any interaction with Experience. Syntactic variables had a weak overall effect on interpreting, and there was a strong interaction of clause embedding (Mtx-NMtx) with Text (Table 5.2). There were more meaning-preserving responses for non-matrix (embedded) clauses for both texts, but fewer meaning-changing responses; the differences were larger for the narrative than for the procedure (Figure 5.3).

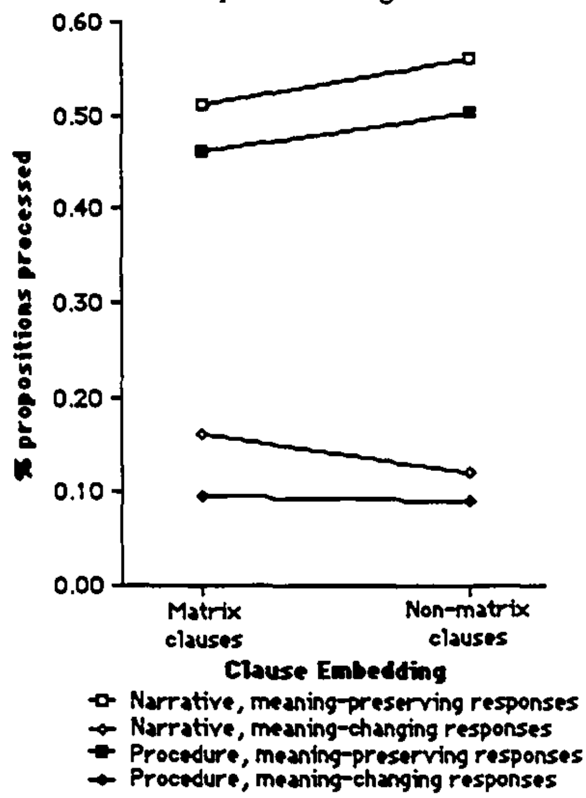


Figure 5.3 Interactions of Clause embedding, Text and Response type.

Table 5.2

Summary of Effects of Syntactic Processing Variables on Interpreting

	Contrast name	$F(1,12)$	p
Clause Density			
	Cls 3-2	7.6067	.0174
	Cls 2-1 x Text	8.2180	.0142
Clause Embedding			
	Mtx-NMtx x Text	17.1142	.0014
	Mtx-NMtx x Text x RT3-2	6.5773	.0248

Proposition generation. The variables indexing proposition generation had very strong effects on interpreting performance. Propositional density (Den) had very strong effects for both the contrast between medium- and low-density (DenMid-Lo) propositions and that between high- and medium-density (DenHi-Mid) propositions (Table 5.2). In general, meaning-preserving responses tended to decrease, and meaning-changing responses tended to increase, as proposition density increased (Figure 5.4). As well, there was generally a greater proportion of responses for the narrative than for the procedure (Figure 5.5). The clauses with lower propositional density (DenMid-Lo) interacted more strongly with the Response-type contrasts, whereas the clauses with higher propositional density (DenHi-Mid) interacted more strongly with Text (Table 5.3). The interaction with Response type is due to a large drop in meaning-preserving responses (paraphrase and verbatim) from low- to medium-density propositions (Figure 5.4).

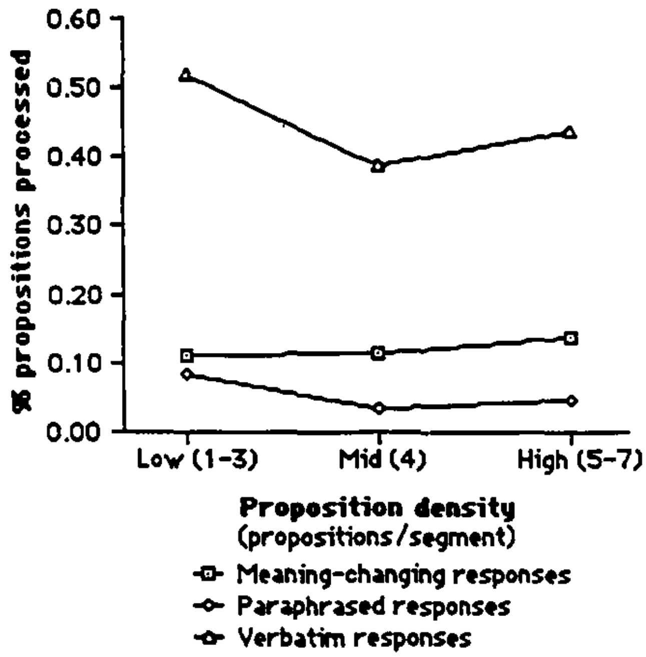


Figure 5.4 Interactions of Propositional density and Response type.

Table 5.3

Summary of Effects of Proposition Density on Interpreting

	Contrast name	$F(1,12)$	p
Proposition Density			
	DenMid-Lo	134.7180	.0001
	DenHi-Mid	11.7727	.0050
	DenMid-Lo x Text	12.6654	.0040
	DenHi-Mid x Text	67.7256	.0001
	DenMid-Lo x RT3-2	131.3964	.0001
	DenMid-Lo x RT2+3-1	104.9934	.0001
	DenHi-Mid x Text x RT3-2	37.7185	.0001
	DenHi-Mid x Text x RT2+3-1	52.6748	.0001

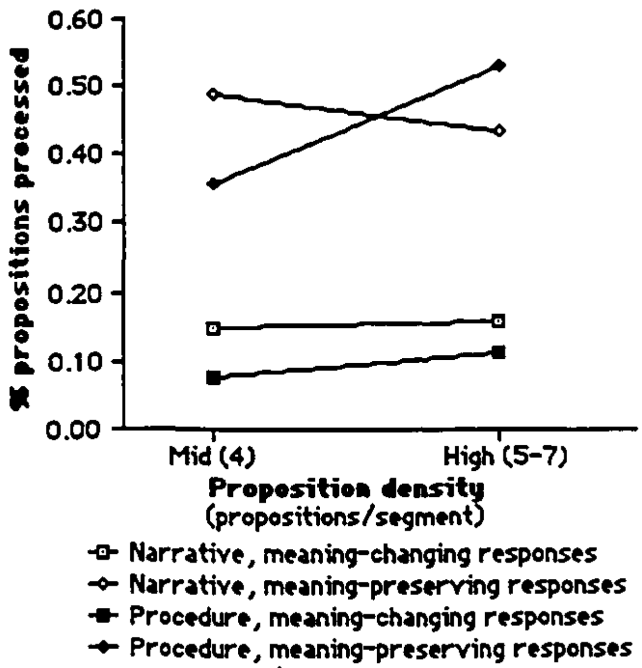


Figure 5.5 Interactions of Propositional density, Text and Response type.

The interaction with Text was due to a decrease in meaning-preserving responses from medium- to high-density propositions (DenHi-Mid) for the narrative, while meaning-preserving responses increased for the procedure (Figure 5.5).

Directness of mapping, that is, the root/non-root-proposition contrast within matrix clauses (RM2-1) vs. within embedded clauses (RM4-3 — Table 5.4), also had very strong effects on interpreting performance, as well as strong interactions with Text and the Response-type contrasts. In general, text differences were apparent for root (unembedded) propositions (RM1 and RM3) but tended to be neutralized in non-root propositions (RM2 and RM4), and there were more meaning-changing responses to the root propositions than to non-root (Figure 5.6). The strong interaction of Directness of mapping with Text and the Response-type contrast for inferential processing (RT2+3-1) was due to an increase in meaning-preserving responses to matrix clauses (RM2-1) for the procedure in contrast with a decrease for the narrative; the opposite pattern held for the non-matrix contrast (RM4-3). As well, meaning-changing responses did not differ greatly across text for the matrix contrast (RM2-1), but did differ for the non-matrix contrast (RM4-3 — Figure 5.6).

Table 5.4

Summary of Effects of Directness of Mapping on Interpreting

Contrast name	$F(1,12)$	p
Directness of Mapping		
RM2-1	184.7604	.0001
RM4-3	131.7132	.0001
RM2-1 x Text	244.9252	.0001
RM4-3 x Text	11.9140	.0048
RM2-1 x RT3-2	178.0147	.0001
RM4-3 x RT3-2	18.0132	.0012
RM2-1 x RT2+3-1	101.5333	.0001
RM2-1 x Text x RT2+3-1	7.9555	.0155
RM4-3 x Text x RT2+3-1	6.5147	.0254

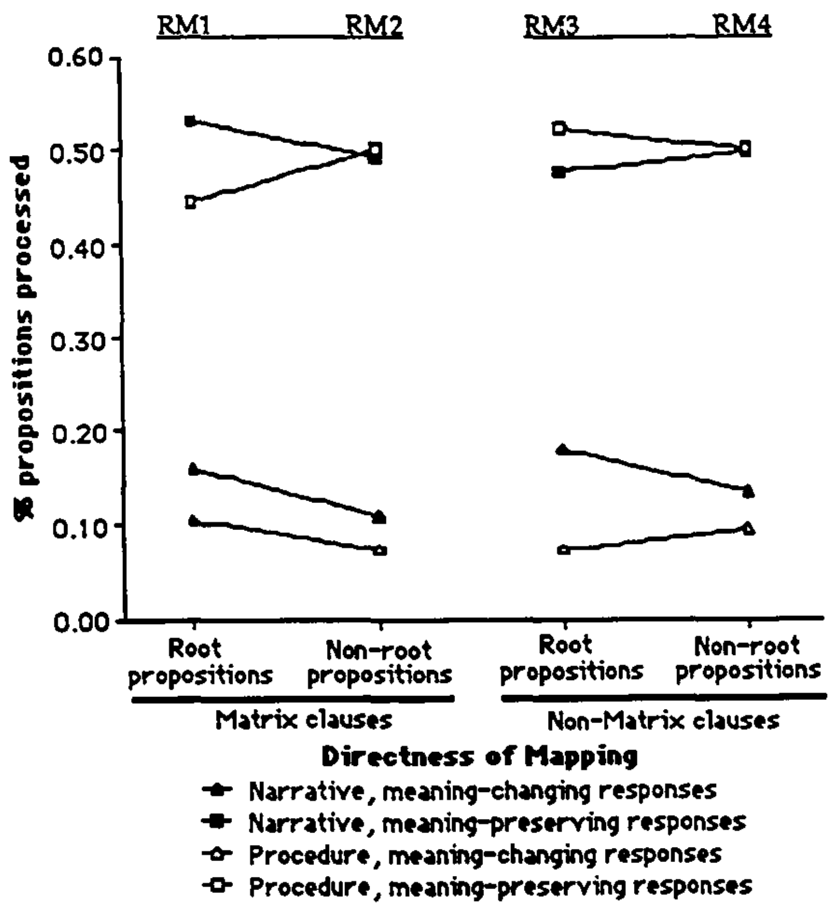


Figure 5.6 Interactions of Directness of Mapping, Text and Response type.

Frame Processing. The variables indexing frame processing varied in their effects on interpreting: the frame/non-frame variable (FNF) showed strong effects and the frame-component variable (Frco) showed weak ones (Table 5.5). The Frame/non-frame variable showed a very strong effect on the narrative, and interacted strongly with Response-type contrast (RT3-2). For the procedure, there were no main effects of frame/non-frame information and only a weak interaction of the Frame/non-frame variable with the Response-type RT2+3-1. In general, there were more meaning-changing responses for the narrative than the procedure, and more for frame propositions than non-frame. Meaning-preserving responses only differed for the narrative, in which there were more responses for the frame than for non-frame propositions (Figure 5.7).

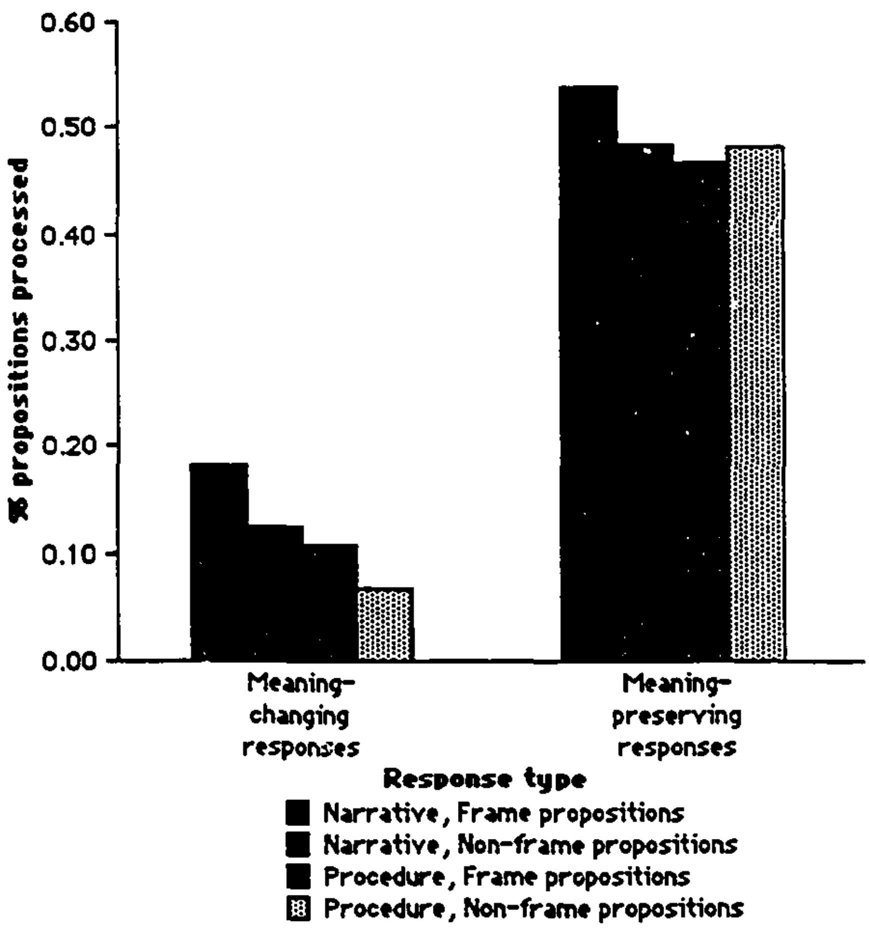


Figure 5.7 Interactions of Frame/non-frame information, Text and Response type.

Table 5.5

Summary of Effects of Frame Processing Variables on Interpreting

	Narrative		Procedure	
Contrast name	*F*(1,12)	*p*	*F*(1,12)	*p*
Frame/non-Frame Information				
FNF	66.7674	.0001	<1.0	ns
FNF x RT3-2	14.6537	.0025	<1.0	ns
FNF x RT2+3-1	<1.0	ns	6.9552	.0217
Frame Components				
Frco2-1	6.4072	.0264	5.3365	.0391
Frco2-1 x RT2+3-1	6.1986	.0285	6.5224	.0253

The frame-component contrasts (Frco2-1, Frco3-2) showed parallel weak effects involving meaning-preserving responses to the first two frame components, for both texts (Figure 5.8).

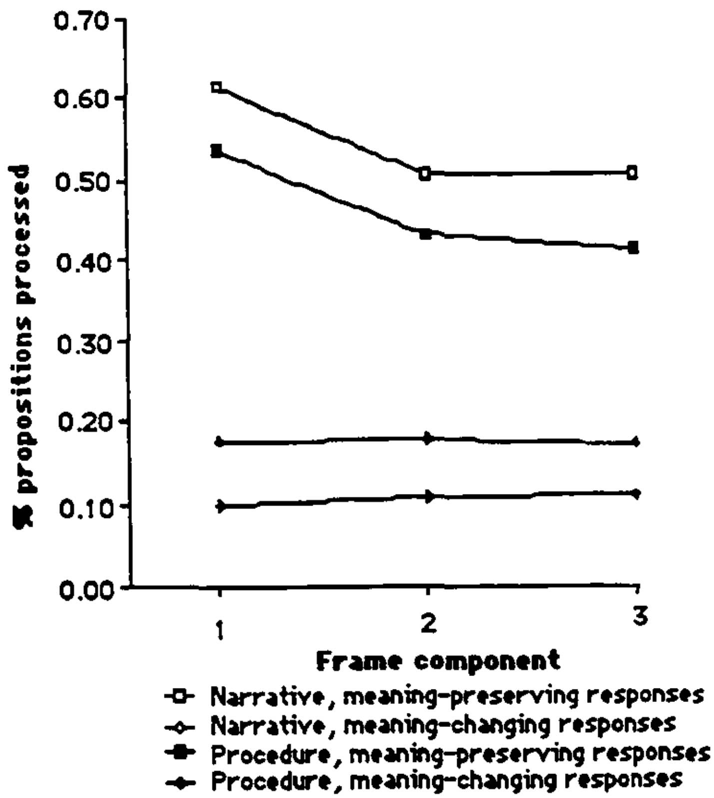


Figure 5.8 Interactions of Frame components and Response type, for both texts.

The Effects of Text Frame Type on Accuracy of Interpreting

The Text-Frame-type (*Text*) contrast had a very strong effect on accuracy of interpreting: the narrative was interpreted significantly more accurately than the procedure

(Figures 5.9 - 5.11). Moreover, for the interpreting data, Text Frame type had significant interactions with text-structure variables indexing processing at *all* levels (Table 5.6).

Table 5.6

Summary of Effects of Text Frame Type on Interpreting

	Contrast name	$F(1,12)$	p
	Text	40.6818	.0001
Clause density			
	Text x Cls 2-1	8.2180	.0142
Clause embedding			
	Text x Mtx-NMtx	17.1142	.0014
	Text x Mtx-NMtx x RT3-2	6.5773	.0248
Proposition density			
	Text x DenMid-Lo	12.6654	.0040
	Text x DenHi-Mid	67.7256	.0001
	Text x DenHi-Mid x RT3-2	37.7185	.0001
	Text x DenHi-Mid x RT2+3-1	52.6748	.0001
Directness of mapping			
	Text x RM2-1	244.9252	.0001
	Text x RM4-3	11.9140	.0048
	Text x RM2-1 x RT2+3-1	7.9555	.0155
	Text x RM4-3 x RT2+3-1	6.5147	.0254

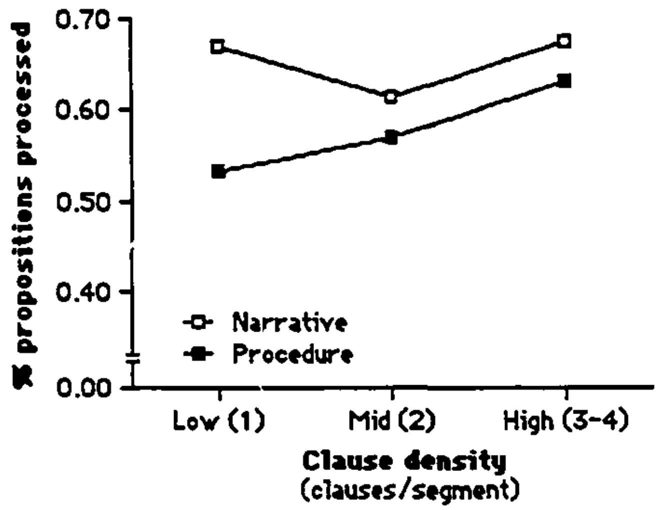


Figure 5.9 Interactions of Text and Clause density.

Figure 5.9 shows that the interaction of Text and Clause density is due to the difference in the processing of low-clause-density (Cls2-1) propositions: more low-density propositions were processed in the narrative than in the procedure.

Figure 5.10 indicates that the interaction of Text and Proposition density is due to the processing of mid-density propositions: considerably fewer responses were given to mid-density propositions in the procedure than in the narrative.

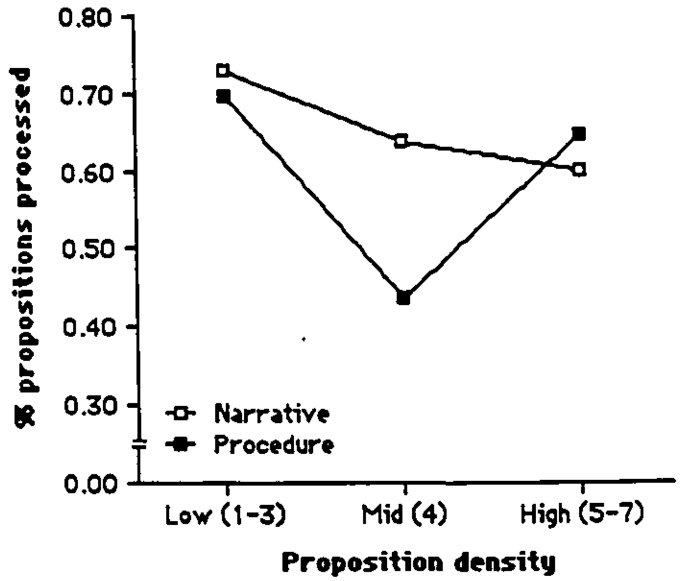


Figure 5.10 Interactions of Text and Proposition density.

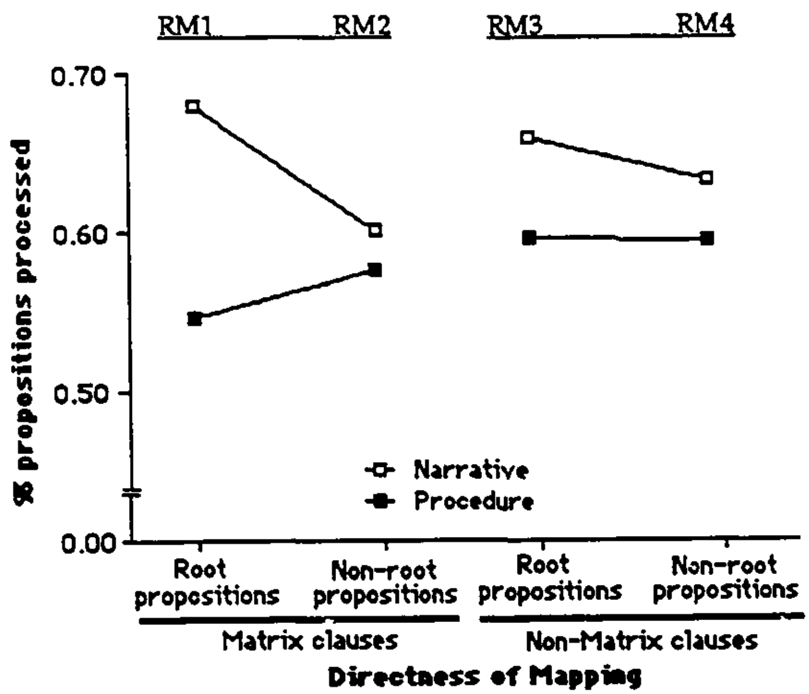


Figure 5.11 Interactions of Text and Directness of Mapping.

Figure 5.11 shows that the interaction of Text and Directness of Mapping was stronger for the matrix clauses than for non-matrix clauses and the direction of the effects was different for the narrative vs. the procedure. In general, the root/non-root distinction was more pronounced for the matrix clauses. For the narrative, more information was processed for the root propositions than for the non-root (embedded) propositions; for the procedure, the reverse was true.

Other effects of Text were plotted in Figures 5.1, 5.3 and 5.5.

The within-subjects effect of Text indicates general quantitative differences in processing due to Text Frame type. The interactions of Text and text-structure variables indicate that aspects of text structure were differentially important in the context of one frame type or the other. In particular, level of clause embedding was more important in the context of the narrative, proposition density was more important to the procedure, and directness of mapping made a bigger difference in processing the narrative. The frame/non-frame distinction was also more important for the narrative, and there was no difference between the texts for the frame components (Tables 5.2 - 5.5).

The Effects of Text Order on Accuracy of Interpreting

There were no effects found of Text Order on accuracy of interpreting.

The Effects of Experience on Recall after Interpreting

There was no main effect of Experience on recall. There were only two weak triple interactions of Experience with Clause density (Cls) and Response type (RT; Table 5.7).

Table 5.7

Summary of Effects of Experience on Recall after Interpreting

Contrast name	$F(1,18)$	p
Experience	<1.0	ns
Exp x Cls3-2 x RT3-2	6.4891	.0203
Exp x Cls3-2 x RT2+3-1	6.8964	.0172

Figure 5.12 summarizes graphically the effects of Experience on recall after interpreting, and some of its interactions. In general, high-experience subjects produced

slightly more responses than low-experience subjects, in particular producing more meaning-preserving responses for medium-density clauses.

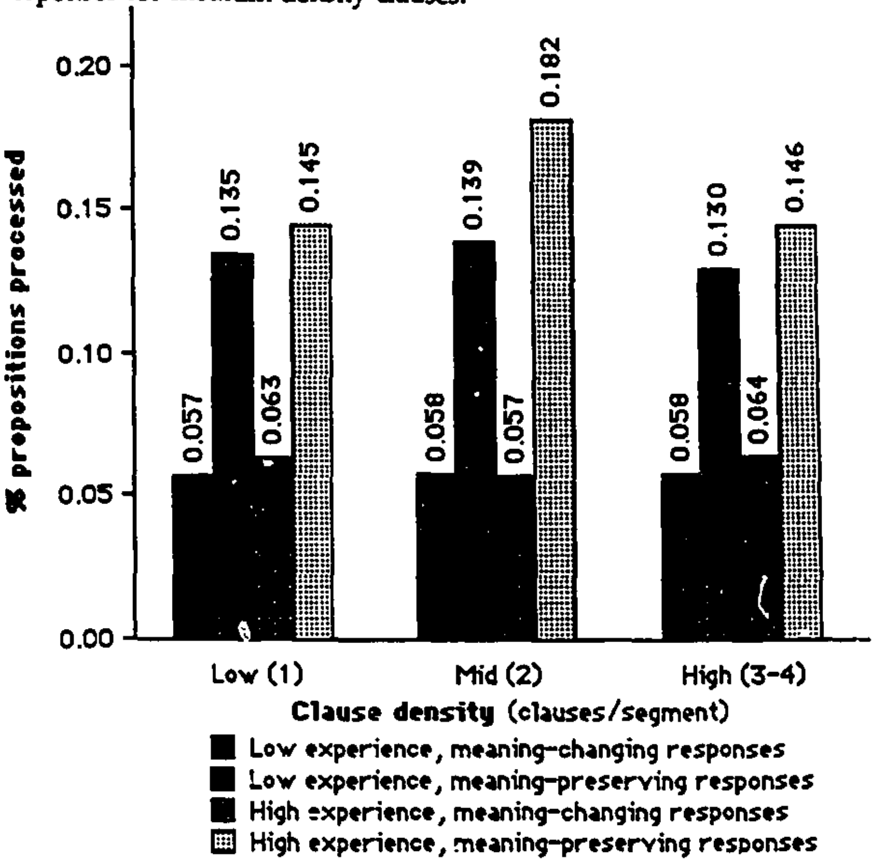


Figure 5.12 Interactions of Experience, Clause density and Response type.

The Effects of Experience and Text Order on Recall

There were only three weak interactions of Experience x Text Order: (a) with Response type (RT), (b) with Proposition density (Den), and (c) with Text by Clause density (Cls) by Response type (RT; Table 5.8).

Table 5.8

Summary of Effects of Experience x Text Order on Recall

Contrast name	$F(1,18)$	p
Exp x Ord	2.3213	ns
Exp x Ord x RT2+3-1	5.4438	.0315
Exp x Ord x DenHi-Mid	5.3034	.0335
Exp x Ord x Text x Cls2-1 x RT2+3-1	6.3153	.0218

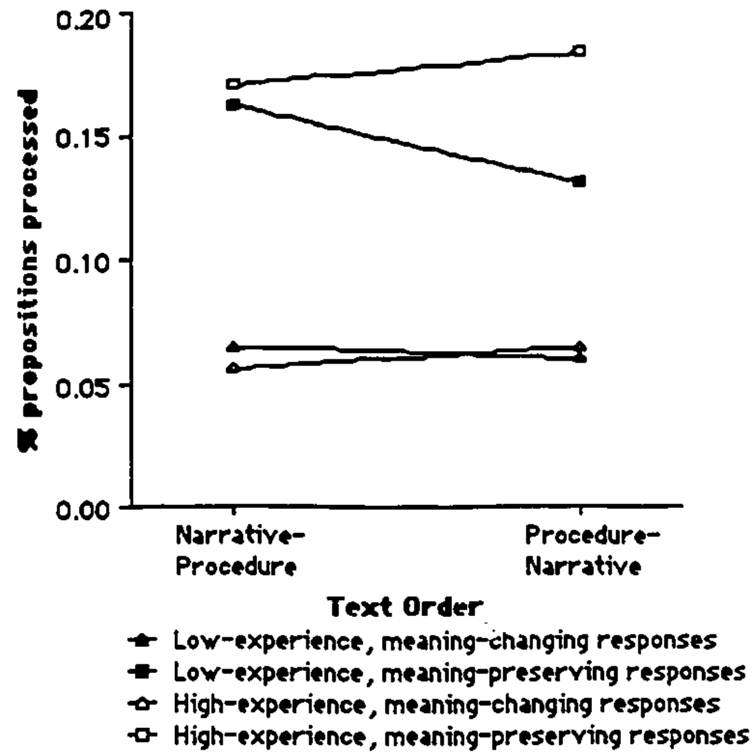


Figure 5.13 Interactions of Experience, Text Order and Response type.

Figure 5.13 shows the effects of Experience and Text Order on recall. In particular the low-experience subjects (black symbols) recalled more accurately if the narrative was first, whereas the high-experience subjects (white symbols) performed better when the procedure was first. A similar pattern held for meaning-changing responses. The fact that there was only one weak multiple interaction of Experience, Text Order, Text and other variables suggests that whether a text was presented first or second made little difference on recall.

Summary. The main effects of between-subjects factors showed weak quantitative differences in interpreting associated with Experience and no differences associated with Text Order: high-experience subjects interpreted more accurately. Moreover, there were no significant effects of Experience, and only weak effects of Experience by Text Order on recall. The pattern of weak or absent between-by-within effects involving Experience shows that there are few qualitative differences between novice and expert interpreters. The main effects of within-subjects variables showed a pattern of general processing that emphasized proposition generation and is common to all subjects. The fact that text-structure variables showed such strong main effects in the absence of between-by-within interactions provides evidence that no specialized processes are involved in interpreting expertise. Rather, expert interpreters appear to perform more accurately using the same processes as bilinguals who have no prior interpreting experience.

The relationship between listening and interpreting

The Effects of Task on Recall

There was no main effect of Task on recall, and the few interactions of Task and text-structure variables that occurred were relatively weak (Table 5.9). Most of these interactions involved Response type RT3-2; listeners recalled mid-clause-density propositions much more accurately than did interpreters (Figure 5.14). The only other significant interactions of Task were a weak one with directness of mapping (RM) and a strong one with Frame components (Frco; Table 5.9; Figure 5.15).

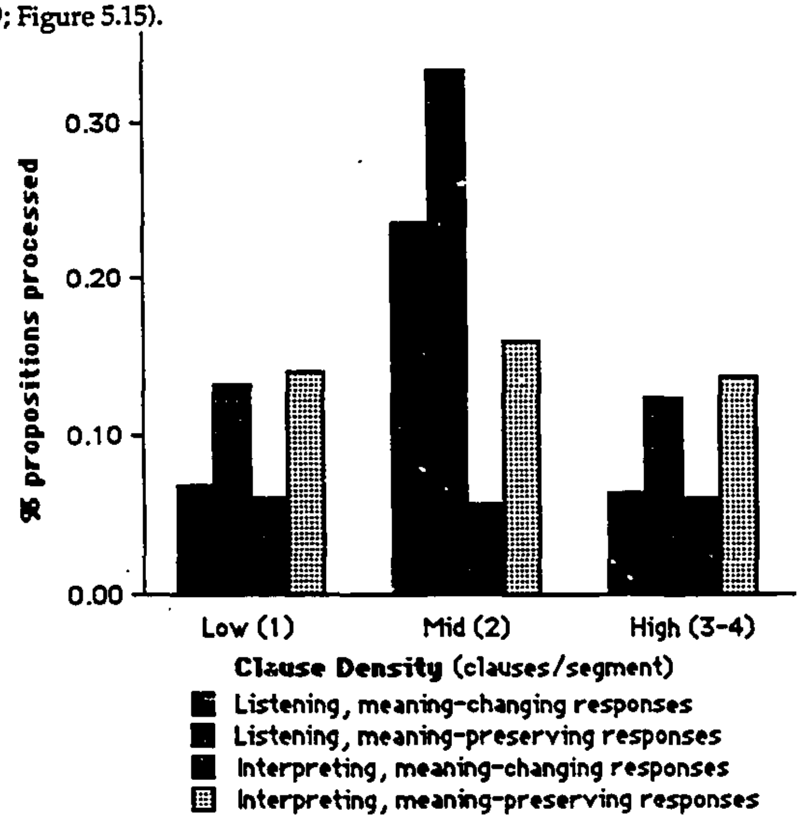


Figure 5.14 Interactions of Task, Clause density and Response type.

Table 5.9

Summary of Effects of Task on Recall

Contrast name	$F(1,18)$	p
Task	<1.0	ns
Task x Cls2-1	5.6519	.0288
Task x Cls2-1 x RT3-2	15.6339	.0010
Task x Cls3-2 x RT3-2	5.4852	.0309
Task x RM4-3 x Text x RT3-2	5.4951	.0308

	Narrative		Procedure	
Contrast name	$F(1,18)$	p	$F(1,18)$	p
Task x Frco3-2	8.8218	.0083	<1.0	ns

Figure 5.15 shows that listeners recalled the first episode better than interpreters, that there was little difference for the second episode, but that interpreters recalled the last episode better. That is, for the listeners processing decreased smoothly from the beginning to the end of the text, perhaps indicating decreasing interest in the task or texts. The interpreters, on the other hand, showed a relatively constant level of processing throughout the text, possibly due to the fact that interpreting requires more attention to the text.

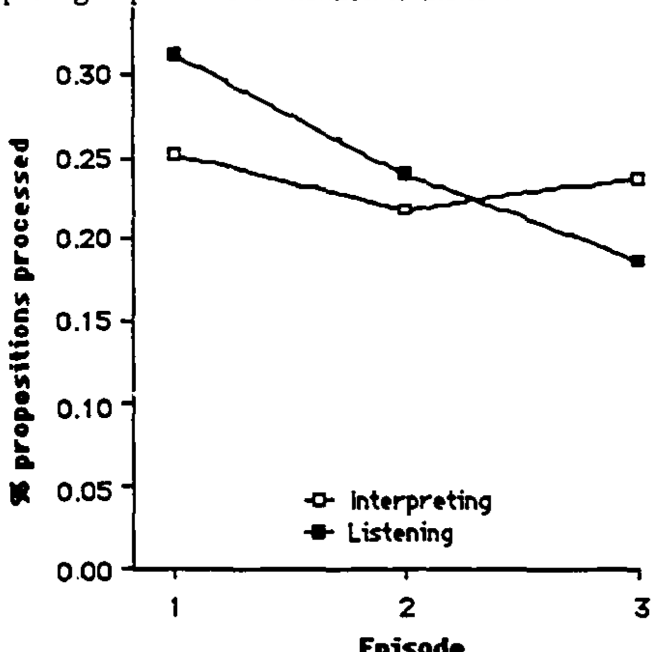


Figure 5.15 Interactions of Task and Frame components for the narrative text.

The Effects of Text-structure Variables on Recall

Syntactic processing. Text structure generally had strong effects on accuracy of recall, independently of Task or Experience. The syntactic variables (Clause density, Clause embedding) had weak effects in isolation, but Clause embedding (Mtx-NMtx) had strong interactions with Text and interacted with Response type, as well (Table 5.10).

Table 5.10

Summary of Effects of Syntactic Processing Variables on Recall

Contrast name	$F(1,18)$	p
Clause density		
Cls 3-2	4.6473	.0449
Cls2-1 x RT2+3-1	6.4881	.0203
Clause embedding		
Mtx-NMtx	5.9108	.0258
Mtx-NMtx x Text	63.2275	.0001
Mtx-NMtx x RT3-2	8.1596	.0105
Mtx-NMtx x RT2+3-1	8.1574	.0105
Mtx-NMtx x Text x RT3-2	20.5400	.0003
Mtx-NMtx x Text x RT2+3-1	9.2831	.0070

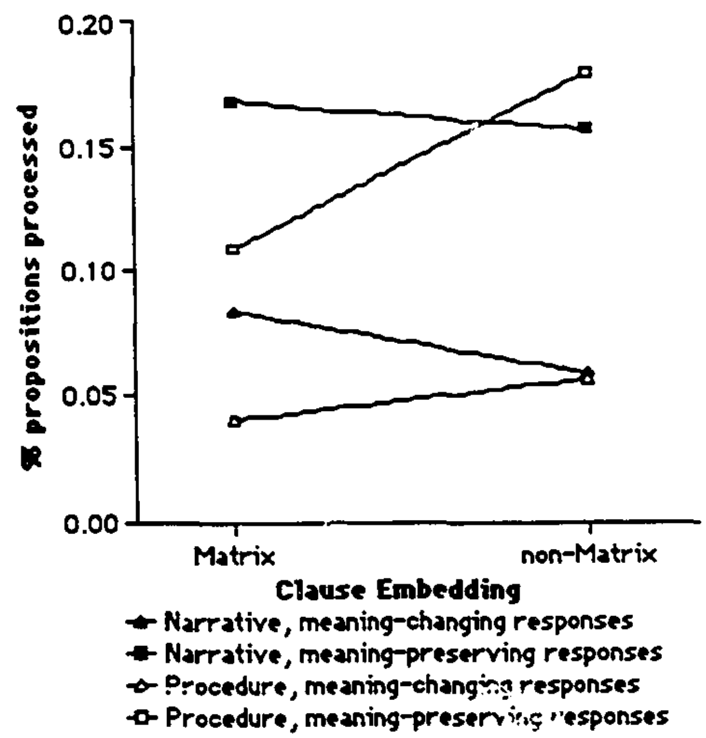


Figure 5.16 Interactions of Clause embedding, Text and Response type.

Figure 5.16 illustrates the effects of Clause embedding on recall. Text Frame type differences were much smaller for propositions found in non-matrix clauses. More matrix propositions were processed in the narrative, but more non-matrix propositions were reproduced for the procedure.

Proposition generation. The variables indexing proposition generation showed different patterns of effects on recall. The high-propositional-density contrast (DenHi-Mid) had a strong main effect on recall, and both density contrasts (DenMid-Lo, DenHi-Mid) interacted weakly with Text and Response type (Table 5.11).

Table 5.11

Summary of Effects of Proposition Density on Recall

Contrast name	$F(1,18)$	p
Proposition density		
DenHi-Mid	26.8859	.0001
DenMid-Lo x Text	7.9762	.0113
DenHi-Mid x RT3-2	7.0431	.0162
DenMid-Lo x Text x RT3-2	5.0509	.0374
DenHi-Mid x Text x RT3-2	8.2958	.0100
DenHi-Mid x Text x RT2+3-1	7.8006	.0121

In Figure 5.17, the general trend is an increase in responses with an increase in proposition density. There were, however, many more meaning-changing responses to the medium-density propositions of the narrative, and many fewer meaning-preserving responses (in particular verbatim responses) to the medium-density propositions of the procedure.

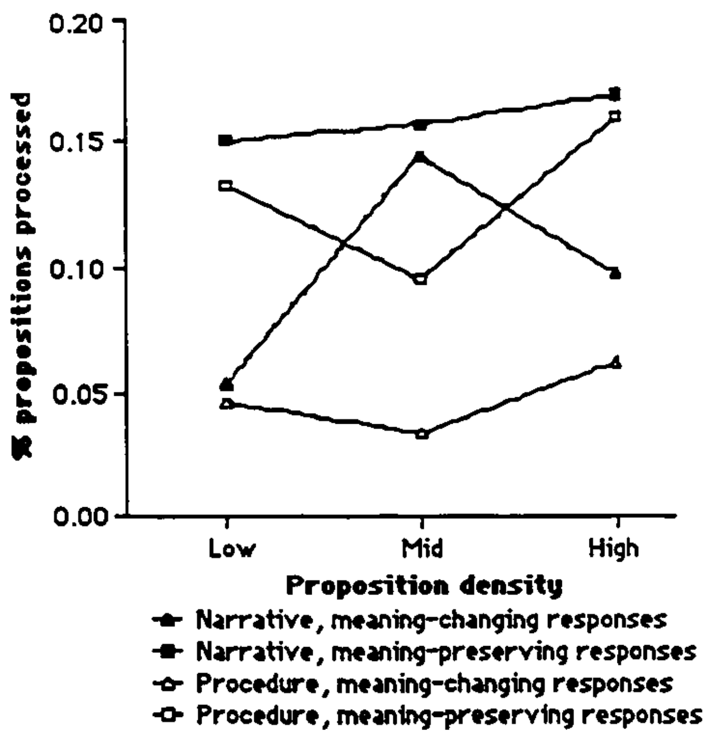


Figure 5.17 Interactions of Proposition density, Text and Response type.

Both directness-of-mapping contrasts (RM2-1, RM4-3) had very strong main effects and interactions with Text and Response type. The matrix-clause contrast (RM2-1) interacted very strongly with Text and both Response-type contrasts, while the non-matrix-clause contrast (RM4-3) interacted only with Response type RT3-2 (Table 5.12).

Table 5.12

Summary of Effects of Directness of Mapping on Recall

Contrast name	$F(1,18)$	p
Directness of mapping		
RM2-1	51.6010	.0001
RM4-3	53.2940	.0001
RM2-1 x Text	149.8441	.0001
RM2-1 x RT3-2	111.4727	.0001
RM4-3 x RT3-2	21.2191	.0003
RM2-1 x RT2+3-1	114.2087	.0001
RM4-3 x Text x RT2+3-1	5.4345	.0316

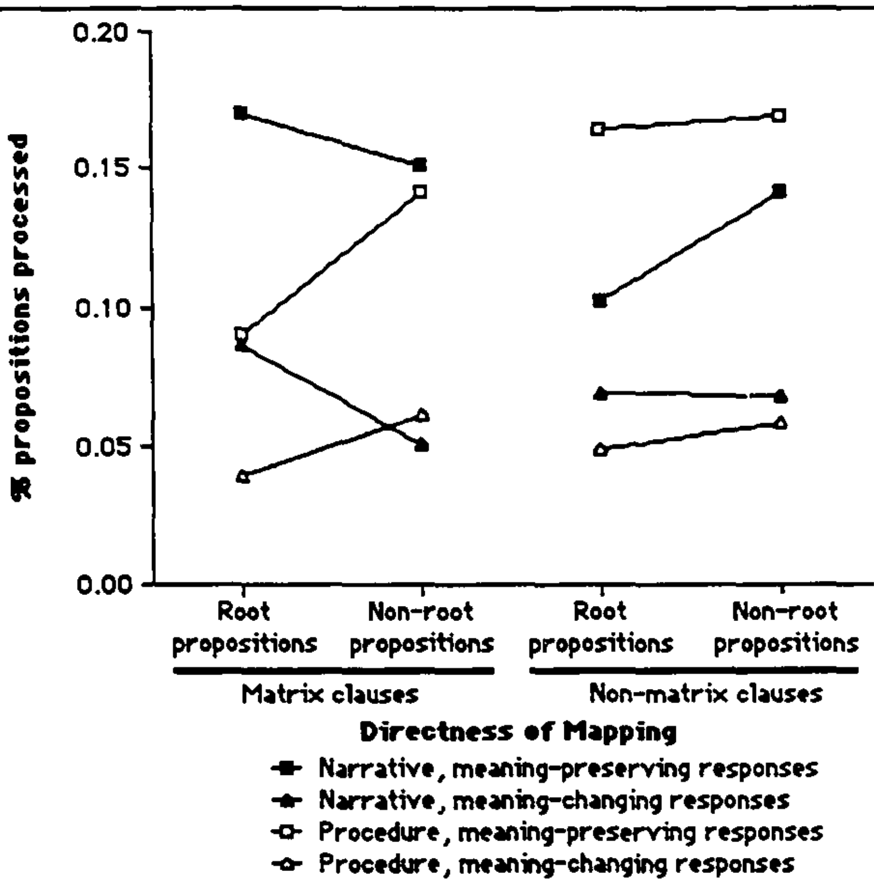


Figure 5.18 Interactions of Directness of Mapping, Text and Response type.

Figure 5.18 shows that there are few differences in the way meaning-changing inferences are distributed over matrix and non-matrix clauses. On the other hand, there were clear text differences and a Text by Directness of mapping interaction for the meaning-preserving responses: there were more meaning-preserving responses to matrix propositions in the narrative, but more responses to non-matrix propositions in the procedure. Similarly, in the narrative there were more responses to direct mappings (root/matrix (RM1) and non-root/non-matrix (RM4) propositions) than to indirect mappings, but in the procedure there were more responses to indirect mappings (root/non-matrix (RM2) and non-root/matrix (RM3) propositions).

Frame processing. The effects of frame-processing variables varied with Text Frame type. There were very strong effects of the frame/non-frame contrast (FNF) and its interactions with the Response-type contrasts, but only for recall of the Procedure. There were no such effects for the Narrative (Table 5.13).

Table 5.13

Summary of Effects of Frame Processing Variables on Recall

	Narrative		Procedure	
Contrast name	$F(1,18)$	p	$F(1,18)$	p
Frame/non-frame information				
FNF	<1.0	ns	30.3053	.0001
FNF x RT3-2	1.8717	ns	17.0788	.0007
FNF x RT2+3-1	4.0405	ns	8.6828	.0087
Frame components				
Frco3-2	<1.0	ns	22.5941	.0002
Frco2-1 x RT3-2	4.4443	.0493	4.9943	.0384
Frco3-2 x RT2+3-1	3.8633	ns	8.9477	.0079

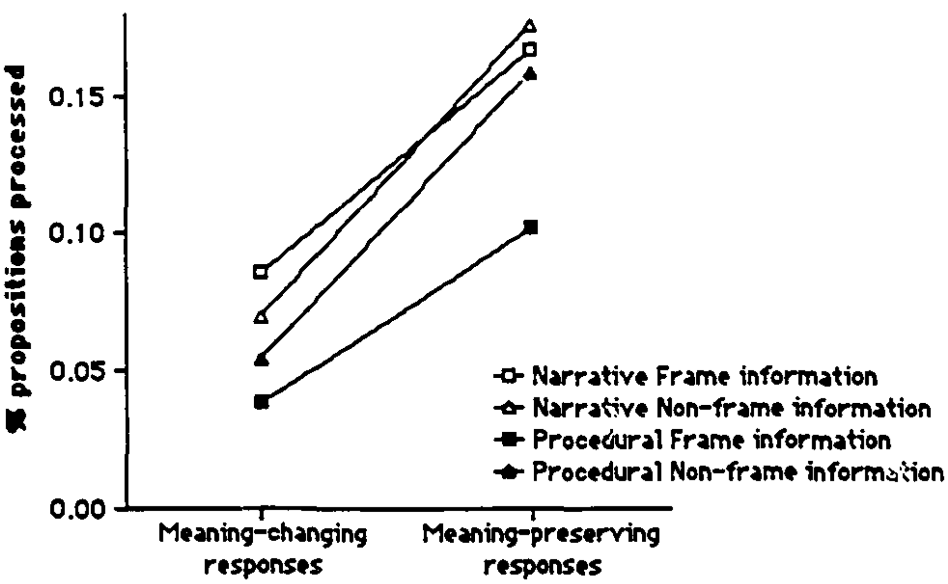


Figure 5.19 Interactions of Text, Frame/non-frame information and Response type.

In Figure 5.19 it is clear that text differences are greatest for frame information (square symbols), that is, for just the information that defines them as different text types. However, for the procedure more of the information that was classified as non-frame was recalled than the frame information, in particular for the meaning-preserving responses.

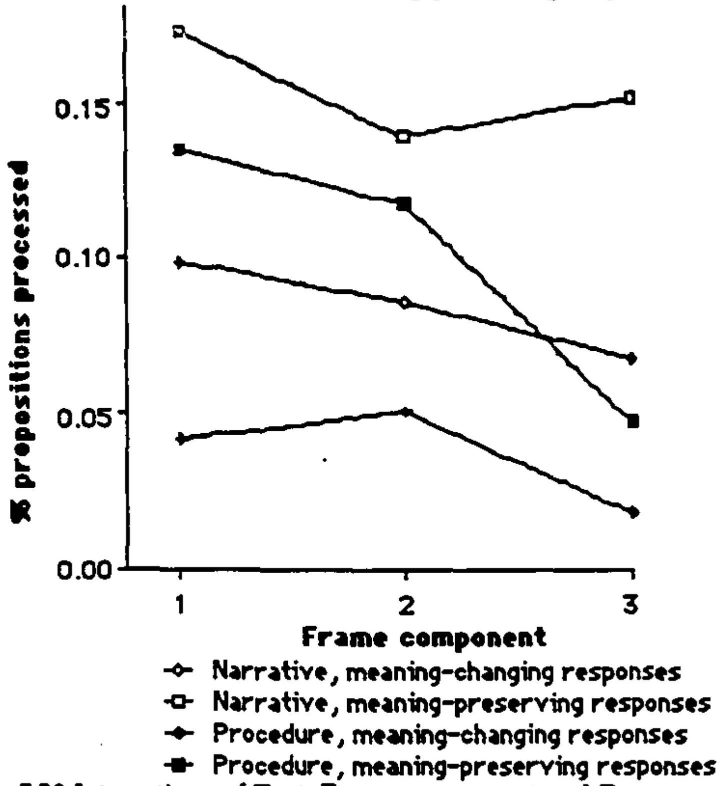


Figure 5.20 Interactions of Text, Frame component and Response type.

There were strong effects involving the contrast between the last two frame components for the Procedure, but again none for the Narrative (Figure 5.20; Table 5.13). Accuracy of recall dropped sharply from the second to the third subprocedure of the procedure, but increased from the second to the third episode of the narrative. Information processed in recall tends to drop from the frame components at the beginning of the text to those at the end; the only exception was that it increased again for the last episode of the narrative.

The Effects of Text Frame Type on Recall

Text Frame type (Text) exerted a very strong main effect on Recall: the narrative was recalled better than the procedure (Figure 5.21). It interacted strongly with clause embedding (Mtx-NMtx) and with the matrix-clause directness-of-mapping (RM2-1) contrasts. There were also interactions with proposition density (Den; Table 5.14).

Table 5.14

Summary of Effects of Text Frame Type on Recall

Contrast name	$F(1,18)$	p
Text	23.7780	.0002
Clause embedding		
Text x Mtx-NMtx	63.2275	.0001
Text x Mtx-NMtx x RT3-2	20.5400	.0003
Text x Mtx-NMtx x RT2+3-1	9.2831	.0070
Proposition density		
Text x DenMid-Lo	17.9762	.0113
Text x DenMid-Lo x RT3-2	5.0509	.0374
Text x DenHi-Mid x RT3-2	38.2958	.0100
Text x DenHi-Mid x RT2+3-1	57.8006	.0121
Directness of Mapping		
Text x RM2-1	149.8441	.0001
Text x RM4-3 x RT2+3-1	5.4345	.0316

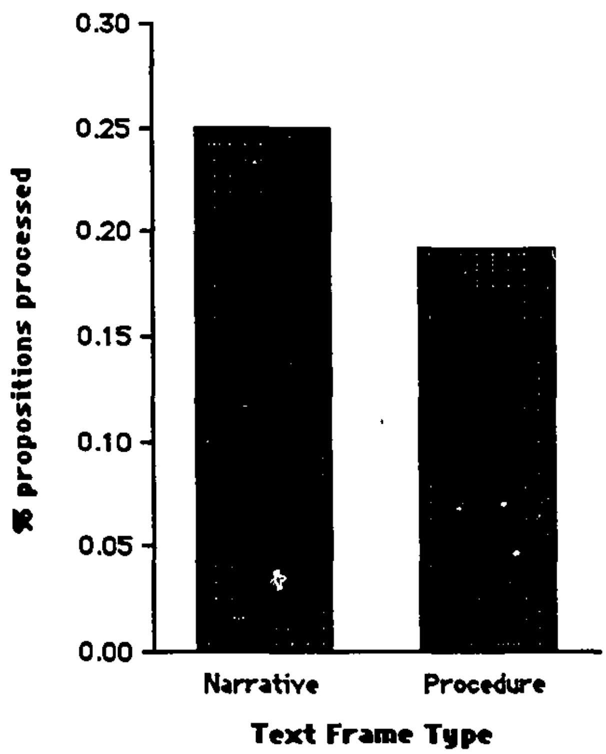


Figure 5.21 Propositions processed in recall, by Text Frame type.

Other effects of Text Frame type were plotted in Figures 5.16 to 5.20.

The Effects of Text Order on Recall

Text Order had no main effect on recall, but interacted with Text and the directness of mapping variables (RM2-1, RM4-3; Table 5.15).

Table 5.15

Summary of Effects of Text Order on Recall

Contrast name	$F(1,18)$	p
Ord x Text	7.3456	.0144
Ord x Text x RT3-2	9.0186	.0077
Ord x Text x RT2+3-1	7.6726	.0127
Ord x Text x RM4-3	8.5593	.0091
Ord x Text x RM2-1 x RT3-2	8.4992	.0093
Ord x Text x RM4-3 x RT3-2	11.0821	.0038
Ord x Text x RM2-1 x RT2+3-1	5.1066	.0365

Figure 5.22 shows that there is a very slight Text by Text Order effect for the meaning-changing responses, but a large difference for the meaning-preserving responses: recall of the narrative is better when it is after the procedure, and meaning-preserving responses to the procedure are more numerous when it comes after the narrative.

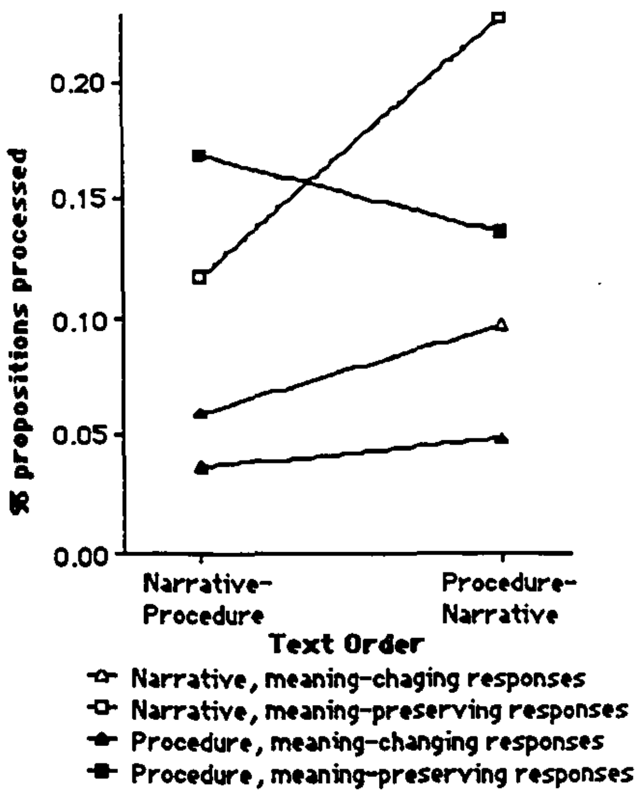


Figure 5.22 Interactions of Text order, Text and Response type.

The Effects of Tasl. by Text Order on Recall

Task interacted strongly with Text Order (Table 5.16): recall was more accurate for interpreters on the second text, but less accurate for listeners.

Table 5.16

Summary of effects of Task by Text Order

Contrast name	$F(1,18)$	p
Task x Ord	13.8896	.0016
Task x Ord x Text	4.5959	.0460
Task x Ord x RT3-2	15.0278	.0012
Task x Ord x RT2+3-1	8.0930	.0108
Task x Ord x Text x RT3-2	4.7928	.0420
Task x Ord x RM2-1 x Text	13.7940	.0016
Task x Ord x RM2-1 x RT3-2	11.6740	.0031
Task x Ord x RM4-3 x RT3-2	5.9080	.0258
Task x Ord x RM2-1 x RT2+3-1	8.5421	.0091

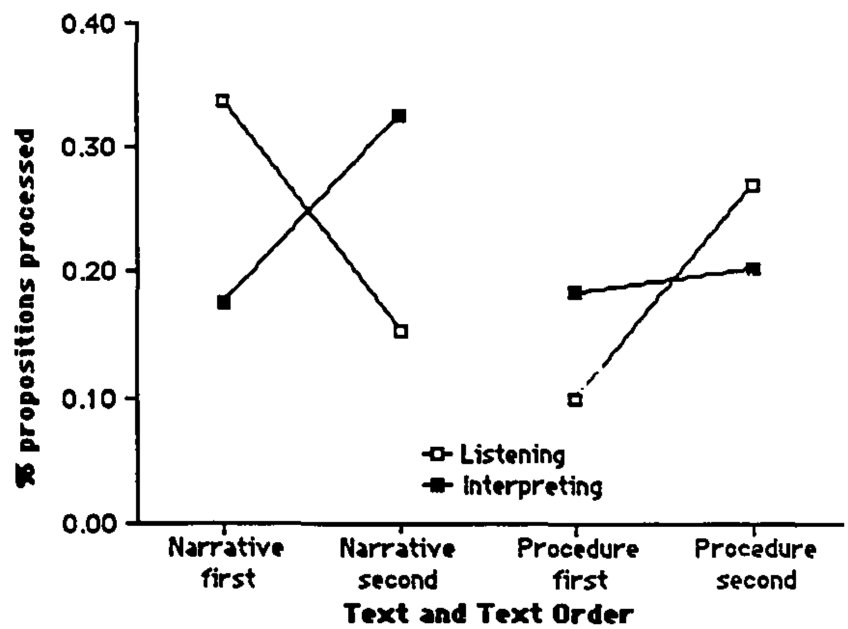


Figure 5.23 Interactions of Task, Text Order and Response type.

The Task by Text Order interactions are most apparent in Figure 5.23: in the second order, interpreters' performance improves, but listeners' performance improves only for the procedural text. The interactions with response type were due to a marked decrease in listeners' verbatim responses when the narrative appeared second. This anomaly, apparently due to waning in'·rest on the subjects' part, requires further investigation.

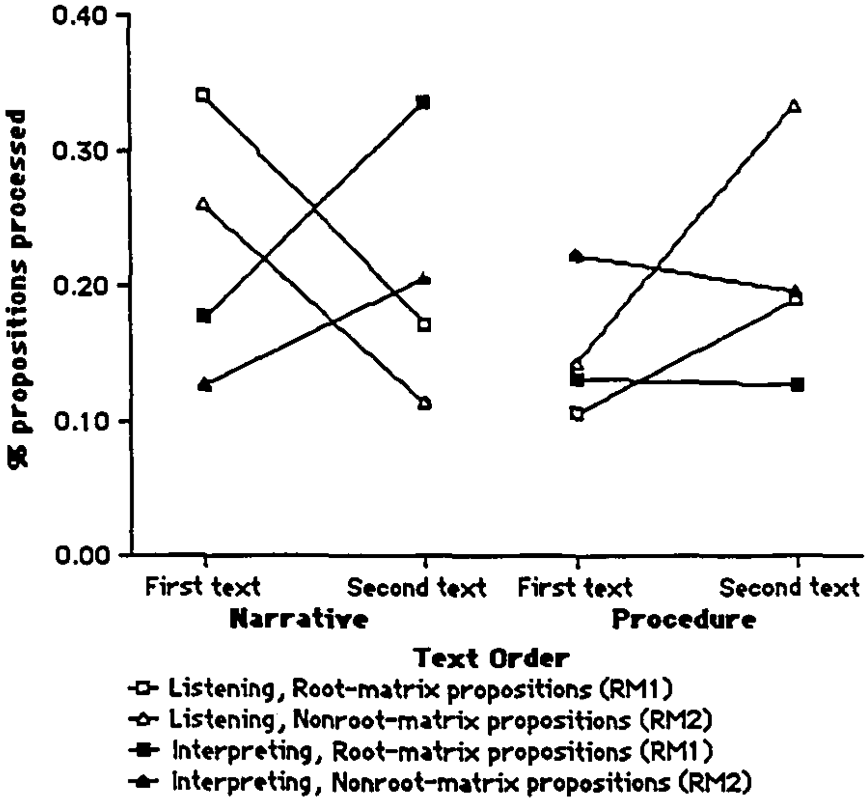


Figure 5.24 Interactions of Task, Text, Text Order and Directness of Mapping (RM2-1 contrast).

The Directness of mapping RM2-1 contrast (matrix clauses only) interacts with Text Order differently for each task (Figure 5.24): Order affected the RM2-1 contrast more on the narrative text for the interpreters (black symbols) and more on the procedure for listeners (white symbols), with the difference greater when the text was second. The interaction for the RM4-3 contrast is similar, but the difference between root and non-root propositions is less marked, and once again, the interactions with response type are due to variations in verbatim responses, so are not plotted.

Summary. There was no main effect of Task and few interactions of Task with text-structure variables on recall. There was no main effect of Text Order, but there were strong effects of the Task x Text Order interaction. The main effects of within-subjects variables showed a pattern of general processing that emphasized proposition generation. The absence of effects involving Task and the weak or absent between-by-within effects involving Task shows that there are few differences between listeners and interpreters in recall.

Chapter Six

Discussion

Although one of the most important characteristics of simultaneous interpreting is its extreme complexity, it is common to see the task carried out not only routinely but well. The present study was concerned, in most general terms, with how this is done. In particular, two aspects of this question were investigated: (a) what are the component processes that are specific to interpreting expertise? and (b) what are the similarities and differences between comprehension during interpreting and normal discourse comprehension?

Skill in simultaneous interpreting

The complexity of the interpreting task suggests that experienced interpreters have mastered a special set of abilities that are not characteristic of bilinguals in general. A principled account of the nature of that skill can be useful for improving the training and performance of interpreters, as well as providing theoretical insights about the nature of very complex discourse processes and their interactions. This general question about the nature of interpreting expertise was broken down into more specific questions about the extent and relative importance of syntactic processing, proposition generation, and frame-structure processing components of comprehension during interpreting.

The nature of interpreting skill was investigated by contrasting experienced interpreters and inexperienced bilinguals interpreting and recalling two texts on an unfamiliar topic. If interpreting expertise involves special processing, then both main effects of Experience and interactions of Experience with text-structure variables are to be expected for the interpreting data. If interpreting expertise diminishes the interference of simultaneous speaking and listening on recall, then similar effects are to be expected for the recall data.

Experience had a weak quantitative effect on interpreting overall, reflecting the fact that the experienced interpreters performed 16.6% more accurately than the inexperienced bilinguals in general (M = 57.6% and 41.0% of the text processed, respectively). There were few interactions of Experience with text-structure variables for the interpreting data, and no effects of Text Order or interactions of Text Order with text-structure variables. There were even fewer effects of Experience on recall: no main effect and only one interaction to speak of was found.

The only exceptions to this general pattern were a weak interaction of Experience with Directness of mapping in interpreting and another of Experience with Clause density in recall. Experienced interpreters were more selective in the on-line processing of non-root propositions in the matrix clauses of the procedure (see Figure 5.2). This suggests that the experienced subjects may have learned to be more selective in the surface information they will process semantically, as a function of the conceptual frame structure that is to be built with it. That is, the subprocess of proposition generation may be more closely tailored to the needs of subsequent frame processing for the experienced interpreters. Experienced interpreters were also more selective in processing mid-clause-density propositions in recall (see Figure 5.12), which may be because much of the relevant frame information for the procedure was found in embedded clauses.

It is possible that some of these results might be strengthened with the use of a larger sample. This, however, seems unlikely in view of the fact that the cross-group difference in experience was intentionally very large (3830 hours, or 8.5 years), and the variability of the subjects' performance overall was very small (for verbatim responses, standard deviations were 3.3% for high-experience and 4.4% for low-experience subjects). It is also likely that other results would have been stronger if the materials had been more variable. For example, Renaud (1989) found that reading times only began to increase substantially when proposition density exceeded 7 propositions/segment, whereas the proposition densities in the materials used here were all 7 or below. However, the present materials were purposely designed to have normal values, so as to reflect normal processing rather than entail special strategies than might be involved in understanding unusual texts.

The pattern of results found here is consistent with the view that experienced interpreters have not acquired any special set of abilities, rather that normal comprehension processes are more flexible than previously believed. This is supported in particular by the presence of main effects of Experience and text-structure variables in the absence of any interactions between them. Thus, although the experienced interpreters performed quantitatively better, there were no significant between-by-within interactions to signal qualitative differences between the groups. The parallel pattern of effects of Experience for the recall data corroborates this view and also shows that interpreting does not impair comprehension.

The view of interpreting as an application of general text-processing ability is also consistent with a view of bilingualism as an extension of the monolingual notion of *register*. Just as children and experts speak different sublanguages with their colleagues, superiors and juniors, so bilinguals speak even more differentiated language varieties with the people in the different social groups they belong to. Code-switching behavior among bilinguals also suggests that lexical items and sentence structures in different languages are seen as synonyms or near equivalents that are simply more appropriate in one context or another. All of this corroborates a view of bilingualism as a natural phenomenon, rather than a specialized skill.

Figure 6.1 depicts performance by experience group as a function of the text-structure variables assessed. The parallelism of the two lines reflects the absence of major group differences; the deviations from parallelism indicate the small differences in processing that were found. Note that experience-related differences only began to appear for the processing of the procedural frame information, and the only significant interaction of Experience was with the Directness of mapping variables. The generation of meaning-changing responses was more similar across groups than the generation of meaning-preserving responses, although the experienced interpreters still showed an advantage overall.

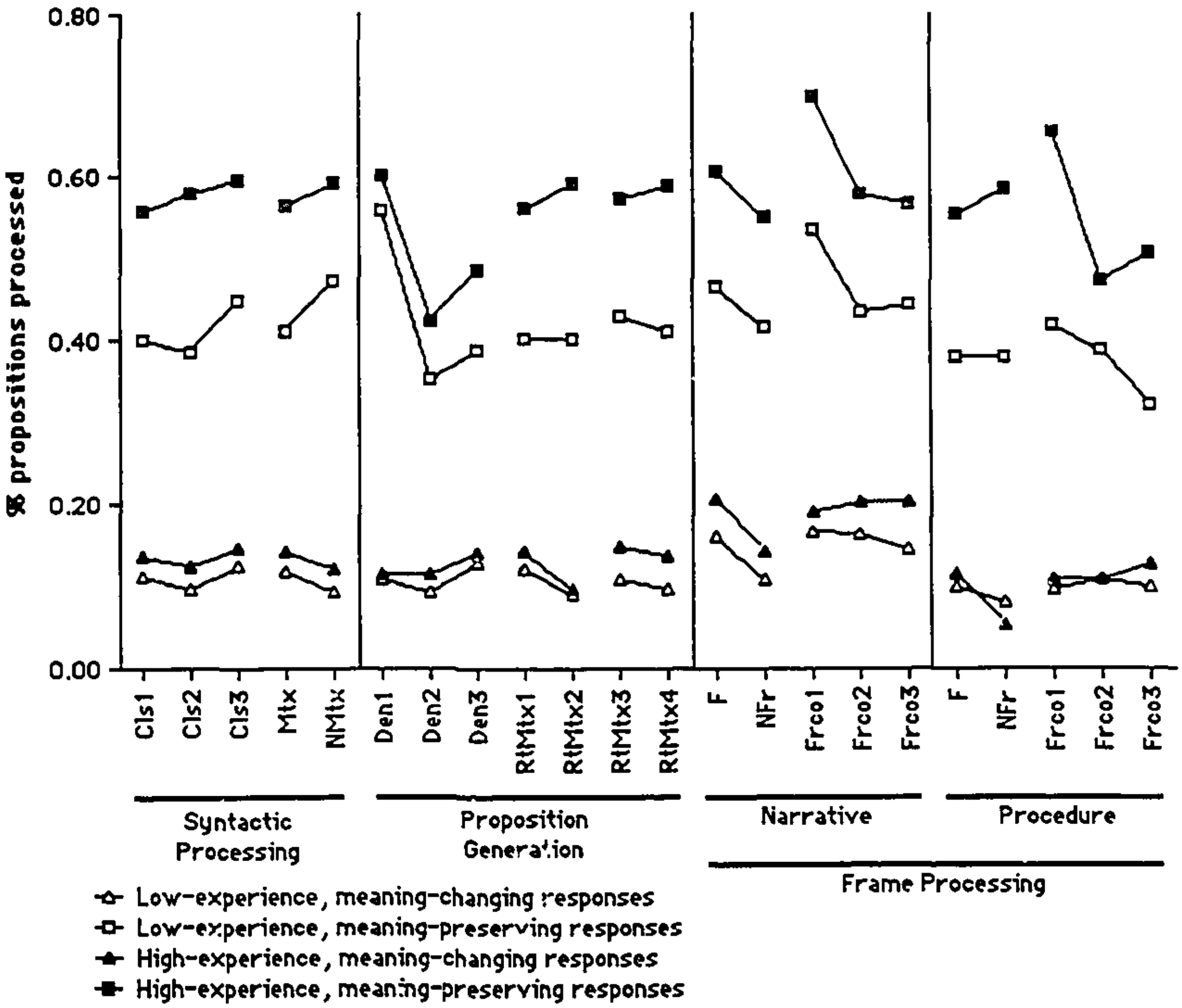


Figure 6.1 Interpreting performance (means) by Experience, Text-structure and Response-type variables.

Note that the results discussed here refer to the simultaneous interpreting of prepared texts in a conference setting, and may not be generalizable to interpreting more spontaneous dialogue or debates. Conversational text is different from the materials used here in that it is generally less explicit and less predictable, so its processing makes greater demands on prior knowledge and inference generation. Moreover, Frederiksen (1989a) argues that the processing of different text types is independent of general comprehension skill, so that it is possible that an interpreter may work well in the booth with the types of pre-prepared materials used here, but not perform so well with conversational dialogue, or vice versa.

Furthermore, it must be made clear that although there were very subtle differences in the comprehension processes used by experienced and inexperienced subjects, this does not mean that they may not be important. Many of the differences appeared in relation to the more difficult procedural text, and showed up under very specific conditions, which suggests that any special comprehension abilities of experienced interpreters may only appear clearly with more difficult materials or at faster rates of presentation. The variables indexing proposition generation interacted with Experience suggesting that the possible differences may bear on this poorly understood component of comprehension.

Perhaps even more importantly, it would be misleading to conclude that there are no differences at all between expert and novice interpreters: the main finding of this study bears on their *comprehension* processes only. Expert interpreters may differ from novices principally with respect to their *production* processes, which have not been studied here. It is possible that experienced interpreters will show more independence in their production; that is, the novices will tend to follow the surface features of the original, whereas the experts will produce target-language texts whose formal features are nearly independent of those of the original. The present study suggests precisely that this difference would not be due to problems in comprehension, but to differences in *production* ability.

Listening and interpreting

The relation between interpreting and listening was investigated by contrasting bilinguals with no experience interpreting who recalled two texts on an unfamiliar topic after either interpreting or listening to them. If interpreting interferes with comprehension, then both main effects of Task and interactions of Task with text-structure variables are to be expected.

An account of the relation between comprehension during interpreting and during listening specifies the nature of any task-specific interference with comprehension. Thus, it may be of use in training interpreters to circumvent this interference. Moreover, it can offer a principled basis for assessing the adequacy of simultaneous interpreting as a task environment for studying normal comprehension processes, in particular for evaluating the extent to which the qualitative on-line data obtained through interpreting is representative of listening as well. More specific questions about the relation between interpreting and listening were generated that addressed the differences in the extent and relative importance of syntactic processing, proposition generation, and frame-structure processing components of comprehension during interpreting as opposed to listening.

The results reviewed in the previous section support the view than there is no special set of abilities which constitute interpreting skill, rather it is characterized by the application of existing comprehension skills under different circumstances. This leads to the expectation that there will be few or no effects of task-dependent interference on recall.

There were, in fact, no main effects of Task or Text Order ($F < 1.0$, for both). In general, the listeners and interpreters recalled the texts just as accurately (M = 14.8% and 16.2%, respectively). The only exceptions to this general pattern were the weak interactions of Task with Clause density and with narrative frame components. Listeners responded more to mid-clause-density propositions than interpreters (see Figure 5.14), as in the interpreting data, again perhaps because much of the procedural information was found in embedded clauses.

The (low-experience) interpreters, on the other hand, responded more to the last episode of the narrative than the listeners (see Figure 5.15). This seems to be a consequence of the trend for sequential position to have a negative effect on the recall of listeners, but no effect on the recall of interpreters, in turn due to the fact that interpreting requires attention to the whole text, whereas listeners' attention seems to have waned as the text progressed. Note that the same arguments cited above with respect to the size of the sample used, apply to this set of analyses as well.

This pattern of results suggests that there was no task-dependent interference on comprehension and retention of the source texts. The absence of Task effects and interactions of Task with text-structure variables together with strong effects of the text-structure variables alone provide specific support for this. These results are consistent with the results of the first set of analyses and reinforce the view of interpreting as a natural skill with the same components as normal discourse comprehension and the same pattern of recall. Thus, these two sets of analyses provide converging evidence that interpreters and listeners are performing the same processes in similar ways.

Although the task comparison was made with low-experience subjects performing interpreting and listening, the results of the first set of analyses suggest that the similarities between listeners and low-experience interpreters will also hold of high-experience interpreters. This permits the conclusion that the similarities across tasks are not due to lack of experience with the interpreting task, but are general processing requirements of the tasks involved. It also suggests that the processes that listeners use are the same as those assessed for both high- and low-experience interpreters.

To summarize, rather than involving a special set of comprehension abilities, expertise in interpreting seems to be made up of the same component processes as listening comprehension. The nature of the profile of processing that characterizes comprehension under these circumstances is discussed below.

Discourse comprehension

The results of both sets of analyses reviewed above provide evidence that high-experience interpreters, low-experience interpreters and listeners are using the same text-comprehension processes and obtaining similar results. The very strong main effects of the text-structure variables for both the interpreting and the recall data thus provide further evidence in support of the view that interpreting expertise does not involve a special set of abilities. The results obtained here also provide evidence about the nature of the component processes of discourse comprehension, and are compared with the results of the Frederiksen and Renaud studies discussed above (Frederiksen & Renaud, 1987; Renaud, 1989) to further illustrate the similarities with comprehension under more usual conditions (i.e., reading).

Syntactic Processing

Clause density, or number of clauses per syntactic segment, had very little effect on either interpreting or recall. Renaud (1989) and Frederiksen & Renaud (1987) found the same result for reading times and recall measures of subjects reading a different procedural text. Since the range of density (1 to 4 clauses per segment) for Frederiksen and Renaud's materials as well as those used here was within the range for normal-to-simple texts, it is to be expected that it would cause subjects little difficulty. Indeed, the fact that clause density made so little difference suggests that syntactic processing of materials of this degree of complexity is highly automatized, and that specialized syntactic processing strategies are only brought to bear on much more complex sentence structures.

Clause embedding had a strong effect on both interpreting and recall, but only in interaction with text frame type. This suggests that the importance of clause embedding lies in its value to *signal* information that is important to the construction of one or another type of conceptual structure, rather than as input to autonomous syntactic processing (see Bracewell, et al., 1982; Frederiksen, et al., 1987). This interaction of syntactic and frame-semantic variables produced a strong effect on line in the interpreting task ($F(1,12)=17.1142$, $p\leq.0014$), suggesting that even under such complex task conditions high-level conceptual processes may be able to influence lower-level linguistic processing. Clause embedding also had a weak effect in isolation, but only on recall ($F(1,18)=5.9108$, $p\leq.0258$), which most likely reflects the much stronger Clause embedding by Text interaction.

In general, these results are consistent with a view in which processing of syntactic information may proceed in parallel with other levels of analysis, but also raises questions about the interactions among these processes. Future research might address the specific nature of the influence of text frame type on clause embedding by investigating different kinds of frames, frame information, frame components, and different levels of syntactic embedding.

Proposition generation

The variables indexing proposition generation were all strong predictors of interpreting and recall performance.

Proposition density, or number of propositions per syntactic segment, indexes the number of propositions that have to be generated for a particular syntactic unit. It had very strong effects on both interpreting and recall, both alone and in interaction with Text Frame type. In the Frederiksen and Renaud studies, proposition density also had very strong effects on reading time and recall, but their materials included denser segments than those used here. If the denser propositions were eliminated, then there would apparently be no effect on reading time, since most of the effect they found was localized in the contrast between the high-density segments, suggesting a threshold phenomenon.

The fact that there were strong effects of proposition density on the on-line measure (interpreting) here where there were none on the on-line measure in Renaud (1989) may be due to task-related differences in the relative importance of proposition generation vis-à-vis other component processes. In particular, the fact that Renaud was using an intentional-recall task, whereas recall in the present experiment was incidental, may have induced subjects to weight frame processing more heavily (hence proposition generation less) in reading than in interpreting.

The directness of mapping variable was used to index the interaction of topicalization and proposition generation, in particular the effects of mapping an embedded clause onto either a root (unembedded) or a non-root (embedded) proposition. This variable had very strong effects on both interpreting and recall, particularly in interaction with text frame type.

There were large text-dependent differences in processing root propositions, but almost none for the non-root propositions. In processing the narrative frame, root propositions in matrix clauses were reproduced more accurately than those in non-matrix clauses. For the procedure, exactly the opposite was the case. This is consistent with the rule-based approach to frame generation (Frederiksen, 1985) in which different frame grammars lead to selective processing of different text propositions.

Although this variable has not been studied before, the results show it to be an important predictor of performance and deserving of further study. As an index of the mapping from syntactic to semantic representations, it may be useful for the empirical testing of computational models of proposition generation. Future research clearly needs to address proposition generation in more detail, since there is very little information available about the process of mapping between syntactic representations and proposition-semantic ones. The present research might be extended to address the details of proposition generation by evaluating the effects of expressing different classes of propositions in different types of syntactic subtrees, or by the use of more detailed analyses of degrees and types of syntactic and propositional embedding.

Frame processing

Frame processing was indexed by using the distinction between frame and non-frame information as well as between the different frame components as predictors of interpreting and recall performance. Text differences were also indicative of differences in frame processing.

Text Frame type exerted strong effects on both interpreting and recall. In both cases, performance was better on the narrative than on the procedure. Since frame processing emphasizes the relations between the propositions that have been understood, and the time-order relations between the events in a narrative usually simply follow the order of presentation of the clauses in which they are found, the narrative frame should in fact be simple to process. Contrast this with the procedural frame which is structured around part-whole relations between propositions, that are not as explicitly signalled in the text and so must be inferred.

The frame/non-frame-information variable had strong effects only on the narrative in interpreting, but only for the procedure in recall. Similarly, in the Frederiksen and

Renaud studies, they found, for a different procedural text, a weak effect on reading time and a strong effect on recall. The non-frame propositions showed longer reading times, and in the procedure of the present study were interpreted more accurately. The frame propositions, however, were the basis of more inferences in both studies.

Frame components showed weak effects for both text frames in interpreting, but strong effects for the procedure in recall. In the Frederiksen and Renaud studies, on the other hand, there was a strong effect of the components of their procedure on reading times and on recall.

The weak effects of frame components on line suggest that subjects were interpreting the text as a sequence of events rather than organizing them into more complex structures. The strong effects on interpreting of the frame/non-frame variable for the narrative but not for the procedure provide further evidence for this hypothesis. The fact that the sequence of events in the text corresponds closely to the narrative frame structure but not to the procedure accounts for the different effects of the frame/non-frame variable. The much stronger frame-component effects in recall suggest that the inferential processes necessary for processing the procedural frame may demand more time or resources than are available on line.

These results on frame processing show that there are clear differences in difficulty of processing between the two text frame types. Processing of the narrative on line was apparently straightforward because of the correspondence between the order of presentation of the events and their structure in the narrative frame. The procedure was more difficult because its structure is not made as explicit in the text and therefore requires more time and resources than are available on line; in this case, it too was processed as a sequence of events.

A very important question to be addressed by future research is that of the nature of these differences, in particular of frame-constructing inference generation in real time. It is not clear, for example, whether the procedure could have been processed more efficiently on line if its structure was more explicitly signalled, or whether the conceptual complexity of the procedure is the limiting factor. In either case, the tradeoff between explicitness of signalling of frame structure and the conceptual complexity that can be processed well in real time needs to be characterized in detail.

The very strong interactions of Text Frame type, a high-level conceptual variable, with all of the other text-structure variables raises an important question with far-reaching theoretical consequences. Do these statistical interactions reflect interactions between component processes? An affirmative answer would not, however, be compatible with the strong modularity hypothesis assumed here. How, then, do the component processes of comprehension interact? Three possibilities come to mind:

(a) a *strong modular system* might allow higher-level frame generation or knowledge integration to exert general control over the *amount* of (or *weighting* of) processing done by other component processes, without violating Fodor's (1983) notion of *informational encapsulation*. Thus, as we have seen, processing a procedural frame may require or allow more syntactic analysis to recover the information in embedded clauses than a narrative which depends more on the information in matrix clauses. This approach, however, seems excessively restrictive: why should there not be any qualitative interactions among components, in particular if they can be executed in parallel?

(b) at the other extreme, a *strategic-interactive system* that proceeds heuristically — which is what van Dijk and Kintsch (1983) seem to propose — would apparently allow each component to influence or be influenced by the others. It is difficult to see, however, how such a model with a heavy emphasis on controlled processing could account for the complex and highly automatized processes that make up simultaneous interpreting, or to account for the application of general heuristics to the comprehension of a complex text about a new topic under interpreting conditions.

(c) a promising middle ground would be a *rule-based, algorithmic system* postulating structured interactions among component processes. Qualitative, informational exchange might be permitted among processes, but with the requirement that it be so structured and automatic that it would hardly be open to more than parametric conscious control, thus rather analogous to computer *firmware*. One scenario for such an approach is that the results of some computations which have been carried out before the analysis of a sequence *s* would be available for the analysis of that segment. In a production-rule system, this would be tantamount to allowing for mixed tests on the condition side of the rule. For example, "if the sequence is part of an embedded clause (syntactic test), and contains an event proposition (semantic test), then attach the proposition to the last node of the frame structure (frame-generating action)". The theoretical and empirical problem, then, is to uncover the principles by which the interactions are structured. This seems a more fruitful and directive stance for the study of discourse comprehension than to exclude the interaction of component processes a priori.

Weighting of component processes. The results of this study also suggest that the component comprehension processes had different relative importance in simultaneous interpreting, regardless of experience with the task. Since all of the tests of within-subjects variables were performed with the same degrees of freedom, the magnitude of the F value for the main effect can be used as an indicator of the relative importance of the variable tested. Figure 6.2 provides a profile of the relative importance of the component processes tested here. In general, syntactic processing was not weighted heavily in the interpreting task. Instead, semantic processing was more important, in particular the component of proposition generation. The frame information in the narrative was more salient than in the procedure, because the subjects were processing the text as a *chain* of events. A similar pattern was found for the F values of the recall data, and the pattern of Task effects shows that the weak effects of frame processing during interpreting are not indicative of curtailment of processing.

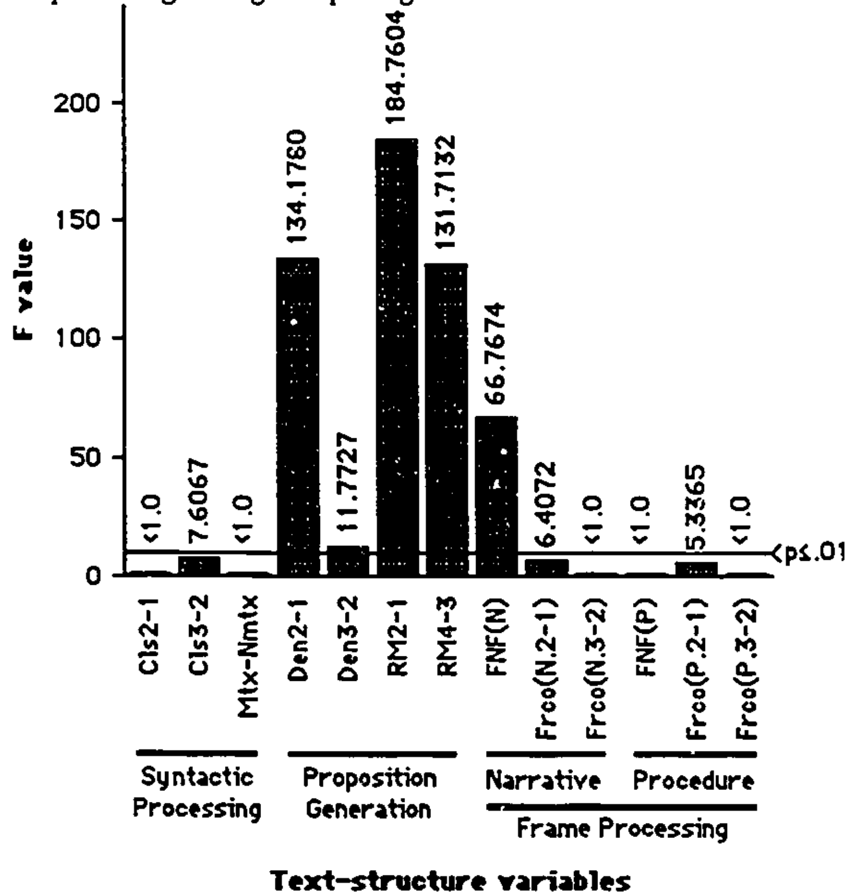


Figure 6.2 F values of main effects of Text-structure contrasts (Interpreting data).

Figure 6.2 can be seen to suggest that the effects of loading the interpreting task — by, for example, using degraded stimuli, making exceptional requirements of prior knowledge, or manipulating the characteristics of the intended audience — can be assessed quantitatively. This may be useful in investigating under what circumstances differences due to experience will appear.

Conclusion

The fact that simultaneous interpreting is possible at all provides evidence for the modularity and parallel execution of the component processes of discourse comprehension. The finding here that it is not a special, acquired skill, but an ability that seems to accompany bilingualism naturally, supports the view that this same modularity and parallelism are features of text processing generally.

The present study has provided evidence suggesting that:

(a) comprehension in interpreting is not a specialized ability, but the application of an existing skill under more unusual circumstances;

(b) interpreting does not systematically interfere with discourse comprehension; and

(c) comprehension in interpreting is characterized by all of the same component processes as listening — processing is not curtailed — with an emphasis on semantic processing, in particular proposition generation.

These findings, if substantiated by further research, will have some important practical and methodological consequences.

They provide principled, empirical support for the intuition current in interpreter training programs that selection is of the utmost importance. If interpreting skill is a function more of general text processing ability than of specific training, then selection is more important than coursework. In particular, if 8.5 years' experience only affords a 16% improvement in accuracy of interpreting, then how much of that is provided by formal training, and how much formal training is necessary? Indeed, this suggests that a program of training in simultaneous interpreting (assuming the necessary language skills) need be neither extensive nor complex.

These findings also suggest that interpreters' performance is limited by the same general parameters that limit text comprehension in general: the nature of the text itself and the prior knowledge that they can bring to bear on understanding it. If, in general, the main factor limiting the efficiency of communication is the difference between the knowledge of the comprehender and the knowledge presupposed by the text, then there are two ways to improve communication involving an interpreter: (a) the interpreter has to have the same knowledge as presupposed by the speaker, which suggests greater specialization of interpreters and the inclusion of specific domain knowledge in their training, and (b) the speaker/writer has to design the text so that the *interpreter*, rather than the speaker's equally knowledgeable peers, can understand it.

To the extent that the methods used here can be made into a practical procedure, the evaluation of the accuracy of interpreting performance can be made more objective and explicit. It is possible, however, that a qualitative analysis of the meaning-changing responses will provide a more interesting tool for evaluating text-processing proficiency; this, unfortunately, will have to await further theoretical and empirical developments in the study of the role and nature of inference in comprehension.

The pattern of results found here also has some specific and important methodological implications. They strongly suggest that simultaneous interpreting is similar enough to normal listening comprehension to serve as a model for the listening task. To the extent that this is the case, a wide variety of quantitative and qualitative information can be acquired using simultaneous interpreting as a task environment to study comprehension. In particular, better methods for analyzing additions and modification of the original text need to be developed to take advantage of the qualitative information made available with the task. In this way, a new tool for the study of the qualitative dimensions of comprehension processing on line will be made available.

References

Albert, M. & Obler, L. (1978). The bilingual brain. New York: Academic.

Allen, J. (1987). Natural language understanding. Menlo Park, CA: Benjamin Cummings.

Altman, G. & Steedman, M. (1988). Interaction with context during human sentence processing. Cognition, 30, 191-238.

Anderson, L. (1979). Simultaneous interpretation: Contextual and translation aspects. Unpublished Master's Thesis, Department of Psychology, Concordia University.

Barik, H. (1969). A study of simultaneous interpretation. Unpublished PhD thesis, Department of Psychology, University of Chapel Hill.

Barik, H. (1970). Some findings on simultaneous interpretation. In Proceedings of the 78th Annual Convention of the American Psychological Association, 5, Part 1, 11-12.

Barik, H. (1971). A description of various types of omissions, additions and errors of translation encountered in simultaneous interpretation. Meta,16 (4): 199-210.

Barik, H. (1972). Interpreters talk a lot, among other things. Babel, 18 (1): 3-10.

Barik, H. (1973). Simultaneous interpretation: temporal and quantitative data. Language and Speech, 16, 237-270.

Barik, H. (1974). A look at simultaneous interpretation. Working Papers in Bilingualism, no. 4. Toronto: Ontario Institute for Studies in Education.

Barik, H. (1975). Simultaneous interpretation: Qualitative and linguistic data. Language and Speech, 18 (3): 272-297.

Barik, H. (1976). Types of translation departures and other linguistic events occuring in simultaneous interpretation. ITL Review of Applied Linguistics, 33, 45-58.

Bracewell, R. J., Frederiksen, C., & Frederiksen, J. (1982). Cognitive processes in composing and comprehending discourse. Educational Psychologist, 17 (3): 146-164.

Bradley, D. & Forster, K. (1987). A reader's view of listening. Cognition, 25, 103-134.

Breuleux, A. (1987). Discourse and the investigation of cognitive skills in complex tasks. Technical Report #87.4, Laboratory of Applied Cognitive Science, McGill University.

Broadbent, D. (1952). Speaking and listening simultaneously. Journal of Experimental Psychology, 43, 267-273.

Carey, P. (1971). Verbal retention after shadowing and after listening. Perception & Psychophysics, 9 (1B): 79-83.

Chernov, G. (1969). Sinkhronnyi perevod: Rechevaya kompressiya — lingvisticheskaya problema [Linguistic problems of the compression of speech in simultaneous interpretation]. Tetradi Perevodchika, 6, 52-65.

Chernov, G. (1973). K postroeniyo psikholingvisticheskoi modeli sinkhronogo perevoda [Towards a psycholinguistic model of simultaneous translation]. Linguistische Arbeitsberichte (Leipzig), 7, 225-260.

Chernov, G. (1975). Kommunikativnaya situatsiya sinkhronogo perevoda i izibitochnost' koobshcheniya [Communicational situation of simultaneous interpretation and redundancy in a message]. Tetradi Perevodchika, 12, 225-260.

Chernov, G. (1977). Kumulative dynamische semantische Analyse des Eingangstexte beim Simultandolmetschen [Cumulative dynamic semantic analysis of introductory texts in simultaneous interpretation]. In O. Kade. (Ed.). Vermittelte Kommunikation, Sprachmittlung, Translation(pp. 93-104). Leipzig.

Chernov, G. (1978). Teoriya e praktika sinkhronnogo perevoda [Theory and practice of simultaneous interpretation]. Moscow: Mezhdunarodniye Otnosheniya.

Chernov, G. (1979). Semantic aspects of psycholinguistic research in simultaneous interpretation. Language and Speech, 22 (3): 277-295.

Chernov, G. (1985). Interpreting research in the Soviet Union: Results and prospects. In H. Bühler (Ed.). Xth World Congress of the FIT: Translators and their position in society (pp. 169-177). Vienna: Wilhelm Braumüller.

Cherry, C. (1953). Some experiments on the recognition of speech, with one and two ears. Journal of the Acoustical Society of America, 26, 975-979.

Cherry, C. & Taylor, W. (1954). Some further experiments on the recognition of speech, with one and two ears. Journal of the Acoustical Society of America, 26, 554-559.

Clark, H. (1977a). Bridging. In P. Johnson-Laird & P. Wason (Eds.), Thinking: Readings in cognitive science (pp. 411-420). Hillsdale, NJ: Earlbaum.

Clark, H. (1977b). Inferences in comprehension. In D. LaBerge & S. Samuuels (Eds.), Basic processes in reading: Perception and comprehension (pp. 243-263). Hillsdale, NJ: Earlbaum.

Clements, P. (1979). The effects of staging on recall from prose. In R. Freedle (Ed.), Advances in discourse processing, vol. 2. Norwood, NJ: Ablex.

Collins, A. & Loftus, E. (1975). A spreading activation theory of semantic processing. Psychological Review, 82: 407-428.

Craik, F. & Lockhart, R. (1972). Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 11, 671-684.

Danks, J. (1986). Identifying component processes in text comprehension: Comment on Haberlandt and Graesser. Journal of Experimental Psychology: General, 113, 193-197.

Danks, J. & Glucksberg, S. (1980). Experimental psycholinguistics. Annual review of Psychology, 31: 391-417.

Décary, M., Frederiksen, C., Hoover, M., Breuleux, A., Emond, B. & Senteni, A. (1987). CODA-X: An interactive environment for COgnitive Discourse Analysis on a XEROX 1186. Documentation Report, Laboratory for Applied Cognitive Science, McGill University.

Dillinger, M. (1987). Segmentation and clause analysis. Unpublished manuscript, Laboratory of Applied Cognitive Science, Department of Educational Psychology, McGill University.

Dillinger, M., Bracewell, R. & Fine, J. (1987). Cohesion as a guide to discourse processes. Unpublished manuscript, Laboratory of Applied Cognitive Science, Department of Educational Psychology, McGill University.

Ericsson, K. & Simon, H. (1984). Protocol Analysis: Verbal reports as data. Cambridge, MA: MIT Press.

Ferreira, F. & Clifton, C. (1986). The independence of syntactic processing. Journal of Memory and Language, 25, 348-368.

Finn, J. & Bock, R. (1985). Multivariance VII [Computer program]. Mooresville, IN: Scientific Software.

Flores d'Arcais, G. (1978). The contribution of cognitive psychology to the study of interpretation. In D. Gerver & W. Sinaiko, (Eds.) Language interpretation and communication (pp. 385-403). New York: Plenum Press.

Fodor, J. A. (1983). The modularity of mind. Cambridge, MA: MIT Press.

Fodor, J. A., Bever, T., & Garrett, M. (1974). The psychology of language. New York: McGraw Hill.

Fodor, J. D. & Frazier, L. (1980). Is the human sentence parsing mechanism an ATN? Cognition, 8, 417-459.

Fodor, J. D. (1988). On modularity in syntactic processing. Journal of Psycholinguistic Research, 17 (2).

Forster, K. (1979). Levels of processing and the structure of the language processor. In W. Cooper & E. Walker (Eds.), Sentence processing: Contemporary studies in psycholinguistics (pp. 27-85). Hillsdale, NJ: Erlbaum.

Foss, D. (1988). Experimental psycholinguistics. Annual Review of Psychology, 39: 301-348.

Foulke, E. & Sticht, T. (1969). Review of research in the intelligibility and comprehension of accelerated speech. Psychological Bulletin, 72 (1): 50-62.

Frauenfelder, U. & Tyler, L. (1987). The process of spoken word recognition: An introduction. Cognition, 25 (1-2): 1-20.

Frazier, L. (1987). Theories of sentence processing. In Garfield, J. (Ed.), Modularity in knowledge representation and natural-language understanding (pp.291-308). Cambridge, MA: MIT Press.

Frazier, L., Clifton, C., & Randall, J. (1983). Filling gaps: Decision principles and structure in sentence comprehension. Cognition, 13, 187-222.

Frederiksen, C. (1975). Representing logical and semantic structure of knowledge acquired from discourse. Cognitive Psychology, 7, 371-458.

Frederiksen, C. (1977). Structure and process in discourse production and comprehension. In M. A. Just & P. A. Carpenter (Eds.), Cognitive processes in comprehension (pp. 313-322). Hillsdale, NJ: Erlbaum.

Frederiksen, C. (1981). Inference in preschool children's conversations — A cognitive perspective. In J. Green & C. Wallat (Eds.), Ethnography and language in educational settings (pp. 303-350). Norwood, NJ: Ablex.

Frederiksen, C. (June, 1985). Comprehension of different types of text structure. Presented at Symposium on Text Processing, Canadian Psychological Association, Halifax, NS.

Frederiksen, C. (1986). Cognitive models and discourse analysis. In C. Cooper & S. Greenbaum (Eds.), Studying writing: Linguistic approaches (pp. 227-267). Beverly Hills, CA: Sage.

Frederiksen, C. (1989a). Text comprehension in functional task domains. In D. Bloom (Ed.), Learning to use literacy in educational settings. Norwood, NJ: Ablex.

Frederiksen, C. (June, 1989b). The representation of procedures: Acquisition and application of procedural knowledge. Presented at Colloque Internationale sur l'informatique Cognitive des Organisations, Québec, PQ.

Frederiksen, C., Bracewell, R., Breuleux, A., & Renaud, A. (1989). The cognitive representation and processing of dicourse: Function and dysfunction. In: Y. Joanette & H. Brownell (Eds.), Discourse ability and brain damage: Theoretical and empirical perspectives. New York: Springer-Verlag.

Frederiksen, C., Décary, M. & Hoover, M. (1988). The semantic representation and processing of natural language discourse: A computational model. Proceedings of the International Colloquium on Informatique et langue naturel, Nantes, France.

Frederiksen, C., Donin-Frederiksen, J. & Bracewell, R. (1987). Discourse analysis of children's text production. In A. Matsuhashi (Ed.), Writing in real time (pp. 254-290). Norwood, NJ: Ablex.

Frederiksen, C., Frederiksen, J., Humphrey, F. & Ottesen, J. (March, 1978). Discourse inference: Adapting to the inferential demands of school texts. Presented at the American Educational Research Association Meeting, Toronto, Canada.

Frederiksen, C. & Renaud, A. (July, 1987). On-line processing of text propositions: Linking reading time, on-line interpretation and recall. Presented at the joint meeting of the Canadian Psychological Association and the British Psychological Society, Oxford, UK.

Gardiner, J., Greg, V., & Hampton, J. (1988). Word frequency and generation effects. Journal of Experimental Psychology: Learning, Memory and Cognition, 14 (4): 687-693.

Garfield, J. (1987). Modularity in knowledge representation and natural-language understanding. Cambridge, MA: MIT Press.

Gernsbacher, M. (1984). Resolving 20 years of inconsistent interactions between lexical familiarity and orthography, concreteness, and polysemy. Journal of Experimental Psychology: General, 113, 256-281.

Gerver, D. (1971a). The effects of source language presentation rate on the performance of simultaneous conference interpreters. In E. Foulke. (Ed.). Proceedings of the second Louisville conference on rate- and/or frequency-controlled speech (pp. 162-184). Louisville, KY: University of Louisville.

Gerver, D. (1971b). Simultaneous interpretation and human information processing. Unpublished PhD thesis, Department of Psychology, Oxford University.

Gerver, D. (1972). Simultaneous and consecutive interpretation and human information processing. Social Science Research Council Report HR5661.

Gerver, D. (1974a). The effects of noise on the performance of simultaneous interpreters: Accuracy of performance. Acta Psychologica, 38, 159-167.

Gerver, D. (1974b). Simultaneous listening and speaking and retention of prose. Quarterly Journal of Experimental Psychology, 26, 337-341.

Gerver, D. (1975). A psychological approach to simultaneous interpretation. Meta, 20 (2): 119-128.

Gerver, D. (1976). Empirical studies of simultaneous interpretation: A review and a model. In R. Brislin (Ed.), Translation: Applications and research (pp. 165-207). New York: Gardner Press.

Gile, D. (1988). An overview of conference interpretation research and theory. In D. Hammond (Ed.), American Translators Association Conference 1988 (pp. 363-372). Medford, NJ: Learned Information, Inc.

Gofman, G. (1963). K istorii sinkhronogo perevoda [On the history of simultaneous interpretation]. Tetradi Perevodchika, 1, 20.

Goldman-Eisler, F. (1968). Psycholinguistics: Experiments in spontaneous speech. London: Academic Press.

Goldman-Eisler, F. (1972). Segmentation of input in simultaneous interpretation. Journal of Psycholinguistic Research, 1 (2): 127-140.

Goldman-Eisler, F. & Cohen, M. (1974). An experimental study of interference between receptive and productive processes relating to simultaneous translation. Language and Speech, 17, 1-10.

Gran, L. & Fabbro, F. (1987). Cerebral lateralization in simultaneous interpreting. In Proceedings of the American Translators' Association Conference 1987. Medford, NJ: Learned Information.

Greenwald, A., Klinger, M. & Liu, T. (1989). Unconscious processing of dichoptically masked words. Memory & Cognition, 17 (1): 35-47.

Grimes, J. (1975). The thread of discourse. The Hague: Mouton.

Halliday, M., & Hasan, R. (1976). Cohesion in English. London: Longman.

Hankamer, J. & Sag, I. (1976). Deep and surface anaphora. Linguistic Inquiry, 7, 391-426.

Harris, B. & Sherwood, B. (1978). Translating as an innate skill. In D. Gerver & H. Sinaiko. (Eds.). Language and interpretation and communication (pp. 155-170). New York: Plenum.

Hayes-Roth, B. (1977). Evolution of cognitive structures and processes. Psychological Review, 84 (3): 260-278.

Hebb, D. (1949). The organization of behavior. New York: Wiley.

Hebert, J. (1968). The interpreter's handbook. Geneva: Georg & Cia.

Henderson, J. (1982). Some psychological aspects of simultaneous interpreting. The Incorporated Linguist, 21 (4): 149-152.

Hendrix, G., Sacerdoti, E., Sagalowitcz, D. & Slocum, J. (1978). Developing a natural language interface to complex data. ACM Transactions - Database systems 3, 105-147.

Henry, R. & D. Henry. (1987). International Bibliography of Interpretation. [Second Edition] Sudbury, Ont: Laurentian University.

Hirst, G. (1987). Semantic interpretation and the resolution of ambiguity. New York: Cambridge University Press.

Holender, D. (1986). Semantic activation without conscious identification. Behavioral and Brain Sciences, 9 (1): 1-66.

Hoover, M., Deffner, G & Ericsson, K. (1989). Text comprehension studies through translation. Technical Report #89.1, Laboratory of Applied Cognitive Science, McGill University.

Hromasová, A. (1972). A study of memory in interpreting. In Acta Universitatis 17 Novembris Pragensis III (pp. 195-216). Prague: University of Prague.

Hurtig, R. (1978). The validity of clausal processing strategies at the discourse level. Discourse Processes, 1, 195-202.

Jackendoff, R. (1977). X′ Syntax: A study of phrase structure. Cambridge, MA: MIT Press.

Just, M. & Carpenter, P. (1980). A theory of reading: from eye fixations to comprehension. Psychological Review, 45, 329-354.

Kade, O. & Cartellieri, C. (1971). Some methodological aspects of simultaneous interpreting. Babel, 17 (2): 12-16.

Kintsch, W. & van Dijk, T. (1978). Towards a model of text comprehension and production. Psychological Review, 85, 363-394.

Kintsch, W. (1974). The representation of meaning in memory. Hillsdale, NJ: Earlbaum.

Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction-integration model. Psychological Review, 95 (2): 163-182.

Kopczyński, A. (1980). Conference interpreting: Some linguistic and communicative problems. Poznan, Poland: Uniwersytet Im. Adama Mickiewicza w Poznaniu.

Kraushaar, B. & Lambert, S. (1987). Shadowing proficiency according to ear of input and type of bilinguality. Bulletin of the Canadian Association of Applied Linguistics, 9 (1): 17-31.

Krušina, A. (1971). Hlavní složky podminující proces a kvalitu simultánního tlumočení [Main factors determining the process and quality of simultaneous interpretation]. In Acta Universitatis 17 Novembris Pragensis II (pp. 67-84). Prague: University of Prague.

Kubeš, M. (1989). The use of prior knowledge in integration of information from technical materials. Unpublished PhD thesis, Department of Educational Psychology, McGill University.

Kučera, H. & Francis, W. (1967). Computational Analysis of Present-day American English. Providence, RI: Brown University Press.

Lambert, S. (1983). Recognition and recall among conference interpreters. Unpublished PhD thesis, Department of Psychology, University of Stirling.

Lambert, S. (1989). Simultaneous interpreters: One ear may be better than two. Journal of the Canadian Association of Translators, in press.

Lawson, E. (1967). Attention and simultaneous translation. Language and Speech, 10, 29-35.

Le Ny, J-F. (1978). Psychosemantics and simultaneous interpretation. In D. Gerver & H. Sinaiko. (Eds.). Language and interpretation and communication (pp. 289-298). New York: Plenum.

Leahey, T. & Holtzman, R. (1979). Intention and attention in the recall of prose. Journal of General Psychology, 101 (2): 189-197.

Lederer, M. (1981). La traduction simultanée: Expérience et théorie. Paris: Minard.

Levelt, W. (1983). Monitoring and self-repair in speech. Cognition, 14: 41-104.

Levin, H. & Addis, A. (1979). The eye-voice span. Cambridge, MA: MIT Press.

Long, J. & Harding-Esch, E. (1978). Summary and recall of text in first and second languages: Some factors contributing to performance differences. In D. Gerver & H. Sinaiko (Eds.), Language interpretation and communication (pp. 273-287). New York: Plenum.

Longley, P. (1978). An integrated programme for training interpreters. In D. Gerver & H. Sinaiko (Eds.), Language interpretation and communication (pp. 45-56). New York: Plenum.

Mandler, J. & Johnson, N. (1977). Remembrance of things parsed: Story recall and structure. Cognitive Psychology, 9, 111-151.

Marshall, N. & Glock, M. (1978). Comprehension of connected discourse: A study into the relationships between structure of text and information recalled. Reading Research Quarterly, 14, 10-56.

Marslen-Wilson, W. & Tyler, L. (1980). The temporal structure of spoken language understanding. Cognition, 8: 1-71.

Marslen-Wilson, W. & Tyler, L. (1981). Central processes in speech understanding. Philosophical Transactions of the Royal Society of London, B 295, 317-332.

Marslen-Wilson, W. & Welsh, A. (1978). Processing interactions and lexical access during word recognition in continuous speech. Cognitive Psychology, 10 (1): 29-63.

Marslen-Wilson, W. (1987). Functional parallelism in spoken word-recognition. Cognition, 25 (1-2): 71-102.

Marslen-Wilson, W., Tyler, L. & Seidenberg, M. (1978). Sentence processing and the clause boundary. In W. Levelt & G. Flores d'Arcais (Eds.) Studies in the perception of language. New York: Wiley.

McClelland, J. & Elman, J. (1986). The trace model of speech perception. Cognitive Psychology, 18: 1-86.

McDonald, J. & Carpenter, P. (1981). Simultaneous translation: Idiom interpretation and parsing heuristics. Journal of Verbal Learning and Verbal Behavior, 20 (2): 231- 247.

Mel'čuk, I. (1984). Un nouveau type de dctionnaire: le Dictionnaire explicatif et combinatoire du français contemporain. In: Dictionnaire explicatif et combinatoire du français contemporain (pp. 3-16). Montréal: Presses de l'Université de Montréal.

Moray, N. & Taylor, W. (1959). The effect of redundancy in shadowing one of two dichotic messages. Language and Speech, 1, 102-109.

Moser, B. (1976). Simultaneous translation: Linguistic, psycholinguistic and human information processing aspects. Unpublished PhD thesis, Department of Psychology, University of Innsbruck.

Moser, B. (1978). Simultaneous interpretation: A hypothetical model and its practical applications. In D. Gerver & H. Sinaiko. (Eds.). Language interpretation and communication (pp. 353-368). New York: Plenum Press.

Nairne, J. & Widner, R. (1988). Familiarity and lexicality as determinants of the generation effect. Journal of Experimental Psychology: Learning, Memory and Cognition, 14 (4): 694-699.

Navon, D. & Gopher, D. (1979). On the economy of the human processing system. Psychological Review, 86, 214-255.

Navon, D. (1985). Attention division or attention sharing? In Posner, M. & Marin, O. (Eds.), Attention and Performance XI (pp. 133-146). Hillsdale, NJ: Earlbaum.

Nida, E. & Taber, C. (1969). The theory and practice of translation. Leiden: E.J. Brill.

Norman, D. (1976). Memory and Attention. New York: Wiley.

Oléron, P. & Nanpon, H. (1965). Recherches sur la traduction simultanée. Journal de Psychologie Normale et Pathologique (Paris), 62, 73-94.

Olson, G., Duffy, S., & Mack, R. (1984). Thinking-out-loud as a method for studying real-time comprehension processes. In D. Kieras & M. Just (Eds.), New methods in reading comprehension research. Hillsdale, NJ: Earlbaum.

Palmer, S. (1978). Fundamental aspects of cognitive representation. In E. Rosch (Ed.), Cognition and categorization (pp. 259-303). Hillsdale, NJ: Earlbaum.

Paneth, E. (1957). An investigation into conference interpreting (with special reference to the training of interpreters). Unpublished Master's thesis, Department of Translation, University of London.

Pinhas, R. (1968). Les retombées scientifiques des opérations 'Apollo' sur l'interprétation simultanée. La Linguistique, 8 (1): 143-147.

Pinter, I. (1968). Der Einfluss der Übung und Konzentration auf simultanes Sprechen und Hören [The influence of practice and concentration on simultaneous speaking and listening]. Unpublished PhD thesis, Department of Psychology, University of Vienna.

Plante, P. (1985). Déredec: Manuel de programmation, version 1.1. Montreal, SAPIA.

Radford, A. (1981). Transformational syntax. Cambridge, Cambridge University Press.

Ramón y Cajal, S. (1895). Histologie du système nerveux de l'homme et des vertébrés. Madrid: Instituto Ramón Cajal, 1952.

Renaud, A. & Frederiksen, C. (1988). On-line processing of a procedural text. In V. Patel (Ed.) Proceedings of the Tenth Annual Conference of the Cognitive Science Society. Hillsdale, NJ: Earlbaum.

Renaud, A. (1989). On-line study of component processes in reading comprehension. Unpublished MA thesis, McGill University, Montreal.

Riesbeck, C. & Schank, R. (1978). Comprehension by computer: Expectation-based analysis of sentences in context. In Levelt, W. & Flores d'Arcais, G. (Eds.), Studies in the perception of language. New York: J. Wiley.

Riesbeck, C. (1974). Computational understanding: Analysis of sentence and context. Unpublished PhD thesis, Department of Computer Science, Stanford University.

Riesbeck, C. (1975). Conceptual analysis. In R. Schank (Ed.), Conceptual information processing (pp. 83-156). Amsterdam: New Holland.

Ritchie, G. (1983). Semantics in parsing. In King, M. (Ed.), Parsing natural language (pp. 199-218). New York: Academic Press.

Romer, G. (1968). Eignige syntaktische Gesetzmaßigkeiten beim Simultandolmetschen. In Grudfragen der Übersetzungswissenschaft (pp. 65-72). Leipzig.

Roothaer, R. (1976). Een model voor simultane vertaling [A model of simultaneous interpretation]. Le Linguiste/De Taalkundige, 21 (1-2): 9-18.

Rumelhart, D. (1980). Schemata: The building blocks of cognition. In R. Spriro, B. Bruce & W. Brewer (Eds.), Theoretical issues in reading comprehension. Hillsdale, NJ: Lawrence Erlbaum.

Salter, D. (1973). Shadowing at one and two ears. Quarterly Journal of Experimental Psychology, 25 (4): 549-556.

Schank, R. (1973). Conceptual depenency: A theory of natural language understanding. Cognitive Psychology, 3, 552-631.

Schank, R. & Abelson, R. (1978). Scripts, Plans, Goals, and Understanding. Hillsdale, NJ: Erlbaum.

Schweda-Nicholson, N. (1987). Linguistic and extralinguistic aspects of simultaneous interpretation. Applied Linguistics, 8 (2): 194-205.

Seidenberg, M. & Tanenhaus, M. (1986). Modularity and lexical access. In I. Gopnik & M. Gopnik (Eds.), From models to modules (pp. 135-160). Norwood, NJ: Ablex.

Seidenberg, M. (1984). The time course of information activation and utilization in visual word recognition. Working Papers of the Cognitive Sciences Group. McGill University.

Seidenberg, M., Waters, G., Sanders, M. & Langer, P. (1984). Pre- and postlexical loci of contextual effects on word recognition. Memory & Cognition, 12 (4): 315-328.

Seleskovitch, D. & Lederer, M. (1984). Interpréter pour traduire. Paris: Didier Érudition.

Seleskovitch, D. (1968). L'interprète dans les conferences internationales. Paris: Minard.

Seleskovitch, D. (1976). Interpretation, a psychological approach to translating. In R. Brislin, (Ed.). Translation: Applications and research (pp. 92-116). New York: Gardner.

Seleskovitch, D. (1984). Les niveaux de traduction. In Seleskovitch, D. & Lederer, M. Interpréter pour traduire (pp. 124-135). Paris: Didier Érudition.

Sells, P. (1985). Lectures on contemporary syntactic theories. Stanford, CA: Center for the Study of Language and Information.

Sheryaev, A. (1979). Sinkhronniye perevod [Simultaneous interpreting]. Moscow: Voennoe Izdatel'stvo Ministerstva Oboroni CCCP.

Slamecka, N. & Graf, P. (1978). The generation effect: Delineation of a phenomenon. Journal of Experimental Psychology: Human Learning and Memory, 14: 592-604.

Small, S. (1983). Parsing as cooperative distributional inference: Understanding through memory interactions. In King, M. (Ed.), Parsing natural language (pp. 247-276). New York: Academic Press.

Souza, C. S. de. (1982). Fundamentos teóricos inicias para o ensino da língua-meta em programa de treinamento de intérpretes simultâneos. Unpublished M. LL. thesis, Departamento de Letras, Pontífica Universidade Católica de Rio de Janeiro.

Sowa, J. (1984). Conceptual structures: Information processes in mind and machine. Reading, MA: Addison-Wesley.

Stewart, D., Akamatsu, C. & Bonkowski, N. (1988). Factors influencing simultaneous communication behaviors in teachers. Journal of the Association of Canadian Educators of the Hearing Impaired (ACEHI), 14 (2): 43-58.

Suci, G. (1967). The validity of pause as an index of units in language. Journal of Verbal Learning and Verbal Behavior, 6, 26-32.

Swets, J. & Kristofferson, A. (1970). Attention. Annual Review of Psychology, 21, 339-366.

Tanenhaus, M., Carlson, G. & Seidenberg, M. (1986). Do listeners compute linguistic representations? In. D. Dowty, L. Kartunnen & A. Zwicky (Eds.), Natural language parsing: Psycholinguistic, theoretical and computational persipectives (pp. 359-408). Cambridge: Cambridge University Press.

Thiéry, C. (1985). La responsabilité de l'interprète de conférence professionel ou Pourquoi nous ne pouvons pas écrir nos memoires. Meta, 30 (1): 78-81.

Trabasso, T. & Nicholas, W. (1978). Memory and inferences in comprehending narratives. In J. Becker & F. Wilkins (Eds.), Information integration by children. Hillsdale, NJ: Earlbaum.

Trabasso, T. & Sperry, L. (1985). Causal relatedness and importance of story events. Journal of Memory and Language, 24, 595-611.

Trabasso, T. & van den Broek, P. (1985). Causal thinking and the representation of narrative events. Journal of Memory and Language, 24, 612-630.

Trabasso, T., Secco, T., & van den Broek, P. (1984). Causal cohesion and story coherence. In H. Mandl, N. Stein & T. Trabasso (Eds.), Learning and comprehension of texts (pp. 83-112). Hillsdale, NJ: Earlbaum.

Treisman, A. (1959). Contextual clues in selective listening. Quarterly Journal of Experimental Psychology, 11 (4): 242-248.

Treisman, A. (1964a). Monitoring and storage of irrelevant messages in selective attention. Journal of Verbal Learning and Verbal Behavior, 3, 449-459.

Treisman, Anne. (1964b). The effect of irrelevant material on the effeciency of selective listening. American Journal of Psychology, 77 (4): 533-546.

Treisman, A. (1965a). The effects of redundancy and familiarity on translating and repeating back a foreign and a native language. British Journal of Psychology, 56 (4): 369- 379.

Treisman, A. (1965b). Verbal cues, langauge and meaning in selective attention. American Journal of Psychology, 77 (2): 206-219.

Tsvilling, M. (1966). Sinkhronnyi perevod kak ob'yekt experimental'nogo issledovaniya [Simultaneous interpretation as an object of experimental investigation]. Tetradi Perevodchika, 3, 87.

Turner, A. (1987). The propositional analysis system, version 1.0. Technical Report nº 87-2, Institute of Cognitive Science, University of Colorado at Boulder.

Tyler, L. & Warren, P. (1987). Local and global structure in spoken language comprehension. Journal of Memory and Language, 26 (6): 638-657.

van Dijk, T. & Kintsch, W. (1983). Strategies of discourse comprehension. New York: Academic.

van Hoof, H. (1962). Théorie et pratique de l'interprétation, avec application particulière à l'anglais et au français. Munich: Max Hüber.

Walker, C. & Meyer, J. (1980). Integrating information from text: An evaluation of current theories. Review of Educational Research, 50 (3): 421-437.

Welford, A. (1968). The fundamentals of skill. London: Methuen.

Wilks, Y. (1975a). Preference semantics. In R. Keenan (Ed.), Formal semantics of natural language. Cambridge: Cambridge University Press.

Wilks, Y. (1975b). An intelligent analyzer and understander of English. Communications of the ACM, 18 (5): 264-274.

Winograd, T. (1972). Understanding natural language. Cognitive Psychology, 3: 1-191.

Winograd, T. (1983). Language as a cognitive process, vol. 1: Syntax. Reading, MA: Addison-Wesley.

Woods, W., Kaplan, R., & Nash-Webber, B. (1972). The lunar sciences language system: Final report. Technical Report 2378, Bolt, Beranek & Newman, Cambridge, MA.

Yantis, S. & Meyer, D. (1988). Dynamics of activation in semantic and episodic memory. Journal of Experimental Psychology: General, 117 (2): 130-147.

Appendix A
Analysis of Narrative Text

SEGMENT# 1
I have a friend named Alex who is a nuclear physicist,

CLAUSES:			DEC(EDQ-WHQ)			
PROPOSITIONS:						
1	1.Ø	*POSS*	PAT: I,OBJ: FRIEND(TOK NUM: SING) =TNS: PRES;			
2	1.1	EQUIV: *NAMED*	[FRIEND(TOK NUM: SING)],[ALEX];			
3	1.2	PHYSICIST (TOK NUM: SING)	CAT: WHO;			
4	1.3	PHYSICIST (TOK NUM: SING)	ATT: NUCLEAR;			
COHESION:						
	1.1	I	32 SRI	Ø	null	Ø
	1.2	who	22 Rp	1.Ø1	Alex	Ø

SEGMENT# 2
but he works in a public hospital instead of at some big university's reactor.

CLAUSES:			DEC			
PROPOSITIONS:						
5	2.Ø	WORK	PAT: HE=LOC: *IN*HOSPITAL(TOK NUM: SING), TNS: PRES;			
6	2.1	HOSPITAL (TOK NUM: SING)	ATT: PUBLIC;			
7	2.2		=LOC: *AT*REACTOR(TOK NUM: SING), NEG *INSTEAD OF*;			
8	2.3	UNIVERSITY (TOK *SOME*NUM: SING)	ATT: BIG;			
9	2.4	*POSS*	PAT: UNIVERSITY(TOK *SOME*NUM: SING), OBJ: REACTOR(TOK NUM: SING)=;			
1Ø	2.5	AND: *INSTEAD*	[2.Ø],[2.2];			
COHESION:						
	2.1	but	52 Cv	1.Ø2	prev. seg.	1
	2.2	he	22 Rp	1.2	who	1

SEGMENT* 3

He spends a lot of his time shooting protons at glucose and other things.

CLAUSES:			DEC(IAJT)			
PROPOSITIONS:						
11	3.Ø	SPEND	PAT:HE=PRT:3.1, TEM:*DUR*TIME(DEG:A LOT OF),TNS:PRES;			
12	3.1	SHOOT	OBJ:PROTON(TOK NUM:PL)=LOC:*DIR**AT* GLUCOSE,THING(TOK NUM:PL), ASPCT:CONT;			
13	3.2	THING (TOK NUM:PL)	ATT:OTHER;			
14	3.3	HIS	TEM:*DUR*TIME;			
COHESION:						
	3.1	he	22 Rp	2.2	he	1
	3.2	his	22 Rp	3.1	he	Ø
	3.3	and	51 Ca	3.Ø1	glucose	Ø
	3.4	other	23 Rc	3.Ø1	glucose	Ø

SEGMENT* 4

Alex makes several different isotopes with the old cyclotron which is in his lab,

CLAUSES:			DEC(WHQ)			
PROPOSITIONS:						
15	4.Ø	MAKE	AGT:ALEX,ISOTOPE(TOK NUM:SEVERAL), INST:*WITH*CYCLOTRON(DEF NUM:SING) =TNS:PRES;			
16	4.1	ISOTOPES (TOK NUM:SEVERAL)	ATT:DIFFERENT;			
17	4.2	CYCLOTRON (DEF NUM:SING)	ATT:OLD;			
18	4.3	WHICH	LOC:*IN*LAB(DEF NUM:SING);			
19	4.4	*POSS*	PAT:HIS,OBJ:LAB(DEF NUM:SING)=;			
COHESION:						
	4.1	Alex	61 L-root	1.Ø1	Alex	3
	4.2	which	22 Rp	4.Ø1	cyclotron	Ø
	4.3	his	22 Rp	4.1	Alex	Ø

SEGMENT* 5
and he often helps one of the computer programmers who works in the hospital's brain scanning center.

CLAUSES: EC(WHQ(IQ))

PROPOSITIONS:

20	5.Ø	HELP	PAT: HE, REC: ONE(TOK NUM: SING)=TEM: OFTEN;
21	5.1	COMPUTER PROGRAMMER CAT: ONE;	
22	5.2	WORK	PAT: WHO=LOC: *IN*CENTER(DEF NUM: SING), TNS: PRES;
23	5.3	CENTER(DEF NUM: SING) LOC: ;	
24	5.4	SCAN	OBJ: BRAIN(GEN)=LOC: ;
25	5.5	EQUIV: LOC:	[5.3], [5.4];
26	5.6	HOSPITAL (DEF NUM: SING)	PRT: CENTER(DEF NUM: SING)

COHESION:

5.1	and	51 Ca	4.Ø2	prev. seg.	1
5.2	he	22 Rp	4.3	his	1
5.3	who	22 Rp	5.Ø1	programmers	Ø
5.4	work	61 L-root	2.Ø1	work	3
5.5	the	21 Rd	2.Ø2	hospital	3
5.6	hospital	61 L-root	2.Ø2	hospital	3

SEGMENT* 6
Yesterday I visited Alex at the hospital.

CLAUSES: DEC

PROPOSITIONS:

27	6.Ø	VISIT	ACT: I, OBJ: ALEX=TEM: YESTERDAY, TNS: PAST, LOC: *AT*HOSPITAL(DEF NUM: SING);

COHESION:

6.1	I	22 Rp	1.1	I	5
6.2	Alex	61 L-root	4.1	Alex	2
6.3	the	21 Rd	5.6	hospital	1
6.4	hospital	61 L-root	5.6	hospital	1

SEGMENT* 7
When I found the right office,

CLAUSES: BAJT

PROPOSITIONS:

28	7.Ø	FIND	PAT: I, OBJ: OFFICE(DEF NUM: SING) =TEM: *WHEN*, TNS: PAST;
29	7.1	OFFICE (DEF NUM: SING)	ATT: RIGHT;

COHESION:

7.1	when	56 Ct2	Ø	null	Ø
7.2	I	22 Rp	6.1	I	1

SEGMENT* 8
it was already 10 o'clock.

CLAUSES:			DEC			
PROPOSITIONS:						
30	8.0	EQUIV: TEM:	[7.0], [10 O'CLOCK];			
31	8.1	ORD: TEM: *ALREADY*	[ ], [10 O'CLOCK];			
COHESION:						
	8.1	it	31 Exo	0	null	0

SEGMENT* 9
Alex was reading a collection of technical articles,

CLAUSES:			DEC			
PROPOSITIONS:						
32	9.0	READ	PAT: ALEX, OBJ: COLLECTION(TOK NUM: SING) ≡TNS: PAST, ASPCT: CONT;			
33	9.1	COLLECTION (TOK NUM: SING)	CAT: ARTICLE(TOK NUM: PL);			
34	9.2	ARTICLE (TOK NUM: PL)	ATT: TECHNICAL;			
COHESION:						
	9.1	Alex	61 L-root	6.2	Alex	3

SEGMENT* 10
but he put his book on a nearby shelf

CLAUSES:			DEC			
PROPOSITIONS:						
35	10.0	PUT	AGT: HE, OBJ: BOOK(DEF NUM: SING), RSLT: 10.1 ≡TEM: , TNS: PAST;			
36	10.1	BOOK (DEF NUM: SING)	LOC: *ON*SHELF(TOK NUM: SING);			
37	10.2	*POSS*	PAT: HIS, OBJ: BOOK≡;			
38	10.3	PROX: LOC: *NEARBY*	[SHELF], [ ];			
COHESION:						
	10.1	but	51 Cv	9.01	prev. seg.	1
	10.2	he	22 Rp	9.1	Alex	1
	10.3	his	22 Rp	10.2	he	0

SEGMENT* 11
when I arrived

CLAUSES:			BAJT			
PROPOSITIONS:						
39	11.0	ARRIVE	AGT: I ≡TEM: *WHEN*, TNS: PAST;			
40	11.1	EQUIV: TEM:	[10.0], [11.0];			
COHESION:						
	11.1	when	55 Ct1	10.01	prev. seg.	1
	11.2	I	22 Rp	7.2	I	4

SEGMENT* 12
and he showed me all around the lab.

CLAUSES:			DEC			
PROPOSITIONS:						
41	12.Ø	SHOW	PAT: HE, OBJ: LAB(DEF NUM: SING), REC: ME ≡DEG: ALL AROUND, TNS: PAST;			
COHESION:						
	12.1	and	51 Ca	11.Ø1	prev. seg.	1
	12.2	he	22 Rp	1Ø.3	his	2
	12.3	me	22 Rp	11.2	I	1
	12.4	the	21 Rd	4.Ø3	lab	8
	12.5	lab	61 L-root	4.Ø3	lab	8

SEGMENT* 13
He turned on the small cyclotron which was in one corner

CLAUSES:			DEC(WHQ)			
PROPOSITIONS:						
42	13.Ø	TURN ON	AGT: HE, OBJ: CYCLOTRON(DEF NUM: SING) ≡TNS: PAST;			
43	13.1	CYCLOTRON (DEF NUM: SING)	ATT: SMALL;			
44	13.2	WHICH	LOC: *IN*CORNER(TOK NUM: SING);			
COHESION:						
	13.1	he	22 Rp	12.2	he	1
	13.2	the	21 Rd	4.Ø1	cyclotron	9
	13.3	cyclotron	61 L-root	4.Ø1	cyclotron	9
	13.4	which	22 Rp	13.3	cyclotron	Ø

SEGMENT* 14
and made some flourine isotope to demonstrate how simply it worked.

CLAUSES:			SF≡DEC(TAJT(WHNG))			
PROPOSITIONS:						
45	14.Ø	MAKE	AGT: *AND*, RSLT: ISOTOPE(DEG: SOME), GOAL: 14.2≡TNS: PAST;			
46	14.1	ISOTOPE (DEG: SOME)	ATT: FLOURINE;			
47	14.2	DEMONSTRATE	THM: 14.3≡;			
48	14.3	WORK	PAT: IT≡ATT: SIMPLY, DEG: *HOW*;			
COHESION:						
	14.1	and	51 Ca	13.Ø1	prev. seg.	1
	14.2	make	61 L-root	4.Ø4	make	1Ø
	14.3	isotope	61 L-root	4.Ø5	isotope	1Ø
	14.4	it	22 Rp	13.3	cyclotron	1
	14.5	work	61 L-root	5.4	work	9

SEGMENT# 15
The small machine made noises

CLAUSES:			DEC			
PROPOSITIONS:						
49	15.Ø	MAKE	PAT: MACHINE(DEF NUM: SING), ACT: NOISES ≡TEM: ,TNS: PAST, ASPCT: CONT;			
5Ø	15.1	MACHINE (DEF NUM: SING)	ATT: SMALL;			
COHESION:						
	15.1	the	21 Rd	13.3	cyclotron	2
	15.2	machine	63 L-gen	13.3	cyclotron	2
	15.3	make	61 L-root	14.2	make	1

SEGMENT# 16
while Alex explained what it was doing.

CLAUSES:			BAJT(REPNG≡WHNG)			
PROPOSITIONS:						
51	16.Ø	EXPLAIN	PAT: ALEX, THM: 16.1≡TEM: ,TNS: PAST;			
52	16.1	DO	PAT: IT(DEF NUM: SING), ACT: *WHAT* ≡TNS: PAST, ASPCT: CONT;			
53	16.2	EQUIV: TEM:	[15.Ø], [16.Ø];			
COHESION:						
	16.1	while	55 Ct1	15.Ø1	prev. seg.	1
	16.2	Alex	61 L-root	9.1	Alex	7
	16.3	it	22 Rp	15.2	machine	1

SEGMENT# 17
Afterwards, Alex made some terrible coffee.

CLAUSES:			DEC			
PROPOSITIONS:						
54	17.Ø	MAKE	AGT: ALEX, RSLT: COFFEE(DEG: SOME) ≡TEM: ,TNS: PAST;			
55	17.1	COFFEE (DEG: SOME)	ATT: TERRIBLE;			
56	17.2	ORD: TEM:	[16.Ø], [17.Ø];			
COHESION:						
	17.1	afterwards	55 Ct2	16.Ø1	prev. seg.	1
	17.2	Alex	61 L-root	16.2	Alex	1
	17.3	make	61 L-root	15.3	make	2

SEGMENT# 18
We talked about the local news for a little while

CLAUSES:			DEC			
PROPOSITIONS:						
57	18.Ø	TALK	PAT: WE, THM: NEWS(GEN) ≡TEM: *DUR* A LITTLE WHILE, TNS: PAST;			
58	18.1	NEWS(GEN)	ATT: LOCAL;			
COHESION:						
	18.1	we	22 Rp	17.2	Alex	1

SEGMENT* 19
until a staff doctor asked for some carbon-eleven glucose in a hurry.

CLAUSES:			BAJT			
PROPOSITIONS:						
59	19.Ø	ASK FOR	PAT:DOCTOR(TOK NUM: SING),THM: 19.2 ≡TEM: ,TNS: PAST;			
6Ø	19.1	STAFF	CAT:DOCTOR(TOK NUM: SING);			
61	19.2		OBJ:GLUCOSE(DEG: SOME) ≡ATT: *IN A HURRY*;			
62	19.3	GLUCOSE (DEG: SOME)	ATT:CARBON-ELEVEN;			
63	19.4	ORD: TEM: *UNTIL*	[18.Ø], [19.Ø];			
COHESION:						
	19.1	until	55 Ct1	18.Ø1	prev. seg.	1
	19.2	glucose	61 L-root	3.Ø1	glucose	16

SEGMENT* 2Ø
He said he would call

CLAUSES:			DEC(REPNG = DEC)			
PROPOSITIONS:						
64	2Ø.Ø	SAY	PAT:HE,THM: 2Ø.1,21.Ø,21.1,21.2,21.3 ≡TNS: PAST;			
65	2Ø.1	CALL	PAT:HE≡TEM: ,TNS: FUT,MOD: COND;			
COHESION:						
	2Ø.1	he	22 Rp	19.Ø1	doctor	1
	2Ø.2	he	22 Rp	2Ø.1	he	Ø

SEGMENT* 21
as soon as he was ready for it.

CLAUSES:			BAJT			
PROPOSITIONS:						
66	21.Ø	HE	ATT:READY≡TNS: PAST;			
67	21.1		OBJ: IT(DEF NUM: SING)≡;			
68	21.2	COND :*FOR*	[21.Ø], [21.1];			
69	21.3	EQUIV: TEM: *AS SOON AS*	[2Ø.1], [21.Ø];			
COHESION:						
	21.1	as soon as	55 Ct1	2Ø.Ø1	prev. seg.	1
	21.2	he	22 Rp	2Ø.2	he	1
	21.3	it	22 Rp	19.2	glucose	2

SEGMENT# 22
Then he prepared the next patient for her scan.

CLAUSES:			DEC			
PROPOSITIONS:						
70	22.0	PREPARE	AGT:HE,OBJ:PATIENT(DEF NUM: SING), GOAL: *FOR*22.2=TNS: PAST;			
71	22.1	ORD: TEM: *NEXT*	[ ], [PATIENT(DEF NUM: SING)];			
72	22.2	SCAN	OBJ:HER=;			
73	22.3	ORD: TEM: *THEN*	[20.0], [22.0];			
COHESION:						
	22.1	then	55 Ct1	21.01	prev. seg.	1
	22.2	he	22 Rp	21.2	he	1
	22.3	her	22 Rp	22.01	patient	0
	22.4	scan	61 L-root	5.02	scanning	17

SEGMENT# 23
Alex explained that since the glucose isotope was only "hot" (or radioactive) for about a half an hour

CLAUSES:			DEC(REPNG=BAJT)			
PROPOSITIONS:						
74	23.0	EXPLAIN	PAT: ALEX,THM: 23.1,23.2,23.3,23.4, 24.0,24.1=TNS: PAST;			
75	23.1	ISOTOPE (DEF NUM: SING)	ATT:HOT,RADIOACTIVE=TEM: *DUR* ;			
76	23.2	ISOTOPE (DEF NUM: SING)	ATT:GLUCOSE;			
77	23.3	ORD: TEM: *DUR* *ONLY*	[HALF AN HOUR], [23.1]=NEG;			
78	23.4	COND: *SINCE*	[23.1,23.2,23.3], [24.0,24.1]			
COHESION:						
	23.1	Alex	61 L-root	17.2	Alex	6
	23.2	explain	61 L-root	16.02	explain	7
	23.3	since	54 Cc2	0	null	0
	23.4	the	21 Rd	14.3	isotope	9
	23.5	glucose	61 L-root	19.2	glucose	4
	23.6	isotope*	61 L-root	14.3	isotope	9
	23.7	isotope*	64 L-gen	19.2	glucose	4
	23.8	or	52 Cv	23.01	hot	0
	23.9	radioactive	62 L-syn	23.01	hot	0

SEGMENT* 24
he could just set up what was in the lab.

CLAUSES:			DEC(WHNG)			
PROPOSITIONS:						
79	24.0	SET UP	AGT: HE, OBJ: WHAT≡TNS: PAST, MOD: CAN;			
80	24.1	WHAT	LOC: *IN*LAB(DEF NUM: SING);			
COHESION:						
	24.1	he	22 Rp	23.1	Alex	1
	24.2	set up	62 L-syn	22.02	prepare	2
	24.3	the	21 Rd	12.5	lab	12
	24.4	lab	61 L-root	12.5	lab	12

SEGMENT* 25
He would only start to make the isotope itself

CLAUSES:			DEC(TNG)			
PROPOSITIONS:						
81	25.0	MAKE	AGT: HE, RSLT: ISOTOPE(DEF NUM: SING) ≡TEM: , TNS: FUT, MOD: COND, ASPCT: INCPT;			
COHESION:						
	25.1	he	22 Rp	24.1	he	2
	25.2	make	61 L-root	15.3	make	10
	25.3	the	21 Rd	23.6	isotope	2
	25.4	isotope	61 L-root	23.6	isotope	2
	25.5	itself	22 Rp	25.4	isotope	0

SEGMENT* 26
when the doctor called again.

CLAUSES:			BAJT			
PROPOSITIONS:						
82	26.0	CALL	PAT: DOCTOR(DEF NUM: SING)≡TEM: *WHEN*, TNS: PAST, ASPCT: ITER *AGAIN*;			
83	26.1	COND: *WOULD*	[26.0], [25.0];			
COHESION:						
	26.1	when	55 Ct1	25.01	prev. seg.	1
	26.2	the	21 Rd	22.2	he	4
	26.3	doctor	61 L-root	19.01	doctor	7
	26.4	call	61 L-root	20.03	call	6

SEGMENT* 27
Not long after Alex was all ready,

CLAUSES: BAJT
PROPOSITIONS:

84	27.0	HE	ATT:READY,DEG:ALL=TEM: ,TNS:PAST;			
85	27.1	DIFF: TEM: (=not long)*AFTER*	[27.0], [28.0];			

COHESION:

27.1	after	56 Ct2	0	null	0
27.2	Alex	61 L-root	23.1	Alex	4
27.3	ready	61 L-root	21.02	ready	6

SEGMENT* 28
the doctor called back to confirm his previous request

CLAUSES: DEC(TAJT)
PROPOSITIONS:

86	28.0	CALL	PAT:DOCTOR(DEF NUM: SING),GOAL: *TO*28.1 =TEM: ,TNS: PAST,ASPCT: ITER *BACK*;
87	28.1	CONFIRM	THM: 28.2=;
88	28.2	REQUEST	PAT: *HIS*=TEM: ;
89	28.3	ORD: TEM: *PREVIOUS*	[28.2],[ ];

COHESION:

28.1	the	21 Rd	26.3	doctor	2
28.2	doctor	61 L-root	26.3	doctor	2
28.3	call	61 L-root	26.4	call	2
28.4	his	22 Rp	28.2	doctor	0
28.5	previous	23 Rc	19.02	ask for	9
28.6	request	62 L-syn	19.02	ask for	9

SEGMENT* 29
and Alex began to prepare his "magic potion" right away.

CLAUSES: DEC(TAJT)
PROPOSITIONS:

90	29.0	PREPARE	AGT: ALEX,OBJ: POTION(DEF NUM: SING) =ATT:RIGHT AWAY, TNS: PAST,ASPCT: INCPT *BEGIN*;
91	29.1	*POSS*	PAT:HIS,OBJ:POTION(DEF NUM: SING)=;
92	29.2	POTION(DEF NUM: SING) ATT:MAGIC;	

COHESION:

29.1	and	51 Ca	28.01	prev. seg.	1
29.2	Alex	61 L-root	27.2	Alex	2
29.3	prepare*	61 L-root	22.02	prepare	7
29.4	prepare*	62 L-syn	25.2	make	4
29.5	his	22 Rp	29.2	Alex	0

SEGMENT* 3Ø
When he had finished it,

CLAUSES:			BAJT			
PROPOSITIONS:						
93	3Ø.Ø	FINISH	ACT: HE, ACT: IT ≡ TEM: * WHEN *, TNS: PAST, ASPCT: COMP, ASPCT: CESS;			
94	3Ø.1	ORD: TEM:	[3Ø.Ø], [31.Ø];			
COHESION:						
	3Ø.1	when	58 Ct2	Ø	null	Ø
	3Ø.2	he	22 Rp	29.5	his	1
	3Ø.3	finish	56 L-ant	29.Ø1	begin	1
	3Ø.4	it	22 Rp	29.3	prepare	1

SEGMENT* 31
he checked whether it was "hot" (or radioactive) enough for the scanner.

CLAUSES:			DEC(WHNG)			
PROPOSITIONS:						
95	31.Ø	CHECK	PAT: HE, THM: 31.1 ≡ TEM: , TNS: PAST;			
96	31.1	IT	ATT: HOT, RADIOACTIVE, DEG: ENOUGH ≡ TNS: PAST, INT * WHETHER *;			
97	31.2		PAT: SCANNER (DEF NUM: SING);			
98	31.3	COND:	[31.1], [31.2];			
COHESION:						
	31.1	he	22 Rp	3Ø.2	he	1
	31.2	it	22 Rp	29.Ø2	potion	2
	31.3	hot*	61 L-root	23.Ø1	hot	8
	31.4	hot*	62 L-syn	23.9	radioactive	8
	31.5	radioactive*	61 L-root	23.9	radioactive	8
	31.6	radioactive*	62 L-syn	31.3	hot	Ø
	31.7	the	13 Npb	22.4	scan	9
	31.8	scanner	61 L-root	22.4	scan	9

SEGMENT# 32
Then we ran up to the scanner room on the third floor, with the solution in a lead bucket.

CLAUSES: DEC

PROPOSITIONS:

99	32.0	RUN	ACT: WE,RSLT: 32.1,STATE: *WITH*32.2 =LOC: *DIR* *UP*,TEM: -,TNS: PAST;
100	32.1	WE	LOC:ROOM(DEF NUM: SING);
101	32.2	SOLUTION (DEF NUM: SING)	LOC: *IN*BUCKET(TOK NUM: SING);
102	32.3	ROOM (DEF NUM: SING)	ATT: SCANNER;
103	32.4	ROOM (DEF NUM: SING)	LOC: *ON*FLOOR(DEF NUM: SING);
104	32.5	FLOOR (DEF NUM: SING)	ATT: THIRD;
105	32.6	BUCKET (TOK NUM: SING)	ATT: LEAD;
106	32.7	ORD: TEM:	[31.0], [32.0];

COHESION:

32.1	then	57 Ct1	31.01	prev. seg.	1
32.2	we	22 Rp	31.1	he	1
32.3	the	13 Npb	31.8	scanner	1
32.4	scanner	61 L-root	31.8	scanner	1
32.5	room	64 L-gen	7.01	office	25
32.6	the	21 Rd	29.02	potion	3
32.7	solution	64 L-sup	29.02	potion	3

SEGMENT# 33
The scanner was a big aluminum ring with millions of wires connecting it to a big computer in the next room.

CLAUSES: DEC(IQ)

PROPOSITIONS:

107	33.0	IDENT:	[SCANNER(DEF NUM: SING)], [33.1,33.2];
108	33.1	RING (TOK NUM: SING)	ATT:BIG;
109	33.2	RING (TOK NUM: SING)	ATT: ALUMINUM;
110	33.3	CONNECT	OBJ: IT,INST: WIRES(TOK NUM: MILLIONS), REC: COMPUTER=;
111	33.4	COMPUTER (DEF NUM: SING)	ATT:BIG;
112	33.5	COMPUTER (DEF NUM: SING)	LOC: *IN*ROOM(DEF NUM: SING);
113	33.6	PROX: LOC: *NEXT*	[ ], [ROOM];

COHESION:

33.1	the	21 Rd	32.4	scanner	1
33.2	scanner	61 L-root	32.4	scanner	1
33.3	it	22 Rp	33.2	scanner	0
33.4	computer	61 L-root	5.03	computer	28
33.5	the next	23 Rc	32.5	room	1
33.6	room	61 L-root	32.5	room	1

SEGMENT* 34
The patient was waiting nervously for an injection on a long table, with her head inside the ring.

CLAUSES:			DEC			
PROPOSITIONS:						
114	34.Ø	WAIT	PAT:PATIENT(DEF NUM: SING),STATE: 34.2, GOAL: *FOR*INJECTION=LOC: *ON*TABLE (TOK NUM: SING),ATT:NERVOUSLY, TNS: PAST ,ASPCT: CONT;			
115	34.1	TABLE (TOK NUM: SING)	ATT: LONG;			
116	34.2	HEAD (DEF NUM: SING)	LOC: *INSIDE*RING(DEF NUM: SING);			
117	34.3	HER	PRT:HEAD(DEF NUM: SING);			
COHESION:						
	34.1	the	21 Rd	22.Ø1	patient	12
	34.2	patient	61 L-root	22.Ø1	patient	12
	34.3	her	22 Rp	34.2	patient	Ø
	34.4	the	21 Rd	33.Ø1	ring	1
	34.5	ring	61 L-root	33.Ø1	ring	1

SEGMENT* 35
As we walked back down the stairs together,

CLAUSES:			BAJT			
PROPOSITIONS:						
118	35.Ø	WALK	PAT: WE=LOC: *DIR* DOWN, LOC: STAIRS(DEF NUM: PL),ATT: TOGETHER, TEM: *AS*,TNS: PAST ,ASPCT: ITER *BACK*;			
119	35.1	EQUIV: TEM:	[35.Ø], [36.Ø];			
COHESION:						
	35.1	as	58 Ct2	Ø	null	Ø
	35.2	we	22 Rp	32.2	we	3

SEGMENT* 36
Alex explained that scanners detect gamma rays coming from inside the patient's brain.

CLAUSES: DEC(REPNG=DEC(IQ))

PROPOSITIONS:

120	36.0	EXPLAIN	PAT: ALEX, THM: 36.1,36.2,36.3,36.4 =TEM: ,TNS: PAST;
121	36.1	DETECT	PAT: SCANNER(GEN),OBJ: RAY(TOK NUM: PL)=;
122	36.2	RAYS (TOK NUM: PL)	ATT: GAMMA;
123	36.3	COME	AGT: RAY(TOK NUM: PL), SOURCE: *INSIDE*BRAIN(DEF NUM: SING)=;
124	36.4	PATIENT (DEF NUM: SING)	PAT: BRAIN(DEF NUM: SING);

COHESION:

36.1	Alex	61 L-root	27.2	Alex	9
36.2	explain	61 L-root	23.2	explain	13
36.3	scanner	61 L-root	33.2	scanner	3
36.4	the	21 Rd	34.3	her	2
36.5	patient	61 L-root	34.2	patient	2
36.6	brain	61 L-root	5.04	brain	31

SEGMENT* 37
I didn't really understand very much of what he was talking about.

CLAUSES: DEC(WHNG)

PROPOSITIONS:

125	37.0	UNDERSTAND	PAT: I, THM: 37.1,37.2 =TNS: PAST, ATT: REALLY, NEG;
126	37.1	TALK	PAT: HE, THM: WHAT=TNS: PAST, ASPCT: CONT;
127	37.2	WHAT	ATT: MUCH, DEG: VERY;

COHESION:

37.1	I	22 Rp	12.3	me	25
37.2	he	22 Rp	36.1	Alex	1
37.3	talking	63 L-gen	36.2	explain	1

SEGMENT* 38
It sounded really crazy to me.

CLAUSES:			DEC			
PROPOSITIONS:						
128	38.0	SOUND	PAT: ME, THM: 38.1 ≡ TNS: PAST;			
129	38.1	IT	ATT: CRAZY, DEG: REALLY;			
COHESION.						
	38.1	it	22 Rp	37.01	what	1
	38.2	me	22 Rp	37.1	I	1

SEGMENT* 39
After lunch, Alex checked in at the lab

CLAUSES:			DEC			
PROPOSITIONS:						
130	39.0	CHECK IN	PAT: ALEX ≡ TEM: , TNS: PAST, LOC: *AT*LAB (DEF NUM: SING);			
131	39.1	ORD: TEM:	[LUNCH], [39.0];			
COHESION:						
	39.1	Alex	61 L-root	36.1	Alex	3
	39.2	the	21 Rd	12.5	lab	27
	39.3	lab	61 L-root	12.5	lab	27

SEGMENT* 40
Then we visited his friend Yoshio who ran the brain scanner's computer system.

CLAUSES:			DEC(WHQ)			
PROPOSITIONS:						
132	40.0	VISIT	AGT: WE, REC: FRIEND (DEF NUM: SING) ≡ TEM: , TNS: PAST;			
133	40.1	*POSS*	PAT: *HIS*, OBJ: FRIEND (DEF NUM: SING) ≡;			
134	40.2	EQUIV:	[FRIEND], [YOSHIO];			
135	40.3	RUN	PAT: WHO, OBJ: SYSTEM (DEF NUM: SING) ≡ TNS: PAST;			
136	40.4	SYSTEM (DEF NUM: SING)	ATT: COMPUTER;			
137	40.5	SCANNER (DEF NUM: SING)	PAT: SYSTEM (DEF NUM: SING);			
138	40.6	SCANNER (DEF NUM: SING)	ATT: BRAIN (DEF NUM: SING);			
139	40.7	ORD: TEM:	[39.0], [40.0];			
COHESION:						
	40.1	then	57 Ct1	39.01	prev. seg.	1
	40.2	we	22 Rp	39.1	Alex	1
	40.3	visit	61 L-Root	6.02	visit	34
	40.4	his	22 Rp	39.1	Alex	1
	40.5	friend	61 L-root	1.03	friend	39
	40.6	who	22 Rp	40.01	Yoshio	0
	40.7	the	21 Rd	32.4	scanner	8
	40.8	brain	61 L-root	36.6	brain	4
	40.9	scanner	61 L-root	32.4	scanner	8
	40.10	computer	61 L-root	33.4	computer	7

SEGMENT# 41
Even before he greeted us,

CLAUSES:			BAJT			
PROPOSITIONS:						
140	41.0	GREET	PAT:HE,REC:US=TEM: ,TNS:PAST;			
141	41.1	ORD:TEM:	[42.0], [41.0];			
COHESION:						
	41.1	before	56 Ct2	0	null	1
	41.2	he	22 Rp	40.6	who	1
	41.3	us	22 Rp	40.4	his	1

SEGMENT# 42
Yoshio pointed at the two TV screens on a large desk

CLAUSES:			DEC			
PROPOSITIONS:						
142	42.0	POINT	PAT:YOSHIO=LOC:*DIR* *AT*SCREEN (DEF NUM:TWO),TEM: ,TNS:PAST;			
143	42.1	SCREEN (DEF NUM:TWO)	LOC:*ON*DESK(TOK NUM:SING);			
144	42.2	DESK (TOK NUM:SING)	ATT:LARGE;			
145	42.3	SCREEN (DEF NUM:TWO)	ATT:TV;			
COHESION:						
	42.1	Yoshio	61 L-root	40.01	Yoshio	2

SEGMENT# 43
and then asked which image was clearer.

CLAUSES:			SF=DEC(REPNG=INT)			
PROPOSITIONS:						
146	43.0	ASK	PAT:*AND*,THM:43.1,43.2,43.3 =TEM:*THEN*,TNS:PAST;			
147	43.1	IMAGE (DEF NUM:SING)	CAT:WHICH;			
148	43.2	WHICH	ATT: CLEAR,DEG: ;			
149	43.3	ORD:DEG:	[ ], [43.2];			
150	43.4	ORD:TEM:	[42.0], [43.0];			
COHESION:						
	43.1	and	51 Ca	42.01	prev. seg.	1
	43.2	then	57 Ct1	42.01	prev. seg.	1
	43.3	clearer	23 Rc	43.01	image	0

SEGMENT* 44
Yoshio was working on a new program to make the images sharper.

CLAUSES:			DEC(TQ)			
PROPOSITIONS:						
151	44.0	WORK ON	PAT: YOSHIO,OBJ:PROGRAM≡TEM: , TNS: PAST ,ASPCT: CONT;			
152	44.1	PROGRAM	ATT: NEW;			
153	44.2	CAU: *MAKE*	[PROGRAM], [44.3,44.4];			
154	44.3	IMAGE (DEF NUM: PL)	ATT: SHARP,DEG: ;			
155	44.4	ORD: DEG:	[ ], [44.3];			
COHESION:						
	44.1	Yoshio	61 L-root	42.1	Yoshio	2
	44.2	work	61 L-root	14.5	work	30
	44.3	program	61 L-root	5.01	programmer	39
	44.4	make	61 L-root	25.2	make	19
	44.5	the	21 Rd	43.01	image	1
	44.6	images	61 L-root	43.01	image	1
	44.7	sharper	23 Rc	44.6	images	0

SEGMENT* 45
Then he pointed at another screen with the same brain image,

CLAUSES:			DEC			
PROPOSITIONS:						
156	45.0	POINT	PAT:HE≡LOC: *DIR* *AT*SCREEN (TOK NUM: SING),TEM: *THEN*,TNS: PAST ;			
157	45.1	SCREEN (TOK NUM: SING)	ATT: ANOTHER;			
158	45.2	SCREEN (TOK NUM: SING)	PRT: IMAGE(DEF NUM: SING);			
159	45.3	IMAGE (DEF NUM: SING)	THM: BRAIN(TOK NUM: SING);			
160	45.4	IDENT: *SAME*	[45.3], [ ];			
162	45.5	ORD: TEM:	[44.0], [45.0];			
COHESION:						
	45.1	then	57 Ct1	44.01	prev. seg.	1
	45.2	he	22 Rp	44.1	Yoshio	1
	45.3	pointed	61 L-root	42.02	pointed	3
	45.4	another	23 Rc	42.03	screen	3
	45.5	screen	61 L-root	42.03	screen	3
	45.6	the same	23 Rc	44.6	images	1
	45.7	brain	61 L-root	40.8	brain	5
	45.8	image	61 L-root	44.6	images	1

SEGMENT* 46
but it had two handles connected to it, like a video game.

CLAUSES:			DEC(EDQ)			
PROPOSITIONS:						
162	46.Ø	IT	PAT: HANDLE(DEF NUM: TWO)≡TNS: PAST;			
163	46.1	CONNECT	OBJ: HANDLE(DEF NUM: TWO),REC: IT≡;			
164	46.2	PROX: ATT:	[46.Ø,46.1], [VIDEO GAME(TOK NUM: SING)];			
COHESION:						
	46.1	but	54 Cv	45.Ø1	prev.seg	1
	46.2	it	22 Rp	45.5	screen	1
	46.3	connected	61 L-root	33.Ø2	connect	13
	46.4	it	22 Rp	46.2	it	Ø
	46.5	like	23 Rc	46.4	it	Ø

SEGMENT* 47
He suggested how we should play around with the handles,

CLAUSES:			DEC(REPNG = WHNG)			
PROPOSITIONS:						
165	47.Ø	SUGGEST	PAT: HE,THM: 47.1≡TNS: PAST;			
166	47.1	PLAY AROUND	PAT: WE,OBJ: *WITH*HANDLE(DEF NUM: PL) ≡ATT: *HOW*,MOD: ROOT *SHOULD*;			
COHESION:						
	47.1	he	22 Rp	45.2	he	2
	47.2	we	22 Rp	47.1	he	Ø
	47.3	the	21 Rd	46.Ø1	handles	1
	47.4	handles	61 L-root	46.Ø1	handles	1

SEGMENT* 48
and when we moved them,

CLAUSES:			BAJT			
PROPOSITIONS:						
167	48.Ø	MOVE	AGT: WE,OBJ: THEM≡TEM: ,TNS: PAST;			
168	48.1	EQUIV: TEM:	[48.Ø], [49.Ø];			
COHESION:						
	48.1	and	53 Ca	47.Ø1	prev. seg.	1
	48.2	when	58 Ct2	Ø	null	Ø
	48.3	we	22 Rp	47.2	we	1
	48.4	them	22 Rp	47.4	handles	1

SEGMENT* 49
the image changed in color and brightness.

CLAUSES:			DEC			
PROPOSITIONS:						
169	49.Ø	CHANGE	OBJ: IMAGE(DEF NUM: SING)≡ATT: *IN*COLOR, BRIGHTNESS, TEM: ,TNS: PAST;			
COHESION:						
	49.1	the	21 Rd	45.8	image	4
	49.2	image	61 L-root	45.8	image	4
	49.3	and	53 Ca	49.Ø1	color	Ø

SEGMENT* 5Ø
Yoshio explained that it was better for the doctors to manipulate the color and brightness of the important parts of the image.

CLAUSES: DEC(REPNG=DEC(TNG)

PROPOSITIONS:

17Ø	5Ø.Ø	EXPLAIN	PAT: YOSHIO,THM: 5Ø.1,5Ø.5,5Ø.6,5Ø.7,5Ø.8 ≡TNS: PAST;
171	5Ø.1	MANIPULATE	PAT: DOCTOR(DEF NUM: PL), STATE: 5Ø.2,5Ø.3,5Ø.4≡;
172	5Ø.2	PART (DEF NUM: PL)	ATT:COLOR;
173	5Ø.3	PART (DEF NUM: PL)	ATT:BRIGHTNESS, DEG: ;
174	5Ø.4	IMAGE (DEF NUM: SING)	PAT:PART(DEF NUM: PL);
175	5Ø.5	PART (DEF NUM: PL)	ATT: IMPORTANT;
176	5Ø.6	IT	ATT: GOOD, DEG: ,TNS: PAST;
177	5Ø.7	ORD: DEG:	[ ], [5Ø.6];
178	5Ø.8	COND:	[5Ø.1], [5Ø.6];

COHESION:

5Ø.1	Yoshio	61 L-root	44.1	Yoshio	6
5Ø.2	explain	61 L-root	36.2	explain	14
5Ø.3	it	71 Cat	Ø	null	Ø
5Ø.4	better	23 Rc	Ø	null	Ø
5Ø.5	the	21 Rd	26.3	doctor	24
5Ø.6	doctors	61 L-root	26.3	doctor	24
5Ø.7	color	61 L-root	49.Ø1	color	1
5Ø.8	and	53 Ca	5Ø.7	color	Ø
5Ø.9	brightness	61 L-root	49.Ø2	brightness	1
5Ø.1Ø	the	21 Rd	49.2	image	1
5Ø.11	image	61 L-root	49.2	image	1

SEGMENT* 51
The telephone rang, interrupting him.

CLAUSES: DEC(IAJT)

PROPOSITIONS:

179	51.Ø	RING	PAT:TELEPHONE(DEF NUM: SING)≡TNS: PAST;
18Ø	51.1	CAU:	[51.Ø], [51.2];
181	51.2	INTERRUPT	OBJ: HIM≡;

COHESION:

51.1	him	22 Rp	5Ø.1	Yoshio	1

SEGMENT* 52
The call was for Alex.

CLAUSES: DEC

PROPOSITIONS:

182	52.Ø	CALL	REC: *FOR*ALEX≡TNS: PAST;

COHESION:

52.1	the	21 Rd	51.Ø1	ring	1
52.2	call	13 Npb	51.Ø2	telephone	1
52.3	Alex	61 L-root	39.1	Alex	13

SEGMENT# 53
He had to go back to the lab

CLAUSES:			DEC			
PROPOSITIONS:						
183	53.0	GO	ACT:HE,GOAL: *TO*LAB(DEF NUM: SING) ≡MOD: ROOT *HAVE TO*, ASPCT: ITER *BACK*,			
		TNS: PAST;				
COHESION:						
	53.1	he	22 Rp	52.3	Alex	1
	53.2	go	64 L-sup	35.01	walk	18
	53.3	the	21 Rd	39.3	lab	14
	53.4	lab	61 L-root	39.3	lab	14

SEGMENT# 54
and it was time I left, too.

CLAUSES:			DEC(WHQ)			
PROPOSITIONS:						
184	54.0	LEAVE	ACT: I ≡TEM: *TIME*,TNS: PAST;			
185	54.1	COND:	[IT], [54.0];			
COHESION:						
	54.1	and	53 Ca	53.01	prev. seg.	1
	54.2	it	13 Npb	0	null	0
	54.3	I	22 Rp	38.2	me	16
	54.4	leave	57 L-ant	11.02	arrive	43
	54.5	too	53 Ca	53.01	prev. seg.	1

SEGMENT# 55
We thanked Yoshio for his explanation of the new program,

CLAUSES:			DEC			
PROPOSITIONS:						
186	55.0	THANK	PAT: WE,REC: YOSHIO,ACT: *FOR*55.1 ≡TNS: PAST;			
187	55.1	EXPLAIN	PAT: HIS,THM: 55.2≡;			
188	55.2	PROGRAM	ATT:NEW;			
COHESION:						
	55.1	we	22 Rp	54.3	I	1
	55.2	Yoshio	61 L-root	50.1	Yoshio	5
	55.3	his	22 Rp	55.2	Yoshio	0
	55.4	explanation	61 L-root	50.2	explain	5
	55.5	the	21 Rd	44.3	program	11
	55.6	new	61 L-root	44.02	new	11
	55.7	program	61 L-root	44.3	program	11

SEGMENT* 56
and walked to the main entrance together.

CLAUSES:		SF=DEC			
PROPOSITIONS:					
189	56.0	WALK	AGT: *AND*, GOAL: *TO*ENTRANCE (DEF NUM: SING)=ATT: TOGETHER, TNS: PAST;		
190	56.1	ENTRANCE(DEF NUM: SING) ATT: MAIN;			
COHESION:					
	56.1	and	53 Ca	55.01	prev. seg. 1
	56.2	walk*	61 L-root	35.01	walk 21
	56.3	walk*	65 L-gen	53.2	go 3

SEGMENT* 57
Then Alex went to make some other kind of isotope

CLAUSES:		DEC(TAJT)			
PROPOSITIONS:					
191	57.0	GO	AGT: ALEX, GOAL: *TO*57.1=TNS: PAST;		
192	57.1	MAKE	RSLT: KIND(TOK NUM: SING *SOME*);		
193	57.2	KIND(TOK NUM: SING *SOME*) ATT: OTHER;			
194	57.3	ISOTOPE(GEN)	CAT: KIND(TOK NUM: SING *SOME*);		
195	57.4	ORD: TEM:	[56.0], [57.0];		
COHESION:					
	57.1	then	57 Ct1	56.01	prev. seg. 1
	57.2	Alex	61 L-root	52.3	Alex 5
	57.3	go*	61 L-root	53.2	go 4
	57.4	go*	64 L-sup	56.3	walk 1
	57.5	make	61 L-root	44.4	make 13
	57.6	other	23 Rc	19.2	glucose 38
	57.7	isotope	61 L-root	23.6	isotope 34

SEGMENT* 58
and I went to the bank to pay some bills.

CLAUSES:		DEC(TAJT)			
PROPOSITIONS:					
196	58.0	GO TNS: PAST;	AGT: I, GOAL: *TO*58.1=LOC: *DIR* *TO*BANK,		
197	58.1	PAY	OBJ: BILL(TOK NUM: SOME)=;		
COHESION:					
	58.1	and	53 Ca	57.01	prev. seg. 1
	58.2	I	22 Rp	54.3	I 4
	58.3	go	61 L-root	57.3	go 1

SEGMENT* 59
It was a very interesting visit.

CLAUSES:		DEC			
PROPOSITIONS:					
198	59.0	VISIT	=ATT: INTERESTING, DEG: VERY, TNS: PAST;		
COHESION:					
	59.1	it	22 Rp	6.02	visit 53
	59.2	visit	61 L-root	40.3	visit 19

Appendix B
Analysis of Procedural Text

SEGMENT* 1
A man goes to visit his doctor.

CLAUSES:			DEC(TAJT)			
PROPOSITIONS:						
1	1.Ø	Go	ACT: MAN(TOK NUM: SING), GOAL: *TO*1.1≡TNS: PRES;			
2	1.1	VISIT	OBJ: DOCTOR(DEF NUM: SING);			
3	1.2	*POSS*	PAT: *HIS*, OBJ: DOCTOR(DEF NUM: SING)≡;			
COHESION:						
	1.1	his	22 Rp	1.Ø1	man	Ø

SEGMENT* 2
He complains that his head often aches.

CLAUSES:			DEC(REPNG=DEC)			
PROPOSITIONS:						
4	2.Ø	COMPLAIN	PAT: HE, THM: 2.1≡TNS: PRES;			
5	2.1	ACHE	PAT: HEAD(DEF NUM: SING)≡ASPCT: ITER *OFTEN*;			
6	2.2	HIS	PRT: HEAD(DEF NUM: SING);			
COHESION:						
	2.1	he	22 Rp	1.1	his	1
	2.2	his	22 Rp	2.1	he	Ø

SEGMENT* 3
He feels weakness in his arms and nausea.

CLAUSES:			DEC			
PROPOSITIONS:						
7	3.Ø	FEEL	PAT: HE, THM: 3.1,3.2,3.3≡TNS: PRES;			
8	3.1	ARM (DEF NUM: PL)	ATT: WEAKNESS;			
9	3.2	HIS	PRT: ARM(DEF NUM: PL);			
1Ø	3.3	*FEEL*	≡ATT: NAUSEA;			
COHESION:						
	3.1	he	22 Rp	2.2	his	1
	3.2	his	22 Rp	3.1	he	Ø
	3.3	and	51 Ca	3.Ø1	weakness	Ø

SEGMENT* 4

The symptoms make the doctor suspect that the patient has a brain tumor.

CLAUSES: DEC(ZAJT(WHNG))

PROPOSITIONS:

11	4.0	CAU: *MAKE*	[SYMPTOM(DEF NUM: PL)], [4.1];
12	4.1	SUSPECT	PAT: DOCTOR(DEF NUM: SING), THM: 4.2,4.3,4.4=;
13	4.2	PATIENT (DEF NUM: SING)	PRT: TUMOR(TOK NUM: SING);
14	4.3	TUMOR (TOK NUM: SING)	ATT: /LOC: BRAIN;

COHESION:

4.1	the	13 Npb	3.01	nausea	1
4.2	symptoms	33 L-gen	3.01	nausea	1
4.3	the	21 Rd	1.02	doctor	3
4.4	doctor	61 L-root	1.02	doctor	3
4.5	the	21 Rd	1.01	man	3

SEGMENT* 5

He cannot be sure, though, without finding out what's happening inside the patient's skull.

CLAUSES: DEC(ING(WHNG))

PROPOSITIONS:

15	5.0	*FEEL*	PAT: HE=ATT: SURE, TNS: PRES, MOD: CAN, NEG;
16	5.1	FIND OUT	ACT: 5.2=NEG *WITHOUT*;
17	5.2	HAPPEN	ACT: WHAT=LOC: *INSIDE*SKULL (DEF NUM: SING), TNS: PRES, ASPCT: CONT;
18	5.3	PATIENT (DEF NUM: SING)	PRT: SKULL(DEF NUM: SING)=;
19	5.4	COND: *WITHOUT*	[5.1,5.2,5.3], [5.0];

COHESION:

5.1	he	22 Rp	4.4	doctor	1
5.2	though	52 Cv	4.01	prev. seg.	1
5.3	the	21 Rd	4.02	patient	1
5.4	patient	61 L-root	4.02	patient	1

SEGMENT* 6
How is it possible to discover, causing no damage, what's going on inside someone's brain?

CLAUSES: INT(TNG(IAJT–WHNG))

PROPOSITIONS:

20	6.Ø	DISCOVER	THM: 6.1, ACT: 6.2≡;
21	6.1	GO ON	ACT: *WHAT*≡LOC: *INSIDE*BRAIN (DEF NUM: SING),TNS: PRES,ASPCT: CONT;
22	6.2	CAU:	[ ], [6.3];
23	6.3	DAMAGE	NEG *NO*;
24	6.4	SOMEONE	PRT: BRAIN(DEF NUM: SING);
25	6.5	AND:	[6.Ø], [6.2]≡MOD: QUAL: POSSIBLE;
26	6.6	COND:	[?HOW], [6.5];

COHESION:

6.1	it	71 Cat	Ø	null	Ø
6.2	go on	62 L-syn	5.Ø1	happen	1
6.3	someone	63 L-gen	5.4	patient	1
6.4	brain	61 L-root	4.Ø3	brain	2

SEGMENT* 7
Technology has provided us with a safe way of getting this information: the PET scanner.

CLAUSES: DEC(IQ)

PROPOSITIONS:

27	7.Ø	CAU:	[TECHNOLOGY], [7.1];
28	7.1	PROVIDE	REC: US,RSLT: 7.3≡TNS: PAST,ASPCT: COMP;
29	7.2	GET	OBJ: INFORMATION(DEF *THIS*)≡PRT: WAY;
3Ø	7.3	WAY	≡ATT: SAFE;
31	7.4	SCANNER (DEF NUM: SING)	ATT: PET;
32	7.5	IDENT:	[7.3], [7.4];**SIC**

COHESION:

7.1	us	31 Exo	Ø	null	Ø
7.2	this	21 Rd	6.Ø1	prev. seg.	1

SEGMENT* 8
Let me explain how it works.

CLAUSES: IMP(2AJT(WHNG))

PROPOSITIONS:

33	8.Ø	REQUEST	THM: 8.1≡;
34	8.1	LET	ACT: 8.2≡TNS: PRES;
35	8.2	EXPLAIN	PAT: ME,THM: 8.3≡;
36	8.3	WORK	PAT: IT≡PRT: HOW,TNS: PRES;

COHESION:

8.1	me	32 SRI	Ø	null	Ø
8.1	it	22 Rp	7.Ø1	scanner	1

SEGMENT# 9
First, the patient is prepared:

CLAUSES:			DEC			
PROPOSITIONS:						
37	9.0	PREPARE	OBJ:PATIENT(DEF NUM: SING)=TEM: ;			
38	9.1	ORD:TEM:	[9.0], [ ];			
COHESION:						
	9.1	the	21 Rd	5.4	patient	4
	9.2	patient	61 L-root	5.4	patient	4

SEGMENT # 10
he lies on his back,

CLAUSES:			DEC			
PROPOSITIONS:						
39	10.0	LIE	ACT:HE,RSLT: 10.1=;			
40	10.1	HE	LOC: *ON*BACK;			
41	10.2	HIS	PRT:BACK;			
COHESION:						
	10.1	he	22 Rp	9.2	patient	1
	10.2	his	22 Rp	10.1	he	0

SEGMENT# 11
his eyes and his ears are covered by wrapping them with gauze,

CLAUSES:			DEC(IAJT)			
PROPOSITIONS:						
42	11.0	COVER	OBJ:EYE(DEF NUM: PL),EAR(DEF NUM: PL) =PRT: 11.3;			
43	11.1	HIS	PRT:EYE(DEF NUM: PL);			
44	11.2	HIS	PRT:EAR(DEF NUM: PL);			
45	11.3	WRAP	OBJ:THEM,INST: *WITH*GAUZE=;			
COHESION:						
	11.1	his	22 Rp	10.2	his	1
	11.2	and	51 Ca	11.01	eyes	0
	11.3	his	22 Rp	11.1	his	0
	11.4	them	22 Rp	11.02	ears	0

SEGMENT# 12
and his head is secured with plastic pins

CLAUSES:			DEC			
PROPOSITIONS:						
46	12.0	SECURE	OBJ:HEAD(DEF NUM: SING), INST: *WITH*PIN(TOK NUM: PL)=;			
47	12.1	HIS	PRT:HEAD(DEF NUM: SING);			
48	12.2	PIN (TOK NUM: PL)	ATT:PLASTIC;			
COHESION:						
	12.1	and	51 Ca	11.03	prev. seg.	1
	12.2	his	22 Rp	11.3	his	1
	12.3	head	61 L-root	2.01	head	9

SEGMENT* 13
so it can't move at all.

CLAUSES:			BAJT			
PROPOSITIONS:						
49	13.Ø	MOVE	PAT: IT=ATT: *AMOUNT*,DEG: AT ALL,MOD: CAN,NEG;			
5Ø	13.1	COND: *SO*	[12.Ø], [13.Ø];			
COHESION:						
	13.1	so	53 Cc1	12.Ø1	prev. seg.	1
	13.2	it	22 Rp	12.3	head	1

SEGMENT* 14
Finally, his head is placed inside a donut-shaped machine

CLAUSES:			DEC(EDQ)			
PROPOSITIONS:						
51	14.Ø	PLACE	OBJ: HEAD(DEF NUM: SING),RSLT: 14.2=TEM: ;			
52	14.1	HIS	PRT: HEAD(DEF NUM: SING);			
53	14.2	HEAD (DEF NUM: SING)	LOC: *INSIDE*MACHINE(TOK NUM: SING);			
54	14.3	MACHINE (TOK NUM: SING)	ATT: DONUT-SHAPED;			
55	14.4	ORD: TEM: *FINALLY*	[ ], [14.Ø];			
COHESION:						
	14.1	his	22 Rp	12.2	his	2
	14.2	head	61 L-root	12.3	head	2
	14.3	machine	63 L-gen	7.Ø1	scanner	7

SEGMENT* 15
and he is given an injection of a radioactive solution.

CLAUSES:			DEC			
PROPOSITIONS:						
56	15.Ø	GIVE	REC: HE,ACT: 15.1=TEM: ;			
57	15.1	*INJECTION*	OBJ: SOLUTION(TOK NUM: SING)=;			
58	15.2	SOLUTION (TOK NUM: SING)	ATT: RADIOACTIVE;			
COHESION:						
	15.1	and	51 Ca	14.Ø1	prev. seg.	1
	15.2	he	22 Rp	14.1	his	1

SEGMENT# 16

This is made from a kind of glucose with a radioactive marker attached to some of its molecules.

CLAUSES:			DEC(EDQ)			
PROPOSITIONS:						
59	16.Ø	MAKE	OBJ: THIS, SOURCE: *FROM*16.1-16.5≡;			
6Ø	16.1	GLUCOSE (GEN UNIV)	CAT: KIND(TOK NUM: SING);			
61	16.2	ATTACH	OBJ: MARKER(TOK NUM: SING), REC: MOLECULES≡;			
62	16.3	MARKER (TOK NUM: SING)	ATT: RADIOACTIVE;			
63	16.4	ITS (KIND)	PRT: MOLECULE(DEF NUM: SOME);			
COHESION:						
	16.1	this	21 Rd	15.Ø1	solution	1
	16.2	radioactive	61 L-root	15.Ø2	radioactive	1
	16.3	its	22 Rp	16.Ø1	kind	Ø

SEGMENT# 17

The marker is usually a carbon isotope produced in a cyclotron.

CLAUSES:			DEC(EDQ)			
PROPOSITIONS:						
64	17.Ø	IDENT:	[MARKER(DEF NUM: SING)], [17.1,17.2]≡ MOD: QUAL: *USUALLY*;			
65	17.1	ISOTOPE (TOK NUM: SING)	ATT: CARBON;			
66	17.2	PRODUCE	RSLT: ISOTOPE(TOK NUM: SING) ≡LOC: *IN*CYCLOTRON(TOK NUM: SING);			
COHESION:						
	17.1	the	21 Rd	16.Ø2	marker	1
	17.2	marker	61 L-root	16.Ø2	marker	1

SEGMENT# 18

This apparatus shoots protons into the nuclei of carbon atoms

CLAUSES:			DEC			
PROPOSITIONS:						
67	18.Ø	SHOOT	AGT: APPARATUS(DEF *THIS* NUM: SING), OBJ: PROTON (TOK NUM: PL), RSLT: 18.1≡TNS: PRES;			
68	18.1	PROTON	NUCLEUS;			
69	18.2	ATOM (TOK NUM: PL)	PRT: NUCLEUS(TOK NUM: PL);			
7Ø	18.3	ATOM (TOK NUM: PL)	ATT: CARBON;			
COHESION:						
	18.1	this	21 Rd	17.Ø1	cyclotron	1
	18.2	apparatus	63 L-gen	17.Ø1	cyclotron	1
	18.3	carbon	61 L-root	17.Ø2	carbon	1

SEGMENT* 19
so they end up with an extra proton

CLAUSES:			BAJT		
PROPOSITIONS:					
71	19.∅	END UP	RSLT: 19.1=;		
72	19.1	THEY	PRT:PROTON(TOK NUM: SING)=;		
73	19.2	PROTON (TOK NUM: SING)	ATT:EXTRA;		
74	19.3	CAU: *SO*	[18.∅], [19.∅];		

COHESION:

19.1	so	53 Cc1	18.∅1	prev. seg	1
19.2	they	22 Rp	18.∅2	nuclei	1
19.3	proton	61 L-root	18.∅3	proton	1

SEGMENT* 2∅
This makes the atoms unstable, but only for a while:

CLAUSES:			DEC
PROPOSITIONS:			
75	2∅.∅	CAU: *MAKE* [THIS], [2∅.∅];	
76	2∅.1	ATOM	ATT:UNSTABLE =TEM: *DUR* *FOR*A WHILE,DEG:ONLY;

COHESION:

2∅.1	this	21 Rd	19.∅1	prev. seg.	1
2∅.2	the	21 Rd	18.∅4	atoms	2
2∅.3	atoms	61 L-root	18.∅4	atoms	2
2∅.4	but	52 Cv	2∅.∅1	prev. part	∅

SEGMENT* 21
after half an hour most of them are normal again.

CLAUSES:			DEC
PROPOSITIONS:			
77	21.∅	MOST	ATT:NORMAL=ASPCT: ITER *AGAIN*, TEM: *AFTER*;
78	21.1	THEM	CAT:MOST;
79	21.2	DIFF: TEM: (*HALF AN HOUR)	[2∅.∅], [21.∅];

COHESION:

21.1	them	22 Rp	2∅.3	atoms	1

SEGMENT* 22
These unstable atoms are attached to the glucose

CLAUSES:			DEC			
PROPOSITIONS:						
80	22.0	ATTACH	OBJ: ATOM(DEF *THESE* NUM: PL), REC: GLUCOSE=;			
81	22.1	ATOM (DEF NUM: PL)	ATT: UNSTABLE;			
COHESION:						
	22.1	these	21 Rd	21.1	them	1
	22.2	unstable	61 L-root	20.02	unstable	2
	22.3	atoms	61 L-root	20.3	atoms	2
	22.4	attached	61 L-root	16.03	attach	6
	22.5	the	21 Rd	16.04	glucose	6
	22.6	glucose	61 L-root	16.04	glucose	6

SEGMENT* 23
and injected into the patient's neck.

CLAUSES:			SF=DEC			
PROPOSITIONS:						
82	23.0	INJECT	RSLT: 23.1=;			
83	23.1	Ø	LOC: *IN* NECK(DEF NUM: SING);			
84	23.2	PATIENT (DEF NUM: SING)	PRT: NECK(DEF NUM: SING);			
COHESION:						
	23.1	and	51 Ca	22.01	prev. seg.	1
	23.2	inject	61 L-root	15.03	injection	8
	23.3	the	21 Rd	15.2	he	8
	23.4	patient	61 L-root	9.2	patient	14

SEGMENT* 24
After the injection, scanning begins.

CLAUSES:			DEC			
PROPOSITIONS:						
85	24.0	SCAN	=ASPCT: INCPT *BEGIN*;			
86	24.1	ORD: TEM: *AFTER*	[INJECTION], [24.0];			
COHESION:						
	24.1	after	56 Ct2	Ø	null	Ø
	24.2	the	21 Rd	23.2	inject	1
	24.3	injection	61 L-root	23.2	inject	1
	24.4	scanning	61 L-root	7.01	scanner	17

SEGMENT* 25
The scanner has gamma ray detectors around the patient's head.

CLAUSES:			DEC			
PROPOSITIONS:						
87	25.Ø	SCANNER (DEF NUM: SING)	PRT: DETECTOR(TOK NUM: PL)≡TNS: PRES;			
88	25.1	DETECTOR (TOK NUM: PL)	ATT: GAMMA RAY;			
89	25.2	DETECTOR (TOK NUM: PL)	LOC: *AROUND*HEAD(DEF NUM: SING);			
9Ø	25.3	PATIENT (DEF NUM: SING)	PRT: HEAD(DEF NUM: SING);			
COHESION:						
	25.1	the	21 Rd	14.3	machine	11
	25.2	scanner	61 L-root	24.3	scanning	1
	25.3	the	21 Rd	23.4	patient	2
	25.4	patient	61 L-root	23.4	patient	2
	25.5	head	61 L-root	14.2	head	11

SEGMENT* 26
That's why it's shaped like a donut:

CLAUSES:			DEC(WHNG(EDQ))			
PROPOSITIONS:						
91	26.Ø	PROX: ATT: *SHAPED LIKE*	[26.1],[26.2];			
92	26.1	IT	ATT: SHAPE;			
93	26.2	DONUT (TOK NUM: SING)	ATT: ;			
94	26.3	COND: *WHY*	[THAT], [26.Ø];			
COHESION:						
	26.1	that	21 Rd	25.Ø1	prev. seg.	1
	26.2	it	22 Rp	25.2	scanner	1
	26.3	shaped	61 L-root	14.Ø1	shaped	12
	26.4	donut	61 L-root	14.Ø2	donut	12

SEGMENT* 27
so his head can fit in the middle.

CLAUSES:			BAJT			
PROPOSITIONS:						
95	27.Ø	FIT	PAT: HEAD(DEF NUM: SING) ≡LOC: *IN*MIDDLE(DEF NUM: SING),MOD: CAN;			
96	27.1	HIS	PRT: HEAD(DEF NUM: SING);			
97	27.2	COND: *SO*	[26.Ø], [27.Ø, 27.1];			
COHESION:						
	27.1	so	53 Cc1	26.Ø1	prev. seg.	1
	27.2	his	22 Rp	25.4	patient	2
	27.3	head	61 L-root	25.5	head	2
	27.4	middle	13 Npb	26.4	donut	1

SEGMENT# 28
The unstable atoms eject positrons to become stable again.

CLAUSES:			DEC(TAJT)			
PROPOSITIONS:						
98	28.0	EJECT	AGT:ATOM(DEF *THE*NUM: PL), GOAL:28.2**SIC**, RSLT:POSITRON(TOK NUM: PL)=;			
99	28.1	ATOM (DEF *THE*NUM: PL)	ATT:UNSTABLE;			
100	28.2	BECOME	RSLT:28.3;			
101	28.3	*ATOMS*	ATT: STABLE=ASPCT: ITER *AGAIN*;			
COHESION:						
	28.1	the	21 Rd	22.3	atoms	6
	28.2	unstable	61 L-root	22.2	unstable	6
	28.3	atoms	61 L-root	22.3	atoms	6
	28.4	stable	66 L-ant	28.2	unstable	0

SEGMENT# 29
The positrons each emit two gamma rays

CLAUSES:			DEC			
PROPOSITIONS:						
102	29.0	EMIT	AGT:POSITRON(TOK NUM: PL),RSLT:GAMMA RAY(TOK NUM:TWO)=TEM: ;			
COHESION:						
	29.1	the	21 Rd	28.01	positron	1
	29.2	positrons	61 L-root	28.01	positron	1
	29.3	each	21 Rd	29.2	positrons	0
	29.4	gamma rays	61 L-root	25.02	gamma rays	4

SEGMENT# 30
when they hit electrons in the patient's tissue,

CLAUSES:			BAJT			
PROPOSITIONS:						
103	30.0	HIT	PAT: THEY, OBJ: ELECTRON (TOK NUM: PL)=TEM: WHEN, TNS: PRES;			
104	30.1	ELECTRON (TOK NUM: PL)	LOC: *IN*TISSUE(DEF);			
105	30.2	PATIENT (TOK NUM: SING)	PRT:TISSUE(DEF);			
106	30.3	EQUIV: TEM:	[29.0], [30.0];			
COHESION:						
	30.1	when	57 Ct1	29.01	prev. seg	1
	30.2	they	22 Rp	29.4	gamma rays	1
	30.3	the	21 Rd	25.4	patient	5
	30.4	patient	61 L-root	25.4	patient	5
	30.5	tissue	62 L-gen	6.4	brain	24

SEGMENT* 31
and this is called annihilation.

CLAUSES:			DEC			
PROPOSITIONS:						
107	31.0	EQUIV: *CALLED*	[THIS], [ANNIHILATION];			
COHESION:						
	31.1	and	53 Ca	30.01	prev. seg	1
	31.2	this	21 Rd	30.01	prev. seg	1

SEGMENT* 32
The gamma rays leave the annihilation site in opposite directions

CLAUSES:			DEC			
PROPOSITIONS:						
108	32.0	LEAVE	AGT: GAMMA RAY(TOK NUM: PL), SOURCE: 32.1 ≡LOC: *DIR* OPPOSITE DIRECTIONS, TNS: PRES;			
109	32.1	ANNIHILATION	≡LOC: SITE;			
COHESION:						
	32.1	the	21 Rd	30.2	they	2
	32.2	gamma rays	61 L-root	29.4	gamma rays	3
	32.3	the	13 Npb	31.01	annihilation	1
	32.4	annihilation	61 L-root	31.01	annihilation	1

SEGMENT* 33
and they have enough energy to leave the brain through the skull.

CLAUSES:			DEC(TAJT)			
PROPOSITIONS:						
110	33.0	THEY	ATT: ENERGY, DEG: ENOUGH;			
111	33.1	LEAVE	SOURCE: 33.2 ≡LOC: *DIR* *THROUGH* SKULL(GEN);			
112	33.2	THEY	LOC: BRAIN(GEN);			
113	33.3	COND: *TO*	[33.0], [33.1];			
COHESION:						
	33.1	and	53 Ca	32.01	prev. seg	1
	33.2	they	22 Rp	32.2	gamma rays	1
	33.3	brain	61 L-root	6.4	brain	27
	33.4	skull	13 Npb	33.3	brain	0

SEGMENT* 34
When they hit two detectors simultaneously,

CLAUSES:			BAJT			
PROPOSITIONS:						
114	34.0	HIT	PAT: THEY, OBJ: DETECTOR(TOK NUM: TWO) ≡ATT: SIMULTANEOUSLY, TEM: WHEN;			
115	34.1	EQUIV: TEM:	[34.0], [35.0];			
COHESION:						
	34.1	when	58 Ct2	0	null	0
	34.2	they	22 Rp	33.2	they	1
	34.3	hit	61 L-root	30.02	hit	4
	34.4	detector	61 L-root	25.03	detector	9

SEGMENT* 35
a signal is sent to a computer.

CLAUSES:			DEC			
PROPOSITIONS:						
116	35.Ø	SEND	ACT: SIGNAL≡LOC: *DIR* COMPUTER (TOK NUM: SING), TEM: ;			
COHESION:		(none)				

SEGMENT* 36
Because each of the detectors has a tube in front of it,

CLAUSES:			BAJT			
PROPOSITIONS:						
117	36.Ø	TUBE (TOK NUM: SING)	LOC: ;			
118	36.1	DETECTOR (TOK NUM: SING *EACH*)	LOC: ;			
119	36.2	P-ORD: LOC: *IN FRONT OF*	[36.Ø], [36.1];			
12Ø	36.3	CAU:	[36.Ø,36.1,36.2], [37.Ø];			
COHESION:						
	36.1	because	56 Cc2	Ø	null	Ø
	36.2	the	21 Rd	34.4	detector	2
	36.3	detector	61 L-root	34.5	detector	2
	36.4	it	22 Rp	36.3	detector	Ø

SEGMENT* 37
it can only "see" straight ahead.

CLAUSES:			DEC			
PROPOSITIONS:						
121	37.Ø	SEE	PAT: IT≡LOC: *DIR* AHEAD, LOC: *DIR* STRAIGHT, MOD: CAN;			
COHESION:						
	37.1	it	22 Rp	36.4	it	1

SEGMENT* 38
Thus each pair of these detectors only gives information about a small area of tissue.

CLAUSES:			DEC
PROPOSITIONS:			
122	38.0	DETECTOR (TOK NUM: PL)	CAT: PAIR(TOK NUM: EACH);
123	38.1	GIVE	PAT: PAIR(TOK NUM: SING), THM: 38.2=;
124	38.2	INFORMATION	THM: AREA(TOK NUM: SING);
125	38.3	AREA (TOK NUM: SING)	ATT: SMALL;
126	38.4	TISSUE (TOK)	PAT: AREA(TOK NUM: SING);
127	38.5	IF: *THUS*	[37.0], [38.0,38.1,38.2,38.3,38.4];

COHESION:

38.1	thus	55 Cc1	37.01	prev. seg	1
38.2	pair	62 L-syn	34.01	two	4
38.3	these	21 Rd	37.1	it	1
38.4	detector	61 L-root	36.3	detector	2
38.5	information	61 L-root	7.02	information	31
38.6	tissue	61 L-root	30.5	tissue	8

SEGMENT* 39
The scanner then collects these signals

CLAUSES:			DEC
PROPOSITIONS:			
128	39.0	COLLECT	PAT: SCANNER(DEF NUM: SING), ACT: 39.1=TEM: ;
129	39.1	SIGNAL	=ASPCT: ITER *S*;
130	39.2	ORD: TEM: *THEN*	[35.0], [39.0];

COHESION:

39.1	the	21 Rd	25.2	scanner	14
39.2	scanner	61 L-root	25.2	scanner	14
39.3	then	57 Ct1	35.01	prior seg.	4
39.4	these	21 Rd	35.02	signal	4
39.5	signals	61 L-root	35.02	signal	4

SEGMENT* 40
and registers which of the detectors they came from.

CLAUSES:			SF=DEC(WHNG)
PROPOSITIONS:			
131	40.0	REGISTER	THM: 40.1=;
132	40.1	COME	AGT: THEY, SOURCE: WHICH=TNS: PAST;
133	40.2	DETECTOR (DEF NUM: PL)	CAT: WHICH;

COHESION:

40.1	and	53 Ca	39.01	prev. seg.	1
40.2	the	21 Rd	38.4	detector	2
40.3	detector	61 L-root	38.4	detector	2
40.4	they	22 Rp	39.5	signals	1

SEGMENT* 41
When the scanner finishes its job,

CLAUSES:			BAJT			
PROPOSITIONS:						
134	41.Ø	FINISH	PAT: SCANNER(DEF NUM: SING), ACT: 41.1≡TEM: WHEN;			
135	41.1	JOB	PAT: ITS≡;			
136	41.2	ORD: TEM:	[41.Ø], [42.Ø];			
COHESION:						
	41.1	when	58 Ct2	Ø	null	Ø
	41.2	the	21 Rd	39.2	scanner	2
	41.3	scanner	61 L-root	39.2	scanner	2
	41.4	finish	66 L-ant	24.Ø1	begin	17
	41.5	its	22 Rp	41.3	scanner	Ø

SEGMENT* 42
the computer starts reconstructing an image of the region that was scanned.

CLAUSES:			DEC(ING(WHQ))			
PROPOSITIONS:						
137	42.Ø	RECONSTRUCT	AGT: COMPUTER(DEF NUM: SING), OBJ: IMAGE(TOK NUM: SING)≡ASPCT: INCPT, TEM: ;			
138	42.1	IMAGE(TOK NUM: SING)	THM: REGION(DEF NUM: SING);			
139	42.2	SCAN	OBJ: REGION(DEF NUM: SING)≡TNS: PAST;			
COHESION:						
	42.1	the	21 Rd	35.Ø2	computer	7
	42.2	computer	61 L-root	35.Ø2	computer	7
	42.3	starts*	66 L-ant	41.4	finish	1
	42.4	starts*	62 L-syn	24.Ø1	begin	18
	42.5	the	21 Rd	38.Ø1	area	4
	42.6	region	62 L-syn	38.Ø1	area	4
	42.7	scanned	61 L-root	41.3	scanner	1

SEGMENT* 43
A program compares the number of signals sent by each pair of detectors and those sent by all the others,

CLAUSES:			DEC(EDQ-EDQ)
PROPOSITIONS:			
14Ø	43.Ø	COMPARE	PAT: PROGRAM(TOK NUM: SING), ACT: 43.1,THOSE≡TEM: ;
141	43.1	SIGNAL	≡ASPCT: ITER NUMBER;
142	43.2	SEND	ACT: PAIR(TOK *EACH*,NUM: SING), RSLT: 43.1≡TNS:PAST;
143	43.3	SEND	ACT: OTHERS(TOK NUM: ALL), RSLT: THOSE≡TNS:PAST;
144	43.4	DETECTOR	CAT: PAIR(TOK *EACH*,NUM: SING);

COHESION:

43.1	signal	61 L-root	39.5	signal	4
43.2	send	61 L-root	35.Ø3	send	8
43.3	each	21 Rd	38.2	pair	5
43.4	pair	61 L-root	38.2	pair	5
43.5	detector	61 L-root	4Ø.3	detector	3
43.6	and	53 Ca	43.Ø1	prev. part	Ø
43.7	those	41 S	43.Ø2	number	Ø
43.8	send	61 L-root	43.2	send	Ø
43.9	the others	41 S	43.5	detectors	Ø

SEGMENT* 44
and then it calculates the number of gamma rays emitted by each of the regions of the brain.

CLAUSES:			DEC(EDQ)
PROPOSITIONS:			
145	44.Ø	CALCULATE	PAT: IT,RSLT: 44.1≡TEM: ;
146	44.1	GAMMA RAY (TOK NUM: PL)	NUM: NUMBER;
147	44.2	EMIT	PAT: REGION(TOK NUM: SING EACH),RSLT: 44.1≡;
148	44.3	BRAIN (DEF NUM: SING)	PAT: REGION(TOK NUM: SING EACH);
149	44.4	ORD: TEM:	[43.Ø], [44.Ø];

COHESION:

44.1	and	53 Ca	43.Ø3	prev. seg	1
44.2	then	57 Ct1	43.Ø3	prev. seg	1
44.3	it	22 Rp	43.Ø4	program	1
44.4	number	61 L-root	43.Ø2	number	1
44.5	gamma rays	61 L-root	32.2	gamma rays	12
44.6	emitted	61 L-root	29.Ø2	emit	15
44.7	each	21 Rd	42.6	region	2
44.8	the	21 Rd	42.6	region	2
44.9	region	61 L-root	42.6	region	2
44.1Ø	the	21 Rd	3Ø.5	tissue	14
44.11	brain	61 L-root	33.3	brain	11

SEGMENT# 45
The image appears on a screen as some colored squares that represent a cross-section of the brain,

CLAUSES:			DEC(WHQ)			
PROPOSITIONS:						
150	45.0	APPEAR	PAT: IMAGE(TOK NUM: SING), THM: 45.1,45.2,45.3 =LOC: *ON*SCREEN(TOK NUM: SING);			
151	45.1	SQUARE (TOK NUM: PL)	ATT: COLORED;			
152	45.2	THAT	THM: 45.3,45.4;			
153	45.3	BRAIN (DEF NUM: SING)	PAT: CROSS-SECTION(TOK NUM: SING);			
COHESION:						
	45.1	the	21 Rd	42.01	image	3
	45.2	image	61 L-root	42.01	image	3
	45.3	that	22 Rp	45.01	squares	0
	45.4	the	21 Rd	44.11	brain	1
	45.5	brain	61 L-root	44.11	brain	1

SEGMENT# 46
and this image is what the doctor interprets to perform his diagnosis.

CLAUSES:			DEC(WHNG(TAJT))			
PROPOSITIONS:						
154	46.0	INTERPRET	PAT: DOCTOR(DEF NUM: SING), OBJ: IMAGE(DEF THIS,NUM: SING),GOAL: 46.1=;			
155	46.1	PERFORM	ACT: 46.2=;			
156	46.2	DIAGNOSE	PAT: HIS=;			
COHESION:						
	46.1	and	53 Ca	45.01	prev. seg	1
	46.2	this	21 Rd	45.2	image	1
	46.3	image	61 L-root	45.2	image	1
	46.4	what	22 Rp	46.3	image	0
	46.5	the	21 Rd	4.4	doctor	42
	46.6	doctor	61 L-root	4.4	doctor	42
	46.7	his	22 Rp	46.6	doctor	0

SEGMENT# 47
Since the different colors represent different amounts of gamma rays

CLAUSES:			BAJT			
PROPOSITIONS:						
157	47.0	EQUIV: *REPRESENT*	[47.1], [47.2];			
158	47.1	COLOR (DEF NUM: PL)	ATT:DIFFERENT;			
159	47.2	GAMMA RAY (TOK NUM: PL)	ATT:AMOUNTS(ATT:DIFFERENT);			
COHESION:						
	47.1	since	56 Cc2	0	null	0
	47.2	the	21 Rd	45.01	colored	2
	47.3	colors	61 L-root	45.01	colored	2
	47.4	represent	61 L-root	45.02	represent	2
	47.5	gamma rays	61 L-root	44.5	gamma rays	3

SEGMENT# 48
and the rays are produced by the radioactive glucose,

CLAUSES:			DEC			
PROPOSITIONS:						
160	48.0	PRODUCE	AGT:GLUCOSE(DEF), RSLT:RAY(DEF NUM: PL)=TNS: PRES;			
161	48.1	GLUCOSE (DEF)	ATT:RADIOACTIVE;			
162	48.2	AND:	[47.0,47.1,47.2], [48.0,48.1];			
163	48.3	COND: *SINCE*	[48.2], [49.0];			
COHESION:						
	48.1	and	53 Ca	47.01	prev. seg	1
	48.2	the	21 Rd	47.5	gamma rays	1
	48.3	rays	61 L-root	47.5	gamma rays	1
	48.4	produced	61 L-root	17.03	produce	31
	48.5	the	21 Rd	22.6	glucose	26
	48.6	radioactive	61 L-root	16.2	radioactive	32
	48.7	glucose	61 L-root	22.6	glucose	26

SEGMENT# 49
he can see where the glucose concentrated.

CLAUSES:			DEC(WHNG)			
PROPOSITIONS:						
164	49.0	SEE	PAT:HE,ACT: 49.1=MOD: CAN;			
165	49.1	CONCENTRATE	PAT:GLUCOSE(DEF) =LOC: WHERE,TNS: PAST;			
COHESION:						
	49.1	he	22 Rp	46.3	doctor	2
	49.2	the	21 Rd	48.7	glucose	1
	49.3	glucose	61 L-root	48.7	glucose	1

SEGMENT* 5Ø
Doctors already know that tumors consume more energy than normal tissue,

CLAUSES: DEC(REPNG=DEC)

PROPOSITIONS:

166	5Ø.Ø	KNOW	PAT: DOCTOR(GEN,UNIV), THM: 5Ø.1,5Ø.2,5Ø.3,5Ø.4,5Ø.5, 5Ø.6,5Ø.7=TEM: ALREADY,TNS:PRES;
167	5Ø.1	CONSUME	PAT: TUMOR(GEN,UNIV), OBJ: ENERGY(TOK)=;
168	5Ø.2	ENERGY(TOK)	ATT: *AMOUNT*,DEG: MORE;
169	5Ø.3	*CONSUME*	PAT: TISSUE(GEN,UNIV), OBJ: *ENERGY*=;
17Ø	5Ø.4	TISSUE	ATT: NORMAL;
171	5Ø.5	ENERGY(TOK)	ATT: ,DEG: ;
172	5Ø.6	ORD: DEG: *MORE*	[5Ø.2], [5Ø.5];
173	5Ø.7	ORD: TEM: *ALREADY*	[5Ø.Ø], [ ];

COHESION:

5Ø.1	doctors	61 L-root	46.6	doctor	4
5Ø.2	tumors	61 L-root	4.Ø4	tumor	46
5Ø.3	more	23 Rc	5Ø.2	tumors	Ø
5Ø.4	energy	61 L-root	33.Ø1	energy	17
5Ø.5	normal tissue	66 L-ant	5Ø.2	tumors	Ø
5Ø.6	tissue	61 L-root	38.6	tissue	12

SEGMENT* 51
and that they get this energy from glucose,

CLAUSES: DEC

PROPOSITIONS:

174	51.7	GET	AGT: THEY,OBJ: *THIS*ENERGY(TOK), SOURCE: GLUCOSE(TOK)=;

COHESION:

51.1	and	53 Ca	5Ø.Ø1	prev. seg.	1
51.2	they	22 Rp	5Ø.2	tumors	1
51.3	this	21 Rd	5Ø.4	energy	1
51.4	energy	61 L-root	5Ø.4	energy	1
51.5	glucose	61 L-root	49.3	glucose	2

SEGMENT# 52
so the doctor can spot the tumor because it will have a brighter color.

CLAUSES: BAJT(BAJT)

PROPOSITIONS:

175	52.0	SPOT	PAT:DOCTOR(DEF NUM: SING), OBJ:TUMOR(TOK NUM: SING)=MOD: CAN;
176	52.1	IT	ATT:COLOR(ATT:BRIGHT,DEG:)=TNS: FUT;
177	52.2	ORD: DEG:	[ ], [52.1];
178	52.3	COND: *SO*	[50.0,51.0], [52.0];
179	52.4	CAU: *BECAUSE*	[52.1,52.2], [52.0];

COHESION:

52.1	so	55 Cc1	51.01	prev. seg	1
52.2	the	21 Rd	46.6	doctor	6
52.3	doctor	61 L-root	50.1	doctors	2
52.4	spot	62 L-syn	37.02	see	15
52.5	the	21 Rd	50.2	tumor	2
52.6	tumor	61 L-root	50.2	tumor	2
52.7	because	55 Cc1	52.01	prev. part	0
52.8	it	22 Rp	52.6	tumor	0
52.9	brighter	23 Rc	47.3	colors	5
52.10	color	61 L-root	47.3	colors	5

SEGMENT# 53
Other disorders also show typical patterns on the image,

CLAUSES: DEC

PROPOSITIONS:

180	53.0	CAU:	[53.1], [53.2];
181	53.1	DISORDER	ATT:OTHER;
182	53.2	SHOW	OBJ:PATTERN =LOC: *ON*IMAGE(DEF NUM: SING);
183	53.3	PATTERN (TOK NUM: PL)	ATT:TYPICAL;

COHESION:

53.1	other	23 Rc	52.6	tumor	1
53.2	disorders	64 L-gen	52.6	tumor	1
53.3	also	53 Ca	52.02	prev. seg	1
53.4	the	21 Rd	46.3	image	7
53.5	image	61 L-root	46.3	image	7

SEGMENT* 54
and with different isotopes we can get information about the processes happening in the brain.

CLAUSES:			DEC(IQ)			
PROPOSITIONS:						
184	54.Ø	ISOTOPE (TOK NUM: PL)	ATT: DIFFERENT;			
185	54.1	GET	AGT: WE, INST: ISOTOPE(DEF NUM: PL), THM: 54.2 ≡MOD: CAN;			
186	54.2	INFORMATION	THM: 54.3;			
187	54.3	HAPPEN	ACT: PROCESSES≡LOC: ≈IN*BRAIN(GEN, UNIV);			
COHESION:						
	54.1	and	54 Ca	53.Ø1	prev. seg	1
	54.2	different	23 Rc	17.Ø4	isotope	37
	54.3	isotopes	61 L-root	17.Ø4	isotope	37
	54.4	we	22 Rp	7.Ø3	us	47
	54.5	information	61 L-root	38.5	information	16
	54.6	happen	62 L-syn	6.2	go on	48
	54.7	brain	61 L-Root	45.5	brain	9

SEGMENT* 55
The isotopes are safe,

CLAUSES:			DEC			
PROPOSITIONS:						
188	55.Ø	ISOTOPE (DEF NUM: PL)	ATT: SAFE;			
COHESION:						
	55.1	the	21 Rd	54.3	isotopes	1
	55.2	isotopes	61 L-root	54.3	isotopes	1

SEGMENT* 56
since they're only radioactive for a short while.

CLAUSES:			BAJT			
PROPOSITIONS:						
189	56.Ø	THEY	ATT: RADIOACTIVE ≡TEM: *DUR* A SHORT WHILE, DEG: ONLY;			
190	56.1	COND: *SINCE*	[56.Ø], [55.Ø];			
COHESION:						
	56.1	since	56 Cc1	55.Ø1	prev. seg	1
	56.2	they	22 Rp	55.2	isotopes	1
	56.3	radioactive	61 L-root	48.6	radioactive	8

SEGMENT# 57
The doctor doesn't have to open the skull,

CLAUSES: DEC(TNG)
PROPOSITIONS:

191	57.0	OPEN	ACT: DOCTOR(DEF NUM: SING), OBJ: SKULL(GEN,UNIV) =MOD: ROOT *HAVE TO*,NEG;

COHESION:

57.1	the	21 Rd	52.3	doctor	5
57.2	doctor	61 L-root	52.3	doctor	5
57.3	skull	61 L-root	33.4	skull	24

SEGMENT# 58
so he doesn't cause any damage.

CLAUSES: BAJT
PROPOSITIONS:

192	58.0	CAUSE	ACT: HE,RSLT: 58.1=NEG;
193	58.1	DAMAGE	DEG: ANY;
194	58.2	COND: *SO*	[57.0,57.1], [58.0];

COHESION:

58.1	so	55 Cc1	57.01	prev. seg	1
58.2	he	22 Rp	57.2	doctor	1
58.3	cause	61 L-root	6.02	cause	52
58.4	damage	61 L-root	6.03	damage	52

SEGMENT# 59
Thus, this technique allows him to see what's happening inside the brain easily and safely.

CLAUSES: DEC(TNG(WHNG))
PROPOSITIONS:

195	59.0	CAU:	[THIS TECHNIQUE], [59.1];
196	59.1	ALLOW	ACT: 59.2=;
197	59.2	SEE	PAT: HIM,ACT: 59.3=ATT: SAFELY,EASILY;
198	59.3	HAPPEN	ACT: WHAT=LOC: *INSIDE*BRAIN(DEF NUM: 1), ASPCT: CONT,TNS: PRES;

COHESION:

59.1	thus	55 Cc1	58.01	prev. seg	1
59.2	this	21 Rd	58.01	prev. seg	1
59.3	technique	61 L-root	7.04	technology	52
59.4	him	22 Rp	58.2	he	1
59.5	happen	61 L-root	54.6	happen	5
59.6	brain	61 L-root	54.7	brain	5
59.7	and	53 Ca	59.01	easily	0

Appendix C
Frame Analysis of Narrative Text

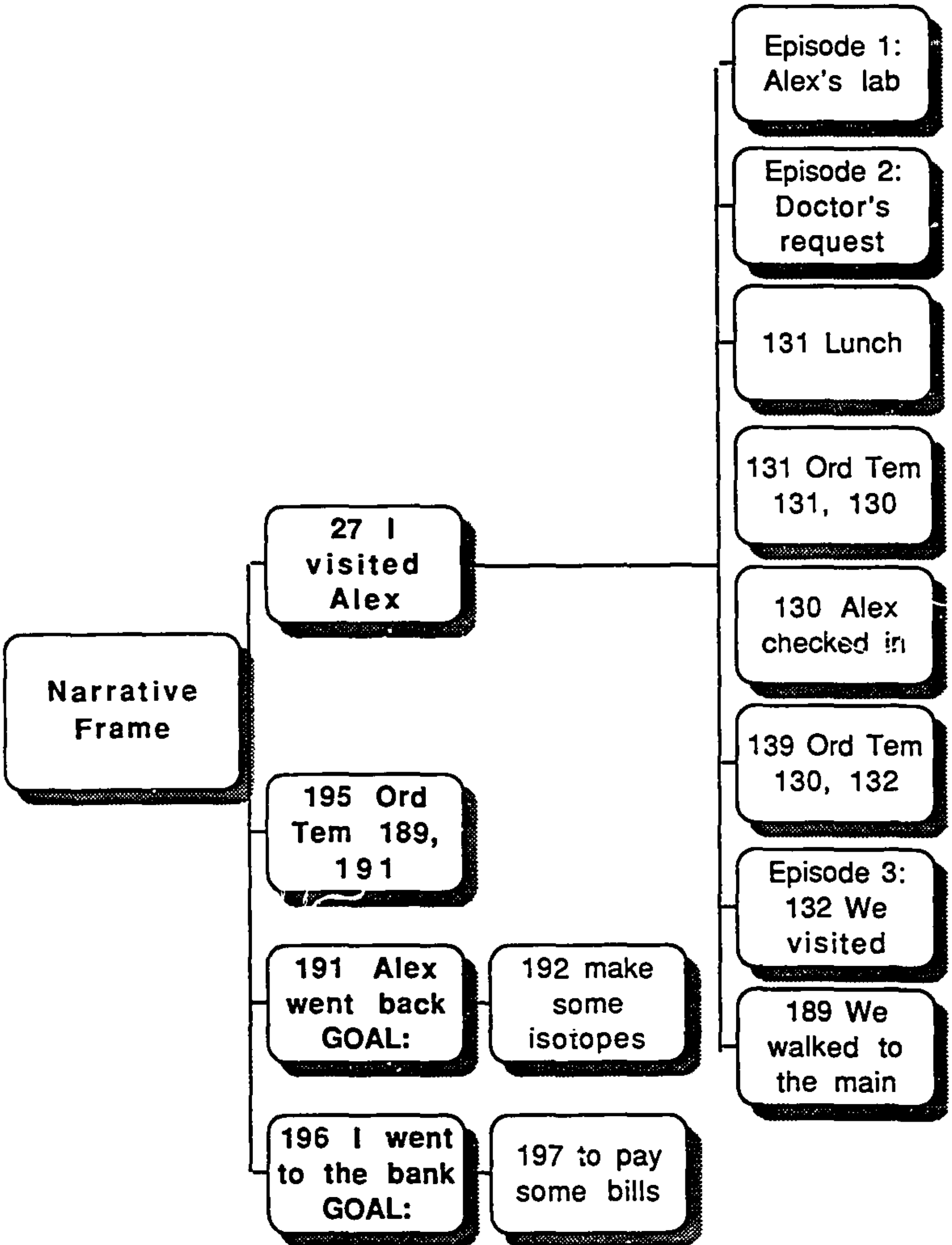


Figure C1: Narrative Frame: Overview.

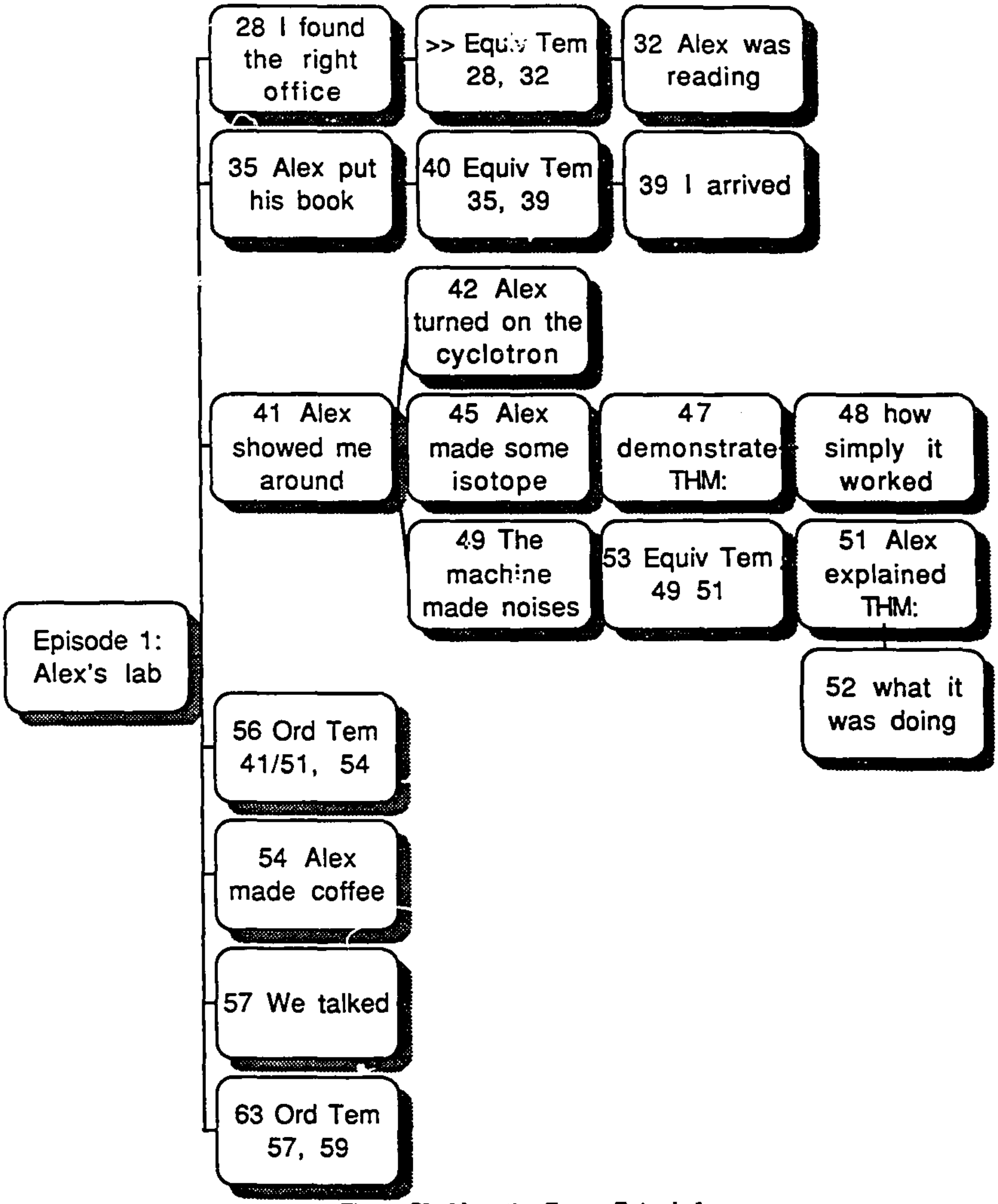


Figure C2: Narrative Frame, Episode 1.

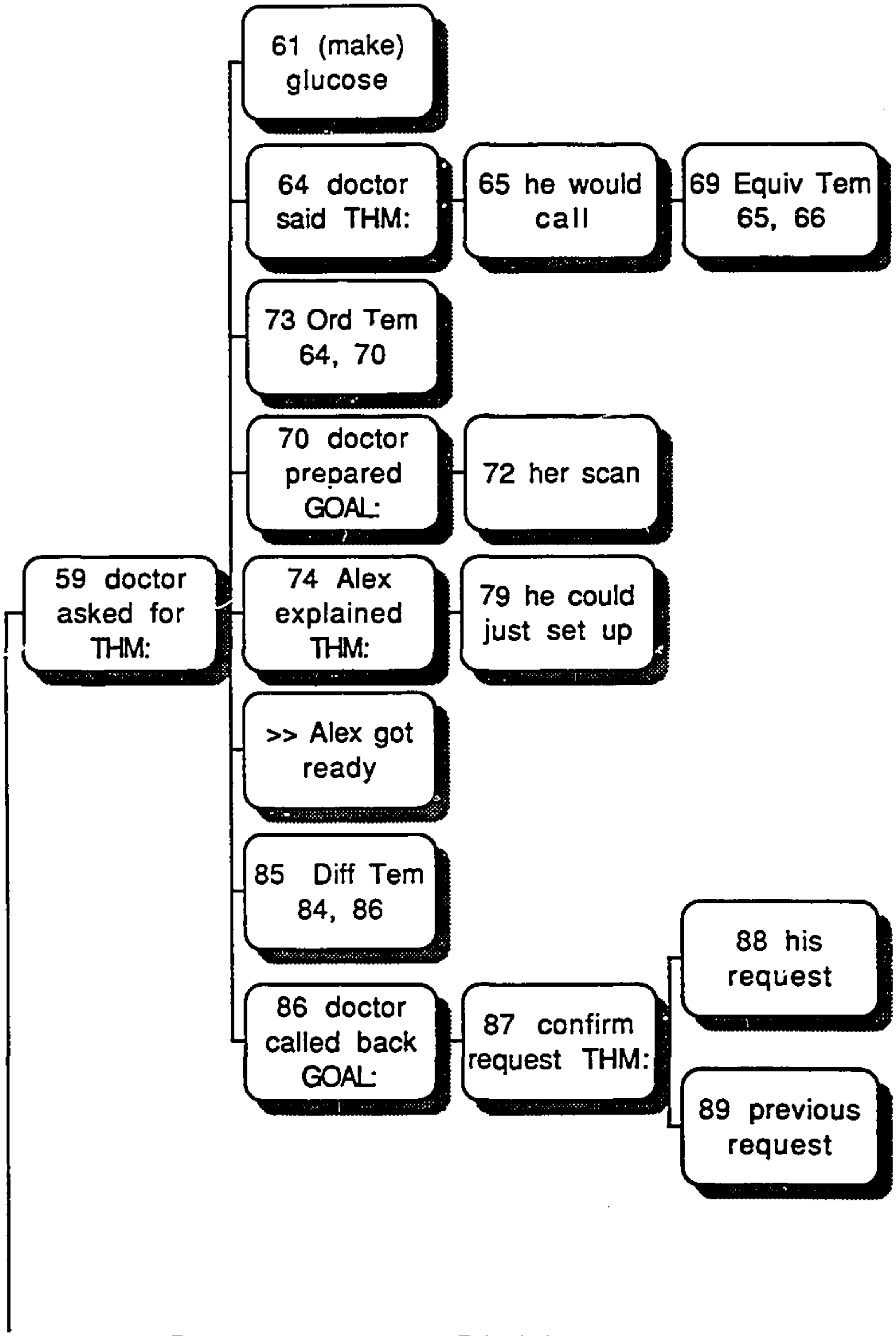


Figure C3: Narrative Frame: Episode 2, part 1.

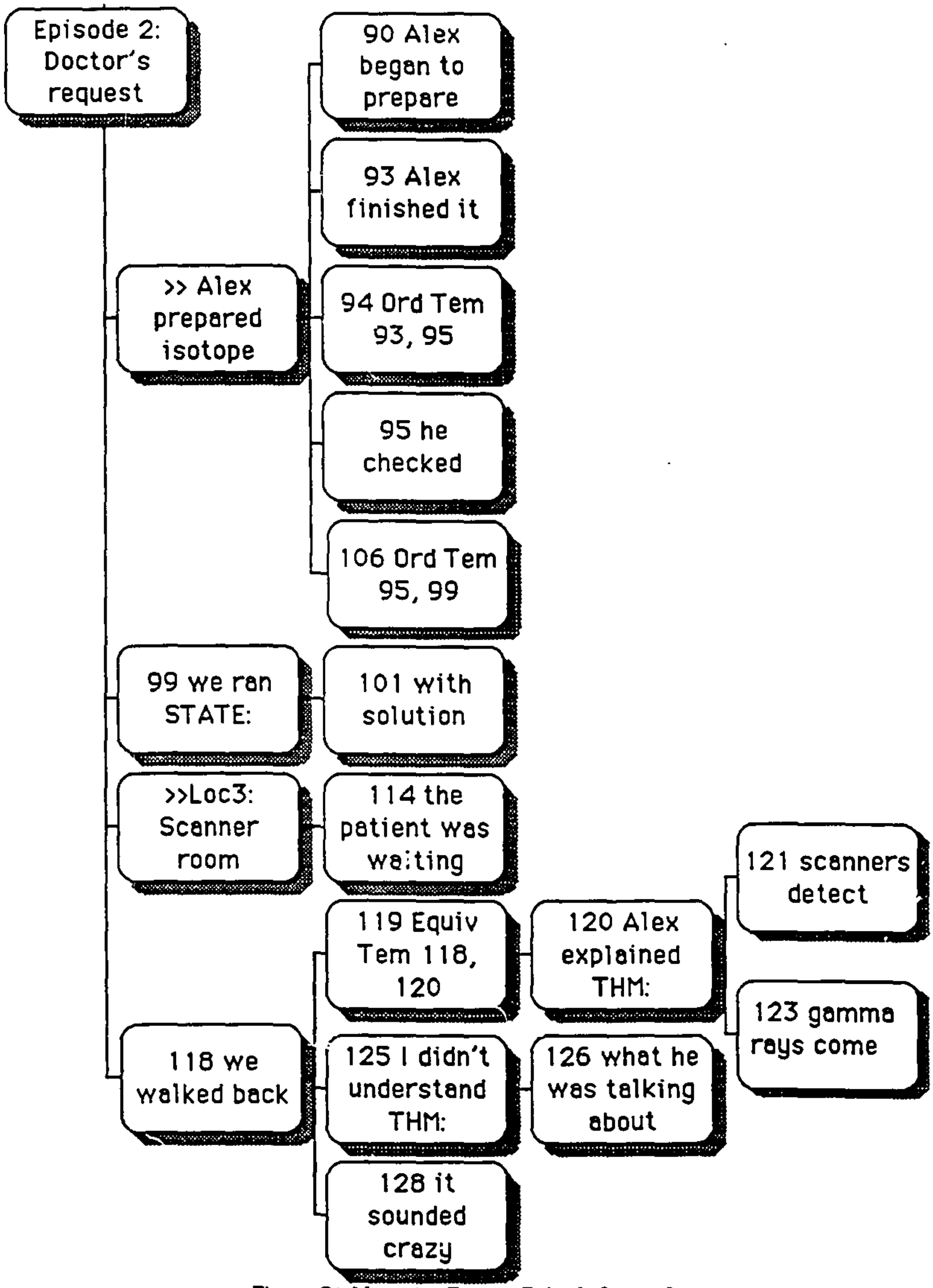


Figure C4: Narrative Frame: Episode 2, part 2

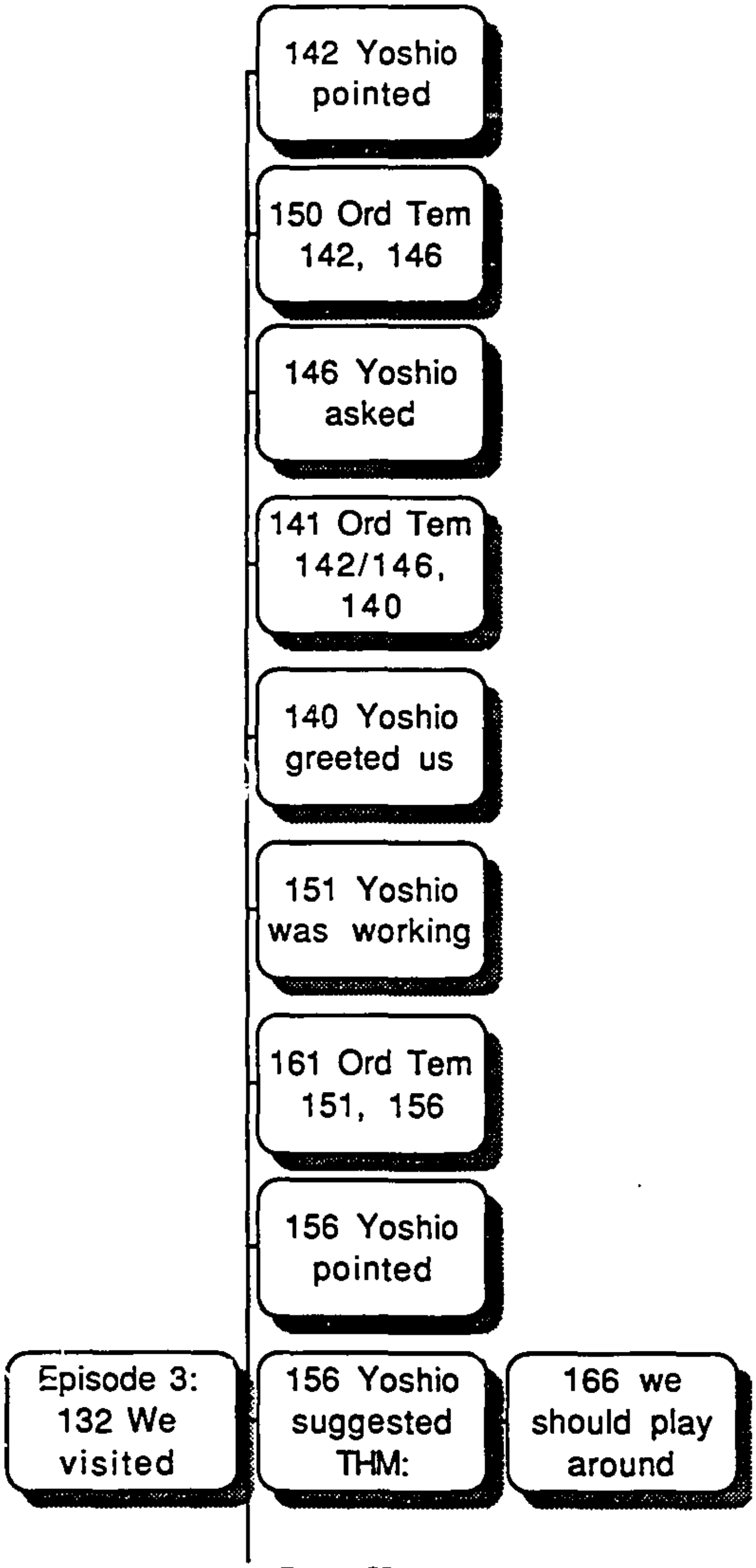


Figure C5: Narrative Frame: Episode 3, part 1.

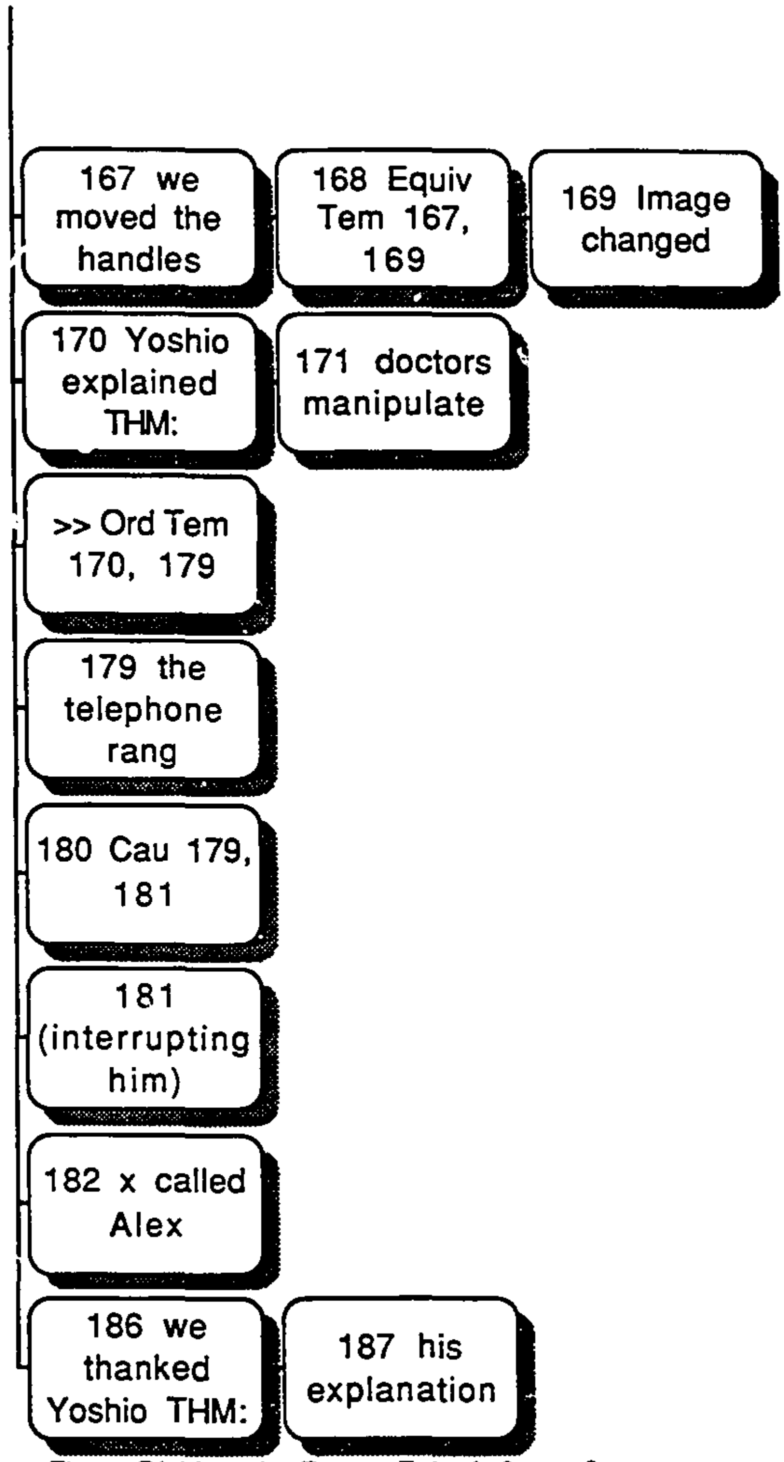
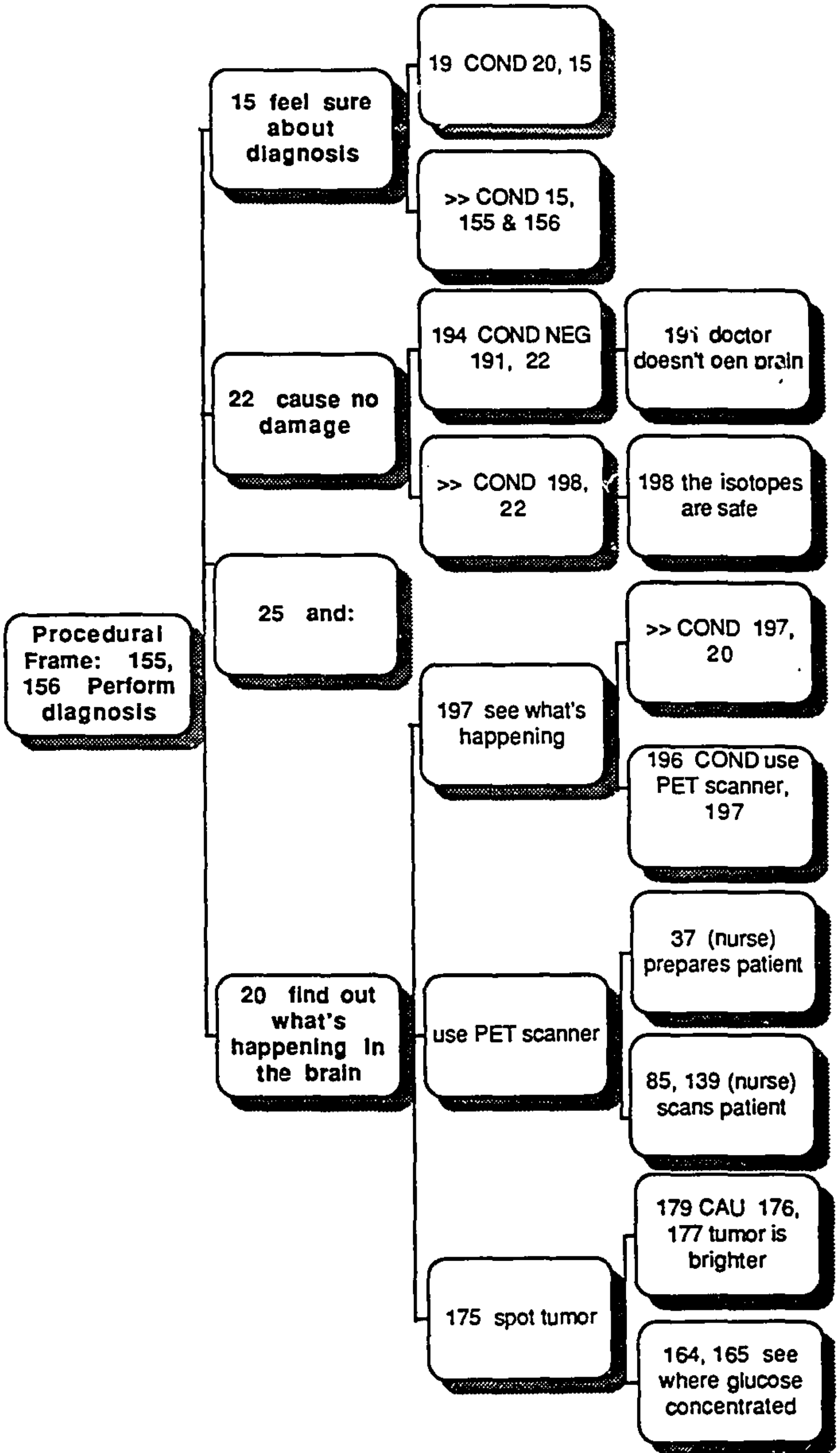


Figure C6: Narrative Frame: Episode 3, part 2.

Appendix D
Frame Analysis of Procedural Text


Procedural Frame: 155, 156 Perform diagnosis
15 feel sure about diagnosis
19 COND 20, 15
>> COND 15, 155 & 156
22 cause no damage
194 COND NEG 191, 22
191 doctor doesn't oen brain
>> COND 198, 22
198 the isotopes are safe
25 and:
197 see what's happening
>> COND 197, 20
196 COND use PET scanner, 197
20 find out what's happening in the brain
use PET scanner
37 (nurse) prepares patient
85, 139 (nurse) scans patient
175 spot tumor
179 CAU 176, 177 tumor is brighter
164, 165 see where glucose concentrated

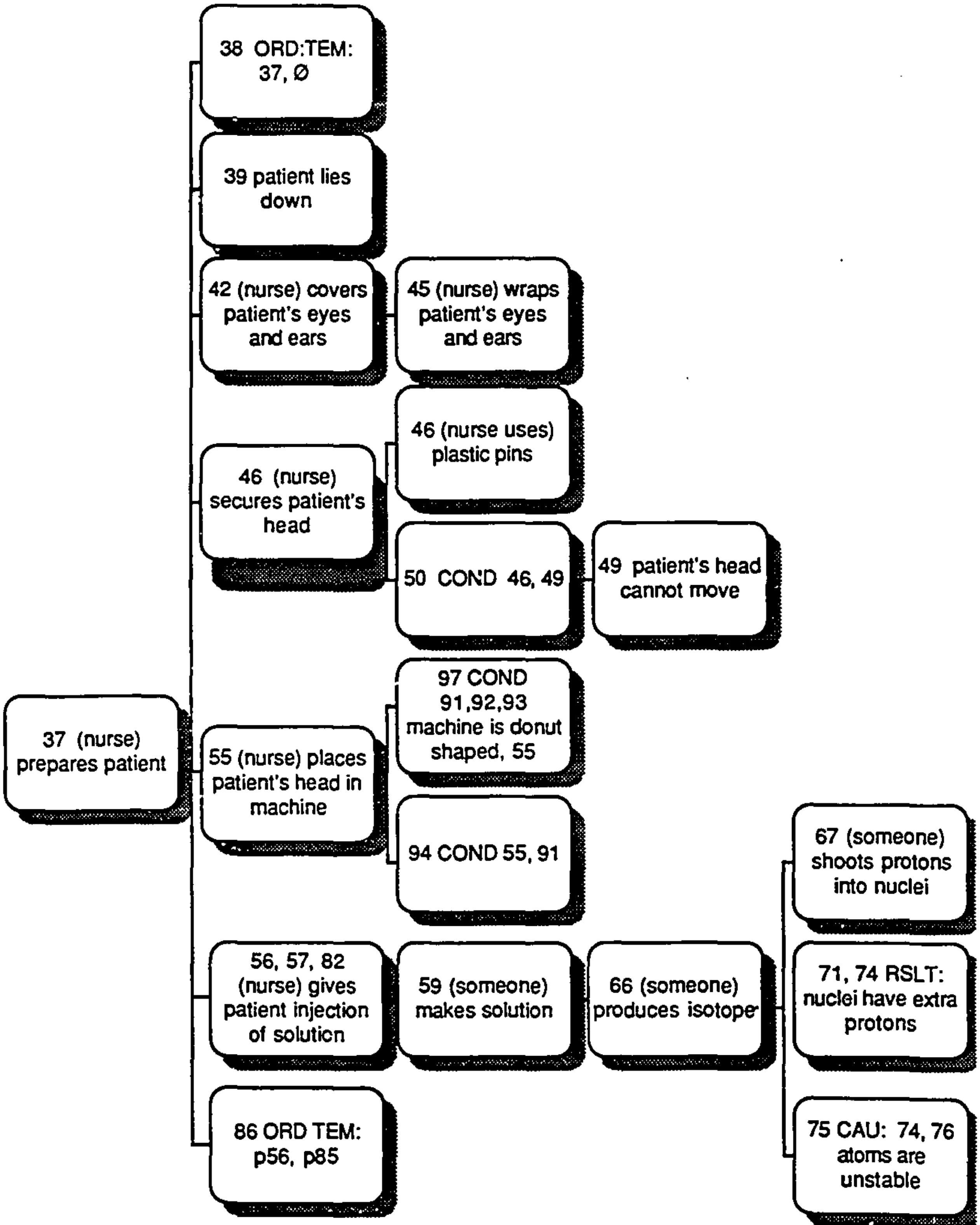


Figure D.2. Procedural Frame: Subprocedure 2.

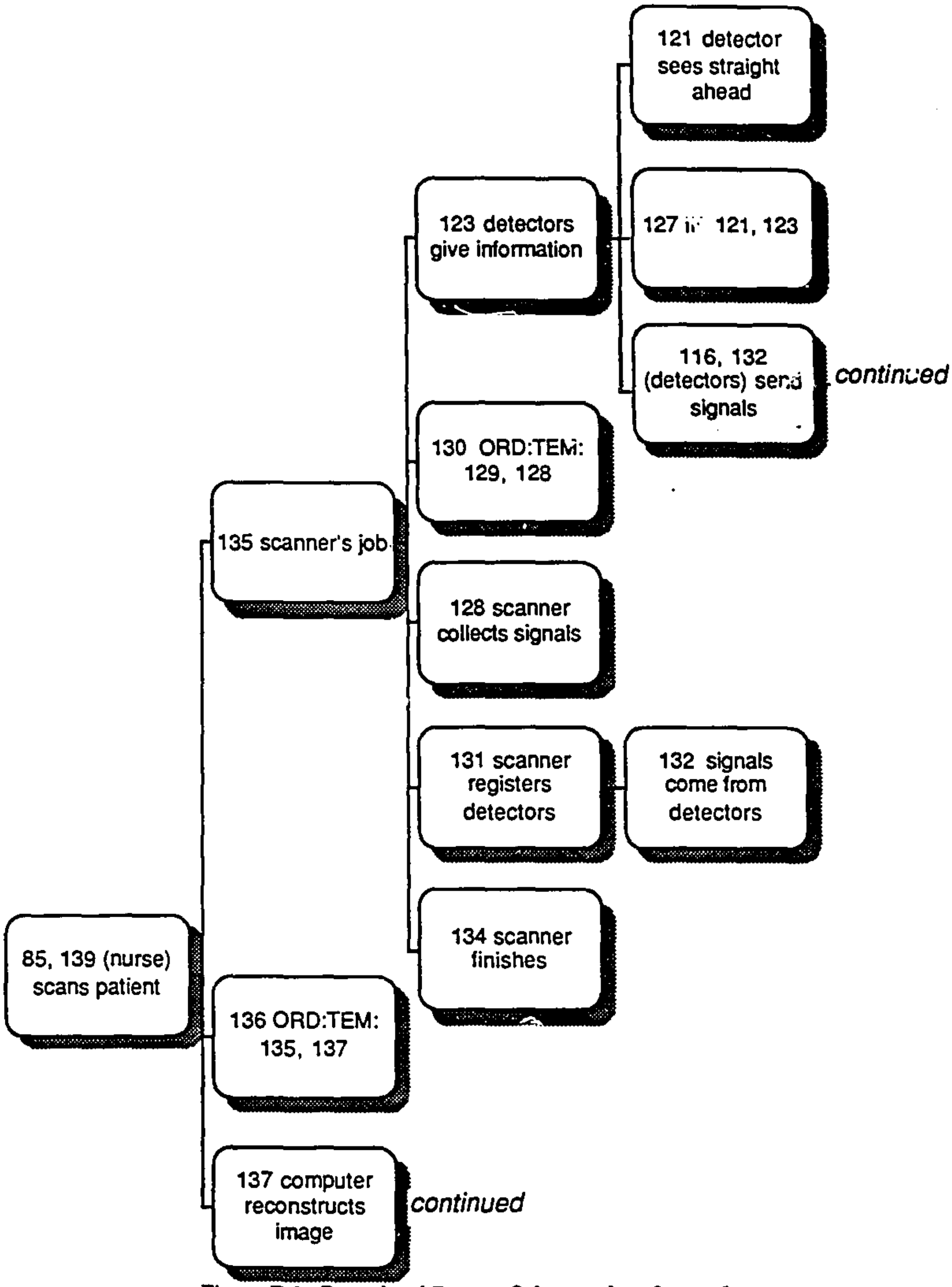


Figure D.3. Procedural Frame: Subprocedure 3, part 1.

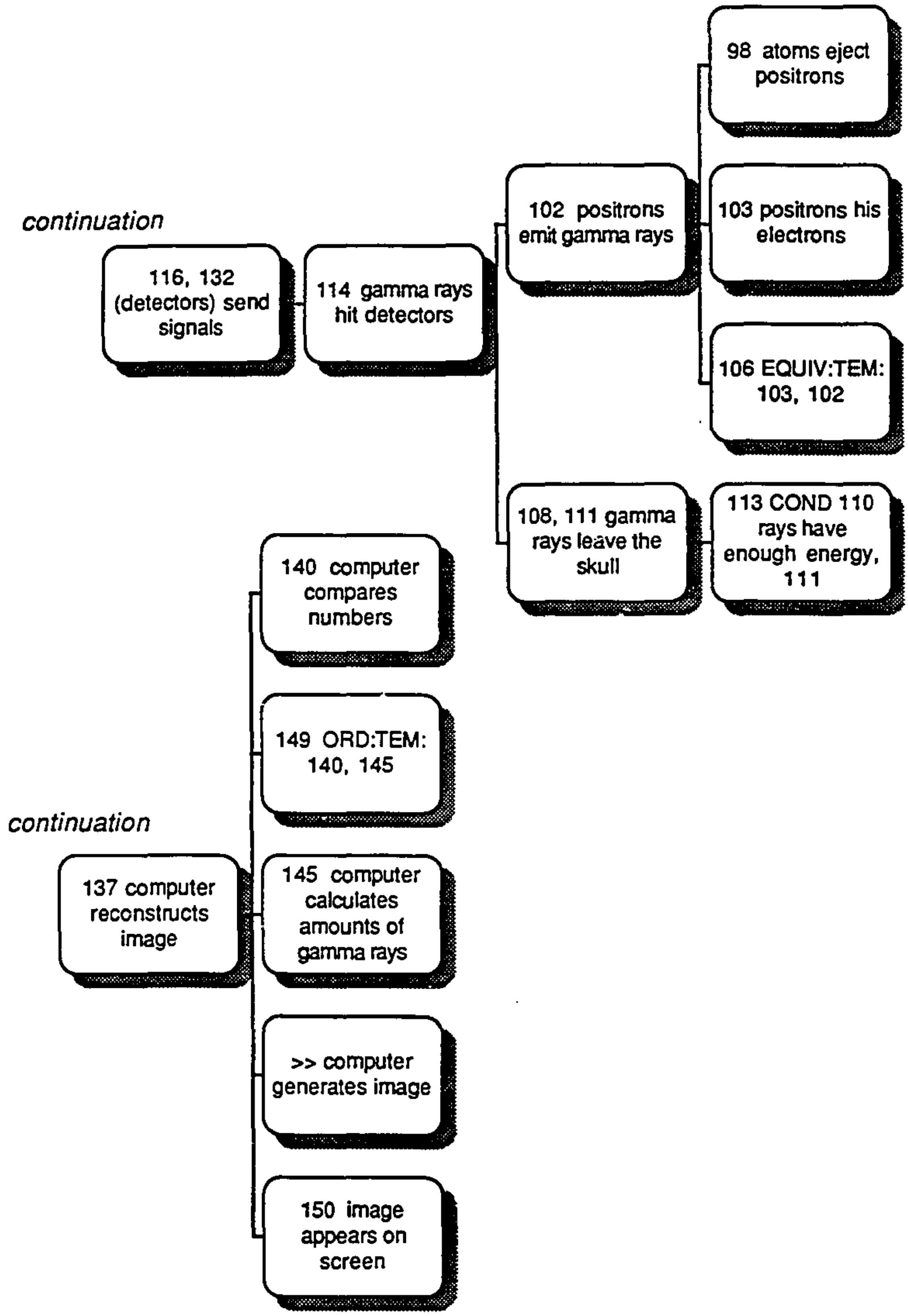


Figure D.4. Procedural Frame: Subprocedure 3, part 2.

Appendix E
Practice Text and Instructions to Subjects

Practice Text (301 words)

Technology is more and more involved in the daily practice of medicine. Computers help doctors keep track of their patients, and even help in making diagnoses. Laboratory workers use the techniques of genetic engineering every day to detect and predict diseases. Neurologists and brain surgeons routinely use sophisticated brain scanners to do their work.

Some people, however, see this as a problem. They fear that since doctors are not specialized enough to understand the underlying physics and chemistry of these techniques, they will rely on them blindly. Moreover, the expense of acquiring and using this complex equipment puts a much greater financial burden on the society and on the individual. These people feel that the benefits of using advanced technology in medicine are much less than the problems associated with them, and that we should try to slow down the technologizing of medicine.

On the other hand, the supporters of increased use of technology in medicine point to how many lives it has saved, how it has helped improve doctors' ability to discover and prevent diseases, and how it has facilitated the investigation of new cures for them. These people would say that less competent doctors rely on whatever they have, whether or not it is sophisticated technology, that society has to bear the economic burden when saving lives is the question, and that the benefits of technological advances in medicine are much greater than the problems they bring.

Clearly, both points of view raise difficult questions: is the vast amount of money in this area being well spent? Are the problems involved enough to make us slow down the search for ways of curing and preventing sickness? Are the problems involved in doctors' use of the technology due mainly to insufficient background? As in every other case, the integration of new technology into society poses problems and challenges for everyone.

(duration at 145 wpm: 2'12")

Introduction (for Interpreting Task)

This experiment is part of a study to find out how people can perform simultaneous interpreting and other tasks that require listening and speaking at the same time. Your cooperation will be of most assistance to us if you try to maximize the accuracy of your translation, and follow the other instructions as closely as you can. You may find parts of a given text easy or difficult, slow or fast -- we would just like you to do your best.

You will be given a short text for practice so that you can get warmed up and used to the experimental surroundings. Then you will be given two texts, each about four or five minutes in length, which you will be asked to interpret into French. You may also be asked to recount the text you heard, but in that case you will be warned to concentrate on remembering it. If you have any questions feel free to ask them now. Thank you very much for your cooperation.

Introduction (for Listening Task)

This experiment is part of a study to find out how people can perform simultaneous interpreting and other tasks that require listening and speaking at the same time. Your cooperation will be of most assistance to us if you listen carefully to the texts, and follow the other instructions as closely as you can. You may find parts of a given text easy or difficult, slow or fast -- we would just like you to do your best.

You will be given a short text for practice so that you can get warmed up and used to the experimental surroundings. Then you will be given two texts, each about four or five minutes in length, which you will be asked to listen to carefully. You may also be asked to recount the text you heard, but in that case you will be warned to concentrate on remembering it. If you have any questions feel free to ask them now. Thank you very much for your cooperation.

Instructions for Practice Text (Interpreting):

You will soon hear a short text which I would like you to interpret carefully into French for practice. Do not worry about trying to remember it, rather concentrate on making your translation as smooth and accurate as possible.

Instructions for Practice Text (Listening):

You will soon hear a short text which I would like you to listen to carefully for practice. Do not worry about trying to remember it, rather concentrate on understanding it as best you can.

Instructions for Experimental Texts (Interpreting)

You will soon hear a text which I would like you to interpret very carefully. That is, you should listen to it and provide an accurate simultaneous translation of it into French. Do not worry about remembering anything from the text, rather concentrate on making your translation as smooth and accurate as possible.

Instructions for Experimental Texts (Listening)

You will soon hear a text which I would like you to listen to very carefully. Do not worry about remembering anything from the text, rather concentrate on understanding it as best you can.

Recall Instructions (both tasks):

Now please retell word-for-word, or as accurately as you possibly can, the text you have just heard. It is very important to retell everything you can remember, even if some of it is not in the same words as the original. Please begin now. Tell the experimenter when you've finished.

Appendix F
Results of Analyses of Variance

Table F.1

Results of Analyses of Experience, Text structure and Response type on Interpreting

	Pooled over between		Experience		Text Order		Experience x Text Order	
	$F(1,12)$	p	$F(1,12)$	p	$F(1,12)$	p	$F(1,12)$	p
Within Contrasts								
Pooled over within	–	–	6.9911	.0215	<1.0	ns	2.3213	ns
Text (Narr-Proc)	40.6818	.0001	<1.0	ns	3.3969	ns	<1.0	ns
Resonse Type								
RT3-2	198.2466	.0001	5.7652	.0335	<1.0	ns	<1.0	ns
RT2+3-1	125.6490	.0001	4.6159	ns	<1.0	ns	1.1110	ns
Text by Response type								
Text x RT3-2	1.1867	ns	1.1324	ns	<1.0	ns	<1.0	ns
Text x RT2+3-1	1.6071	ns	5.3876	.0387	2.3509	ns	<1.0	ns
Text-structure variables								
Clause density (Cls)								
Cls 2-1	<1.0	ns	1.1529	ns	<1.0	ns	1.6378	ns
Cls 3-2	7.6067	.0174	1.3070	ns	<1.0	ns	<1.0	ns
Cls 2-1 x Text	8.2180	.0142	<1.0	ns	<1.0	ns	<1.0	ns
Cls 3-2 x Text	<1.0	ns	<1.0	ns	1.0767	ns	<1.0	ns
Cls2-1 x RT3-2	<1.0	ns	<1.0	ns	<1.0	ns	2.3336	ns
Cls3-2 x RT3-2	4.6666	ns	<1.0	ns	<1.0	ns	<1.0	ns
Cls2-1 x RT2+3-1	<1.0	ns	<1.0	ns	<1.0	ns	2.7932	ns
Cls3-2 x RT2+3-1	<1.0	ns	1.0082	ns	<1.0	ns	1.9132	ns
Cls2-1 x Text x RT3-2	1.8114	ns	<1.0	ns	2.9431	ns	<1.0	ns
Cls3-2 x Text x RT3-2	<1.0	ns	<1.0	ns	1.7499	ns	<1.0	ns
Cls2-1 x Text x RT2+3-1	<1.0	ns	<1.0	ns	2.9844	ns	<1.0	ns
Cls3-2 x Text x RT2+3-1	1.9633	ns	<1.0	ns	1.0676	ns	<1.0	ns
Clause embedding (Mtx)								
Mtx-nMtx	<1.0	ns	1.6172	ns	<1.0	ns	1.6571	ns
Mtx-nMtx x Text	17.1142	.0014	3.4602	ns	1.23	ns	<1.0	ns
Mtx-nMtx x RT3-2	<1.0	ns	1.5189	ns	<1.0	ns	1.6790	ns
Mtx-nMtx x RT2+3-1	4.0266	ns	<1.0	ns	<1.0	ns	<1.0	ns
Mtx-nMtx x Text x RT3-2	6.5773	.0248	1.7832	ns	<1.0	ns	<1.0	ns
Mtx-nMtx x Text x RT2+3-1	<1.0	ns	1.5267	ns	<1.0	ns	<1.0	ns
Proposition density (Den)								
DenMid-Lo	134.7180	.0001	<1.0	ns	<1.0	ns	1.8927	ns
DenHi-Mid	11.7727	.0050	<1.0	ns	<1.0	ns	1.3219	ns
DenMid-Lo x Text	12.6654	.0040	<1.0	ns	<1.0	ns	<1.0	ns
DenHi-Mid x Text	67.7256	.0001	<1.0	ns	<1.0	ns	<1.0	ns
DenMid-Lo x RT3-2	131.3964	.0001	1.1590	ns	<1.0	ns	<1.0	ns
DenHi-Mid x RT3-2	5.1801	.0420	3.1012	ns	<1.0	ns	<1.0	ns
DenMid-Lo x RT2+3-1	104.9934	.0001	2.8972	ns	<1.0	ns	<1.0	ns
DenHi-Mid x RT2+3-1	2.3193	ns	2.9964	ns	<1.0	ns	<1.0	ns

Table F.1 (cont.)

Results of Analyces of Experience, Text structure and Response type on Interpreting

	Pooled over between		Experience		Text Order		Experience x Text Order	
	$F(1,12)$	p	$F(1,12)$	p	$F(1,12)$	p	$F(1,12)$	p
Proposition density (Den) (cont.)								
DenMid-Lo x Text x RT3-2	3.1120	ns	<1.0	ns	<1.0	ns	<1.0	ns
DenHi-Mid x Text x RT3-2	37.7185	.0001	<1.0	ns	1.7940	ns	<1.0	ns
DenMid-Lo x Text x RT2+3-1	<1.0	ns	<1.0	ns	<1.0	ns	<1.0	ns
DenHi-Mid x Text x RT2+3-1	52.6748	.0001	<1.0	ns	1.6530	ns	<1.0	ns
Directness of mapping (RtMtx)								
RM2-1	184.7604	.0001	7.9886	.0153	<1.0	ns	3.2535	ns
RM4-3	131.7132	.0001	3.1668	ns	<1.0	ns	<1.0	ns
RM2-1 x Text	244.9252	.0001	6.1834	.0287	<1.0	ns	<1.0	ns
RM4-3 x Text	11.9140	.0048	<1.0	ns	2.2637	ns	1.7444	ns
RM2-1 x RT3-2	178.0147	.0001	5.6753	.0347	<1.0	ns	<1.0	ns
RM4-3 x RT3-2	18.0132	.0012	<1.0	ns	<1.0	ns	<1.0	ns
RM2-1 x RT2+3-1	101.5333	.0001	3.4316	ns	<1.0	ns	1.2191	ns
RM4-3 x RT2+3-1	<1.0	ns	1.7484	ns	<1.0	ns	<1.0	ns
RM2-1 x Text x RT3-2	<1.0	ns	2.7881	ns	<1.0	ns	3.9746	ns
RM4-3 x Text x RT3-2	<1.0	ns	2.0492	ns	<1.0	ns	3.9125	ns
RM2-1 x Text x RT2+3-1	7.9555	.0155	12.3588	.0043	1.6554	ns	4.0770	ns
RM4-3 x Text x RT2+3-1	6.5147	.0254	1.5793	ns	<1.0	ns	2.6119	ns
Narrative Frame variables								
Frame/Non-frame information (FNF)								
FNF	66.7674	.0001	<1.0	ns	<1.0	ns	<1.0	ns
FNF x RT3-2	14.6537	.0025	<1.0	ns	<1.0	ns	<1.0	ns
FNF x RT2+3-1	<1.0	ns	<1.0	ns	<1.0	ns	<1.0	ns
Frame Components (Frco): Episodes								
Frco2-1	6.4072	.0264	<1.0	ns	<1.0	ns	2.6177	ns
Frco3-2	<1.0	ns	<1.0	ns	<1.0	ns	2.2952	ns
Frco2-1 x RT3-2	2.2758	ns	<1.0	ns	<1.0	ns	2.4602	ns
Frco3-2 x RT3-2	1.1216	ns	<1.0	ns	<1.0	ns	2.0019	ns
Frco2-1 x RT2+3-1	6.1986	.0285	<1.0	ns	<1.0	ns	1.1982	ns
Frco3-2 x RT2+3-1	<1.0	ns	<1.0	ns	<1.0	ns	2.2284	ns
Procedure Frame variables								
Frame/Non-frame information (FNF)								
FNF	<1.0	ns	<1.0	ns	<1.0	ns	1.6049	ns
FNF x RT3-2	<1.0	ns	<1.0	ns	3.8578	ns	1.6956	ns
FNF x RT2+3-1	6.9552	.0217	2.1412	ns	1.1611	ns	<1.0	ns
Frame Components (Frco): Subprocedures								
Frco2-1	5.3365	.0391	3.5623	ns	<1.0	ns	<1.0	ns
Frco3-2	<1.0	ns	3.3642	ns	<1.0	ns	<1.0	ns
Frco2-1 x RT3-2	4.7285	ns	1.3253	ns	1.0294	ns	<1.0	ns
Frco3-2 x RT3-2	<1.0	ns	2.3168	ns	3.9510	ns	<1.0	ns
Frco2-1 x RT2+3-1	6.5224	.0253	2.4889	ns	1.2780	ns	<1.0	ns
Frco3-2 x RT2+3-1	<1.0	ns	1.5962	ns	2.7724	ns	<1.0	ns

Table F.2

Results of Analyses of Experience, Text structure and Response type on Recall

	Pooled over between		Experience		Text Order		Experience x Text Order	
	F(1,18)	*p*	*F*(1,18)	*p*	*F*(1,18)	*p*	*F*(1,18)	*p*
Within Contrasts								
Pooled over within	–	–	<1.0	ns	<1.0	ns	2.3213	ns
Text (Narr-Proc)	23.7780	.0002	<1.0	ns	7.3456	.0144	<1.0	ns
Resonse Type								
RT3-2	144.6230	.0001	<1.0	ns	<1.0	ns	3.8057	ns
RT2+3-1	143.7040	.0001	<1.0	ns	<1.0	ns	5.4438	.0315
Text by Response type								
Text x RT3-2	3.5799	ns	<1.0	ns	9.0186	.0077	<1.0	ns
Text x RT2+3-1	<1.0	ns	1.6162	ns	7.6726	.0127	<1.0	ns
Text-structure variables								
Clause density (Cls)								
Cls 2-1	1.4830	ns	<1.0	ns	2.7739	ns	<1.0	ns
Cls 3-2	4.6473	.0449	3.7397	ns	<1.0	ns	<1.0	ns
Cls 2-1 x Text	2.5757	ns	<1.0	ns	1.4863	ns	<1.0	ns
Cls 3-2 x Text	<1.0	ns	2.3354	ns	<1.0	ns	1.6665	ns
Cls2-1 x RT3-2	<1.0	ns	<1.0	ns	7.1315	.0156	<1.0	ns
Cls3-2 x RT3-2	4.0216	ns	6.4891	.0203	2.5129	ns	<1.0	ns
Cls2-1 x RT2+3-1	6.4881	.0203	1.9478	ns	1.2134	ns	<1.0	ns
Cls3-2 x RT2+3-1	1.0246	ns	6.8964	.0172	<1.0	ns	<1.0	ns
Cls2-1 x Text x RT3-2	2.4356	ns	1.4019	ns	1.8353	ns	2.0427	ns
Cls3-2 x Text x RT3-2	<1.0	ns	2.4743	ns	<1.0	ns	1.1281	ns
Cls2-1 x Text x RT2+3-1	3.7224	ns	1.1532	ns	2.9500	ns	6.3153	.0218
Cls3-2 x Text x RT2+3-1	2.7233	ns	1.3469	ns	1.8186	ns	2.1545	ns
Clause embedding (Mtx)								
Mtx-nMtx	5.9108	.0258	<1.0	ns	<1.0	ns	1.3267	ns
Mtx-nMtx x Text	63.2275	.0001	1.2516	ns	1.806	ns	<1.0	ns
Mtx-nMtx x RT3-2	8.1596	.0105	<1.0	ns	4.713	.0436	<1.0	ns
Mtx-nMtx x RT2+3-1	8.1574	.0105	<1.0	ns	<1.0	ns	<1.0	ns
Mtx-nMtx x Text x RT3-2	2.5400	.0003	1.3355	ns	1.9298	ns	<1.0	ns
Mtx-nMtx x Text x RT2+3-1	9.2831	.007	<1.0	ns	<1.0	ns	2.6260	ns
Proposition density (Den)								
DenMid-Lo	1.5270	ns	<1.0	ns	1.6635	ns	3.2147	ns
DenHi-Mid	26.8859	.0001	<1.0	ns	2.3210	ns	5.3034	.0335
DenMid-Lo x Text	7.9762	.0113	<1.0	ns	2.9256	ns	<1.0	ns
DenHi-Mid x Text	3.0660	ns	<1.0	ns	3.4276	ns	<1.0	ns
DenMid-Lo x RT3-2	<1.0	ns	<1.0	ns	1.3714	ns	<1.0	ns
DenHi-Mid x RT3-2	7.0431	.0162	<1.0	ns	2.5235	ns	2.8098	ns
DenMid-Lo x RT2+3-1	2.6400	ns	1.8389	ns	3.9445	ns	2.3683	ns
DenHi-Mid x RT2+3-1	1.1930	ns	<1.0	ns	2.6435	ns	2.8603	ns
DenMid-Lo x Text x RT3-2	5.0509	.0374	<1.0	ns	<1.0	ns	<1.0	ns
DenHi-Mid x Text x RT3-2	8.2958	.01	<1.0	ns	2.2414	ns	<1.0	ns
DenMid-Lo x Text x RT2+3-1	2.9200	ns	<1.0	ns	<1.0	ns	<1.0	ns
DenHi-Mid x Text x RT2+3-1	7.8006	.0121	<1.0	ns	1.1613	ns	<1.0	ns

Table F.2 (cont.)

Results of Analyses of Experience, Text structure and Response type on Recall

	Pooled over between		Experience		Text Order		Experience x Text Order	
	F(1,18)	p	F(1,18)	p	F(1,18)	p	F(1,18)	p
Directness of mapping (RtMtx)								
RM2-1	51.6010	.0001	1.9428	ns	<1.0	ns	1.8831	ns
RM4-3	53.2940	.0001	<1.0	ns	<1.0	ns	<1.0	ns
RM2-1 x Text	149.8440	.0001	<1.0	ns	<1.0	ns	2.6179	ns
RM4-3 x Text	2.7405	ns	<1.0	ns	8.5593	.0091	<1.0	ns
RM2-1 x RT3-2	111.4730	.0001	<1.0	ns	<1.0	ns	2.3086	ns
RM4-3 x RT3-2	21.2191	.0003	1.5197	ns	<1.0	ns	<1.0	ns
RM2-1 x RT2+3-1	114.2090	.0001	<1.0	ns	<1.0	ns	2.9602	ns
RM4-3 x RT2+3-1	<1.0	ns	1.0586	ns	1.4507	ns	<1.0	ns
RM2-1 x Text x RT3-2	<1.0	ns	1.7927	ns	8.4992	.0093	<1.0	ns
RM4-3 x Text x RT3-2	<1.0	ns	<1.0	ns	11.0821	.0038	<1.0	ns
RM2-1 x Text x RT2+3-1	<1.0	ns	2.3033	ns	5.1066	.0365	<1.0	ns
RM4-3 x Text x RT2+3-1	5.4345	.0316	1.2594	ns	2.9617	ns	<1.0	ns
Narrative Frame variables								
Frame/Non-frame information (FNF)								
FNF	<1.0	ns	1.9400	ns	<1.0	ns	<1.0	ns
FNF x RT3-2	1.8717	ns	1.0097	ns	2.9020	ns	<1.0	ns
FNF x RT2+3-1	4.0405	ns	1.5174	ns	1.5557	ns	<1.0	ns
Frame Components (Frco): Episodes								
Frco2-1	2.8655	ns	1.4857	ns	<1.0	ns	<1.0	ns
Frco3-2	<1.0	ns	3.2009	ns	4.5821	.0463	3.3806	ns
Frco2-1 x RT3-2	4.4443	.0493	<1.0	ns	<1.0	ns	<1.0	ns
Frco3-2 x RT3-2	<1.0	ns	1.8027	ns	1.0958	ns	1.4238	ns
Frco2-1 x RT2+3-1	1.7245	ns	2.0667	ns	<1.0	ns	<1.0	ns
Frco3-2 x RT2+3-1	3.8633	ns	<1.0	ns	<1.0	ns	<1.0	ns
Procedure Frame variables								
Frame/Non-frame information (FNF)								
FNF	30.3053	.0001	<1.0	ns	<1.0	ns	<1.0	ns
FNF x RT3-2	17.0788	.0007	<1.0	ns	<1.0	ns	<1.0	ns
FNF x RT2+3-1	8.6828	.0087	<1.0	ns	<1.0	ns	<1.0	ns
Frame Components (Frco): Subprocedures								
Frco2-1	<1.0	ns	1.2173	ns	1.4350	ns	<1.0	ns
Frco3-2	22.5941	.0002	<1.0	ns	<1.0	ns	<1.0	ns
Frco2-1 x RT3-2	4.9943	.0384	3.5772	ns	3.2406	ns	<1.0	ns
Frco3-2 x RT3-2	3.1523	ns	<1.0	ns	<1.0	ns	<1.0	ns
Frco2-1 x RT2+3-1	3.2930	ns	2.1834	ns	1.2607	ns	<1.0	ns
Frco3-2 x RT2+3-1	8.9477	.0079	<1.0	ns	<1.0	ns	<1.0	ns

Table F.3

Results of Analyses of Task, Text structure and Response type on Recall

	Pooled over between		Task		Text Order		Task x Text Order	
	$F(1,18)$	p	$F(1,18)$	p	$F(1,18)$	p	$F(1,18)$	p
Within Contrasts								
Pooled over within	–	–	<1.0	ns	<1.0	ns	13.8896	.0016
Text (Narr-Proc)	23.7780	.0002	<1.0	ns	7.3456	.0144	4.5959	.0460
Resonse Type								
RT3-2	144.6230	.0001	<1.0	ns	<1.0	ns	15.0278	.0012
RT2+3-1	143.7040	.0001	<1.0	ns	<1.0	ns	8.093	.0108
Text by Response type								
Text x RT3-2	3.5799	ns	<1.0	ns	9.0186	.0077	4.7928	.0420
Text x RT2+3-1	<1.0	ns	<1.0	ns	7.6726	.0127	1.6225	ns
Text-structure variables								
Clause density (Cls)								
Cls 2-1	1.4830	ns	5.6519	.0288	2.7739	ns	<1.0	ns
Cls 3-2	4.6473	.0449	<1.0	ns	<1.0	ns	1.5940	ns
Cls 2-1 x Text	2.5757	ns	<1.0	ns	1.4863	ns	1.7761	ns
Cls 3-2 x Text	<1.0	ns	<1.0	ns	<1.0	ns	1.5601	ns
Cls2-1 x RT3-2	<1.0	ns	15.6340	.0010	7.1315	.0156	1.3799	ns
Cls3-2 x RT3-2	4.0216	ns	5.4852	.0309	2.5129	ns	<1.0	ns
Cls2-1 x RT2+3-1	6.4881	.0203	1.9184	ns	1.2134	ns	<1.0	ns
Cls3-2 x RT2+3-1	1.0246	ns	<1.0	ns	<1.0	ns	1.6302	ns
Cls2-1 x Text x RT3-2	2.4356	ns	<1.0	ns	1.8353	ns	2.7090	ns
Cls3-2 x Text x RT3-2	<1.0	ns	<1.0	ns	<1.0	ns	<1.0	ns
Cls2-1 x Text x RT2+3-1	3.7224	ns	<1.0	ns	2.9500	ns	<1.0	ns
Cls3-2 x Text x RT2+3-1	2.7233	ns	<1.0	ns	1.8186	ns	<1.0	ns
Clause embedding (Mtx)								
Mtx-nMtx	5.9108	.0258	2.1961	ns	<1.0	ns	1.1638	ns
Mtx-nMtx x Text	63.2275	.0001	<1.0	ns	1.8060	ns	1.2483	ns
Mtx-nMtx x RT3-2	8.1596	.0105	4.1173	ns	4.7130	.0436	1.1163	ns
Mtx-nMtx x RT2+3-1	8.1574	.0105	3.2379	ns	<1.0	ns	1.0387	ns
Mtx-nMtx x Text x RT3-2	2.5400	.0003	1.1617	ns	1.9298	ns	<1.0	ns
Mtx-nMtx x Text x RT2+3-1	9.2831	.007	1.6183	ns	<1.0	ns	<1.0	ns
Proposition density (Den)								
DenMid-Lo	1.5270	ns	<1.0	ns	1.6635	ns	1.2373	ns
DenHi-Mid	26.8859	.0001	4.3015	ns	2.3210	ns	<1.0	ns
DenMid-Lo x Text	7.9762	.0113	1.7183	ns	2.9256	ns	<1.0	ns
DenHi-Mid x Text	3.0660	ns	<1.0	ns	3.4276	ns	<1.0	ns
DenMid-Lo x RT3-2	<1.0	ns	<1.0	ns	1.3714	ns	<1.0	ns
DenHi-Mid x RT3-2	7.0431	.0162	2.8131	ns	2.5235	ns	1.2382	ns
DenMid-Lo x RT2+3-1	2.6400	ns	<1.0	ns	3.9445	ns	2.8405	ns
DenHi-Mid x RT2+3-1	1.1930	ns	3.1590	ns	2.6435	ns	<1.0	ns
DenMid-Lo x Text x RT3-2	5.0509	.0374	1.7373	ns	<1.0	ns	<1.0	ns
DenHi-Mid x Text x RT3-2	8.2958	.01	1.2553	ns	2.2414	ns	<1.0	ns
DenMid-Lo x Text x RT2+3-1	2.9200	ns	1.0637	ns	<1.0	ns	<1.0	ns
DenHi-Mid x Text x RT2+3-1	7.8006	.0121	<1.0	ns	1.1613	ns	<1.0	ns

Table F.3 (co.it.)

Results of Analyses of Task, Text structure and Response type on Recall

	Pooled over between		Task		Text Order		Task x Text Order	
	F(1,18)	p	F(1,18)	p	F(1,18)	p	F(1,18)	p
Directness of mapping (RtMtx)								
RM2-1	51.6010	.0001	<1.0	ns	<1.0	ns	1.7016	ns
RM4-3	53.2940	.0001	<1.0	ns	<1.0	ns	3.8316	ns
RM2-1 x Text	149.8440	.0001	<1.0	ns	<1.0	ns	13.7940	.0016
RM4-3 x Text	2.7405	ns	<1.0	ns	8.5593	.0091	1.9603	ns
RM2-1 x RT3-2	111.4730	.0001	<1.0	ns	<1.0	ns	11.6740	.0031
RM4-3 x RT3-2	21.2191	.0003	<1.0	ns	<1.0	ns	5.9080	.0258
RM2-1 x RT2+3-1	114.2090	.0001	<1.0	ns	<1.0	ns	8.5421	.0091
RM4-3 x RT2+3-1	<1.0	ns	<1.0	ns	1.4507	ns	<1.0	ns
RM2-1 x Text x RT3-2	<1.0	ns	<1.0	ns	8.4992	.0093	1.3891	ns
RM4-3 x Text x RT3-2	<1.0	ns	5.4951	.0308	11.0821	.0038	<1.0	ns
RM2-1 x Text x RT2+3-1	<1.0	ns	1.7774	ns	5.1066	.0365	1.3321	ns
RM4-3 x Text x RT2+3-1	5.4345	.0316	2.6455	ns	2.9617	ns	4.1638	ns
Narrative Frame variables								
Frame/Non-frame information (FNF)								
FNF	<1.0	ns	2.7614	ns	<1.0	ns	<1.0	ns
FNF x RT3-2	1.8717	ns	<1.0	ns	2.9020	ns	1.7110	ns
FNF x RT2+3-1	4.0405	ns	<1.0	ns	1.5557	ns	3.5386	ns
Frame Components (Frco): Episodes								
Frco2-1	2.8655	ns	<1.0	ns	<1.0	ns	<1.0	ns
Frco3-2	<1.0	ns	8.8218	.0083	4.5821	.0463	2.3511	ns
Frco2-1 x RT3-2	4.4443	.0493	<1.0	ns	<1.0	ns	<1.0	ns
Frco3-2 x RT3-2	<1.0	ns	<1.0	ns	1.0958	ns	4.1057	ns
Frco2-1 x RT2+3-1	1.7245	ns	<1.0	ns	<1.0	ns	1.0614	ns
Frco3-2 x RT2+3-1	3.8633	ns	1.0266	ns	<1.0	ns	1.9234	ns
Procedure Frame variables								
Frame/Non-frame information (FNF)								
FNF	3.3053	.0001	1.4090	ns	<1.0	ns	<1.0	ns
FNF x RT3-2	17.0788	.0007	<1.0	ns	<1.0	ns	<1.0	ns
FNF x RT2+3-1	8.6828	.0087	1.3814	ns	<1.0	ns	<1.0	ns
Frame Components (Frco): Subprocedures								
Frco2-1	<1.0	ns	<1.0	ns	1.435	ns	<1.0	ns
Frco3-2	22.5941	.0002	<1.0	ns	<1.0	ns	1.6128	ns
Frco2-1 x RT3-2	4.9943	.0384	<1.0	ns	3.2406	ns	2.3450	ns
Frco3-2 x RT3-2	3.1523	ns	<1.0	ns	<1.0	ns	<1.0	ns
Frco2-1 x RT2+3-1	3.2930	ns	<1.0	ns	1.2607	ns	<1.0	ns
Frco3-2 x RT2+3-1	8.9477	.0079	<1.0	ns	<1.0	ns	<1.0	ns