THE INTERACTION OF BIAS, CONTEXT, AND INTONATION IN THE PERCEPTION OF SURFACE STRUCTURE AMBIGUITY

by

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Chapter 1

INTRODUCTION

An integral part of the process of sentence recognition is the listener's assignment of a surface constituent analysis to the input utterance. This procedure presumably follows the assignment of phonetic representation but precedes the recovery of underlying structure. A viable theory of psycholinguistic processing must specify the kinds of information listeners make use of in parsing an utterance. It has generally been assumed (Trager and Smith, 1951; Braine, 1963; Neisser, 1967) that intonational cues play a crucial role in signalling the intended phrase marker. This assumption is largely based on a consideration of the relationship between surface structure and intonation in sentence production, i.e. the fact that the linguistically significant prosodic features are determined by constituent structure.

While the cues to surface structure assignment include function words, grammatical morphemes, word order etc., intonation is often singled out as the most important; Gleason (1965) writes:

> Hearing conditions are seldom perfect, and the hearer is always faced with an elaborate task in detecting and interpreting all the signals that are presented to him. He does not pay equal attention to all. There is some reason to believe that he puts his heaviest reliance on the intonation, often conforming his understanding of other signals to the basic outline he derives from it. Many of the features which,

> it would seem, might allow him to guess the intonation, are instead guessed at from the intonation. (p. 173)

The privileged status of prosodic cues as structure signals is assumed to derive support from their role in the resolution of those ambiguities (referred to as 'surface structure' ambiguities) in which the same lexical items in the same order can be assigned distinct constituent structures. In other words, the assumption is that such sentences may be ambiguous in writing but are not perceived as such in speech. A classic example is the following:

(1.1) Connie hates fat girls and boys.

where a pause before and encourages the interpretation 'Connie hates (all) boys and fat girls', while a pause before girls encourages the interpretation 'Connie hates fat girls and fat boys.'

Despite indications that listeners do attend to objective acoustic cues (Bolinger and Gerstman, 1957; Wingfield and Klein, 1971), research into the psychological reality of constituent structure has revealed that perceptual segmentation is an active process whereby the listener uses his linguistic knowledge to impose structure on incoming utterances. Moreover, it has been demonstrated for unambiguous sentences (Garrett, Bever, and Fodor, 1966; Caplan, 1972) that this process is independent of the acoustic reflections of structure; segmentation takes place in the absence of intonational cues and often despite them. These studies argue for the position that the perception of intonation is determined by the perception of structure, a position antithetical to that of Gleason,

sketched above. The role of intonation in specifying the meaning of surface structure ambiguities is thus called into question.

The present study attempts to ascertain the extent to which intonation determines the listener's interpretation of surface structure ambiguities. The claim that intonation is perceived in terms of the listener's knowledge of possible constituent structures is of no help here since no unique structure can be specified for these sentences. The present study predicts that external context and interpretive bias (i.e. the internal context provided by lexical items of the utterance), which determine meaning in the absence of prosodic cues (as in writing), do so even when intonation is supplied.

Evidence as to whether surface structure ambiguities are in fact indeterminate in speech will thus provide insight into the overall mechanisms of general sentence processing. The following investigation of the roles played by intonation, context, and bias in interpreting surface structure ambiguities is therefore a specific case of Wanner's (1973) question: 'Do we understand sentences from the outside-in or the inside-out?'[1]

The characterization of ambiguity provides the focus for Chapter 2, which treats purely linguistic approaches (based on either syntactic or phonological aspects of the sentence) as well as those of psycholinguistics (based on behavioral parameters). Chapter 3 then discusses what is entailed by the theory of active speech perception -- in particular, the contributions of context, bias (as determined by syntactic, pragmatic, and behavioral considerations), and intonation. The remaining

chapters present and discuss an experiment testing the interaction of context, bias, and intonation.

NOTES TO CHAPTER 1

[1] 'Outside-in' processes refer to those where the objective stimulus is the determining factor; 'inside-out' processes are those featuring an active imposition of an internal reality on the objective stimulus.

Chapter 2

CHARACTERIZATION OF AMBIGUITY

Part I Linguistic Characterization

The notion of ambiguity can be viewed either semantically or syntactically. The former postion (see Katz and Bever, 1974) defines ambiguity as a condition which obtains when a single surface string is associated with more than one semantic interpretation. Part I of this chapter, on the other hand, outlines an essentially structural view, one in which ambiguity characterizes a derivation in which a single surface string is associated with more than one deep structure. On syntactic grounds, three types of ambiguity will be motivated, with phonological and semantic considerations focusing the present study on one particular sub-type.

1. The Distinction Between Vagueness and Ambiguity

Within linguistics, a distinction is drawn between 'ambiguity' and 'vagueness', analogous to that drawn between 'sense' and 'reference' (Frege, 1952). The meaning of sentences (the ambiguity/vagueness distinction) as well as the meaning of words (the sense/reference distinction) is thus distinguished from the conditions appropriate to their use -- the 'actual things, situations, activities, events, and such to which words [and sentences] refer' (Katz, 1972). The concept of 'vagueness' or 'indefiniteness of reference' is illustrated by (2.1), which

(2.1) Ellen finished the manuscript.

could be used to describe situations in which a particular manuscript was read, written, typed, translated, or edited, by any number of persons named 'Ellen'. (2.1) is insufficiently specified with respect to which task was completed and by whom. Most, if not all sentences, then, are to some extent vague, though not all are ambiguous. The distinction is motivated by the consideration that each of the alternative interpretations of an ambiguous constituent is itself referentially indefinite. For example, sentence (2.2) is

(2.2) He looked at the table.

ambiguous in that it can indicate either a piece of furniture or a list of data. Yet, as Gleason (1965) points out, on the furniture reading this sentence might refer to 'a large dinner table or a small coffee table, to one with chrome legs and a plastic top or to one of hand-carved cherry wood.' The data interpretation is similarly unspecified, applying equally well to any array of information.

Having narrowed the scope of ambiguity to exclude instances of vagueness, we still find a number of different notions that are referred to by the term 'ambiguity'. Linguistic studies generally define ambiguity as a property of those sentences which can be assigned more than one interpretation (Katz and Bever, 1974; Kooij, 1971; MacKay and Bever, 1967). In this view ambiguity is seen as a condition that obtains

when a surface string is associated with more than one semantic representation.

The conditions under which ambiguity is said to obtain are always defined with respect to a particular theory of grammar. The following section presents a structural characterization of ambiguity within standard generative theory.

2. Structural Classification.

Within this context, an unambiguous surface string is one to which a single deep strucutre is assigned.[1] This structure is then interpreted by the semantic component, yielding one semantic representation, and transformed by the transformational component to produce one surface representation (Figure 2.1).

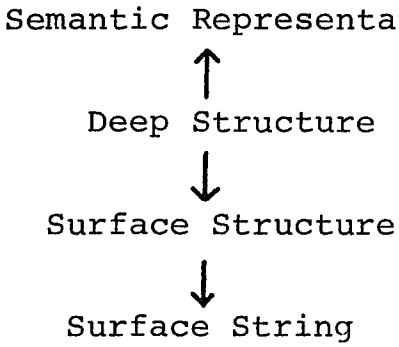

Figure 2.1 Derivation of an unambiguous sentence.

Within this theory ambiguous surface strings[2] fall into several categories:

Type A: Two distinct deep structures generated by the base component of a standard theory grammar give rise to two surface structures, as in the ambiguous (2.3)-(2.5).

(2.3) The instructor examined the solution.

(2.4) Connie hates fat girls and boys.

(2.5) The child was crippled.

Each deep structure determines a unique semantic representation and surface structure as shown in Figure 2.2. In view of the varied terminology used to characterize ambiguities,

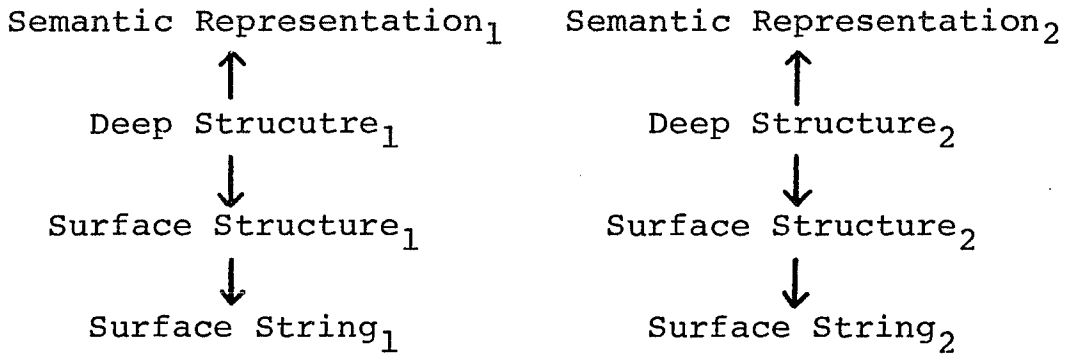

Figure 2.2 Derivation of Type A ambiguity.

sentences of this kind will simply be referred to as 'Type A'.

The two phrase markers representing the underlying structures of sentence (2.3) are identical until the stage of lexical insertion. It is at this point that two distinct bundles of semantic features, associated with the different meanings of solution are inserted in the object NP position, resulting in distinct deep structures. These semantic features are then carried over into the derived structures yielding two distinct surface structures.

The lexical items in the deep structures of (2.4) share the same semantic features. Nevertheless the underlying phrase

markers into which they are inserted are distinct, as indicated in (2.6). These underlying representations are then converted

(2.6a) $[_{S_5}[_{S_3}$ Connie hates girls $[_{S_1}$ girls be fat$]_{S_1}]_{S_3}$ and
$[_{S_4}$ Connie hates boys $[_{S_2}$ boys be fat$]_{S_2}]_{S_4}]_{S_5}$

(b) $[_{S_4}[_{S_2}$Connie hates girls $[_{S_1}$girls be fat$]_{S_1}]_{S_2}$ and
$[_{S_3}$Connie hates boys$]_{S_3}]_{S_4}$

into the surface structure trees shown in Figures 2.3 and 2.4 respectively.

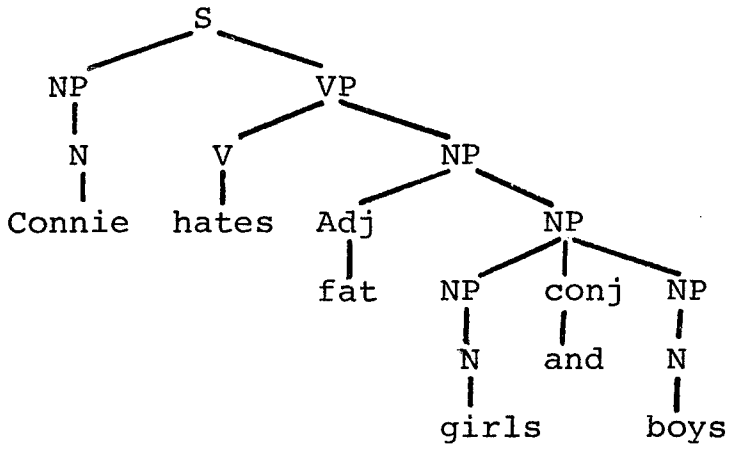

Figure 2.3 Structure for sentence (2.6a).

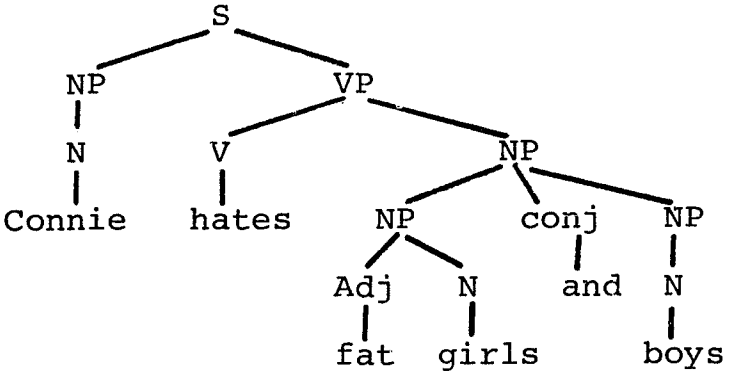

Figure 2.4 Structure for sentence (2.6b).

In addition to instances in which different deep structures result in different surface structure configurations, there are sentences in which the resulting surface phrase markers are configurationally identical while the grammatical categories involved are distinct. In (2.5) the child is either the logical subject or the logical object. However, the surface structure trees differ only in that crippled is dominated by an Adjective Phrase in one case, and by a Verb Phrase in the other.

Type B: This classification applies to surface strings which are assigned two deep structures and two semantic interpretations but only one surface structure (Figure 2.5). In

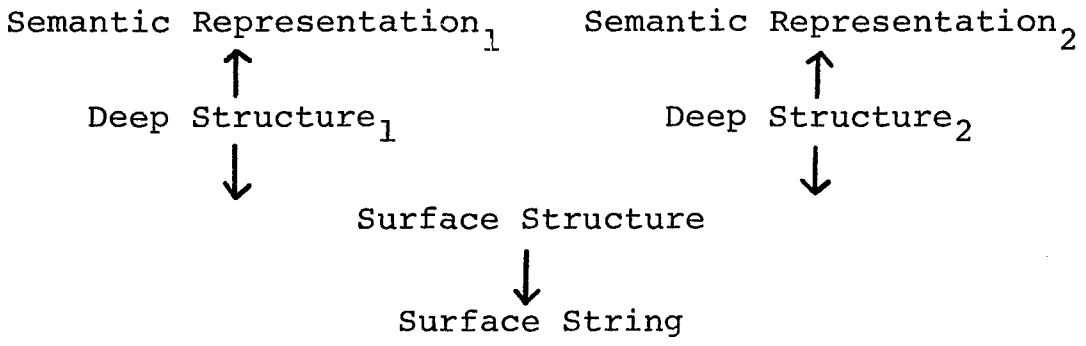

Figure 2.5 Derivation of Type B ambiguity.

sentences like (2.7)-(2.9), which have been referred to as cases

(2.7) What has your dog in its paws?

(2.8) Who do you want to help paint the wall?

(2.9) No teacher has that student.

of 'syntactic ambiguity' (Langendoen, 1971), the ambiguity is effected by grammatical transformations which neutralize

distinctions made explicit in deep structure. The question word in (2.7) originated as either subject or object as seen in the underlying structures in Figures 2.6 and 2.7.

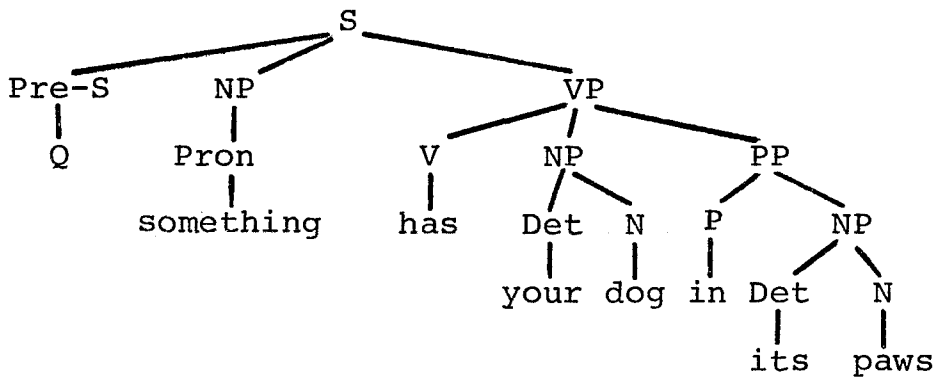

Figure 2.6 A possible deep structure for sentence (2.7).

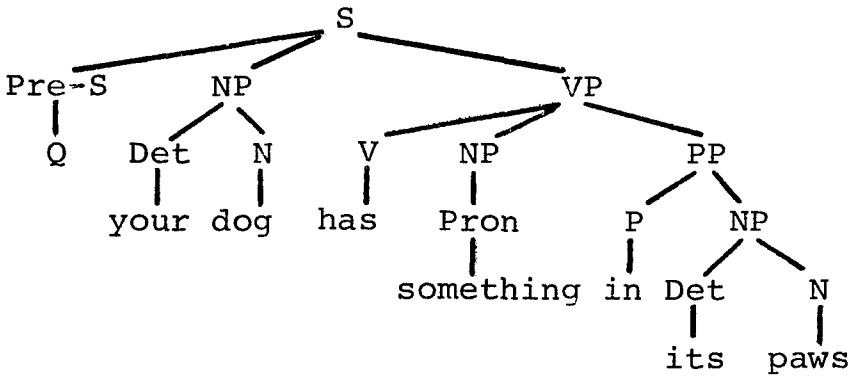

Figure 2.7 A possible deep structure for sentence (2.7).

Applying Question Formation to 2.6 and Question Formation plus Subject-Verb Inversion to 2.7, in both instances, yields the single surface tree in Figure 2.8.

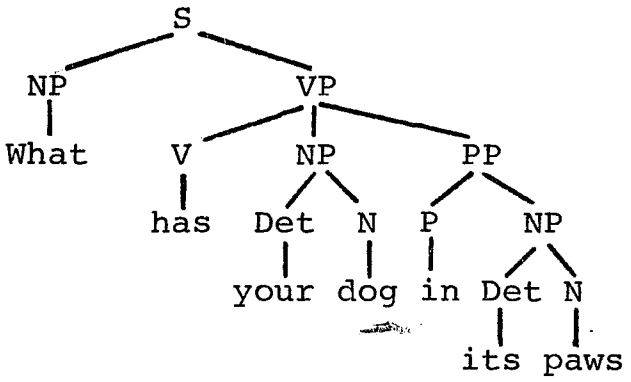

Figure 2.8 Surface structure for sentence (2.7).

Whether a particular sentence is considered to be an example of 'syntactic ambiguity' depends on assumptions as to its deep structure and the rules employed in its derivation. Two competing analyses are presently available to relate sentences (2.10) and (2.11). In one analysis, sentence (2.10)is

(2.10) I gave Sarah a book.

(2.11) I gave a book to Sarah.

taken as basic from which (2.11) is derived by a rule of Dative Movement featuring to-/for- insertion. The alternate analysis posits (2.11) as primary, obtaining (2.10) by a rule of Dative Movement featuring to-/for- deletion. Under the latter formulation the sentence (2.12) is the result of applying Dative

(2.12) I brought Sarah a book.

Movement to the structures underlying sentences (2.13) and (2.14)

(2.13) I brought a book to Sarah.

(2.14) I brought a book for Sarah.

and is thus an instance of Type B ambiguity. Subscribing to

the former analysis of Dative Movement entails the assumption that (2.13) and (2.14) are derived from (2.12). In this description sentence (2.12) is no longer a Type B example. If the verb bring is specified with respect to whether to or for is inserted by Dative Movement ($bring_1$ takes to- insertion, $bring_2$ takes for- insertion), this sentence will be assigned two distinct underlying representations. It then follows the derivation of other Type A ambiguities (cf. sentence [2.3]).

It should be noted that many sentences which are generally taken to be instances of 'deep structure' ambiguity (to be discussed below) such as (2.15) and (2.16) may not quality as

(2.15) Smoking cigars can be a nuisance.

(2.16) The duck is ready to eat.

cases of syntactic (Type B) ambiguity (Klima, 1970; Langendoen, 1971). Though both groups share the characteristic that differences in underlying grammatical relations are neutralized at the level of surface structure, each of the two interpretations of (2.15), (2.16) are nevertheless assigned distinct surface structure representations. The surface structure representations of (2.15) differ with respect to the grammatical labels dominating smoking. In (2.16), the NP duck might be assigned different semantic features depending on whether the sentence calls for the 'bird' or 'food' interpretation. Apart from the specification of the lexical item duck, Langendoen (personal communication) points out that (2.16) can be assigned the different surface structures in Figures 2.9 and 2.10 if an analysis employing Δ-notation

(Chomsky, 1965) is adopted.

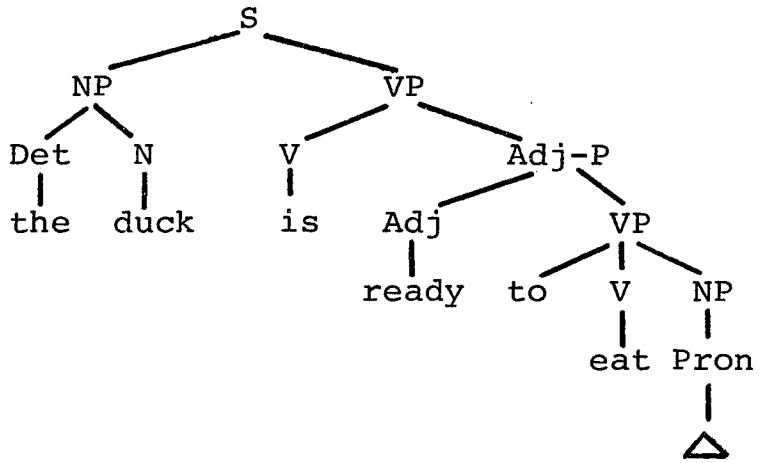

Figure 2.9 A possible surface structure for sentence (2.16).

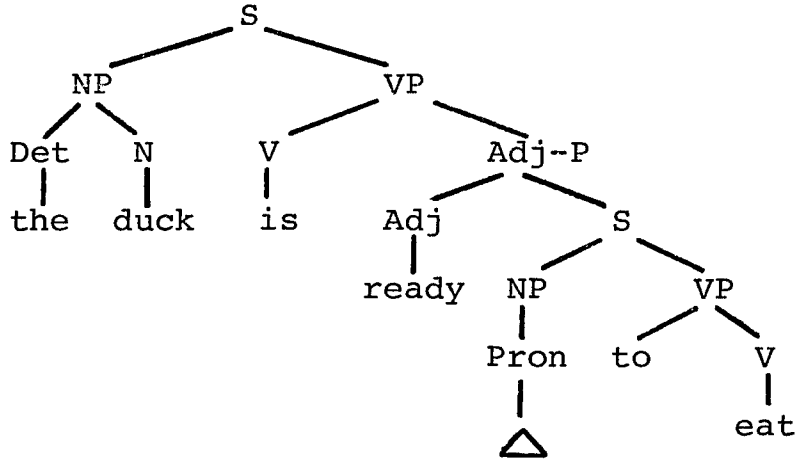

Figure 2.10 A possible surface structure for sentence (2.16).

Type C: Sentence (2.17) is a case of Type A ambiguity

(2.17) Alan painted the picture in the hall.

since the grammar assigns it two deep structures, two semantic representations, and two surface structures. The structurally equivalent sentence (2.18) is provided with the same type of

(2.18) I wrote a letter to Saul.

deep and surface configurations as those of (2.17). The two surface trees are shown in Figures 2.11 and 2.12. Yet only

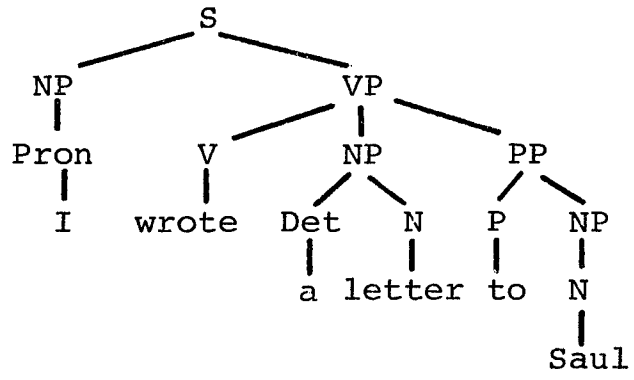

Figure 2.11 A possible surface structure for sentence (2.18).

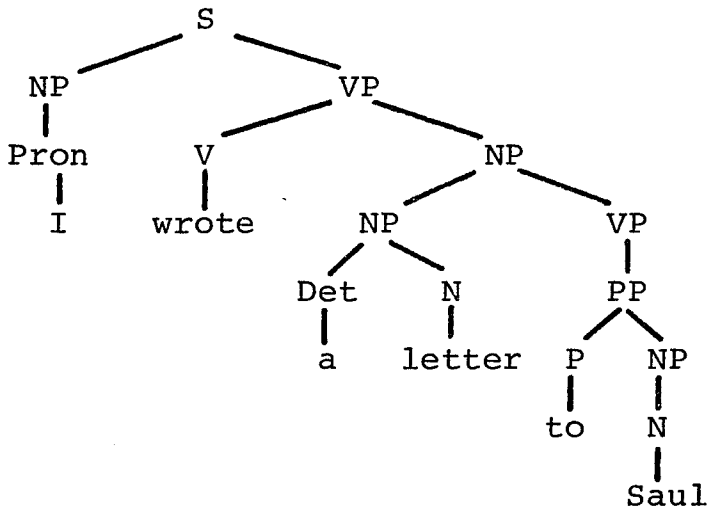

Figure 2.12 A possible surface structure for sentence (2.18).

one semantic representation will be specified for the two deep structures of this sentence, i.e. unlike (2.17), (2.18) cannot be interpreted in more than one way. There is no sentence on the order of (2.19) corresponding to (2.18) the way (2.20)

(2.19) *I wrote (a letter to Saul) to Sidney.

(2.20) Alan painted (the picture in the hall) in his studio.

does to (2.17).

Katz and Bever (1974) provide yet other examples in which two deep and surface structures yield only a single meaning:

(2.21) It was done by an automated processing device.

(2.22) John wrote a letter about his experience.

(2.23) Don't buy bright green rugs.

Sentences of this type, which will be referred to as 'Type C' ambiguity, are derived as in Figure 2.13.

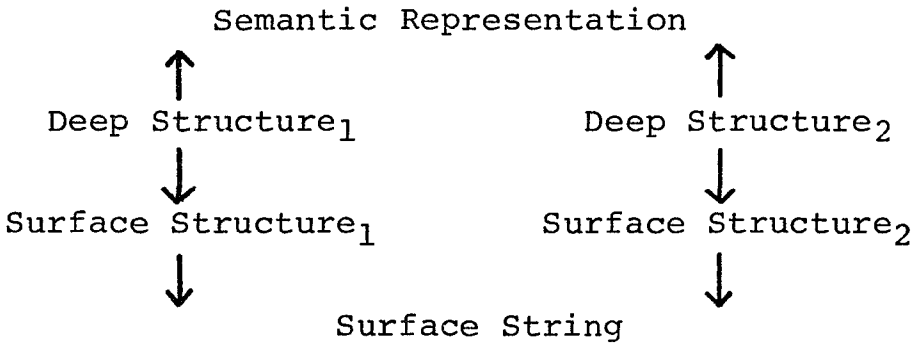

Figure 2.13 Derivation of Type C ambiguity.

The present analysis, which classifies these sentences as ambiguous represents a departure from the traditional assumption that ambiguity covers cases of multiple meanings. Whereas Katz and Bever offered sentences (2.21)-(2.23) to indicate the need for a semantic explication of ambiguity, the present analysis provides an essentially syntactic account, emphasizing once again that accounts of ambiguity are defined with respect to some particular theory of grammar.

Type C sentences indicate that ambiguity need not be restricted to a condition which holds when a surface string corresponds to two or more semantic representations. Ambiguities of Type B rule out a definition in terms of surface structure.

In all the examples discussed thus far, however, two deep structures are assigned despite differences in the number of corresponding surface and semantic representations. Given the syntactic analysis presented above, ambiguity is defined as a condition obtaining when a surface string is associated with two or more deep structures.

The consideration of other relations that might hold among the levels of linguistic analysis raises an interesting question: are there cases where a deep structure assigned a single semantic reading corresponds to two surface structures but only one surface string? The only apparent such case involves the so-called vacuous movement rules.

In applications of Extraposition, structures of the form NP - S - X are transformed into those of NP - X - S, as in:

(2.24) The student who called yesterday is here.

(2.25) The student is here who called yesterday.

Applying Extraposition to the structure underlying sentence (2.26), in which X is null, results in the assignment of two

(2.26) I met the student who called yesterday.

surface structures to the same surface string. This would occasion the type of derivation shown in Figure 2.14, representing a case of structural ambiguity not accounted for by our definition, which requires more than a single deep structure. However, vacuous movement rules such as those alleged to produce two surface structures for (2.26) are ruled out by

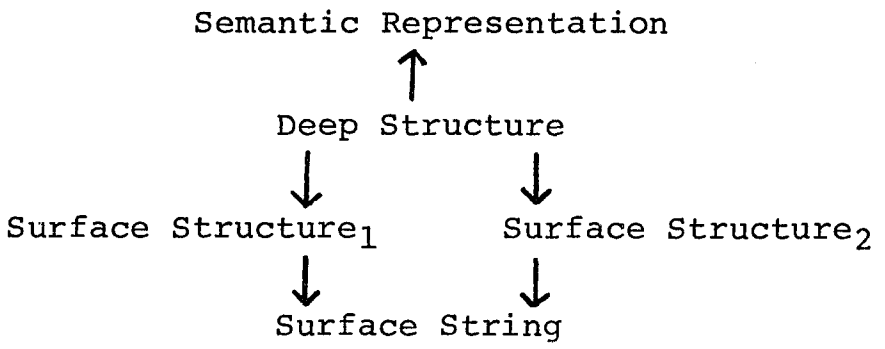

Figure 2.14 A derivation using vacuous movement rules.

the restriction in standard generative theory that transformations do not introduce structure, i.e. transformational rules cannot change structure without also changing strings (Chomsky, 1961)[3]. Thus derivations of the type illustrated in Figure 2.14 are precluded.

Consider Table 2.1. Cases (g) and (h) are ruled out by

	Semantic Representations	Deep Structures	Surface Structures	Surface Strings	Classification
(a)	1	1	1	1	Unambiguous
(b)	2	2	2	1	Type A
(c)	2	2	1	1	Type B
(d)	1	2	2	1	Type C
(e)	2	1	1	1	Logical Ambiguity
(f)	1	1	2	1	ruled out (vacuous movement rules)
(g)	1	2	1	1	ruled out
(h)	2	1	2	1	ruled out

Table 2.1 Logically possible derivational histories with respect to four levels of analysis.

the premises of standard theory, where the semantic component

takes as input a deep structure; accordingly there can be no cases where the number of semantic representations corresponds to the number of surface structures but not to the number of deep structures. Within standard theory, the only remaining possibility is that shown in Figure 2.15.

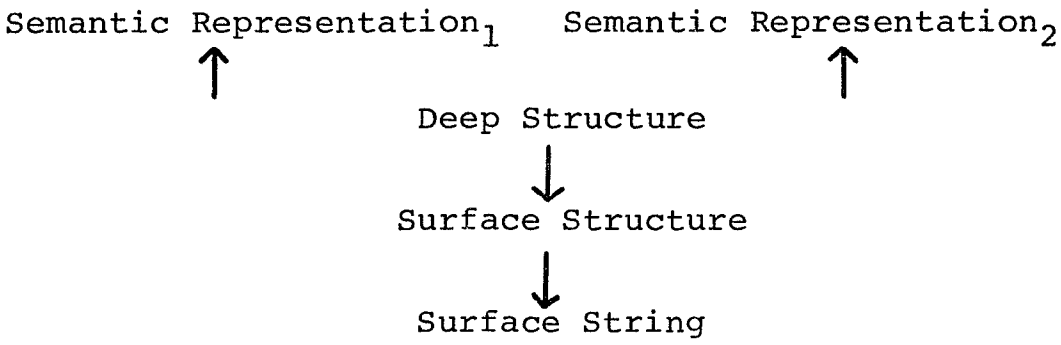

Fig. 2.15 Derivation of logical ambiguity.

This is precisely the analysis proposed for instances of 'logical ambiguity' (Ioup, 1975).

Sentence (2.27) can be interpreted in two ways (either

(2.27) All the rabbits are digging a hole.

they are digging one hole collectively, or each is digging a [separate] hole), depending upon which quantifier is assigned higher scope. Nevertheless the factors which distinguish the two readings are not handled by the syntactic component of the grammar, so that the deep structures for both are identical. This is what Chomsky (1965) suggests for sentences (2.28), (2.29). Though many speakers of English

(2.28) Everyone in the room knows at least two languages.

(2.29) At least two languages are known by everyone in the room.

interpret these sentences as referring to the same two languages in (2.29) but many different languages in (2.28), Chomsky maintains that each sentence has a latent interpretation in addition to its preferred reading. The grammar indicates this by assigning identical deep structures to both sentences. That the two differ in preferred interpretation is accounted for by extraneous factors, involving the surface order of quantifiers, which filter out the latent interpretation.

Deriving the two readings of logical ambiguities from one underlying syntactic structure is problematic for a theory of ambiguity (such as that proposed here) which explains the notion as a property involving two deep structures. Ambiguity would then have to be defined as a property of a surface string corresponding to either two deep structures, two semantic representations, or both. Nevertheless there may be alternate treatments of logical ambiguity that do not jeopardize the analysis of ambiguity presented in this section. One approach is to deny that sentences such as (2.27) are in fact ambiguous and, instead, to consider them vague with respect to the individual or collective readings (Katz [personal communication] in Ioup, 1975). The second alternative, although outside standard theory, is the analysis of logical ambiguity found in Keenan's (1972) semantically-based grammar. In contrast to the approach of standard theory, Keenan derives sentences such as (2.27) from two underlying representations. Within the framework

of Keenan's model, logical ambiguities would be a subset of the Type B class of ambiguous sentences.

The demonstration that a linguistic characterization of ambiguity requires reference to the relationship between a single surface string and its deep structures serves as independent motivation for the level of deep structure (Langendoen, personal communication); postulating an underlying level of analysis has allowed for the classification of all types of ambiguous sentences.

3. Phonological Aspects

In the standard model of generative grammar the phonological component operates on surface structures to specify pronunciation. Thus the intonation pattern of a sentence should be predictable from information about its constituent structure. The following two ordered cyclic rules, specified by Chomsky and Halls, (1968), are characteristic of the phonological rules which determine stress contours:

(CR) A compound rule that assigns stress in initial position in compound nouns, adjectives, and verbs.

(NSR) A nuclear stress rule applying elsewhere that makes the last main stress dominant, thus weakening all other stresses in the construction.

Derivations of the contours appropriate to the two readings of the phrase (2.30) are provided in Figures 2.16

(2.30) old coin collector

and 2.17 and are based on the two distinct surface

representations assigned to (2.30) by the grammar. Following the assignment (Figure 2.16) of word stress in the noun phrase old coin collector (that is, 'old collector of coins'; old coin collector meaning 'collector of old coins' is a compound noun, not a noun phrase), CR is applied on the first cycle, weakening all other stresses. The innermost brackets are erased and NSR is applied on the second cycle, giving the contour 2 1 3. In the compound noun

$[_{NP}$old$[_{N}$coin collector$]_{N}]_{NP}$

1	1	1	word stress
	1	2	first cycle: CR
2	1	3	second cycle: NSR

Figure 2.16 Derivation of the noun phrase old coin collector.

'old coin collector' CR is bypassed on the first cycle and NSR is applied, resulting in primary stress on the rightmost constituent of the NP. On the second cycle CR applies to yield a 3 1 2 contour.

$[_{N}$ $[_{NP}$old coin$]_{NP}$ collector$]_{N}$

1	1	1	word stress
2	1		first cycle: NSR
3	1	2	second cycle: CR

Figure 2.17 Derivation of the compound noun old coin collector.

Bresnan (1971) points out that there are many instances in which different stress patterns corresponding to syntactic differences are not accounted for by the NSR. In the sentence:

(2.31) Sidney left directions for Sam to follow.

directions gets primary stress if Sam must follow the directions:

(2.31a) Sidney left dírections for Sam to follow.

while the dominant stress is on follow if Sidney intends Sam to follow him:

(2.31b) Sidney left directions for Sam to fóllow.

Bresnan proposes that all the apparent exceptions to the NSR-generalization can be accounted for if the NSR is ordered after all the syntactic transformations on each cycle. The stress difference in the two readings of sentence (2.31) is predictable from the fact that follow has a direct object in the deep structure of (2.31a) which is not present in the deep structure of (2.31b). Bresnan in thus proposing, contrary to the assumptions of standard theory, that intonation is determined at least in part by factors present only at underlying levels.

Chomsky and Miller (1963) found it reasonable to assume that the rules assigning stress contours underlie the production and perception of actual speech. Whether these rules

operate on surface or deeper structures, the present study bears on the extent to which the assumption of psychological reality is justified.

Of the four cases discussed in Section 2, Type B and logical ambiguities are assigned a single surface representation. The phonological rules are then applied to this structure yielding a single phonetic representation. Thus the two interpretations cannot be differentiated on the basis of the prosodic pattern. The underlying structures of Types A and C, on the other hand, do result in two distinct surface representations. These surface representations can differ in terms of the semantic features assigned to a particular lexical item, in terms of the grammatical categories dominating an item, or in terms of the surface configuration itself. Only the latter difference generally affects pronunciation, however. Thus the phonological component assigns distinct phonetic representations to only a subset of Type A and C ambiguities. In the case of Type C ambiguities the two resulting pronunciations do not correspond to different senses and so are mere variants of each other. However, in that subset of Type A ambiguities whose two surface representations are characterized by distinct bracketings, the resulting phonetic representations correspond to the two possible meanings. This subset of Type A, generally referred to as 'surface structure' ambiguities, can thus be disambiguated by intonational cues (pause, stress, pitch, etc.) which signal the alternate

segmentations. It is this class of ambiguities on which the present study is focused.

Part II Psycholinguistic Characterization of Ambiguity

4. Behavioral Parameters

Psycholinguists investigating the effects of ambiguity on sentence comprehension have adopted a three-way classification of ambiguous sentences into lexical, surface structure, and deep structure types. This taxonomy differs in two respects from the one outlined in the first part of this chapter. To begin with, the definition of ambiguity which is presupposed in experimental studies is semantically-based, i.e. an ambiguous sentence is one which can be assigned more than one semantic reading. Thus Type C ambiguities for which only one semantic representation is specified, would not be considered ambiguous in this framework. Secondly, the structural classification presented above considered the complete derivation of each sentence, whereas the psycholinguistic typology focuses on one particular level of analysis in each ambiguous sentence.[4]

The three types of ambiguities manipulated in experimental research are determined by three linguistic levels: lexical, surface structure, and deep structure. A sentence is lexically ambiguous if one of its lexical items has two readings neither of which is precluded by selectional restructions imposed by the constituents of the sentence. Sentences (2.32) through (2.34) represent cases of lexical ambiguity.

(2.32) The plumber installed the washer.

(2.33) They found the speaker in a room down the hall.

(2.34) The punch at the party made Betty sick.

The two meanings of a lexical ambiguity may be conceptually related as in speaker, iron, or glasses. These are referred to as 'systematic' lexical ambiguities versus those such as punch, bank, and suit, whose two readings are 'unsystematically' related (MacKay and Bever, 1967).

If the constituents of a sentence can be grouped in more than one way, the sentence is an example of 'surface structure' ambiguity. For each of the sentences

(2.35) Ruth fed her dog biscuits.

(2.36) Paul read the letter to his mother.

(2.37) The man is looking for stray dogs and cats.

two surface phrase markers can be assigned to indicate the alternate bracketings (e.g. [2.37] would be treated analogously to sentence [2.4] analyzed in Figures 2.3 and 2.4).

The two meanings of a 'deep structure' ambiguity are distinguished at the underlying level of analysis. As indicated by sentences (2.38) through (2.40) the different

(2.38) They requested the police to stop drinking.

(2.39) Everyone was surprised by the congressman's selection.

(2.40) The elephant is ready to lift.

interpretations depend upon a change in the logical relations

that the constituents enter into.

Lexical, surface structure, and most cases, e.g. (2.38)-(2.40), of deep structure ambiguity (the three types of ambiguities manipulated by psycholinguists) are all subsumed under Type A discussed in Section 2. (The remaining cases of deep structure ambiguity are classified as Type B.) In deriving these sentences, a single surface string is associated with two deep structures, two surface structures[5] and two semantic representations. Nevertheless behavioral differences found in experimental studies of ambiguity support the grouping of ambiguous sentences into distinct lexical, surface structure, and deep structure classes. The following review of the behavioral evidence will also serve as an overview of the experimental literature on the processing of ambiguous sentences.

The model of sentence perception consistent with current psycholinguistic data assumes that input material is processed only after it is assigned to a clause (Bever, Garrett, and Hurtig, 1973). At that point perceptual mapping operations are applied to the surface sequence in order to recover its underlying structure. Behavioral differences in the comprehension of lexical versus structural ambiguities have been explained by an appeal to the different kinds of processing strategies involved. On the one hand, attention has been focused on the mapping operations themselves (Bever et al., 1973). An alternate explanation is provided by a consideration of the differential output strategies available

to the comprehension device (Cairns, 1973). The latter interpretation suggests a basic processing difference, namely that lexical decisions are made soon after lexical items are received, while structural decisions never take place before the clause boundary.

It is generally the case that the results obtained for lexical ambiguities differ significantly from those for deep structure ambiguities, with the data for surface structure ambiguities falling between the two. For example, MacKay and Bever (1967), in a study to determine the time it takes to discover the two meanings of an ambiguous sentence, found that the meanings of lexical ambiguities were perceived more quickly[6] than those of surface structure ambiguities. Perception time was longest in the case of deep structure ambiguities.

In a sentence completion task, MacKay (1966) discovered a similar pattern of results: lexical ambiguities were completed faster than surface structure ambiguities, which in turn were faster than deep structure ambiguities. In both the MacKay (1966) and MacKay and Bever (1967) studies, the sentences were presented in writing. Foss (1970) using aural rather than visual presentation of materials, found that lexical ambiguities were indentified faster than deep structure ambiguities, lending additional support to the previous findings.

When Bever,Garrett and Hurtig (1973) asked subjects to provide a sentence that might logically follow a given

ambiguity, they found that sentences with deep structure ambiguities were responded to faster than their unambiguous controls. While these results were surprising in light of the studies just mentioned, Bever et al. provide an explanation in terms of the perceptual rules used in mapping underlying relations onto surface sequences. The three types of ambiguity differ with respect to the relative independence of the perceptual strategies employed in perceiving the two interpretations. The two interpretations of a deep structure ambiguity correspond to underlying structures which differ from each other far more radically than do those which correspond to the two interpretations of either a lexical or surface structure ambiguity. It is argued (Bever et al., 1973) that therefore the perceptual mapping operations involved in the comprehension of deep structure ambiguities are relatively independent when compared with those of lexical or surface structure ambiguities. Thus in tasks which come after the sentence boundary and allow for either interpretation, the existence of two independent mappings is facilitating. In tasks initiated before the clause boundary, however, deep structure ambiguities are the most adversely affected while lexical ambiguities, which require no active choice of competing perceptual operations show the least effect.[7] Bever et al. in fact suggest that behavioral differences in response to the three types of ambiguities (lexical, surface structure, deep structure) are governed not so much by differences corresponding to levels of analysis

but by the 'perceptual independence of interpretations'.

Other differences among the three types of ambiguities appeared in the MacKay and Bever (1967) study. In the case of deep structure ambiguities it was shown that the time necessary to perceive the second meaning was a direct function of its probability, i.e. the less likely the second interpretation, the longer the perception time. This again suggests that the two meanings of a deep structure ambiguity are perceptually independent. Lexical and surface structure ambiguities showed a long perception time for sentences in which one interpretation was highly favored. Nevertheless this was the case regardless of which interpretation was perceived first, indicating that the meanings for these ambiguities are not independent.

Using the picture verification paradigm, Foss, Bever and Silver (1968) found that differences in the verification time between expected and unexpected pictures was longer for lexical ambiguities than for surface and deep ambiguities. At the time these results seemed to conflict with studies indicating that the two meanings of an ambiguity are discovered fastest in the case of lexical ambiguities. The observation that this type of ambiguity is more difficult to reprocess once one meaning has been assigned is explained by the assumption that explicit lexical material is destroyed at the clause boundary, at which point only relevant semantic information is retained.

These results were replicated by Cairns (1970) in a

judgment task in which highly biased lexical and structural ambiguities were followed by sentences compatible with either their expected or unexpected meanings. Subjects were asked to judge the compatibility of the sentence pairs and response latencies were recorded. Increased judgment latencies, indicating a reprocessing effect, were revealed only for lexical ambiguities. Cairns (1973) reports similar results for unbiased lexical ambiguities. Cairns, however, does not interpret these differences as indicating that structural ambiguities are easier to reprocess. Instead she adopts a weaker version of the perceptual closure hypothesis (see p. 28) and suggests that, in the case of structurally ambiguous sentences, closure can be delayed beyond the clause boundary in tasks requiring both interpretations. Since both structural analyses are available no reprocessing is necessary. If, on the other hand, only one meaning is called for by the experimental task, the comprehension device will output no more than a single interpretation. The latter strategy accounts for those instances in which response latencies are no greater for deep structure ambiguities when compared with their unambiguous controls. However, in the case of lexical ambiguities only one meaning is available as output regardless of the particular task.

Recent experimental studies on ambiguity support two conflicting hypotheses concerning the number of interpretations assigned during sentence processing. Though it is somewhat oversimplified, the view that both readings of

an ambiguous sentence are computed is confirmed by research which reports increased performance difficulty with ambiguous sentences as compared with their unambiguous controls. Studies indicating no added complexity support the hypothesis that only one reading is available.

In his sentence completion task, MacKay (1966) found that ambiguous sentence fragments take longer to complete than their unambiguous controls.[8] Using lexical and deep structure ambiguities only, Foss (1970) found greater phoneme-monitor[9] latencies following ambiguous portions of a sentence than following corresponding unambiguous portions. Lackner and Garrett (1972) (to be discussed below, p. 45) showed that a disambiguating context will affect the interpretation of a simultaneously presented ambiguous sentence, whether lexical, deep structure, or surface structure. The above results can all be explained by assuming that multiple readings are available during the processing of ambiguities.

One might infer from these studies that both readings of an ambiguous sentence should be reacted to with equal facility. However, the picture verification task carried out by Foss, Bever, and Silver (1968) showed significantly greater response latencies following the less likely interpretation. Though most of this effect is due to the lexically ambiguous sentences, surface and deep structure ambiguities showed the same trends. In a similar task using sentences of the <u>They are visiting relatives</u> pattern (which have characteristics of both surface and deep structure

ambiguities), Carey, Mehler, and Bever (1970) showed that subjects were not influenced by the second interpretation when pre-set to expect one particular reading. Thus these two experiments argue for the view that only one reading is computed in the comprehension of ambiguous sentences.

The general theory of psycholinguistic processing (Bever, Garrett, and Hurtig, 1973) assigns primacy to the clause as a unit of perception. At the clause boundary, underlying relations are recovered and working memory is cleared. These assumptions can resolve the apparently conflicting results in the above studies if we assume that both readings of an ambiguity are activated but only one is retained at the clause boundary. Bever et al. point out that the 'multiple meaning hypothesis' is confirmed only in tasks initiated during sentence processing (pre-clause boundary), while the 'one-meaning hypothesis' is supported in tasks initiated upon completion of such processing (post-clause boundary). In a reanalysis of MacKay's (1966) data, Bever (reported in Fodor, Bever and Garrett, 1974) found that the slower completion time for ambiguous fragments is due largely to those cases in which the ambiguity was presented in an incomplete clause. It should be noted in this regard, however, that in the sentence completion task which Bever et al. (1973) devised to test this hypothesis, ambiguous fragments in incomplete clauses had significantly longer latencies than their unambiguous controls only in the case of deep structure ambiguities.

Cairns and Kamerman (1975) point out that in the case of lexical ambiguities there is no evidence for the 'short term memory hypothesis'--the claim that both meanings are retained until the clause boundary. In a phoneme monitoring task they found that increased monitor latencies following ambiguous lexical items disappeared when two words intervened between the ambiguity and the target sound. These results support the 'immediate decision hypothesis' which maintains that both meanings of an ambiguous lexical item are retrieved but only one is immediately transferred to working memory. Thus it appears that the resolution of deep structure ambiguities is postponed until the clause boundary whereas lexical decisions are made long before that point.

This evidence supporting the claim that both interpretations of a lexical ambiguity are not retained until the clause boundary can account for some of the experimental results discussed earlier. Recall that Bever et al. (1973) found no ambiguity effect for lexically ambiguous fragments in incomplete clauses. They argue that the two structures underlying lexical ambiguities do not produce interference since the same perceptual strategies are involved in both interpretations. However, the fact that longer latencies were not found for lexical ambiguities can be explained by assuming that, though both meanings were originally retrieved, by the time the fragmentation occurs, one had already been selected. Cairns and Kamerman further

observe that greater phoneme monitoring latencies following ambiguous lexical items (Foss, 1970) do not necessarily imply that both meanings are stored. Instead, the response delay can be attributed to the decision process which occurs immediately after an ambiguous lexical item.

5. Comparison of Linguistic and Psycholinguistic Characterizations

The psycholinguistic characterization of ambiguity in effect subdivides the class of Type A ambiguities into three sub-types (lexical, surface structure, deep structure). The experimental research considered in Section 4 indicates that this subdivision is motivated on behavioral grounds. Fundamental differences are revealed between lexical and structural processing. Moreover, despite the fact that all three are assigned similar derivations by the syntactic component, they are not handled alike by the phonological component; only one phonetic representation is provided in the case of lexical and deep structure ambiguities while two are provided for surface structure ambiguities.

Type B ambiguities form a very small part of the psycholinguist's deep-structure ambiguity category. Such cases are difficult to construct and therefore have not been included in experimental studies. Finally, Type C ambiguities fail to satisfy the psycholinguist's definition of ambiguity and so have escaped study.

NOTES TO CHAPTER 2

[1] The grammar may in fact pair this deep structure with additional surface structures which however would not, in general, correspond to this same surface string (e.g. consider a grammar with an optional Passive transformation). The question of vacuous movement rules, where additional surface structures would correspond to the same string, will be taken up later (p. 18).

[2] Each ambiguity type will be defined as a relation between two derivations of the same surface string where 'surface string' refers to a representation of the lexical items and their order. It does not include constituent bracketing or phonological information.

[3] This stricture is not always observed (see Rosenbaum, 1967).

[4] This does not mean to imply that the psycholinguistic typology is insensitive to differences at other levels of analysis. In classifying the sentence They fed her dog biscuits as a case of surface structure ambiguity, MacKay and Bever (1967) point to the two different underlying structures. However, since the relationship of the deep structure subject-verb and verb-object are the same in both readings, this sentence and others in the surface structure ambiguity class are not considered examples of deep structure ambiguities.

[5] Sentences (2.38) through (2.40) would fail to satisfy Langendoen's (1971) definition of syntactic ambiguity on the grounds that the ambiguity involved is in part a function of the transitive versus intransitive readings of the verbs drink, select and lift on which basis (2.38)-(2.40) are classified as Type A.

[6] The two meanings for systematic lexical ambiguities were discovered faster than those for non-systematic ambiguities, suggesting that these types are represented differently in the mental lexicon.

[7] Cairns and Kammerman (1975), to be discussed below (p. 35), provide a different interpretation.

[8] However, see p. 34 for Bever's reanalysis of this data.

[9] In the phoneme-monitoring task, subjects are instructed to listen for a particular word-initial sound and push a button as soon as that sound is heard.

Chapter 3

THE CONSTRUCTIVE NATURE OF SPEECH PERCEPTION

Neisser (1967) captured the cognitive approach to perception with his statement that 'the world of experience is produced by the man who experiences it'. With respect to the processing of speech this implies that the stimulus properties of the speech signal are not the sole determinants of perception. Rather, the sentence comprehension process is viewed as one in which the listener actively imposes an analysis on the incoming utterance. In forming hypotheses about the input signal the listener makes use of his knowledge of linguistic structure as well as the context (linguistic and situational). This chapter investigates the role played by context, bias, and intonation in the construction of these hypotheses. The effects of linguistic context are discussed in Section 1. Context is shown to operate at all levels of analysis--from the perception of vowel segments in terms of the acoustic context to the assignment of meaning in terms of the syntactic and semantic context.

The effects of internal context, i.e. bias, are investigated next. Section 2 outlines some principles which account for the preferred interpretation of sentences which can be assigned two distinct parses. It is argued that the

bias judgments of the surface structure ambiguities pretested for the present study are determined by the interaction of syntactic/semantic knowledge on the one hand, and pragmatic and behavioral factors on the other.

The final section assesses the contribution of intonational cues to sentence processing. Whereas it was demonstrated that bias and context influence hypothesis construction, intonation is shown to be a relatively weak cue. This finding serves to reinforce the view that the listener is in no sense passive toward the incoming stimuli.

1. The Effects of Context

In a classic experimental paradigm in speech perception (Ladefoged and Broadbent, 1957), the same sound waves were presented to a group of subjects, in each case preceded by an introductory question whose formant frequencies were varied. The sound sequences in question were interpreted as the lexical items bit, bet, bat, or but depending upon the formant structure of the preceding question. These results, taken in conjunction with their analogs in studies of visual perception, clearly illustrate the effects of context on pattern recognition.

The influence of contextual information is evident at all linguistic levels, from the identification of speech sounds to the higher-level assignment of semantic interpretation. At the level of phonetic representation, Warren and Warren (1970) revealed the importance of context in a phenomenon they referred to as 'phonemic restoration'. The sentence

(3.1) The state governors met with their respective legislatures convening in the capital city.

was recorded. The first [s] in legislatures was excised and a recorded cough of the same duration was spliced in its place. When the resulting sentence was played to subjects, the substitution was not 'heard'; in Warren and Warren's terms, the phoneme /s/ had been restored. Even when subjects were informed that a sound had been replaced, they could not locate the site of the cough. Phonemic restorations occurred for entire syllables as well. Moreover, these effects were found both for cases in which prior context identified the missing element as well as instances where phonemic restoration was determined by a subsequent context.

The effects of context on the intelligibility of lexical items was further investigated in an experiment by Miller, Heise, and Lichten (1951). The same stimulus materials, presented under varying degrees of noise, were either spoken in isolation or embedded in sentential contexts. Words in sentences were correctly understood at higher levels of background noise than the same words heard in isolation. In a related study, Miller et al. showed that the ability to recognize a word in isolation can be improved by providing the listener with information as to the set from which it is drawn.

Similar results were obtained by Bruce (1968), in an experiment in which subjects were asked to identify monosyllabic words presented in noise. Words drawn from a contextual series (e.g. things to eat) showed significantly superior

intelligibility over those compiled from a random list. The results indicated that context not only facilitates lexical item identification over the whole series but also produces a sudden marked improvement when the implicit contextual pattern is perceived.

That context exerts as great an influence in ordinary conversation is evident from an experiment by Pollack and Pickett (1964). They obtained recordings of conversational speech under optimal acoustic circumstances from speakers who were unaware that they were being recorded. Samples containing eight words each were selected. Eight recordings of each sample were prepared such that the first recording consisted of the first word, the second consisted of the first two words, and so on. Subjects listened to the recordings of each sample played in order of increasing length. It was discovered that in order to achieve an accuracy level of .90 in stimulus identification, listeners had to be exposed to an average of 7.5 words.

Lieberman (1967a) notes that in listening to these excised segments of speech the recordings do not gradually become more intelligible as the number of words increases. Rather, the signal remains unintelligible until a critical point when it suddenly becomes perfectly clear. This sudden effect of context was already observed in Bruce's study, discussed above. Clearly it is not additional acoustic information that enables the listener to identify the phonetic signal. On the basis of acoustic cues and his knowledge of the language, the hearer is able to construct hypotheses

concerning the phonetic content of an utterance. However, in order to test these hypotheses the listener apparently needs the linguistic context furnished by a rather long segment of speech. Once a tested hypothesis is confirmed, instant intelligibility follows.

Furthermore, speakers seem to be aware of the facilitating effects of context. Lieberman (1963) showed that speakers may not be as precise in their articulation of words that can be inferred from the context of the utterance. Sentences (3.2) and (3.3) were recorded

(3.2) A stitch in time saves nine.

(3.3) The number that you will hear is nine.

When the word nine was excised from these sentences and played to subjects, listeners could identify it only 50 percent of the time when it came from sentence (3.2). However this same word was recognized 90 percent of the time when it was isolated from the context in (3.3). Since the word in question is predictable, hence uninformative, in sentence (3.2) the speaker apparently sees no need for careful articulation.

Different types of context affect the outcome of perception. Most of the studies on the intelligibility of lexical items presented above involved some form of prior semantic information. Apart from semantic context, the grammatical structure of a sentence can affect the recognition of individual words. Miller and Isard (1963) prepared 50 grammatical sentences with structural descriptions as in

(3.4) Gadgets simply work around the house.

(3.5) Bears steal honey from the hive.

From these, 50 anomalous sentences such as (3.6) and (3.7) were constructed, in which the syntactic structure is maintained.

(3.6) Bears shoot work on the country.

(3.7) Accidents carry honey between the house.

Finally, 50 ungrammatical strings were produced by randomly combining the words so as to destroy the original grammatical structure.

(3.8) From hunters house motorists the carry.

(3.9) Between gadgets highways passengers the steal.

Sentences from the three groups were randomized and presented to subjects who were requested to 'shadow' exactly what they heard, i.e. to repeat the sentence aloud as they heard it. Eighty-nine percent of the grammatical sentences, 80 percent of the anomalous sentences, and 56 percent of the ungrammatical strings were correctly repeated. The observation that anomalous sentences were significantly more intelligible than ungrammatical ones indicates the role played by syntactic context in the perception of sentences.

In investigating the effect of context on sentence processing, attention has again (as in the case of lexical processing) been focused on the role of prior semantic information. Nevertheless, Carey, Mehler, and Bever (1970) showed

that syntactic expectations of listeners determine the interpretation they assign to ambiguous sentences. Subjects were first presented with a group of unambiguous sentences of the form They are X-ing NP in which the variable was either an adjective, e.g. They are performing monkeys, or a participle, as in They are unearthing diamonds. Each subject heard sentences of only one construction and was then presented with an ambiguous sentence, as They are lecturing doctors. Lecturing was interpreted as either an adjective or a participle depending on the type of sentences the subject had listened to prior to hearing the ambiguous case.

The effect of context in processing ambiguous sentences is related to a central issue in the study of ambiguity, namely the number of meanings activated by the comprehension device. Two competing explanations can account for the fact that a disambiguating context determines the interpretation assigned to an ambiguity. Context may guide perception so that only one reading of an ambiguity is accessed, i.e. predisposes the listener to come up with one particular reading. Alternatively, all meanings are activated but only one is chosen, the choice being determined by the context. Lackner and Garrett (1972) used a technique in which subjects heard an ambiguous sentence in one ear and a simultaneously presented biasing context in the other. The context consisted of another sentence which was semantically related to one of the possible interpretations of the ambiguity. They found that the biasing context in the unattended ear significantly affected the meanings assigned to the ambiguities. Lackner and Garrett

argue that unless both readings of an ambiguous sentence are available during processing, the biasing context could not exert an influence.

Lackner and Garrett, in a post hoc analysis of their results, found that the disambiguating portion of the context sentence was sometimes heard prior to the ambiguous part of the experimental sentence and sometimes subsequent to it (rather than uniformly simultaneous with it). Context exerted its effect in all three cases.

The results of this experiment support the 'Post Effect Hypothesis' of context (Swinney, 1974). This model of sentence comprehension assumes that context operates by choosing one of the two meanings which are always activated when an ambiguous sentence is encountered.

Where the relevant context precedes the ambiguity there is a competing hypothesis known as the 'Prior Effect Hypothesis', which maintains that prior context eliminates the need to compute those interpretations which are incompatible with it. Thus, under these conditions only one interpretation is activated and ambiguous sentences are processed as are unambiguous ones. Foss and Jenkins (1973) tested these two models (which they termed 'Choice Point Decision' vs. 'Prior Decision') using a phoneme monitoring task with lexical ambiguities.

Half of the ambiguities in the Foss and Jenkins experiment had prior contexts which made one of the interpretations more likely while the other half had neutral contexts. They found that monitor response times were longer following

ambiguous words compared with their unambiguous controls, regardless of whether the prior context had been biased or neutral. These results suggest that, in the case of lexical items, prior context does not limit the number of meanings that are computed.

Though the Prior Effect Hypothesis was not confirmed by Foss and Jenkins, they do offer suggestions as to how it could be saved. They mention variables which might be involved in producing a Prior Effect of context such as the distance between the biasing context and the ambiguous word, consideration of clause boundaries, and the use of stronger biasing contexts. Swinney (1974) manipulated these variables in a phoneme monitor experiment similar to that of Foss and Jenkins to see whether prior context can bias the interpretation of ambiguous lexical items to the extent that they behave like unambiguous ones. He found longer reaction times in ambiguous sentences than in unambiguous ones in the condition containing no relevant prior context. However, in the presence of a relevant context there was no reaction time difference between ambiguous and unambiguous controls, indicating the effect of prior context. This effect was related to the strength of the context-ambiguity relationship rather than to the variables of distance or intervening clause boundaries.

When limited to the distinction between the Post versus Prior Effect Hypotheses, these results support the latter model. Nevertheless, as Swinney suggests, the effects of

prior context can be accounted for by an alternate hypothesis--the Immediate Decision Hypothesis mentioned above in Chapter 2, Section 4. This model, in common with the Post Effect Hypothesis, assumes that both readings of an ambiguous lexical item are accessed. A decision process ensues in which one meaning is selected, with selection speed determined by the strength of the context. Swinney stresses that until there is evidence that the second meaning of an ambiguous word is activated in the face of a strong prior context, the Prior Effect Hypothesis cannot be rejected.

The models proposed for the processing of ambiguous sentences have been tested with respect to lexical ambiguities. Not much is known about the effects of context in the processing of structural ambiguities. In view of behavioral differences between the different ambiguity types uncovered in experimental studies, the above observations on lexical ambiguities can not automatically be generalized to the other categories of ambiguity.

A recent study by Cairns and Berkovits (forthcoming) did, however, confirm the facilitative effects of context in the processing of structural ambiguities. Structurally ambiguous clauses were constructed preceded by either biasing or neutral sentential contexts. Using the probe-word technique developed by Caplan (1972), subjects heard a sentence followed by a single word; their task was to decide whether the probe word had been part of the previous sentence.

Affirmative recognition latency was the dependent variable. Previous experimental studies (Cairns and Blank, forthcoming) indicated that probe words from more psycholinguistically complex clauses are recognized more quickly than those from less complex clauses. The explanation for this effect was that less complex clauses are processed more quickly, hence the phonetic information associated with their individual lexical items is more quickly discharged from operating memory. To accomplish the recognition task, the subject must retrieve the phonetic information. This extra retrieval time associated with the more quickly processed clauses results in longer recognition latencies. Cairns and Berkovits predicted that if context facilitates the processing of structural ambiguities, greater response delays should be revealed for ambiguous clauses preceded by a biasing context compared with their counterparts preceded by a neutral context. This was precisely what was found: subjects took more time to identify a probe word if the preceding context was biased. It was concluded that the presence of a biasing context speeds clausal processing by providing input to the system of perceptual strategies which directs the recovery of underlying grammatical relations.

2. Bias

The observation that most ambiguities go unnoticed implies that ambiguous sentences are generally assigned one particular meaning. Moreover, it is usually the case that they are biased toward one of the grammatically possible

interpretations. The notion of bias is typically quantified: bias is defined as the proportion of subjects who perceive a particular meaning first. In actual language use, the external context often determines the most likely reading. What is of interest here, however, is that in the absence of a context external to the sentence, one interpretation of an ambiguity is often heavily preferred across speakers. Of the 83 surface structure ambiguities pretested in this study, 82% had bias values over .60 for one meaning. 66% of the ambiguities had biases over .70, while only 8% of the sentences showed bias judgments below .55. While there is as yet no comprehensive theory that will predict sentence bias, factors that determine the most likely reading of an ambiguity can be isolated.

The theory of surface structure parsing proposed by Kimball (1973) outlines a set of perceptual strategies which determine the surface trees that are assigned to input strings:

> A model of parsing in natural language must allow for more than one parse and should predict on the basis of conditions of surface structure complexity which parse will most likely be offered as the first choice by a native speaker. (Kimball, p. 20)

These principles should therefore predict bias judgments for instances of surface structure ambiguity.

Of the seven principles suggested by Kimball, two are directly involved in the parsing of those ambiguities investigated in this study:

Right Association: Terminal symbols optimally associate to the lowest nonterminal node.

Closure: A phrase is closed as soon as possible, i.e. unless the next node is an immediate constituent of that phrase.

Right Association predicts that the most likely interpretation of sentence (3.10) would be that associated with the

(3.10)=(2.17) Alan painted the picture in the hall.

structure in Figure 3.1 as opposed to that in Figure 3.2.

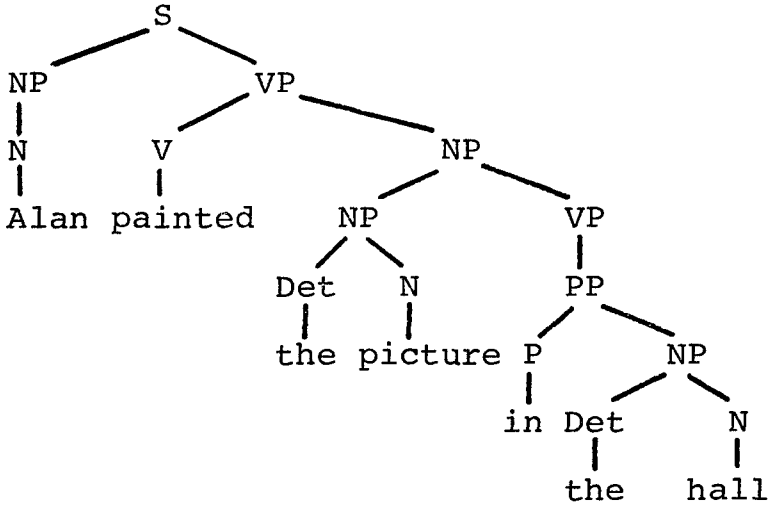

Figure 3.1 A possible surface structure for sentence (3.10).

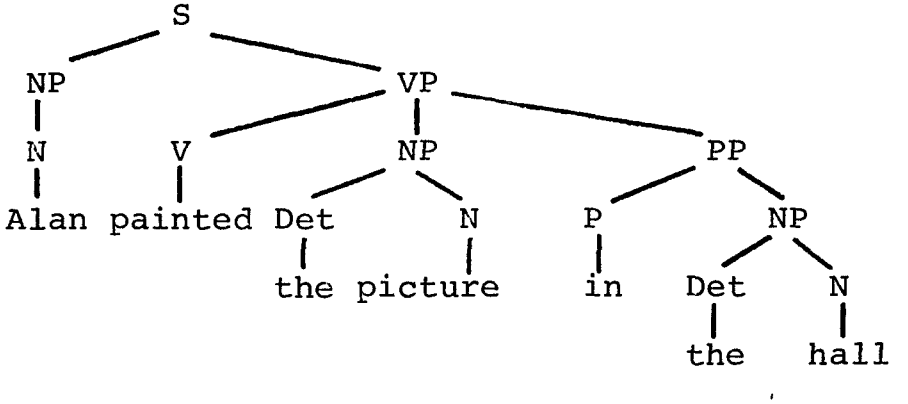

Figure 3.2 A possible surface structure for sentence (3.10).

In the pretest conducted to determine bias values for the

surface structure ambiguities in this study, .86 of the subjects associated the prepositional phrase in the hall in sentence (3.10) with the lowest rightmost node--the NP the picture--rather than with the higher VP node painted. Similarly, Right Association correctly predicts the bias judgments of test sentences (3.11)-(3.14). (See Appendix A for bias values. Parentheses indicate the preferred reading.)

(3.11) The repairman fixed (the T.V. set in the living room).

(3.12) She told me to (go without hesitating).

(3.13) He asked me to (leave at five o'clock).

(3.14) John said he was (coming today).

Kimball questions whether the principle of Closure is in fact distinct from that of Right Association (RA). For example, in the surface tree in Figure 3.2 above, violating RA leads to the re-opening of the higher VP node and thus the violation of Closure. Nevertheless the specification of Closure remains unclear in the sense that when applied to a lower phrase (as in closing the NP the picture in 3.2) the principle is, at the same time, violated with respect to a higher phrase (the VP in 3.2). Thus the principles of RA and Closure lead to conflicting predictions as to the preferred parse in cases of surface structure ambiguity. In test sentence (3.15), RA predicts the reading associated

(3.15) Susan told her baby stories.

with Figure 3.3 as most likely, while Closure accounts for

an interpretation as in Figure 3.4.[1]

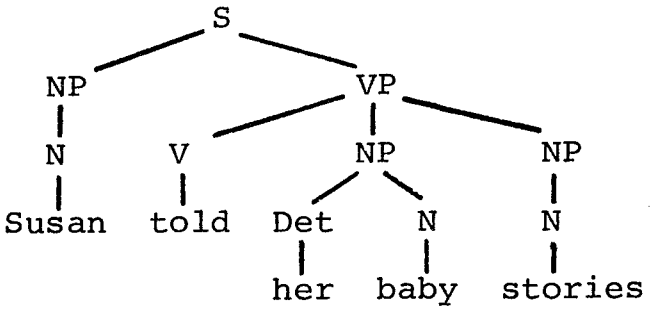

Figure 3.3 A possible surface structure for sentence (3.15).

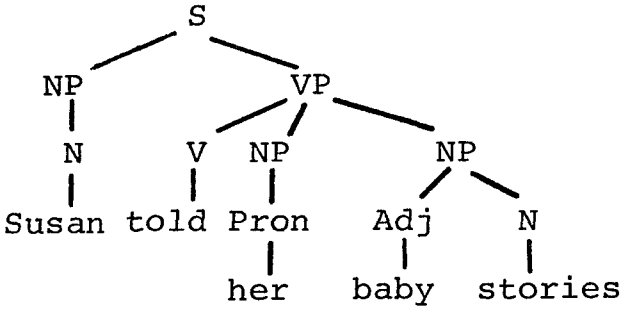

Figure 3.4 A possible surface structure for sentence (3.15).

Kimball defends Right Association in the light of apparent counter-examples by arguing that this principle 'defines the optimal functioning of the parsing algorithm if no outside effects are relevant'. For experimental sentence (3.16)

(3.16) Joe fried the potatoes in the pan.

RA predicts a bias toward the interpretation that 'Joe fried the potatoes which were in the pan'. The pretest results however indicate a high bias (.92) toward the other reading. Kimball attributes such cases to an interaction between the parsing mechanism and semantic information available

to the speaker while constructing the surface tree. Though he does not specifically refer to the following aspects of syntactic theory, Kimball implies that lexical information in the form of strict subcategorization rules and selectional restrictions plays a role in determining sentence bias.

A consideration of the syntactic information associated with lexical items may help to specify the conditions under which Right Association and Closure operate. Thus, if a constituent is strictly subcategorized for a preposition, Closure is applied to a lower phrase and the prepositional phrase is attached to a higher node. If, however, a constituent is not subcategorized for a preposition RA is applied. This specification of Closure correctly predicts the preferred interpretations of sentences (3.16), (3.17), and (3.18)

(3.17) Paul read the letter (to his mother).

(3.18) We decided to keep the little dog (in the box).

as indicated by the pretest. Similarly, the subcategorization of verbs for manner adverbials accounts for the more likely readings of (3.19)-(3.21).

(3.19) The boss dismissed the salesman (with enthusiasm).

(3.20) They talked about the problem (with the mathematician).

(3.21) The hostess greeted the girl (with a smile).

Strategies of sentence processing also account for bias in surface structure ambiguities of the progressive modifier

scope type (see Chapter 4). An investigation of Adjective-Genitive-Noun constructions in adult speakers of English (Berkovits, 1973) revealed a distinct tendency to place the adjective immediately before the noun (either head or genitive) it modifies. When the adjective describes the head noun, speakers generally prefer Genitive-Adjective-Noun constructions. A subsequent survey of the comprehension of Adjective-Genitive-Noun constructions provides evidence for a segmentation strategy which assigns the scope of the initial adjective to the immediately following genitive. Despite the anomaly involved, .25 of the subjects interpreted the phrase (3.22) as 'a dress belonging to the torn

(3.22) the torn girl's dress

girl' though they indicated that this is improbable or perhaps an instance of a misplaced modifier.

The strategy which assigns adjective scope applies as well to Adjective-Noun-Noun and Adjective-Noun-Conjunction-Noun constructions predicting the preferred interpretations for test sentences (3.23) through (3.28). In sentences of

(3.23) That (handsome man)'s shirt cost $38.

(3.24) The government decided to crack down on (big building) owners.

(3.25) Could this be the (invisible man)'s hair tonic?

(3.26) He told me to give (more realistic) details.

(3.27) (Young widows) and orphans are eligible for the new benefits.

(3.28) Our (fifth grade) advisor just resigned.

the Adjective-Noun-Conjunction-Noun type bias depends on the relative strength of relationships between constituents of the phrase, i.e. whether a stronger bond obtains between the Adjective and Noun, or between the Noun-Conjunction-Noun elements. Thus the above-mentioned strategy is overruled in sentences (3.29)-(3.31) in which the two nouns form a cohesive unit, more so than in in the case of sentence (3.27).

(3.29) The man is looking for stray (dogs and cats).

(3.30) They evacuated the old (men and women).

(3.31) Connie hates fat (girls and boys).

Perceptual strategies can likewise account for the preferred reading of 'NP of NP's N' phrases. Langendoen (1974) shows that RA predicts a right branching, i.e. NP (of NP's N) interpretation for sentences such as (3.32), leading to

(3.32) The daughter of Pharoah's son is handsome.

a semantically anomalous reading. This same principle results in the preferred interpretation of test sentence (3.33).

(3.33) The president (of the university's finance committee) submitted the recommendation.

Sentences (3.29)-(3.31) indicate that in the course of comprehension, strategies of sentence processing often are, or must be overridden. These cases point to the role of semantic and pragmatic factors in determining sentence bias. Consider once more sentence (3.27). It was observed

(3.27) Young widows and orphans are eligible for the new benefits.

that the nouns in the compound widows and orphans may not be as closely related semantically as those in dogs and cats, men and women, and girls and boys. Furthermore, the bias value of that sentence may be affected by the semantic features assigned to the lexical items under consideration. The feature [+young] is presumably already part of the meaning of orphan; parsing the sentence so that the initial adjective modifies both nouns of the compound results in the redundant phrase young orphans. This principle operates in reverse in the processing of the phrases old men and women as opposed to old men and babies. The latter is not ambiguous because none of the features specified for babies is compatible with the meaning of old.

Pragmatic considerations--the speaker's 'knowledge of the world', are most likely involved in the preferred readings of the following sentences:

(3.34) The teenagers (rolled up) the carpet.

(3.35) The kids rolled (over the carpet).

1.00 of the pretest subjects interpreted (3.34) as 'rolling the carpet up' while .97 of another group interpreted (3.35) as 'rolling on the carpet'. When the ambiguity of (3.34) was pointed out, many students argued that one cannot roll (in its intransitive sense) up a surface. The bias differences in (3.34) versus (3.35) can therefore be attributed to a knowledge of the laws of gravity.[2] Similarly the preferred interpretation of sentence (3.36) can

(3.36) The seamstress (stitched on) the labels.

be explained by the fact that sewing labels onto garments is a more likely activity that stitching on top of them.

Another factor that may be involved in interpretive bias is related to strategies of speech production rather than perception. Sentence (3.37) is highly biased toward the 'wearing' reading.

(3.37) Jane (had worn) old tennis shoes.

These same results were found for

(3.38) Jane (has worn) old tennis shoes.

(3.39) Jane (has worn) old leather boots.

which were presented to different groups. Some subjects reported that they would not use this construction to say that 'Jane owned an old pair of torn sneakers'. They suggested that for the latter statement the adjectives worn and old might be reversed as in (3.40) or a different con-

(3.40) Jane had old worn tennis shoes.

struction might be substituted. Though stylistic preferences of the speaker may motivate bias judgments these aspects of production may ultimately stem from perception strategies. The study of Adjective-Genitive-Noun constructions referred to above indicated that speakers prefer the adjective directly in front of the element it describes. This, and perhaps

other stylistic preferences, may very well be an unconscious attempt on the part of the speaker to avoid evoking a misleading interpretation. In Adjective-Genitive-Noun constructions this is supported by the observation that the adjective is generally interpreted as describing the genitive rather than the head noun. That processing strategies are responsible for aspects of production has been argued by Bever (1970). He claimed that the preferred order of prenominal adjectives is constrained by a particular segmentation strategy which is an instance of a more general principle of perceptual grouping.

We have seen that the interpretation that listeners assign to an ambiguous sentence is determined by the interaction of syntactic, pragmatic, and behavioral factors. To the extent that bias is constrained by general strategies of speech perception, sentences with similar structural descriptions should be assigned similar readings. The sentences considered in this chapter indicate that this is generally the case. Sentences (3.41)-(3.43), in which the

(3.41) They need some (more convincing) evidence.

(3.42) Our defense system needs (more modern) arms.

(3.43) She told me to give (more realistic) details.

quantifiers are all interpreted as modifying the following adjectives, and (3.44)-(3.46), which are all biased toward the participial reading, serve as additional evidence.

(3.44) They are (lecturing doctors).

(3.45) They are (visiting sailors).

(3.46) They are (moving sidewalks).[3]

It has already been noted that perceptual strategies are sensitive to syntactic information in the lexicon. That perceptual strategies interact with other aspects of syntactic structure is indicated by the following sentences and their bias results:

(3.47)=(3.15) Susan told (her baby) stories.
stories to her baby .78
baby stories to her .22

(3.48) She told (her baby) stories.
stories to her baby .75
baby stories to her .25

(3.49) I told her (baby stories).
stories to her baby .29
baby stories to her .71

Sentences (3.47)-(3.49) differ only with respect to their subject NPs. Substituting the pronoun she for the proper noun Susan does not alter the bias values. However, when the first-person pronoun occupies subject position the bias judgments are reversed. The preferred reading in these sentences apparently depends on coreference relations between the subject noun phrase and object pronoun. This was substantiated by results obtained with different pronouns replacing the subject noun in sentence (3.50). As soon as the subject and object pronouns must be interpreted

(3.50) Ruth fed (her dog) biscuits.
biscuits to her dog .97
dog biscuits to her .03

(3.51) She fed (her dog) biscuits.
biscuits to her dog .81
dog biscuits to her .19

(3.52) I fed her dog biscuits.
biscuits to her dog .64
dog biscuits to her .36

(3.53) They fed her dog biscuits.
biscuits to her dog .59
dog biscuits to her .41

as referring to two different people the strong bias found for (3.50) and (3.51) is weakened. That bias was reversed in the case of sentence (3.49) but only weakened in (3.52) and (3.53) is probably due to the strength of dog biscuits as a unit relative to baby stories.

3. Intonation

The term 'intonation' is generally reserved for the characterization of pitch differences; as such the supra-segmental features of stress, juncture, etc. are excluded. For the purposes of the present study these factors need not be distinguished since it is their cumulative effect on the perception of surface structure ambiguities which is of interest here. Accordingly, throughout this work 'intonation' will refer tc the entire range of prosodic devices employed in pronunciation.

This section studies the interaction of intonation and syntactic structure in the acquisition and development of language (Section 3.1) as well as in adult speech

perception (Section 3.2). The issue is then approached from the point of view of neurolinguistic evidence (Section 3.3). Finally its role in constituent structure segmentation is analyzed (Section 3.4), motivating the present experimental study.

3.1 Ontogenesis and Developmental Considerations

Observers of child language provide evidence of early sensitivity to and reproduction of supra-segmental features. At the babbling stage children already produce utterances with contours characteristic of declarative and interrogative sentences. Nakazima (1962) reports that by the age of 9 months, infants begin imitating adult intonation patterns. According to Engel (1973), these different patterns are not simply imitations, but are employed to communicate semantic differences. Engel's position derives further support from a study of a child's utterances during the holophrastic period, conducted by Menyuk and Bernholtz (1969), which showed that the same one-word utterances were produced with different fundamental frequencies to alternately make statements, ask questions, or for emphasis.

There is some evidence that intonational features, like many other linguistic variables, are perceived before they are manipulated in production. Kaplan (1969, cited in Menyuk, 1972) tested 4- and 8-month old children, measuring cardiac and overt orienting responses to supra-segmental changes. While no response differences were found in the 4-month old group, children at 8 months showed different response patterns

in reaction to declarative and interrogative intonation contours. Blasdell and Jensen (1970) report that children of 28-39 months are more likely to repeat stressed monosyllables than those that are unstressed, suggesting that prosodic features influence what the child extracts from adult speech.

Though children aged 3 to 4 years correctly employ contrastive stress (Hornby and Hass, 1970) the ability to discriminate subtle stress differences is not displayed until relatively late in the acquisition process. Atkinson-King (1970) investigated the perception of stress contrasts in compound nouns, e.g. greenhouse, versus Adjective + Noun constructions, e.g. green house. Children of ages 5 to 13 years identified the test phrases they had heard by selecting an appropriate picture. The results indicated that the ability to identify these minimal pairs increases with age. Children at age 5 did not perform significantly above chance, while those at age 11 did.

In view of the early acquisition of other aspects of intonation, the observation that these stress rules are mastered relatively late requires explanation. Atkinson-King suggests that the stress contrasts under consideration may not be produced in speech since the intended sense is usually clear from context. The possibility of interference from the rules of contrastive stress is also considered (the prosodic difference between the contrastive gréen house and gréenhouse is quite subtle.) In any case compound nouns and noun phrases

represent a situation in which the relevant syntactic rules are necessarily acquired prior to the rules of stress. Other grammatical structures show a different developmental trend. In the acquisition of questions, for example, the child first makes use of a rising intonation while only later acquiring the syntactic processes of question formation.

The relative significance of intonation versus grammatical structure at different stages of language development is investigated in Hornby's (1973) study of presupposition. The relation between presupposition and assertion can be indicated by using cleft constructions, as in It was the prisoner who fired the gun, or contrastive stress, as in The prisoner fired the gun. Both sentences presuppose that someone fired the gun and assert that the prisoner was the one to do it. Hornby employed children from 2nd, 5th and 9th grades in a picture verification task in which either the asserted or the presupposed proposition was misrepresented. He found that the youngest subjects were highly sensitive to contrastive stress though they were not affected by presuppositions that were syntactically marked. The oldest subjects, however, were affected by syntactic structure but not by contrastive stress. These results indicate that between the ages of 8 and 15 years sensitivity to intonation as the marker of presupposition is replaced by sensitivity to syntactic structure. Hornby suggests that the acquisition of reading skills, whereby the child must rely on structure rather than intonation, may account for this declining sensitivity to intonation.

3.2 Speech Perception as an Active Process

Behaviorist theories of perception are based on the assumption that a given stimulus invariably evokes a uniform response. Applied to models of language comprehension this suggests a simple correlation between the acoustic properties of an utterance and the listener's interpretation. However, psycholinguistic research fails to support the stimulus-response account of language behavior. Instead, the perception of sentences has been established as an active process whereby the listener imposes a structural analysis on the acoustic signal. Moreover it has become evident that perception is a function of the listener's knowledge of the rules of grammar; the hearer's linguistic competence filters the objective acoustic signal and to a great extent determines his perception of that stimulus.

Ladefoged and Broadbent (1960) introduced the 'click' technique in an attempt to ascertain the perceptual units of speech. Extraneous clicks were superimposed at some point in a sentence or sequence of digits. Subjects, who were asked to listen to the stimuli and indicate the point at which the extraneous sound occurred, tended to 'hear' the clicks in positions prior to their objective locations. To verify the hypothesis that clicks migrate toward constituent boundaries, Fodor and Bever (1965) devised an experiment in which clicks were placed in various positions relative to the major phrase boundaries of sentences. They found that clicks were consistently displaced in the direction

of the major syntactic break. Under the assumption that a perceptual unit resists interruption, these results indicated that sentences are perceived in terms of their phrase structure.

These results do not, however, preclude the possibility that acoustic cues which signal the phrase boundaries are responsible for the click migration. To determine the effect of acoustic pauses, Fodor and Bever compared the degree of intensity drop at sentence breaks with the degree of click displacement. No correlation was found: boundaries exhibiting no measurable pause did not evince a weaker click migration. However, since the effects of other physical cues such as intonation and stress could not be ruled out, a further experiment was carried out.

Garrett, Bever and Fodor (1966) constructed pairs of sentences such as (3.54) and (3.55) in which a string

(3.54) In order to catch his train George drove furiously to the station.

(3.55) The reporters assigned to George drove furiously to the station.

of lexical items is shared but which are assigned different constituent structures on the basis of their previous segments. The major syntactic break precedes George in (3.54) but follows it in (3.55). The shared portions were made acoustically identical by splicing a copy of the string George drove furiously to the station from sentence (3.54) to (3.55). Thus both had identical acoustic material in the

region of the phrase boundary though their constituent structures still varied. If physical cues are responsible for click migration, the pattern of displacement should be the same in both sentences. However, Garrett et al. found that the perception of click location varied in each version, e.g. a click placed in George in both sentences was heard in the break between train and George in (3.54) but between George and drove in (3.55). Thus the same acoustic stimulus was perceived differently on the basis of the listener's analysis of phrase structure.[4]

It should be noted that, as a result of splicing, one sentence in each pair contained a portion whose intonation was appropriate to a different sentence. The results indicate that this was not detected by subjects in the Garrett et al. study. Similar findings are reported in a probe word task by Caplan (1972). In order to show that segmentation of sentences into clauses is independent of intonational cues Caplan constructed sentence pairs differing with respect to position of the clause boundary. Sentences (3.56) and (3.57)

(3.56) Whenever one telephones at night, rates are lower.

(3.57) Make your calls after six, because night rates are lower.

each contain a subordinate followed by a main clause; the sentences were constructed so that one word of the shared fragment preceded the clause boundary in one case but followed it in the other. The common portion from sentence (3.57) was spliced onto (3.56) resulting in identical stimuli in

the area of the clause boundary. Caplan found that despite the absence of cues to segmentation the same probe word (e.g. snow in [3.56] and [3.57]) was responded to faster when it appeared in the final clause of the sentence. Thus, the perception of clause boundaries is shown to be independent of intonation contour. The subjects in this experiment were not alone in their insensitivity to intonation differences. Prior to the experiment Caplan presented the sentences to naive and alerted judges to ensure that the spliced version sounded natural. Both groups reported that they could not tell that the sentences had been spliced.

The relation between the acoustic signal and speech perception was further investigated by Martin and Strange (1968). Subjects listened to recordings of spontaneous speech, which they were asked to repeat as accurately as possible including all pauses and hesitations. In reproducing the utterances, listeners tended to filter out hesitations. Moreover, within-constituent hesitations were consistently displaced to constituent boundaries.[5] To rule out the possibility that this shift is a result of a tendency on the part of the speaker to pause between constituents, an additional task was carried out. This time subjects were requested to simply mark the occurrence of hesitations on provided transcripts without repeating the utterance. Hesitation displacement persisted, indicating that a new structure is actively imposed on the acoustic speech signal.

In their Outline of English Structure, Trager and

Smith (1951) claim that the primary function of the prosodic features of pitch and stress is to cue the listener as to the segmentation of the sentence. They further claim that a system for the transcription of intonation elevates the recognition of immediate constituents into the ranks of 'solidly established objective procedures', a position based on one's being able to perceive intonation objectively. Lieberman (1965) attempted to verify whether linguists using the Trager-Smith notation were in fact objective in their analysis of the acoustic signal. Two competent linguists were asked to transcribe the intonation contour of (3.58)

(3.58) They have bought a new car.

read as an expression of different emotions. Lieberman found that the two resulting transcriptions disagreed fully 60 percent of the time. Furthermore, in analyzing the transcription of a single linguist relative to the fundamental frequency measurements of the utterance, no correlation was found between the Trager-Smith pitch levels and discrete frequency ranges.

Lieberman then asked the linguists to transcribe the intonation contours of a continuous [a] vowel, synthesized to reproduce the fundamental frequency and amplitude contours of the originally presented utterances. Compared with his original transcription, each linguist changed fifty percent of his previous judgments. These latter transcriptions of a single continuous vowel sound turned out to be more accurate

in terms of the actual fundamental frequency contours. Moreover, whereas the linguists were able to transcribe four degrees of stress when presented with the words of the utterance, they could transcribe no more than two levels when hearing just the fixed vowel signal. The results of this experiment clearly demonstrate that the linguists' assignment of intonation contours is not based solely on prosodic features of the utterance. Lieberman suggests that the linguist subjectively supplies the contour on the basis of what he knows about the language.

If perception is a function of linguistic knowledge there should be instances where the same acoustic stimulus will be 'heard' differently by speakers of diverse languages. This is precisely what a study by Hadding-Koch and Studdert-Kennedy (1964) revealed. A set of 42 intonation contours was electronically prepared from a recording of the utterance For Jane, which was found to be acceptable to both English and Swedish speakers. The stimuli were presented to English and Swedish speakers who, in two separate sessions, were asked to indicate whether a presented item would be best classified as a statement or a question, and whether it ended in a rising or falling pitch. The same contour which was classed as a downward terminal glide by speakers of American English was judged an upward terminal glide by Swedish speakers. Thus it is once again evident that perceptual responses are to a large extent specified by the listener's language system.

3.3 Neurolinguistic Considerations

Bever (1971) has argued that strategies of speech perception are located in the language-dominant left hemisphere. To determine hemispheric differences in the strategy for segmenting an utterance into clauses, Clark (reported in Zurif, 1974) devised a dichotic listening task using a modified click technique and the materials of Garrett et al. (1966). In this experiment, sentences such as (3.54) and (3.55) from Section 3.2 were simultaneously presented -- one to the left ear, the other to the right. A binaurally presented click was placed

(3.59)=(3.54) In order to catch his train George drove furiously to the station.

(3.60)=(3.55) The reporters assigned to George drove furiously to the station.

in the middle of the word which is surrounded by the competing boundaries (here, George). Click location was observed under conditions in which both sentences were read with intonation or both delivered in a monotone. Before each trial subjects were directed to attend to either the right- or left-ear sentence. Clark found that when both sentences were presented with intonation and subjects attended to the right ear, clicks were generally reported as occurring at the constituent break of the right-ear sentence. Such displacement appeared regardless of whether the break preceded or followed the 'click word'. In the case of the left-ear sentences, however, errors in click location appeared to be determined by the constituent structure of the unattended right-ear sentences. No consistent

displacement pattern was discerned in the monotone condition. These results suggest that the left hemisphere is responsible for the segmentation of utterances and, moreover, that acoustic cues are necessary for the analysis. That these findings are contrary to those of Fodor and Bever (1965) as well as Garrett et al. (1966) may very well be a function of the differing tasks involved. Overloading the processing capacity of the left hemisphere with a dichotic task may have led to increased reliance on prosodic cues in establishing constituents.

Though there is substantial evidence supporting the claim that language is a function of the left hemisphere, the acoustic features of intonation contours, namely, fundamental frequency and to some extent amplitude, have been found to be lateralized in the right hemisphere (reported in Blumstein and Cooper, 1974.) The interaction between the acoustic structure of intonation, on the one hand, and its linguistic role on the other, has led to some recent investigations of the hemispheric processing of intonation contours.

Subjects in the Blumstein and Cooper (1974) study heard dichotic pairs of intonation contours that had been filtered from four English sentence types -- declarative, interrogative, imperative, and conditional. A perceptual matching task in which subjects were to decide whether a single binaural stimulus matched either member of the dichotic pair yielded a significant left-ear advantage. In the second task, subjects were either asked to identify the contours by sentence type

or by their melodic pitch patterns. The latter condition, which was characterized as 'nonlinguistic', likewise resulted in a significant left-ear superiority. In the former task, which required a linguistic response, a nonsignificant left-ear advantage was found. The results of these three tasks suggest that intonation contours extracted from a phonetic context are processed more efficiently by the right hemisphere.

In a second experiment the dichotically paired intonation contours were presented in the phonetic medium of CV syllables. It was felt that a right-ear advantage might be produced in a task which was closer to the normal speech situation. Once again, however, a left-ear advantage was revealed, providing further evidence that the perception of intonation is largely a function of the right hemisphere. Additional support comes from Blumstein and Cooper's observation that the processing of prosodic features is not significantly affected as a result of damage to the left hemisphere.

The experiments carried out by Blumstein and Cooper indicate that, despite its linguistic function, intonation is not processed by the language dominant hemisphere. Nevertheless contrary results were found by Zurif and Mendelsohn (1972). In a dichotic listening task, subjects were presented with pairs of nonsense sequences under 'structured' and 'semi-structured' conditions. The structured sequences were read with the intonation characteristic of the original sentences from which they were derived; the semistructured sequences were delivered in a monotone. The results revealed a significant right-ear superiority (indicating left hemisphere

lateralization) in the structured condition, while no asymmetry effect was found in the semistructured condition. Zurif (1974) points out that listeners do not normally separate the intonation contour from the utterance as was required in the Blumstein and Cooper study. In the second experiment, though the contours were presented in a phonetic context, the stimulus which was to be matched was filtered. The foils in the Zurif and Mendelsohn task included the same phonetic information as did the dichotic stimuli. The right-ear advantage in their experiment, which was found only in the intonated sequences, is attributed not to the contour but rather to the linguistic nature of the perceptual task. Considering the findings of both studies, Zurif concludes that though intonation is probably processed by the acoustic analyzers of the right hemisphere, it is utilized by the language mechanism of the left hemisphere in making linguistic analyses.

3.4. Intonation as a Cue to Constituent Structure Segmentation

The discussion of the active nature of speech perception presented in Section 3.2 was not meant to imply that prosodic phenomena have no function in speech processing. In fact, evidence for the facilitating effects of intonation is found in psycholinguistic studies of recall and comprehension. O'Connell, Turner, and Omiska (1968) investigated the influence of grammatical structure and prosody on the learning of nonsense strings. Subjects heard strings of nonsense syllables which were either high-structured (function words and morphological endings retained in the same order as English),

low-structured (English morphology simulated but syntax scrambled), or unstructured (neither morphology nor syntax simulated.) Each version was read either with an intonation appropriate to English sentences or in a monotone. Subjects were instructed to repeat the nonsense string aloud; each stimulus was presented 25 times. Intonation was found to facilitate recall of syllables in both low- and high-structure conditions and recall times at all levels of structure. Of equal interest is the fact that the facilitative effect of grammatical structure was evident only in the intonated conditions.

That intonation provides clues to segmentation is further argued in an experiment by Braine (1963) in which a single nonsense sentence was spoken with different stress patterns. Subjects were requested to provide an English sentence which seemed grammatically similar to each nonsense utterance. Braine found that the subject-predicate division in the response sentences corresponded to that point in the nonsense sentence following the first main stress. On this basis, Braine concludes that intonational phenomena transmit structural information.

The positive effects of prosodic cues were revealed in a study of the perceptual complexity of self-embedded constructions (Fodor and Garrett, 1967). Subjects were tested on the accuracy and time required to paraphrase self-embedded sentences which differed with respect to the absence or presence of relative pronouns. In an initial experiment the stimulus sentences were presented with flat intonation; Fodor and Garrett found that subjects performed better on sentences in which the relatives were present. The second experiment

used the same materials differing only in that the sentences were read with normal intonation. Comparison of the performance of the groups in Experiment 1 with that of Experiment 2 indicated that prosodic cues significantly improved scores in sentences in which the pronouns were deleted. Nevertheless intonation did not produce a significant improvement in sentences in which the relative pronouns were retained. Thus in the case of center-embedded constructions as opposed to nonsense strings the facilitation of grammatical structure was independent of intonation effects.

Though there is little support for the claim (Trager and Smith, 1951) that sentence segmentation is specified entirely by intonational cues, there is evidence that prosodic features do provide some clues to constituent analysis. Bolinger and Gerstman (1957) were able to change the interpretation of the utterance

(3.61) lighthouse keeper

to that of

(3.62) light housekeeper

by splicing in a pause at the boundary between light and house. Thus perception of the different stress patterns is related to acoustic cues provided by disjuncture. Of particular interest to the present study is the fact that the originally recorded versions of (3.61) and (3.62), which were also presented in the course of the experiment, were not equally effective in

eliciting the two interpretations. Stimulus (3.61) was invariably perceived as lighthouse keeper (1.00 of the responses), whereas (3.62) avoked the light housekeeper reading in slightly fewer than .70 of the cases. Bolinger and Gerstman explain that these stimuli were presented in isolation while the perception of contrastive stress, as (3.62), generally requires prior context. This amounts to the observation that even at the level of phrases the effectiveness of disjuncture is dependent on interpretive bias.

That acoustic pauses can influence structural organization is supported by a study by Garrett (reported in Fodor and Bever, 1965.) Clicks were superimposed on sequences of spoken digits which were marked by relatively long pauses. Garrett found that the clicks were subjectively heard at the point of disjuncture. As was already suggested by the Bolinger and Gerstman results, it appears that, in the absence of sentential context, pauses are perceived during processing.

The studies of Fodor and Bever (1965) and Garrett, Bever, and Fodor (1966), discussed in Section 3.2, however, showed that the effects of disjuncture are limited in the segmentation of sentential utterances. Lieberman (1967a) embedded the morphemes light house keeper in the contexts provided by sentences (3.63) and (3.64). Spectrograms which were prepared

(3.63) The life of a lighthouse keeper was very lonely.

(3.64) Our maid weighed 180 pounds, but the Joneses had a light housekeeper.

from readings of these sentences indicated that speakers used

disjuncture to mark the constituent structure of the two phrases. Lieberman then spliced the phrase light house keeper from (3.63) and (3.64) and switched them. The resulting sentences sounded no different from the original ones indicating that context can override the effect of acoustic cues.

An experiment by Wingfield and Klein (1971), on the other hand, showed the effects of prosodic cues despite the presence of a sentential context. The test sentences were presented monaurally and were switched to the other ear either between or within major syntactic boundaries. Subjects were asked to recall the sentence and localize the point at which the switch had occurred. The materials were prepared in a manner similar to that used by Garrett, Bever, and Fodor (1966). Sentence fragments identical in wording and acoustic pattern were inserted into different contexts. Together with the original unspliced versions, this resulted in two sentence pairs, one of which had an intonation pattern appropriate to its structure while the other did not. Sentences (3.65) and (3.66) illustrate:

(3.65a) (By forgetting to call George) we lost a crucial vote.
(b) (By forgetting to call) George we lost a crucial vote.

(3.66a) (By forgetting to call) George forfeited his chance to go.
(b) (By forgetting to call George) forfeited his chance to go.

The sentences were switched at positions preceding, at, or following the major clause boundary. In the (b) versions of sentences (3.65) and (3.66) syntactic structure and intonation are placed in opposition.

For the unspliced (a) sentences, switches occurring at the clause boundaries were located most accurately, replicating the results of the click experiments. However in the case of the spliced versions, in which syntactic structure and prosodic cues were placed in opposition, localization accuracy was significantly greater at the boundary indicated by intonation. While these results may suggest that intonation is a stronger cue than structure, Wingfield and Klein note that the number of mislocated switches which migrated to the acoustic boundary was equal to the number which were reported at the major syntactic break. That both prosodic and structural features are involved in perceptual segmentation is further supported by an analysis of the error patterns in recalling the sentences. Errors in recalling the unspliced sentences involved substitutions and omissions of lexical items while the syntactic structure was generally retained. In the case of the spliced versions, on the other hand, 38 percent of the errors were marked by syntactic changes which conformed to the intonation pattern, indicating the influence of acoustic cues in constituent structure segmentation.

Nonetheless, the prosodic feature of juncture is not always manipulated by the speaker. Lieberman had speakers read the phrases

(3.67)=(3.61) lighthouse keeper

(3.68)=(3.62) light housekeeper

(3.69) light heavyweight

Spectrographic analysis revealed that disjuncture differentiated

(3.67) and (3.68) though it was not marked in (3.69). In the latter case, instead of pausing between light and heavyweight the entire phrase is uttered at an even rate. These differences are presumably attributed to the speaker's awareness of the fact that, in (3.69), the lexical items themselves indicate the correct segmentation. Thus the relative ambiguity of the constituent structure determines the extent to which disjuncture is manipulated.[6]

These observations are particularly relevant to instances of surface structure ambiguity. The different readings of a surface structure ambiguity are determined by the alternate constituent structures formed from the sentence elements. Lieberman notes that these sentences can be disambiguated in speech by division of the utterance into 'breath-groups'.[7] These breath-groups in turn divide the signal into segments that acoustically reflect the constituent structure. Thus the sentence

(3.70) They kept the car in the garage.

could be divided into two breath-groups as in either (3.71) or (3.72

(3.71) They kept, the car in the garage.

(3.72) They kept the car, in the garage.[8]

To claim, as Lieberman does, that 'the division of the utterances into breath-groups disambiguates them' implies that the listener is sensitive to the acoustic correlates of breath-group division.

That listeners determine the interpretation of a surface structure ambiguity from intonational cues is generally assumed and often made explicit. Fries (1952) claims that intonation provides 'the deciding signal of structural grouping' in expressions such as

(3.73) the King of England's empire

(3.74) the president of the university's committee on educational policies.

Psycholinguists are quick to point out that, whereas this is not the case in lexical and deep structure ambiguities, surface structure ambiguities 'are usually indicated by intonation which can, therefore, disambiguate [them]' (Foss, Bever, and Silver, 1968). In investigating the processing strategies associated with different types of ambiguity, Cairns (1970) considered only lexical and deep structure ambiguities. Among the reasons for excluding instances of surface structure ambiguity she cites the fact that 'they are disambiguated by intonation, and sentences used in the present study were presented aurally to subjects'.

The evidence presented in this section indicates that acoustic cues are involved in the segmentation of utterances. Nevertheless even these studies revealed that the effects of prosody interact with those of context and bias. Moreover the literature supporting the constructive nature of speech perception makes it clear that the analysis which is ultimately imposed on the speech signal is not determined solely by properties of the stimulus. Segmentation is imposed in

in the absence of, and often in spite of, intonational cues.

In light of these considerations, it is curious that researchers invariably assume that surface structure ambiguities are disambiguated by intonation. It is understandable that this view is held by followers of the structuralist school of linguistics, who, in keeping with behaviorist tradition, conceive of the listener as a passive recipient of physical cues in the speech signal. What is surprising, however, is that even proponents of the opposite viewpoint, namely the claim that perception is determined by linguistic knowledge, uphold this same view. In considering the ambigious string

(3.75) John saw the man eating shark.

Wanner (1974) observes that the sentence is highly biased toward the sense in which a type of shark which eats men is being characterized. He accounts for this bias by appealing to linguistic information in the mental lexicon: 'a lexical entry for a verb like <u>eat</u> which specifies that given a subject noun like <u>man</u>, an object noun such as <u>shark</u> is pragmatically unlikely because it does not denote a typical food which <u>man</u> <u>eats</u>.' Not only does Wanner suggest that such information is supplied by the mental lexicon (thus accounting for the bias in this case) but he recognizes that 'the listener brings the whole weight of his personal knowledge to bear upon the problem of [sentence comprehension]'. Yet in a footnote to sentence (3.75) he argues that the sentence is strictly speaking ambiguous only in writing:[9] 'If the input is acoustic then a cue which Lieberman .. calls

disjuncture serves to disambiguate the sentence.'

Even Lieberman (1967b), whose name is often associated with the theory of active perception, accepts this view:

> Intonation furnishes acoustic cues that tell the listener when he has a block of speech that constitutes a satifactory input to his syntactic recognition routines. Intonation can furnish different meanings to utterances that have the same words by grouping the words into different blocks which direct the listeners' recognition routines toward one underlying phrase marker rather than another. (p. 315)

Nevertheless, Lieberman concludes that 'perception is a function of the listener's knowledge of the basic constructs and grammar of his language'.

The present study was undertaken to investigate whether a stronger version of the constructive theory of speech perception, one not modified by intonation-based discovery procedures, is empirically warranted.

NOTES TO CHAPTER 3

1

There is no question that in fact Kimball's two principles are in conflict in this case in that the assignment of node labels is posponed until the relevant structure has been generated, i.e. at the time baby is to be attached to the tree, her is not labelled and so cannot serve as a determining factor. This applies to all cases of lexical-category surface structure ambiguity (to be discussed in Chapter 4). In addressing this issue, Kimball's simplifying assumption is that English is a 'look-ahead language' (allowing the storage of one symbol while scanning as many as two subsequent ones before attaching it to the tree); a symbol in storage is not assigned a node label.

2

These bias differences could conceivably be related to the observation that 'kids' are more likely than teenagers to roll around on floors. This can easily be tested by interchanging the subject nouns in (3.34), (3.35) and obtaining bias judgements for the resulting sentences.

3

It may be noted that the bias judgments for sentences (3.44)-(3.46) violate Bever's (1970) sequential labelling strategy according to which a Noun-Verb-Noun sequence in the surface structure is interpreted as corresponding to actor-action-object. (Though Bever specified that this strategy applies in the absence of semantic constraints, it is questionable whether the participial interpretations in these sentences are due to overriding semantic or pragmatic considerations). The preferred adjectival interpretation of (3.44)-(3.46) is surprising in view of the report (Bever, 1971) that unambiguous participial constructions (e.g. They are performing monkeys)are responded to significantly more slowly than progressive constructions (e.g. They are fixing benches) when presented to the right ear in a picture verification task (see also Mehler and Carey, 1968). Bever explains that the response latency to these sentences is shortest for the construction that conforms to the Noun-Verb-Noun=actor-action-object pattern and longest for the construction that does not conform. He concludes that 'the progressive construction must exhibit a construction that actively conforms to a perceptual pattern for which the right ear is preset'(emphasis added). On the basis of these considerations a bias toward the progressive reading of (3.44)-(3.46) would be predicted. The actual bias values of (3.44)-(3.46) therefore remain unexplained.

4
A visual analog is presented in Mehler, Bever and Carey (1967). In studying the interaction between grammatical structure and eye-fixation patterns in reading, they found that strategies of visual scanning are determined by the surface phrase structure of sentences.

5
Valian (personal communication) notes, however, that the data do not justify this conclusion. Martin and Strange analyzed the proportion of hesitations preceding content and function words, assuming that constituent boundaries can be identified on the basis of the content/function word distinction.

6
This being the case, we would predict that the relevant phrases in (3.63) and (3.64) would show no contrasts in disjuncture since the segmentation is clear from the context. Lieberman attributes the disjuncture in these sentences to the speaker's awareness of the differences involved in reading both sentences several times.

7
Lieberman defines the breath-group as the pattern of articulatory activity that 'produces a prosodic pattern . . . characteristic of the ones that are used to delimit the boundaries of unemphatic, declarative sentences in normal speech'.

8
Lieberman represents 'unmarked breath-groups' with the symbol ⌒ and 'marked breath-groups' with the symbol ⌒\. The first breath-group is always marked, to indicate that the utterance is not yet complete.

9
In fact this sentence would probably not be ambiguous in writing since the hyphenated 'man-eating shark' is commonly used to express the preferred reading.

Chapter 4

THE EXPERIMENT

Surface structure ambiguities provide an excellent opportunity to test this stronger version of the constructive character of speech perception since the three factors of context, bias, and intonation can be manipulated and placed in opposition. The present study was devised to ascertain which aspects of the input utterance ultimately determine the interpretation the listener assigns to these ambiguities. It is predicted that objective intonational cues play a relatively minor role in the processing of ambiguities which were independently established as highly biased toward one reading. More specifically, it is predicted that the strength of the preferred reading (i.e. bias) will be attenuated to a greater degree by an opposing context than by an opposing intonation.

Four sub-types of surface structure ambiguities are tested to ascertain whether the effects of intonation vary with ambiguity type. (See Appendix B for typological classification of the experimental sentences.) The first three are syntactic:

(1) 'lexical category' -- in which an element is characterized by different grammatical categories in each of the two readings, e.g. worn is either an adjective or participle in Jane had worn old tennis shoes.

(2) 'regressive modifier scope' -- in which a phrase can either be associated with a lower or higher rightmost constituent, e.g. in Alan painted the picture in the

hall, the prepositional phrase in the hall can either modify the NP the picture or the verb painted.

(3) 'progressive modifier scope' -- in which the scope of a modifier extends over one or more following constituent, e.g. in That handsome man's shirt cost $38, handsome describes either the man or the shirt.

The fourth class is semantic and as such includes sentences from the above three syntactic sub-groups:

(4) 'semantic overlap' -- in which one of the two interpretations implies part of the other. In the case of Jane had worn old tennis shoes, if she wore them she certainly had them.

1. Method

PRETEST I

Surface structure ambiguities were pre-tested to determine bias values for the two interpretations of each sentence. Three types of surface structure ambiguities were constructed: lexical category, progressive modifier scope, and regressive modifier scope. The types were randomized and presented in writing, together with unambiguous filler sentences, to groups of students at Queens College. The students, who were not informed that some of the sentences were ambiguous, were instructed to paraphrase each sentence, i.e. to provide another sentence that means the same thing. Upon completion, they were told that some of the sentences were ambiguous and the two interpretations of each ambiguous sentence were specified. Subjects were then asked to examine their paraphrases and indicate for each sentence which of the two meanings was originally perceived. This step is necessary in view of the fact that paraphrases of ambiguous sentences are often

themselves ambiguous and must be excluded from the analysis. Since only highly biased ambiguities were used in the experiment, sentences for which the bias value for the preferred meaning was lower than .70 were discareded. Only judgments of native speakers of English were included in the analysis.

PRETEST II

The sentences with bias values over .70 for the more probable interpretation were recorded on tape. Each sentence was read several times with intonation patterns appropriate to either the more probable (high-bias) interpretation -- HB Intonation, or the less probable (low-bias) interpretation -- LB Intonation. The tape was then played to four judges (one graduate student in linguistics and three undergraduate students) who were told that each sentence was ambiguous and asked to indicate which of the two possible interpretations was conveyed by each recording. Readings which were deemed unnatural, i.e. exaggerated, were eliminated. Sentences were re-recorded and re-tested until each sentence had two readings -- one HB Intonation and one LB Intonation -- which were considered appropriate by the experimenter, the linguist, and at least two of the three student judges. A master tape of the test sentences was prepared.

Materials and Design

Thirty-six highly-biased surface structure ambiguities (twelve of each sub-type) were selected and each paired with three context questions: a question appropriate to the more probable interpretation (HB Context), a question appropriate

to the less probable interpretation (LB Context), and a neutral question (N Context) appropriate to either interpretation. In the construction of HB and LB Context questions care was taken so as not to parse the sentences for the listeners, i.e. the ambiguous constituents did not appear unambiguously in the context questions. Thus question-answer pairs such as the following were avoided:

Q. What had Jane worn to the party?

A. Jane had worn old tennis shoes.

Each ambiguous sentence appeared in the following six conditions:

(a) Read with an intonation pattern appropriate to the high-bias interpretation (HB Intonation) and preceded by a context appropriate to the high-bias interpretation HB Context).

(b) Read with HB Intonation and preceded by a context appropriate to the low-bias interpretation (LB Context).

(c) Read with HB Intonation and preceded by a Neutral Context.

(d) Read with LB Intonation and preceded by an HB Context.

(e) Read with LB Intonation and preceded by an LB Context.

(f) Read with LB Intonation and preceded by a Neutral Context.

In the following example, parentheses indicate the intonation pattern in which the sentence was read. Appendix A presents the bias results and context questions associated with the test sentences.

a. HB How did the boss treat the lazy salesman?
   HB The Boss dismissed the salesman (with enthusiasm).

b. LB Which salesman did the boss fire?
   HB The boss dismissed the salesman (with enthusiasm).

c. N What happened while I was out?
HB The boss dismissed the salesman(with enthusiasm).

d. HB How did the boss treat the lazy salesman?
LB The boss dismissed (the salesman with enthusiasm).

e. LB Which salesman did the boss fire?
LB The boss dismissed (the salesman with enthusiasm).

f. N What happened while I was out?
LB The boss dismissed (the salesman with enthusiasm).

The six versions of each sentence were counterbalanced across six material sets so that each sentence appeared in only one of its conditions (i.e. (a)-(f), as above) in each set. Each set included six instances of each condition. Three copies of the two readings of each sentence were prepared from the master recording; the readings were then spliced into the experimental tape following a context question in order to create identical acoustic material across sets. Each set also contained the same 24 unambiguous filler sentences, half of which had context questions clearly unrelated to their answers, e.g.

Q. Is the movie as good as the book?

A. Fran's idea is to call for a general strike.

and others (the remaining twelve) in which the mis-match was not as obvious, e.g.

Q. Who's the youngest member of the Senate?

A. I judged him to be about seventy-five.

The experimental sentences were randomized so that not more than one surface structure ambiguity type (lexical category, regressive modifier scope, progressive modifier scope) appeared in succession. The test and filler sentences were then randomized so that the subject heard no more than two successive experimental sentences.

Each subject heard a total of 60 question-answer pairs: 36 test sentences (6 in each experimental condition) and 24 fillers. Of the 36 test sentences, 12 answer sentences were appropriate to the context questions -- those in the HB-HB and LB-LB conditions, and 12 were inappropriate -- those in the LB-HB and HB-LB conditions. The remaining 12 neutral context questions were not incompatible with their answers, yet a written pretest of compatibility judgments revealed that the ambiguous sentences were not always judged as appropriate answers when preceded by neutral-context questions. The 24 filler sentences were all incompatible question-answer pairs, 12 obviously so.

The design was thus a 2(Intonation) x 3(Context) x 6(Materials), with the first two variables within subjects and the third between groups. Type of surface structure ambiguity was not an independent variable though each subject heard 12 sentences of each type.

Subjects

The subjects were 60 (ten per group) undergraduates, who were enrolled in introductory courses in linguistics and communications arts and sciences at Queens College. All were native speakers of English and, while not the same subjects who took part in Pretest I, were drawn from the same population. They participated in the one-hour experiment as part of a course requirement and were paid for their time.

Procedure

Subjects were randomly assigned to six tapes, and were

tested individually. Each heard the 60 binaurally-presented question-answer pairs over headphones. Subjects were informed that in each case they would hear a question followed by a response. The first task was to decide whether the given response was an appropriate answer to the question; subjects indicated their decision by pushing a 'yes' or 'no' button. For half the subjects in each set the 'yes' button was to the subject's right, for the other half it was to the left. Subjects were further instructed that their responses were being timed, and cautioned not to sacrifice accuracy for speed. Appendix C presents the instructions which were read to each subject.

The second task was to write a paraphrase for the answer in each question-answer pair regardless of compatibility. Subjects were not timed on this task. The tape-recorder was stopped after each question-answer pair. Upon completion of each paraphrase the subject pushed the button to his right and the tape was started for the next pair. Four practice question-answer pairs were provided.

There was a one-second interval between the question, which had been recorded by a male speaker, and the answer, recorded by a female speaker. An inaudible tone was placed on a second track of the tape coinciding with the end of the final sound in each sentence. The tone activated a millisecond timer which was stopped by the subject's button-push. Appropriateness judgments and response latencies were recorded by the experimenter.

Following the presentation of all question-answer pairs, subjects were informed that some of the answer sentences were ambiguous. (See Appendix D for posttest instructions.) They were provided with mimeographed sheets which did not repeat the test sentences but which presented the two possible interpretations for each sentence. (See Appendix E for a sample sheet.) Subjects were asked to compare their paraphrases with the possible readings and indicate which interpretation came to mind first on hearing the sentence.

2. Results

The three dependent variables, namely (1) the number of affirmative responses in the judgment task, (2) reaction time, and (3) the number of paraphrases corresponding to the high-bias interpretation, will be discussed individually. The three scores assigned to a subject in each condition are the means of the six sentences in that condition. These scores were subjected to three separate analyses of variance, the results of which are presented in Appendices F through H.

Appropriateness Judgments

Table 4.1 shows the mean number of 'yes' responses for the six conditions summed across groups. Significant main effects were found for all three independent variables. Comparison by orthogonal weighting coefficients indicates that whereas both intonation conditions contribute to the significant main effect of Context, $F(2,108)=134.28$, $p < .001$, the significant main effect of Intonation, $F(1,54)=25.95$,

$p < .001$, is completely accounted for by scores in the low-bias context conditions. The Groups variable was significant, $F(5,54)=3.45$, $p < .01$ and interacted significantly with Context, $F(10,108)=3.43$, $p < .001$. A significant interaction was also found for Intonation by Context, $F(2,108)=28.16$, $p < .001$.

The conditions of primary interest in this study are those in which the intonation of the answer sentence is inappropriate to the context question, i.e. conditions HB-LB and LB-HB. A comparison of means reveals no significant differences between affirmative judgments to HB-LB pairs when compared with the same judgments to HB-HB pairs. Furthermore, high-bias context questions answered by low-bias intonation responses were judged to be compatible significantly more often than LB-LB pairs. The significantly greater number of affirmative responses to HB-LB pairs compared with LB-HB pairs can be interpreted as revealing the relative strengths of context and bias. The incompatibility of LB-HB pairs is presumably noted because the expectancy occasioned by the context is contradicted by bias. In the case of HB-LB pairs, on the other hand, the inappropriate intonation is not strong enough to counteract the effects of the context question. While significantly fewer 'yes' responses were found in the LB-HB condition it should be noted that more than half of these answer sentences were judged as appropriate responses.

Table 4.1 Mean number of 'yes' responses to the six context by intonation conditions.

		INTONATION		
		HIGH BIAS	LOW BIAS	
CONTEXT	High Bias	5.05	5.15	(5.10)
	Low Bias	3.22	4.62	(3.92)
	Neutral	5.68	5.48	(5.58)
		(4.65)	(5.08)	

Table 4.2 Mean reaction times (sec) to the six context by intonation conditions

		INTONATION		
		HIGH BIAS	LOW BIAS	
CONTEXT	High Bias	1.24	1.38	(1.31)
	Low Bias	1.63	1.44	(1.53)
	Neutral	1.19	1.25	(1.22)
		(1.35)	(1.36)	

Table 4.3 Mean number of high bias responses to the six context by intonation conditions.

		INTONATION		
		HIGH BIAS	LOW BIAS	
CONTEXT	High Bias	5.57	4.82	(5.19)
	Low Bias	3.85	2.13	(2.99)
	Neutral	5.07	3.88	(4.47)
		(4.83)	(3.61)	

Reaction Time

Mean response latencies in the judgment task are presented in Table 4.2. A significant main effect was found for Context only, $F(2,108)=17.98$, $p < .001$. This effect is accounted for by the slower reactions in the LB context conditions, though response times to HB-LB and LB-LB pairs do not differ significantly. The Context variable was also involved in three significant interactions: Context by Groups, $F(10,108)=4.56$, $p < .001$; Context by Intonation, $F(2,108)=5.61$, $p < .005$; and Context by Groups by Intonation, $F(10,108)=4.51$, $p < .001$.

Reaction time was included as a dependent variable in order to determine whether listeners notice an inappropriate intonation pattern. All of the measures in this experiment were taken on sentence completion and therefore reveal little about on-line processing. Nevertheless greater response latencies in LB-HB and HB-LB pairs might indicate that subjects were conscious of a mis-match, though their paraphrases and appropriateness judgments fail to reveal this. A comparison of reaction times indicates that subjects take longer to respond to HB-LB pairs when compared with HB-HB pairs, though not when compared with either LB-LB or N-LB pairs. Reaction time in the LB-HB condition, however, was significantly greater than that in all other test conditions. The crucial comparison is once again that between LB-HB and HB-LB pairs. Though the intonation patterns in both these conditions are inappropriate with respect

to the context questions, LB-HB pairs were responded to significantly more slowly than HB-LB pairs.

Paraphrase Task

Of the three measures taken in this study, the paraphrase task is the most indicative of the effects of intonation and context on sentence comprehension. Though the judgment and latency variables were included to detect effects that might otherwise go unnoticed, these latter tasks may involve factors unrelated to the effects of intonation.

Responses on the posttest were classified as either high-bias (HB) or low-bias (LB) depending on whether the subject's interpretation corresponded to the more likely or less likely reading as determined by Pretest I. The overall mean number of HB responses is shown in Table 4.3. The main effect of HB responses is shown in Table 4.3. The main effect of Context, $F(2,108)=110.37$, $p < .001$ is revealed in both intonation conditions, while the main effect of Intonation, $F(1,54)=105.05$ is revealed in all three context conditions. The materials variable was not significant and was involved in only one significant interaction, namely that of Intonation by Context gy Groups, $F(10,108)=4.41$, $p < .001$. The only other significant interaction is that of Intonation by Context, $F(2,108)=6.77$, $p < .002$. Comparison by orthogonal weighting coefficients indicates the effectiveness of context: the number of high-bias responses to HB-HB pairs is greater ($p < .05$) than those to N-HB pairs,

with the number of HB responses to HB-LB pairs greater ($p < .01$) than those to N-LB pairs. Furthermore, the greater number of HB paraphrases in N-LB compared with LB-LB pairs, and N-HB compared with LB-HB pairs indicates that context attenuates the effects of bias when intonation is held constant. The effects of bias are similarly apparent: despite the finding that the number of high-bias readings is significantly lower in the N-LB and LB-HB conditions when compared with all others, in both cases more than half of the responses were HB interpretations. Equally striking is the observation that the number of HB readings in the LB-LB condition is far from zero ($\bar{X}=2.13$). Finally, the significantly greater number of HB responses found in HB-LB pairs when compared with LB-HB pairs confirms the earlier prediction that the preferred interpretation is affected to a greater extent by a conflicting context than by a conflicting intonation.

Types of Surface Structure Ambiguity

Though type of surface structure ambiguity was not a variable in this experiment, equal numbers of the three types were included in each set. The Spearman rank-order correlation test was performed on the results of a by-Type analysis to observe the extent to which the distribution of scores in each type of surface structure ambiguity corresponded to the overall results of the study.

Type of ambiguity was not a significant factor in the paraphrase task. All types correlated significantly

with the overall number of HB readings: lexical category, $r=.943$, $p \leq .01$; progressive modifier scope, $r=.943$, $p \leq .01$; regressive modifier scope, $r=1$.

In the judgment task the lexical category and progressive modifier scope scores corresponded to the overall patterning: lexical, $r=.943$, $p \leq .01$; progressive modifier scope, $r=.998$, p .01. The absence of a significant correlation in the regressive modifier scope type is due to a relatively small number of 'yes' responses in the N-HB condition. A by-Sentence analysis indicates that experimental sentence #31 is alone responsible. The neutral-context question is this condition was such that not enough subjects perceived its connection to the answer.

(#31) N What took them so long?

HB They talked about the problem (with the mathematician).

The by-Type analysis of response latencies shows that sentences of the progressive modifier scope class were responded to most quickly in high-as well as low-bias intonation conditions. Sentences of the lexical-category type showed the longest response delays. Within this group, subjects hesitated most when responding to sentences in the HB-LB condition. This is the case despite the fact that, in this condition, sentences of this type are assigned a large number of HB readings and judged to be appropriate more often than even HB-HB pairs. If long reaction time is an indication that the subject

senses the inappropriate intonation pattern, intonation appears to have some effect in this sub-group of surface structure ambiguities. Nevertheless, even in these cases intonation is not strong enough to affect the interpretation assigned to the sentence, i.e. intonation has a minimal effect on comprehension.

A fourth group of surface structure ambiguity--'semantic overlap'--was isolated to determine whether intonation effects depend upon the extent to which the two readings of a surface structure ambiguity are related. This group contained sentences from the other three types though not in equal numbers: 6 progressive modifier scope, 2 lexical-category, and 1 regressive modifier scope. In all three tasks the results of this group showed no significant differences when compared with the overall data: in the paraphrase task $r=.943$, $p \leq .01$; in the judgment task $r=1$; and in reaction time $r=.943$, $p \leq .01$. It might be noted that this group is the only one for which a significant reaction time correlation with the overall results was found.

Chapter 5

Theoretical and Empirical Implications

The present study evaluated the respective contributions of bias, context, and intonation to the comprehension of surface structure ambiguities. Though this question is interesting in and of itself, the implications extend to the broader issue of general sentence processing. The experimental results confirm the hypothesis that intonation is a relatively weak cue in determining the interpretation assigned to a surface structure ambiguity. This observation can only be accounted for within a theory of speech perception which is essentially constructive: sentences are heard as a function of the way they are understood, i.e. a theory which emphasizes the central role of syntactic processing.

Given these results one might speculate as to why intonation is a weak cue, i.e. why listeners do not rely more heavily on prosodic features in the course of sentence processing. The psycholinguistic research reviewed above revealed that the listener brings his knowledge about language and the linguistic context to bear in the task of speech perception. Viewed this way, intonation turns out to be merely an additional cue which can be utilized in forming hypotheses about the incoming signal.

Much of the discussion on the effectiveness of intonational features presupposes that intonation is manipulated by the speaker in producing utterances. However, in the light of research (Lieberman, 1963; 1967a) discussed above, it is apparent that the speaker does not necessarily include more information than he believes is required for comprehension, i.e. the speaker assumes that the listener too will make use of his linguistic knowledge in decoding. Thus cues are generally omitted in utterances where the constituent structure is already clear due to selectional restrictions imposed by the words chosen, pragmatic considerations, or the surrounding linguistic context. Moreover, the studies in which the same acoustic stimuli were inserted into different linguistic contexts showed that the effects of context override those of prosodic cues even in cases where intonation <u>is</u> marked.

These two observations are not unrelated. If the speaker fails to provide intonational cues, relying instead on the context, as listener he would not attach too much importance to these cues. Thus the communication situation is largely determined by assessments made by speakers and hearers as to the actions of the conversational partner. All of this would seem to imply that intonation will be marked in cases of ambiguity; this is probable when the speaker is conscious of the fact that his utterance can be assigned more than one reading. However, speakers are rarely aware of potential ambiguity in the course of

producing a sentence. A speaker who is cognizant of the ambiguity will in all likelihood substitute an unambiguous paraphrase. This may well be a manifestation of an intuitive feeling as to the weakness of intonation.

Sepakers do not manipulate intonation even in situations where they might be expected to do so. Scholes (1971) had speakers read sentences containing ambiguous phrases. Each sentence was recorded under two conditions: a noise-free condition and a noise condition. In the latter the speaker received 80db of white noise via earphones while recording the sentence. The ambiguous phrases were excised from the sentences and presented to listeners who were asked to deterime the location of the disjuncture. It was assumed that if disjuncture is in fact an important cue it should be more apparent when the speaker must override a noisy environment. Though the VU meter confirmed that the amplitude of the readings was significantly increased in the noise conditon, the number of correct judgments in locating the disjuncture was no greater than in the noise-free condition. According to Scholes these results indicate that 'the likelihood that any speaker will use disjuncture to indicate phrase structure does not relate to his desire to "make himself understood".' However, since he provides no spectographic evidence, Scholes has not actually shown that speakers do not make more use of acoustic cues to segmentation even when overall amplitude is increased. What he has

shown, though, is that the listener is not affected by the objective cue to a greater extent when it is produced in a situation where a conscious effort is made to preserve intelligibility.

Lieberman (1967a) notes that disambiguation by means of breath-groups is a relatively complex process. Not only must the speaker carry out an analysis of the particular string to be uttered but the alternate structure, corresponding to the second grouping of the constituents, must also be determined. The two structures are then presumably compared to ascertain the alternate phonetic representations. Lieberman argues that in producing a paraphrase, on the other hand, 'the speaker need only consider the particular deep phrase marker that he wishes to convey'. Lieberman is here considering a situation where a speaker has produced an ambiguity and the listener has requested clarification. The case is different when the speaker himself voluntarily substitutes a paraphrase realizing that his original utterance might be misinterpreted. With respect to the latter situation the speaker must have computed the alternate interpretation. Even here, however, the speaker would not have to carry out a phonological analysis of the second reading. In either case the procedure is simpler than that called for in disambiguating via intonation.

We have thus accounted for the weakness of intonation as a cue to perception on the basis of factors in production,

i.e. prosodic features are not listened for because they are not usually provided.[1] Experiments which placed intonation and context in direct conflict were interpreted as indicating that hearers do not usually rely on objective intonational cues in processing. Still, the results are consistent with the claim that the given intonation is analyzed but any hypothesis which is determined by the intonation is rejected on the basis of context. While the first account assumes that the prosodic cues are 'heard' in terms of the linguistic context, the second claims that the objective cue determines its subjective interpretation which, if inappropriate to the context, is then discarded and the string reprocessed. Note the similarity between these two accounts and the hypotheses concerning the effects of context on the number of meanings accessed during the comprehension of ambiguities.

In order to decide between these conflicting hypotheses, the nature of on-line processing must be investigated. Reprocessing effects during sentence processing are evinced by longer latencies in tasks initiated before the sentence is completed. In the experiments (click studies and dichotic switching taskes) which show that acoustic cues do not determine segmentation, measures were generally taken on sentence completion. Those sentences which did tap on-line processing did not, however, measure the time taken to respond and thus do not reveal reprocessing effects. The judgment and paraphrase tasks involved in

the present study are similarly initiated after the sentence is completed. Nevertheless a response latency variable was introduced to ascertain whether subjects took more time judging the appropriateness of question-answer pairs in which the context and intonation were mismatched.

A significant response delay was, in fact, found in comparing LB-HB pairs with all other conditions. In the case of HB-LB pairs, on the other hand, though a response delay was revealed when compared with the HB-HB condition,[2] no such delay appeared in comparison with the LB-LB condition. In post-test questioning .90 of the subjects claimed they noted nothing strange about the intonation in which the sentences were read. An analysis of the reaction times of the six subjects who reported noticing the ambiguity did in fact reveal a non-significant correlation with the overall response delay pattern. Nevertheless the differences are due entirely to the fact that this group responded most quickly to LB-LB pairs while taking longest to judge those in the N-LB condition. Neither condition involves a mismatch. The conditions in question, namely LB-HB and HB-LB, do not differ from the overall pattern. In fact LB-HB pairs wre judged faster than HB-HB pairs, and HB-LB pairs faster than N-LB. Moreover the judgment and paraphrase responses of these subjects did correlate significantly with the overall pattern. These observations indicate that 'noticing' acoustic cues does not automatically mean that these cues

will be used to determine segmentation. This was already noted with respect to the long response delays to HB-LB pairs in the case of lexical-category surface structure ambiguities. Anecdotal evidence from the judges who listened to the sentences of the experiment indicate that listeners are able to 'hear' the intonational difference between two versions of an ambiguous sentence without being able to tell which interpretation is intended by which intonation. While Mehler, Bever, and Cary (1967) may be correct in assuming that 'different surface structures are easily noted since they effect differences in the prosodic features of pronunciation', this does not ensure that such strings are aurally unambiguous.

Since intonation effects were found in several of the studies reviewed above these effects must be accounted for. In defining the cognitive approach to psychology, Neisser (1967) notes: 'The central assertion is that seeing, hearing, and remembering are all acts of construction, which may make more or less use of stimulus information depending on circumstances.' Having outlined the conditions under which less reliance is placed on the acoustic features of the stimulus, we will now outline the circumstances under which the effects of intonation seem stronger. If the importance of intonation is reduced in the presence of structural and semantic cues we would predict a greater reliance on acoustic features in situations where the other clues are weakened. This is

precisely what was found in Garrett (reported in Fodor and Bever, 1965) and Bolinger and Gerstman (1957). In the absence of cues provided by sentential contexts, the effects of prosodic features become apparent.

The inverse relationship between contextual and prosodic cues is further supported by evidence from studies of language acquisition. It was noted that children are sensitive to prosodic features of language very early in their linguistic development. As a matter of fact, Braine (1963) has argued that the discrimination of these acoustic properties explains how children learn to correctly segment the utterances they hear. This claim in turn is challenged by evidence (Fodor and Bever, 1965; Garrett, Bever, and Fodor, 1966) that the perception of intonation is generally a function of syntactic knowledge and that the perceptual correlates of intonational phenomena are often lacking in the acoustic signal.[3] Thus it appears that syntactic knowledge is prerequisite to the perception of some aspects of intonation. Hornby (1973), on the other hand, has demonstrated a developmental shift from intonation to syntax in the comprehension of presupposition. Though there is as yet no evidence that this change represents a general shift from intonation to syntactic structure, it is not unlikely that increased knowledge of syntactic structure is directly responsible for the decreased sensitivity to prosodic features.

Several studies mentioned above (p. 75) revealed the

facilitating effects of intonation. Multiply embedded sentences whose relative pronouns were deleted were recalled faster and more correctly when intonated (Fodor and Garrett, 1968). Similar results were shown in a recall task with nonsense syllables (O'Connor et al., 1968). Evidence that pauses can induce structure in nonsense syllables is provided by Braine (1963). Wingfield and Klein (1971) found a sensitivity to acoustic pauses in an experiment in which the stimulus sentence was switched from one ear to the other in the course of presentation. Finally, Zurif (1974) reported that pauses attracted clicks in a dichotic listening task. These results appear to contradict the claim that intonational cues play a minor role in speech perception.

It must be noted however that the tasks with nonsense syllables and center-embedded sentences contrasted normally-intonated sentences with others read in a monotone. The facilitating effects of intonation in these studies can be attributed to the linguistic status that normal intonation contours assign to utterances, thereby aiding processing. These results thus do not challenge those of the present study, which investigates the perception of subtle differences in intonation. Furthermore all of these experiments involve tasks which impose an increased cognitive load on perceptual processes. Thus is appears that intonation has an effect primarily when using material (e.g. center-embedding and nonsense syllables) or tasks

(dichotic listening and monaural switching) which severely tax the listener's capacity.

Psycholinguistic studies of ambiguous sentences indicate that ambiguity increases the burden placed on the processing mechanisms. These results obtain whether or not the subject reports having noticed that an ambiguity is present. This again seems to suggest that prosodic features would be effective cues in disambiguating surface structure ambiguities, where intonation can be manipulated. The present experiment indicated that the situation is not quite that straightforward. Posttest questioning revealed that the majority of subjects had in fact noticed that some of the sentences were ambiguous. Nevertheless, subjects did not take full advantage of intonational cues, depending instead on the external context and their knowledge of English structure. In the absence of external context, e.g. in the condition where a neutral-context question is paired with a low-bias intonation, prosodic cues have some effect in determining the interpretation. However, even in this condition the effect is a weak one. Out of a possible score of six, the average number of low-bias readings in the N-LB condition is only 2.12. The internal context, i.e. bias provided by the ambiguous sentence itself, is sufficient for listeners to make use of their linguistic knowledge and arrive at an interpretation. Thus it seems that an ambiguous sentence per se does not increase the cognitive load to a degree sufficient

that intonation effects become apparent.

Having established that intonation effects vary with the specific task, we might consider the possibility that the effectiveness of intonation is furthermore materials-dependent, i.e. varies with the particular type of utterance. Of interest here is the possibility that some types of surface structure ambiguities are disambiguated by intonational cues to a greater extent than other types. The present experiment included three syntactic sub-groups of surface structure ambiguity: lexical category, progressive modifier scope, regressive modifier scope, and one semantic sub-group: semantic overlap. The results of the rank-order correlation indicated that the relative effects of bias, context, and intonation are similar with respect to all these sub-types. Nevertheless, in order to assess the absolute effects of intonation the number of HB responses in the N-HB and N-LB conditions were compared. The influence of intonation is evinced by a greater number of HB responses in N-HB compared with N-LB pairs. A by-type analysis of the number of HB responses using this N-HB > N-LB criterion reveals that this is the case in .92 of the sentences in the regressive modifier scope class and .83 of the lexical category class. However, in .50 of the progressive modifier scope sentences the number of HB readings in the N-LB condition is equal to or greater than the number of HB readings in the N-HB condition. (Four of these sentences are also cases of

semantic overlap.) This analysis suggests that intonation is least effective with surface structure ambiguities of the progressive modifier scope type.

In addition to increasing cognitive load (or perhaps because of it) the tasks which revealed intonation effects are somewhat unnatural when compared with the processing of actual speech. The present experimental design was closer to the normal speech situation. The stimuli were presented binaurally in question-answer form; questions were asked by one speaker and answered by another. The judgment and paraphrase tasks were not unnatural. Under these circumstances intonation appeared as a relatively weak cue. The diverse results indicate once more that the effects of intonation are task dependent.

The effects of intonation were revealed in yet another study. Scholes (1971) conducted a series of experiments to determine whether speakers provide acoustic signals for constituent structure. Throughout the series, listeners were presented with excised sentence fragments and were essentially asked to locate syntactic boundaries. In many of the tasks, subjects <u>were</u> able to detect constituent structure.[4] Not only were listeners deprived of the cues provided by the sentential context but they were specifically listening for prosodic signals. Moreover subjects were provided with written versions of the sentences before the experiment and were alerted as to the different grammatical structures involved. Finally,

though the stimuli were randomized the subjects were exposed to both readings of each fragment in the course of the experiment. It would be most surprising if no intonation effects were revealed in such a task.

Surprisingly, directing the subject's attention to the intonation does not strengthen the effects of intonation to as great an extent as eliminating the surrounding sentential context. Evidence for this is provided by Pretest II of the present study. In the course of preparing two acceptable intonated versions for each of the 36 experimental sentences, a total of 409 recordings were made. Of these only 179 were correctly identified by all four of the judges (an interpretation was considered correct when it corresponded to the one intended by the speaker). In each case, the judges were aware of the ambiguity involved and were consciously attending to the intonation. Nevertheless .56 of the pretest sentences were not interpreted as intended (i.e. the other meaning was perceived) by at least one of the judges. In fact in .02 of the recordings (10 sentences) the experimenter could not tell which recording she herself had intended. Since the pretest judges and Scholes' subjects were both attending to the intonation, the diverse results are probably due to the fact that the ambiguities in this study were pretested in full sentences. Apparently the other cues provided by the structure of the sentence attenuated the effects of prosody.

We have thus seen that neither listening for prosodic cues nor independently noticing them (see p. 108) ensures that the listener will come up with the meaning intended by the speaker. It has, however, been suggested (Bever, personal communication) that speakers employ idiosyncratic mechanisms in disambiguating ambiguous sentences so that being familiar with a speaker's idiolect helps the listener make use of intonational cues.[5] This hypothesis can be tested by presenting ambiguities to two groups of subjects which differ with respect to whether they are prefamiliarized with the idiolect of the speaker. Though this variable was not manipulated in the present experiment, seven of the subjects were familiar with the speech of the experimenter.[6] An analysis of the results of these subjects revealed a significant correlation with the overall results in all three dependent variables. This does not, of course, constitute substantial evidence against the above hypothesis. This observation, however, is strengthened by an experiment (Scholes, 1971) in which the same five subjects read the stimulus sentences and judged the location of the major syntactic boundary in an excised portion. It was assumed that if speakers choose different acoustic parameters as disjuncture cues, a given subject should be more accurate in locating the boundaries in his own readings than in the readings of others. Scholes found, however, that listeners did not do significantly better in identifying the original sentence when the stimulus was

their own voice (.88 correct) than when it was not (.85 correct). Furthermore, listeners did not show greater consistency for their own readings when judging the same stimulus on different trials. Finally listeners did not assign higher confidence ratings for their own voices than for others. Scholes maintains that 'it does not appear that there is any sort of consistent and identifiably individual selection of acoustic cues for disjuncture.'

Nevertheless, there is evidence that intonation effects are a function of the particular speaker. In his experiment to ascertain the effects of noise on the production of disjuncture cues, Scholes (1971) had the stimulus sentences recorded by ten speakers. Though the particular listeners serving as subjects did not effect the results, their ability to identify syntactic boundaries varied significantly with the particular speaker. Similarly the group as a whole displayed higher confidence ratings for certain readers than for others. Scholes concludes that 'speakers differ to a significant degree in their tendencies to mark phrase boundaries with disjunctures'. Once again, spectrographic evidence is necessary to substantiate this claim. Though it seems plausible we cannot simply assume that the relationship between the subjective percept and the objective cue is a simple one. Given the results, we can only conclude that speakers differ in the extent to which they affect the listener's perception. It is an open question whether

this is due to their using different techniques (speaker A uses disjuncture, speaker B prefers pitch differences) or because they differ in manipulative expertise.

The finding that intonational cues do not necessarily determine the comprehension of surface structure ambiguities has practical implications for experimental studies. Psycholinguists hesitate to present ambiguous stimuli aurally for fear that they may thereby influence the listener's perception. As a result, researchers have either excluded this type of ambiguity from their studies or resorted to written presentation of their materials. Experimenters who do present surface structure ambiguities aurally go to great lengths to maintain a 'flat intonation' in reading the sentence. The results of this study imply that these measures are to a large extent unnecessary; spoken surface structure ambiguities are still ambiguous. Note that the mean number of HB responses in the N-HB condition (.85) is practically identical to the overall number of HB responses on the written pretest (.84).

Similarly these results indicate that experimental effects must not be too easily attributed to intonation. In their picture verification task Foss, Bever, and Silver (1968) noted a discrepancy in the preferred interpretation of one ambiguous sentence. In posttest questioning, .90 of the subjects claimed that they had expected the reading which was classified as unexpected on the basis of the pretest. As it turned out, this

sentence was a surface structure ambiguity. Foss et al. explain the discrepancy quite simply:

> This was not surprising since these ambiguous sentences are very sensitive to slight intonational changes and recording the sentences in a 'flat' voice does not eliminate all such cues. Apparently the intonation for this sentence was slightly changed from the pretest since 18 of the 20 Ss who heard the sentence reported that they had expected the version which was classfied unexpected on the basis of the pretest. (p.305)

The results of the present experiment do not imply that intonational cues are never objectively perceived. Hence Foss et al.'s explanation is by no means ruled out a priori. The present study does suggest, however, that 'slight' intonational changes are unlikely to affect perception so drastically. Consideration of the specific conditions under which the two instances of the sentence were presented may reveal alternate explanations for the differing bias judgments. In light of the present study, any claim attributing a reversal of bias judgments to intonation effects requires independent empirical substantiation.

Whereas this is not the case with respect to the influence of intonation, the results of the present experiment clearly demonstrate the effects of context on the processing of surface structure ambiguities; the same intonation pattern was perceived differently depending on the preceding question. Sentences read with low-bias intonation received .80 high-bias readings when following high-bias contexts but only .36 such readings when following low-bias contexts. Though the effects are not as

pronounced in the case of high-bias intonation sentences, significant differences are still obtained: high-bias intonation sentences received .93 high-bias interpretations when preceded by a high-bias context but .64 such interpretations when preceded by a low-bias context.

These effects are all the more convincing in view of the nature of the experimental task. Recall that subjects were alerted to the fact that the answer sentence could be an inappropriate response, i.e. they were aware that some of the context questions would not serve as effective cues. This differs from the normal speech situation where listeners seldom doubt the appropriateness of the context. However, despite the possibility that the provided context would be useless, subjects still relied on contextual cues. These results underscore the listener's recognition of the communicative function of language.

Nevertheless, the interpretations assigned to the surface structure ambiguities cannot be accounted for solely in terms of context. Were this the case we would expect 1.00 high-bias readings for sentences heard in HB-HB and HB-LB conditions, and no such readings in the LB-LB and LB-HB conditions. The fact that .36 of the responses in the LB-LB condition were high-bias interpretations, despite the low-bias context and low-bias intonation, clearly indicates the role of bias, reflecting processing strategies independent of context and intonation, in the perception of ambiguous sentences. The effects

of an opposing context can, however, attenuate those of bias. This is evident from a comparison of LB-LB and N-LB conditions. In the absence of external context, sentences read with low-bias intonation (N-LB condition) were assigned .65 high-bias readings. This number is surprisingly high[7] in view of the expectation that more attention would be paid to intonation in situations where contextual cues are not provided.

It would therefore be an error to ignore bias in assessing the effects of acoustic cues. Scholes (1971) had five speakers read sentences (5.1) and (5.2) several times.

(5.1) The good flies quickly past.

(5.2) The good flies quickly passed.

The recordings were then randomized and played to the same group, who were asked to locate the major syntactic break. His results are presented in Table 5.1

	good ↑ flies	flies ↑ quickly
(5.1)	64%	36%
(5.2)	10%	90%

Table 5.1 Interpretations assigned to sentences (5.1) and (5.2).

Though the overall effect of intonation was significant, Scholes offers no explanation for the fact that intonation was a stronger cue in the case of sentence (5.2). Though

no actual bias values are available for this phonetic string it would seem that the interpretation represented by sentence (5.2) would be the preferred one. Thus the stronger intonation effect in (5.2) can be attributed to the independent effect of interpretive bias.

The surface structure ambiguities in the present experiment were highly biased ($\bar{X}$=.84) toward one particular reading. It may be argued that the results obtained with these sentences cannot automatically be extended to cases in which neither interpretation is more likely, i.e. it may be the case that intonation determines the meaning in unbiased surface structure ambiguities. However it should be remembered that bias values represent the preferred interpretation of a sample of speakers. Sentences are seldom unbiased with respect to the individual speaker. Thus these results can be interpreted with respect to surface structure ambiguities in general: the meaning assigned to a surface structure ambiguity is to a large extent determined by internal context (i.e. bias) rather than by acoustic cues to segmentation. This study thus presents independent experimental evidence for the constructive character of speech perception, establishing that sentence comprehension is, in Wanner's terms, an 'inside-out' process.

NOTES TO CHAPTER 5

1
Note that the opposite account is equally plausible, i.e. prosodic features are not provided by the speaker since listeners seldom rely on them.

2
These reaction time data might serve to disconfirm one of the two possible hypotheses concerning the effects of context on the perception of intonation. If intonational cues are subjectively perceived in terms of the context (rather than objectively perceived and then reprocessed) we should expect no reaction time difference between HB-HB and HB-LB pairs.

3
It would be interesting to see whether intonational features are manipulated to a greater extent when speaking to young children. Even if this were found to be the case it could not completely account for this early sensitivity to intonation since much of the speech to which children are exposed is not directed specifically to them.

4
Scholes found that disjuncture was generally a stronger clue in complex sentences where the boundary occurs between clauses than in simple sentences where it occurs between the noun phrase and verb phrase.

5
Actually this suggestion was made for deep structure ambiguities despite the fact that it is generally assumed that these ambiguities cannot be disambiguated by intonation.

6
These observations may not constitute counter-evidence to Bever's proposal. Perhaps the subjects were not sufficiently exposed to the experimenter's voice to achieve 'familiarity'. Furthermore,it may not be the case that the speaker is most sensitive to his own disambiguating cues, i.e.. he may not be the one most 'familiar' with his own speech.

7
Note that the average number of HB readings in the N-HB condition is only .85.

APPENDIX A

Experimental surface structure ambiguities, with pretest bias values for each meaning. Context questions appropriate to high bias (HB) interpretation, low bias (LB) interpretation, and neutral (N) question appropriate to both interpretations.

1. That handsome man's shirt cost $38.
   .88 handsome man
   .12 handsome shirt

   (HB) How much did that good-looking guy pay for his shirt?

   (LB) What was the price of that shirt in the window?

   (N) What did you say cost $38.

2. Susan told her baby stories.
   .78 stories to her baby
   .22 baby stories to her

   (HB) How did Susan entertain her little boy?

   (LB) What kind of stories did Susan tell her?

   (N) What did Susan do?

3. The government decided to crack down on big building owners.
   .76 owners of large buildings
   .24 wealthy building owners

   (HB) Why are the men who own the skyscrapers so worried?

   (LB) Why are the rich landlords so worried?

   (N) What action is the government going to take?

4. They sent the requisition over a week ago.
   .85 more than
   .15 sent over

   (HB) Have we had that requisition for less than or more than a week?

   (LB) What did they do with the requisition seven days ago?

   (N) What did his secretary say?

5. Alan painted the picture in the hall.
   .86 the picture hanging in the hall
   .14 place where he painted the picture

   (HB) Which painting did Alan do?

   (LB) Where did Alan work on his picture?

   (N) And what about Alan?

6. The man is looking for stray dogs and cats.
   1.0 stray dogs and stray cats
   0. stray dogs and all cats

   (HB) Why did he ask if we'd seen any lost animals?

   (LB) Is he looking for anything besides cats?

   (N) What is he looking for?

7. The boss dismissed the salesman with enthusiasm.
   .85 dismissed enthusiastically
   .15 enthusiastic salesman

   (HB) How did the boss treat the lazy salesman?

   (LB) Which salesman did the boss fire?

   (N) What happened while I was out?

8. Jane had worn old tennis shoes.
   .79 Jane wore
   .21 Jane possessed

   (HB) What had Jane done to ruin her feet?

   (LB) What did Jane keep in her suitcase?

   (N) What was that you said about Jane?

9. Could this be the invisible man's hair tonic?
   .71 tonic beloning to the invisible man
   .29 invisible hair tonic for men

   (HB) Where does he keep his hair tonic, or has that vanished too?

   (LB) Where can I find that hair tonic with the new vanishing formula?

   (N) What's that?

10. I just wanted to know how old Fred was.
    .94 his age
    .06 how he was

    (HB) Why did you ask for his date of birth?

    (LB) Why did you call the hospital?

    (N) Haven't you learned to mind your own business?

11. Paul read the letter to his mother.
    .89 read aloud to his mother
    .11 letter sent to his mother

    (HB) How did his mother know what was in the letter?

    (LB) Whose letter did Paul read, while pretending to watch the game?

    (N) What happened when he found it?

12. He told me to give more realistic details.
    .72 details that are more realistic
    .28 additional realistic details

    (HB) He felt that your story wasn't convincing?

    (LB) Does he want you to elaborate on the realism or the fantasy?

    (N) What did he tell you?

13. It is the beginning of a speech which is most important.
    .82 the beginning is always important
    .18 this is a most important speech

    (HB) What's more important--an impressive beginning, or a dynamic ending?

    (LB) That phrase--what speech is it from?

    (N) What do <u>you</u> think?

14. Barbara looked up the street.
    .82 gazed up the street
    .18 consulted her phone book

    (HB) How did Barbara notice that her car was missing?

(LB) What did Barbara do with the phone book?

(N) What did Barbara do then?

15. Young widows and orphans are eligible for the new benefits.
.79 young widows and all orphans
.21 young widows and young orphans

(HB) Do these benefits apply to anyone other than orphans?

(LB) What about those under 18?

(N) Who is eligible for the new benefits?

16. Joe fried the potatoes in the pan.
.92 place where he fried them
.08 the potatoes that were in the pan

(HB) Where did he fry the potatoes?

(LB) Which potatoes did he fry?

(N) How did Joe help?

17. The president of the university's finance committee submitted the recommendation.
.82 president of the finance committee
.18 committee of the president of the university

(HB) Which member of the finance committee submitted the recommendation?

(LB) Which committee appointed by the president submitted the recommendation?

(N) Who submitted the recommendation?

18. The hostess greeted the girl with a smile.
.93 smiling hostell
.07 smiling girl

(HB) How did the hostess greet her guest?

(LB) Which girl did the hostess greet?

(N) What did the hostess do?

19. They are lecturing doctors.
.71 doctors who lecture
.29 they lecture to doctors

(HB) Why are the M.D.'s taking a course in public speaking?

(LB) Which professional group are they addressing now?

(N) And what about <u>them</u>?

20. Our fifth grade advisor just resigned.
.98 advisor to the fifth grade
.05 the fifth one resigned

(HB) Why do you need an advisor for grade five?

(LB) How many advisors have you managed to scare off?

(N) Who just resigned?

21. The carpenter looked over the fence.
.72 looked beyond the fence
.28 inspected the fence

(HB) How did he know that we were in the garden?

(LB) Aside from the wooden bench, did he examine anything else?

(N) What did the carpenter do?

22. John said he was coming today.
.88 coming today
.12 said today

(HB) When is John coming?

(LB) When did John announce his plans?

(N) Any news from John?

23. Ruth fed her dog biscuits.
.97 biscuits to her dog
.03 dog biscuits to her

(HB) Who'd she feed biscuits to?

(LB) What did Ruth feed her baby sister?

(N) What did Ruth do?

24. We decided to keep the little dog in the box.
.87 have him stay in the box
.13 keep the one that is in the box

(HB) Where are you keeping him?

(LB) Which dog did you finally decide on?

(N) What did you decide?

25. They evacuated the old men and women.
.85 old men and old women
.15 old men and all the women

(HB) What happened to the elderly people?

(LB) Did they evacuate only women?

(N) How did they handle the crisis?

26. You know how great symphonies sound.
.79 all symphonies sound great
.21 the sound of great symphonies

(HB) Why are you taping these symphonies if no one's ever heard of them?

(LB) How do Beethoven's sympthonies sound?

(N) <u>What</u> did you say?

27. Our conversation was interrupted by a loud visitor's knock.
.85 loud knock of a visitor
.15 knock of a loud visitor

(HB) What kind of knock interrupted your conversation?

(LB) Whose knock interrupted your conversation?

(N) What interrupted your conversation?

28. They are visiting sailors.
.71 sailors who visit
.29 they visit sailors

(HB) These sailors aren't stationed here, are they?

(LB) Why are these sailors here?

(N) Why are they here?

29. She told me to go without hesitating.
.73 go without hesitating
.27 told me without hesitating

(HB) What were her instructions?

(LB) Did she falter when she told you to go?

(N) What just happened?

30. England had raised tariffs this year.
.97 England raised tariffs
.03 England suffered high tarrifs

(HB) What had England done to discourage foreign imports?

(LB) What did the English suffer from this year?

(N) What does the report say?

31. They talked about the problem with the mathematician.
.94 consulted the mathematician
.06 they have a problem with the mathematician

(HB) Who did they discuss the problem with?

(LB) Which incompetent faculty member was reviewed at the meeting?

(N) What took them so long?

32. Connie hates fat girls and boys.
.90 fat girls and fat boys
.10 fat girls and all boys

(HB) How does Connie feel about fat kids?

(LB) Is it just boys that she can't stand?

(N) Who does Connie hate?

33. He asked me to leave at five o'clock.
.85 leave at five
.15 asked me at five

(HB) Weren't you supposed to leave at four?

(LB) When were you thrown out of class?

(N) What happened?

34. The seamstress stitched on the labels.
.96 she sewed them on
.04 she stitched on top of them

(HB) How do you know what size it is?

(LB) Where did the seamstress practice her embroidery?

(N) What did the seamstress do?

35. They kidnapped the old coin collector.
.80 aged coin collector
.20 collector of old coins

(HB) What ever happened to the old man?

(LB) What ever happened to the boy who collects antique currency?

(N) Any new kidnappings lately?

36. The repairman fixed the television set in the living room.
.73 the set that is in the living room
.27 place where he fixed it

(HB) Which T.V. did he fix?

(LB) Where did he fix the T.V.?

(N) What did the repairman do?

APPENDIX B

Typological Classification of Experimental Sentences

I. Lexical Category

1. Susan told her baby stories.
2. They sent the requisition over a week ago.
3. Jane had worn old tennis shoes.
4. I just wanted to know how old Fred was.
5. Barbara looked up the street.
6. They are lecturing doctors.
7. The carpenter looked over the fence.
8. Ruth fed her dog biscuits.
9. You know how great symphonies sound.
10. They are visiting sailors.
11. England had raised tariffs this year.
12. The seamstress stitched on the labels.

II. Progressive Modifier Scope

1. That handsome man's shirt cost $38.
2. The government decided to crack down on big building owners.
3. The man is looking for stray dogs and cats.
4. Could this be the invisible man's hair tonic?
5. He told me to give more realistic details.
6. Young widows and orphans are eligible for the new benefits.
7. The president of the university's finance committee submitted the recommendation.
8. Our fifth grade advisor just resigned.
9. They evacuated the old men and women.
10. Our conversation was interrupted by a loud visitor's knock.
11. Connie hates fat girls and boys.
12. They kidnapped the old coin collector.

III. Regressive Modifier Scope

1. Alan painted the picture in the hall.
2. The boss dismissed the salesman with enthusiasm.
3. Paul read the letter to his mother.
4. It is the beginning of a speech which is most important.
5. Joe fried the potatoes in the pan.
6. The hostess greeted the girl with a smile.
7. John said he was coming today.
8. We decided to keep the little dog in the box.
9. She told me to go without hesitating.
10. They talked about the problem with the mathematician.
11. He asked me to leave at five o'clock.
12. The repairman fixed the television set in the living room.

IV. Semantic Overlap

1. The man is looking for stray dogs and cats.
2. Jane had worn old tennis shoes.
3. Could this be the invisible man's hair tonic?
4. Young widows and orphans are eligible for the new benefits.
5. Joe fried the potatoes in the pan.
6. They evacuated the old men and women.
7. You know how great symphonies sound.
8. Our conversation was interrupted by a loud visitor's knock.
9. Connie hates fat girls and boys.

APPENDIX C

PRETEST INSTRUCTIONS

This is a psycholinguistic experiment that investigates sentence comprehension. In each case you will hear a question followed by a response. Your first task is to decide whether the response given is an appropriate answer to the question. If you think the answer is appropriate push the 'yes' button; if you think it is not appropriate, push the 'no' button. Your responses are being timed so make your decision as fast as possible. However, accuracy is of equal imporatnce. Do not sacrifice accuracy for speed, that is do not push the button until you're sure but push it as soon as possible. Also, wait until the answer is completed before pushing the button. Your initial decision is recorded; once you've pressed a button you cannot change your mind.

After pushing a button, your second task is to paraphrase the answer in each question-answer pair, that is write down another sentence that means the same thing as the answer you heard. This is an important task so listen to the answer carefully. Remember that your task is to paraphrase the answer sentence even if it is not an appropriate response to the question. You are not being timed on your paraphrases but do them as fast as possible as we are short on time. Remember, do not start paraphrasing before pushing a button to indicate appropriateness of the answer.

The tape recorder will be stopped after each question-answer pair. After you've finished your paraphrase push the 'yes'/'no' button and the tape will be started for the next question-answer pair.

So to repeat: when the answer is completed make an accurate decision as to whether it is an appropriate one and push the button as fast as possible. Then write the answer sentence in your own words. When you're ready for the next pair push the 'yes'/'no' button.

We'll first have four practice question-anser pairs so that you can familiarize yourself with the task.

APPENDIX D

Posttest Instructions

You may have noticed that some of the answer sentences were ambiguous, that is, could have been understood in more than one way.

Your final task is to compare your paraphrase, or the meaning you got when you heard the sentence, with the two possible interpretations. Then choose the one phrase in each pair which corresponds to the way you understood the sentence circling either (a) or (b). Please read the alternatives carefully. There are no right or wrong answers in interpreting these sentences. Both are possible interpretations; we just want to know which came to mind first when you heard the sentence. I can help you with this task so feel free to ask any questions.

APPENDIX E

Sample Posttest Answer Sheet

Subject # _____ Set _____ Date _____ Time _____

THE SENTENCE REFERRED TO ...

1) a. a handsome man
   b. a handsome shirt for a man

3) a. stories told to her baby
   b. baby stories told to her

5) a. wealthy building owners
   b. owners of large buildings

6) a. sending over a requisition a week ago
   b. sending a requisition more than a week ago

8) a. a picture that is hanging in the hall
   b. a picture that was painted in the hall

9) a. stray dogs and stray cats
   b. stray dogs and all cats

11) a. an enthusiastic salesman
    b. a salesman who was dismissed enthusiastically

13) a. wearing old tennis shoes
    b. having tennis shoes that are worn and old

14) a. a man's hair tonic that is invisible
    b. hair tonic belonging to an invisible man

16) a. concern about Old Fred
    b. Fred's age

18) a. a letter that Paul read aloud to his mother
    b. a letter sent to Paul's mother

20) a. a request for details that are more realistic
    b. a request for additional realistic details

21) a. an important speech
    b. the fact that beginnings are important

23) a. consulting a phone book (etc.) for an address
    b. gazing up a street

24) a. young widows and all orphans
b. young widows and young orphans

26) a. frying those potatoes that were in the pan
b. using a pan to fry potatoes in

28) a. the finance committee of a President of a University
b. the president of a finance committee

29) a. a smiling hostess
b. a smiling girl

31) a. giving lectures to doctors
b. doctors who give lectures

33) a. the advisor of the fifth grade
b. the fifth advisor

35) a. gazing beyond a fence
b. inspecting a fence

36) a. saying today that he'd come
b. coming today

38) a. feeding biscuits to her dog
b. feeding dog biscuits to her

39) a. keeping the dog that was in the box
b. having the dog stay in a box

41) a. old men and old women
b. old men and all women

43) a. the fact that symphonies all sound so great
b. the sound of great symphonies

44) a. a loud visitor
b. a loud knock

46) a. sailors who visit
b. making visits to sailors, i.e. visiting the sailors

48) a. going without hesitation
b. telling without hesitation

50) a. suffering raised (i.e. high) tariffs
b. raising tariffs

51) a. consulting a mathematician
b. having a problem with a mathematician

53) a. fat girls and all boys
b. fat girls and fat boys

54) a. asking me at five o'clock
b. leaving at five o'clock

56) a. sewing labels on
b. sewing on top of labels

58) a. a collector of old coins
b. an old person who collects coins

59) a. the place where the T.V. was fixed
b. fixing the T.V. that is in the living room

APPENDIX F

Summary of Analysis of Variance for Appropriateness Judgments

Source	df	Sum of Squares	Mean Squares	F-Ratios
Total	359	571.602	1.592	
Subjects	59	100.602	1.705	
Groups (G)	5	24.368	4.874	3.4523*
Intonation (I)	1	16.902	16.902	25.9531*
Context (C)	2	176.468	88.234	134.2783*
I X G	5	7.598	1.520	2.3335
C X G	10	22.565	2.257	3.4341*
I X C	2	43.398	21.699	28.1560*
I X C X G	10	14.702	1.470	1.9076

*p .01

APPENDIX G

Summary of Analysis of Variance for Response Latencies

Source	df	Sum of Squares	Mean Squares	F-Ratios
Total	359	193.916	.540	
Subjects	59	130.408	2.210	
Groups (G)	5	12.932	2.586	1.1889
Intonation (I)	1	.004	.004	.0436
Context (C)	2	6.285	3.143	17.9821*
I X G	5	.638	.128	1.4236
C X G	10	7.975	.797	4.5631*
I X C	2	1.699	.850	5.6083*
I X C X G	10	6.826	.683	4.5059*

*p .01

APPENDIX H

Summary of Analysis of Variance for High Bias Responses

Source	df	Sum of Squares	Mean Squares	F-Ratios
Total	359	921.668	2.567	
Subjects	59	64.501	1.093	
Groups (G)	5	3.485	.697	.6168
Intonation (I)	1	133.229	133.229	105.0529*
Context (C)	2	302.160	151.080	110.3717*
I X G	5	10.788	2.158	1.7012
C X G	10	22.674	2.267	1.6564*
I X C	2	14.063	7.031	6.7701*
I X C X G	10	45.771	4.577	4.4070*

*p .01

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