



I L L I N O I S

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

-

PRODUCTION NOTE

University of Illinois at
Urbana-Champaign Library
Large-scale Digitization Project, 2007.

370, 152

T2261

**T
E
C
H
N
I
C
A
L**
**R
E
P
O
R
T
S**

Technical Report No. 33

SYNTACTIC ASPECTS OF
READING COMPREHENSION

A. W. F. Huggins

Bolt Beranek and Newman Inc.

April 1977

Center for the Study of Reading

THE LIBRARY OF

OCT 7 1981

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN
1005 West Nevada Street
Urbana, Illinois 61801

BOLT BERANEK AND NEWMAN INC.
50 Moulton Street
Cambridge, Massachusetts 02138

CENTER FOR THE STUDY OF READING

Technical Report No. 33

SYNTACTIC ASPECTS OF
READING COMPREHENSION

A. W. F. Huggins

Bolt Beranek and Newman Inc.

April 1977

University of Illinois
at Urbana-Champaign
1005 West Nevada Street
Urbana, Illinois 61801

BBN Report No. 3581

Bolt Beranek and Newman Inc.
50 Moulton Street
Cambridge, Massachusetts 02138

This report was prepared under Contract No. MS-NIE-C-400-76-0116 from the National Institute of Education, and will appear in R. J. Spiro, B. C. Bruce, and W. F. Brewer (Eds.), Theoretical Issues in Reading Comprehension, to be published by Lawrence Erlbaum Associates. I thank Dr. Marilyn Jager Adams for substantial help with both the content and the form of the manuscript.

ABSTRACT

For the last twenty years, psycholinguists have been trying to account for the differences in psychological complexity associated with different syntactic constructions. Neither readability formulas nor surface structure measures are adequate descriptors of complexity for single sentences. According to current theories, extraction of meaning depends on recovering the simple propositions that underlie each clause in the message. How easily a perceiver recovers this information depends critically on his processing capabilities.

In this view, syntax is a tool for adjusting the complexity and compactness of a message to achieve the best balance between economy and clarity, taking into account the level of competence and processing ability of the perceiver. This argument leads to an emphasis on the pragmatics of syntax, and such questions as:

- 1) what are the uses of the various syntactic constructions?
- 2) would children become syntactically competent more easily if these uses were formalized, and taught explicitly?

At the same time, the research reviewed constantly points up the importance of meaning, and its interaction with syntax.

Introduction

"To read, in effect is to translate the writing into speech" (Egger, 1881, quoted in Kleiman, 1975).

The idea expressed in the foregoing quote, together with the premise that children are competent in language by the time they are five years old, apparently underlies much of the research on reading in the last twenty years. Since children know language by the time they are five, the argument goes, all they need to learn, to be able to read, is how to convert the printed words into spoken words. Then they can apply their spoken-language skills. Unfortunately, both premises are false. Written language differs in significant ways from spoken language, and requires of the reader both new skills, and greater sophistication in existing skills, beyond those acquired for speaking. Secondly, although the child of five is impressively competent in spoken language, there is still much to learn before adult competence is acquired.

In this chapter, we will concentrate on the syntactic aspects of competence. The various other skills required for reading comprehension, and the differences between written and spoken language, are addressed in detail in other chapters, but one difference between listening and reading deserves special emphasis here. In spoken language, the intonational pattern of what is said (pitch and timing) contains many clues about which words go

together, and also about the relations between different groups of words. In written language, on the other hand, this information is not given explicitly, except minimally by punctuation. The reader must both recognize the words, and also impose the correct syntactic structure on them. Although we will be concerned only with literal meaning in what follows, the correct extraction of syntactic function is a prerequisite for all comprehension, including inferred and implicated meanings (Grice, 1975).

Children are NOT syntactically competent by the time they are five, although one could be forgiven for drawing that inference from current surveys of language development. These state that most of the syntactic rules used in adult speech can also be found in the speech of five year olds. For example: "normal children ... acquire syntax almost completely at 48 - 60 months" (McNeill, 1970, p.1062); "... 4 or 5 years of age, when the child has succeeded in mastering the exceedingly complex structure of his native language" (Slobin, 1971, p.1). An obvious, but incorrect, inference is that the child should be credited with mastery of a syntactic rule as soon as it begins to appear in his speech.

There are in fact two separate aspects of syntax a child must acquire. First, he must learn how to combine single words to form larger syntactic units, such as a noun (phrase) and a verb (phrase) to make a sentence, or later a determiner, an (optional) adjective, and a noun to make a noun phrase. Then he must learn

simple syntactic rules, such as those used to produce the passive or the negative, which modify the order of the constituents, or introduce auxiliary verbs or function words where necessary. Later still, he must learn how to combine single rules to produce complex sentences. For example, consider the three sentences:

My son has a teacher.

The teacher has a dog.

The dog has fleas.

The first two sentences can be combined, by using different sets of rules, to yield several different sentences with a common (literal) meaning:

My son's teacher has a dog. (Possessive)

The teacher of my son has a dog. (Prepositional)

The teacher that my son has, has a dog. (Relative)

The teacher my son has has a dog. (Reduced relative)

All of the foregoing are fairly acceptable, and would be more so if each of the original sentences had a different verb. When both the second and third of the simple sentences must be embedded in the first, some restrictions begin to apply on how the rules can be combined. Failure to observe these restrictions can produce unacceptable complex sentences (marked * below):

my son's teacher's dog has fleas.

The dog of my son's teacher has fleas.

The dog that my son's teacher has has fleas.

The dog of the teacher of my son has fleas.

? The dog that the teacher of my son has has fleas.

* The teacher-of-my-son's dog has fleas.

* The teacher-that-my-son-has's dog has fleas.

* The dog of the teacher that my son has has fleas.

* The dog that the teacher (that my son has) has has fleas.

* The dog the teacher my son has has fleas.

It is interesting that the first two starred items, with the hyphenated possessives, are in fact found in children's speech. The point to be made is the following: The study of language acquisition does not stop when a child can produce single words in isolation. Rather, it becomes more interesting as single words begin to be combined into larger units. In the same way, the study of syntax acquisition should not stop with the appearance of single transformations. Describing the child as syntactically competent, when he starts to use each of the adult transformations one at a time, is rather like describing someone who has just learned the moves of chess as a competent player. Furthermore, there is reason to question even the assertion that most of the transformations found in adult speech can be found in the speech of a 5-year old (see Palermo & Molfese, 1972).

Generative Grammar

In the remainder of this chapter, we will repeatedly refer to transformational or generative grammar. Therefore, before proceeding further, we will briefly summarize this theory, to put the arguments that follow in proper perspective.

First, transformational grammar is a linguistic theory, not a psychological theory. A grammar is a formal device for distinguishing all the grammatical sentences in a language from all other ungrammatical strings of words. Since only a small proportion of real utterances are in fact fully grammatical, this legitimizes the study of idealized abstract forms, corresponding to what a speaker "knows to be correct" as opposed to what he actually produces. The grammar is a device for relating certain sound patterns to certain meanings, and its purpose is to explain the native speaker's knowledge about his language.

A transformational grammar consists of three parts: a semantic or base component, a syntactic component, and a phonological component.

"..the various parts of the base (component) interact to generate initial phrase markers, and the transformational component converts an initial phrase marker, step by step, into a phonologically represented sentence with its phrase

marker. The latter complex we call a 'surface structure.' The sequence of phrase markers generated in this way we call a 'transformational derivation.'" (Chomsky, 1976, p. 81).

The phonological component, which will not concern us further here, makes explicit what speakers know about the sound patterns of their language. The phonological component consists of a set of rules (Chomsky and Halle, 1968) that produce a phonetic representation of the sentence, including its stress pattern, by operating on the (abstract) surface structure obtained as output from the syntactic component. In this surface representation, words appear (as they do in the Lexicon) as underlying phonological representations. Phonological rules convert these into phonetic forms. A single phonological form underlies such phonetically different words as: nature / natural, divine / divinity, know / knowledge, resign / resignation, and telegraph / telegraphy / telegraphic. In English, the written form of a word is very closely related to its underlying phonological representation, with the result that English spelling patterns tend to capture commonality of meaning, rather than commonality of sound. This is one of the strongest arguments against spelling reform, since it suggests that the spelling of English is very nearly ideal (C. Chomsky, 1970).

The initial phrase marker produced by the base component consists of an abstract phrase marker, into which lexical items

from the lexicon are substituted by "lexical transformations." The abstract phrase marker specifies the hierarchical organization of the constituent categories as a tree, or as a labelled bracketing. For example, the structure of the following three sentences:

The bad boy chased a cat.

A hungry tiger ate the lamb.

The rich uncle doubted the story.

(and countless others) is captured in the following abstract phrase marker:

[S [NP [Det] [Adj] [Noun]] [VP [V] [NP [Det] [Noun]]]]

where the letters following each opening parenthesis stand for Sentence, Noun-Phrase, Determiner, Adjective, Noun, Verb-Phrase, and Verb respectively.

In earlier statements of transformational grammar (Chomsky, 1965), initial phrase markers were called "deep structures", and had two important functions. One was to provide a starting point for the transformational derivation. The other followed from the claim that all the information required for semantic interpretation was contained in the deep structure. A major advantage of this separation was its implication that transformations were meaning-preserving, with the result that they

could be analyzed and described without any reference to meaning. These two properties have been dissociated in the most recent accounts of the theory (e.g. Chomsky, 1976), which now claim that all semantic interpretation can be done from a suitably enriched notion of surface structure. These latest developments will not concern us here, since they do not affect the critical importance of correct assignment of syntactic function for semantic interpretation.

The need to consider deep-structure relations in extracting meaning is best illustrated by ambiguous sentences that have a single surface constituent structure, such as:

Visiting relatives can be fun.

which can mean either:

It is fun when WE visit relatives, or

It is fun when relatives visit US.

The difference between the two interpretations arises because in one, relatives is the subject of visit, and in the other it is the object, and this difference is not marked in the surface structure. Many similar examples occur later in the chapter, and we will have more to say later about ambiguity. Whatever the psychological status of deep structure, correct assignment of syntactic function is essential to interpretation, and deep structures provide a convenient way of representing this fact.

Now let us turn to the syntactic component. One of the most convincing demonstrations of the power of transformations is the set of rules Chomsky (1957) outlined for describing English auxiliary verb structure. The rules capture the following generalizations about auxiliaries:

1. The marker for number (singular or plural subject) and for tense (present or past) always operates on the first member of the verb construction. Thus, we have:

He walk <u>s</u>	vs	He walk <u>ed</u> .
He <u>is</u> walking	vs	He <u>was</u> walking.
He <u>has</u> been walking	vs	He <u>had</u> been walking.

2. Any use of be as an auxiliary adds -ing to the main verb, serving to mark the temporary aspect of the verb. Thus we have:

He is walking.
He was walking.
They may be walking.

3. Any use of have as an auxiliary, to mark the perfect mode of the main verb, adds a perfect suffix to the following verb. This appears as -ed for most verbs, but as -en for be and for eat, and a few others. (Such details would be handled by morphophonemic rules in the phonological component.) Thus we have:

He has eaten.

They had walked.

They should have been walking.

4. A modal auxiliary, such as may, will, shall, can, or must, has no effect on the verb following it. Thus we have:

we must walk.

He may be walking.

She could have been walking.

5. The order in which the foregoing items occur is fixed, and can be captured in the following single rule (with optional items parenthesized):

Aux \longrightarrow C[] + (Modal) + (have + en) + (be + en)

where C[] stands for the number and tense marker.

Unfortunately, the foregoing rules, which capture virtually all of the structure of English auxiliary verbs, cannot be expressed in a phrase-structure grammar, since the re-write rules of which they are made up cannot handle discontinuous constituents. Transformations fill precisely this gap: they enormously extend the power of phrase structure rules, by bringing discontinuous constituents within their domain. To return to auxiliary verbs, a single transformation, called the affix transformation, simply permutes the order of each affix + verb it encounters. This converts the underlying string:

John + C[past, sing.] + may + have + en + be + ing + run

into:

John + may-C[past,sing.] + have + be-en + run-ing.

Morphophonemic rules would then convert may-C(past,sing) into the past tense might, be-en into been, and run-ing into running, with the plus signs now being interpreted as word boundaries, to yield the sentence:

John might have been running.

Introducing transformations has allowed the structure of English auxiliary verbs to be captured in two rules, which, moreover, lead on to further generalizations concerning the role of do (as we shall see further below), and to the negative and question constructions. On the other hand, it would take eight phrase structure rules to capture the same structure, and the parallel extensions to do, and to negatives and passives, do not work.

To summarize, transformational grammar both provides economical ("elegant") description, and also allows highly significant generalizations to be made. It is impossible to give an adequate summary of the enormous power of transformational grammar in the space available here. Recent surveys can be found

in Fodor, Bever, and Garrett (1974), Carroll and Bever (1976), or Fromkin (1976); and excellent elementary treatments are given by Cattell (1969), or Dale (1972).

The Pragmatics of Syntax

The analytic approach to syntax developed by linguists has yielded a wealth of insight into language phenomena, but at the same time it has lost sight of a question of fundamental importance. What is syntax for? For the last twenty years or so, linguists have not been very interested in such pragmatic questions, because they were fully occupied by the task of describing the abstract properties of language. Thus, a linguist might answer the question in terms of his abstract interests: syntax is a set of rules for producing an infinite variety of sentences from a limited vocabulary (e.g. Fromkin, 1976); or, syntax is a set of rules for relating abstract deep structure sentoids, which are closely related to meaning, to surface structures, which are more closely related to sound patterns (e.g. Chomsky, 1957, 1965).

The answer we propose below, which might be given by a psychologist, is quite different. We will argue that syntax is a way of maximizing the rate of transfer of meaning from a language producer (a speaker or writer) to a language receiver (a listener or reader), allowing for the limited memory and processing

abilities of the receiver. The receiver's memory is limited in two ways: it has a limited capacity, and its contents decay with the passage of time. Capacity is limited in that only a small number of items of a single type can be held in memory simultaneously (Miller, 1956; Simon, 1974), and any processing that has to be carried out may be competing for the same memory space. Whatever form meaning has in the heads of producer and receiver, the channel of communication between them requires that the message be sequential. If the message is made very thin, for example by using only simple, active, declarative statements, then it also becomes very long and redundant. Many opportunities for economy are missed, such as deleting or simplifying repeated references to a single concept. Messages in this form tax the temporal limitations of the receiver's memory: the sequence is long, and by the time all the concepts that are to be related have been received, the early items may have been lost from working memory. On the other hand, if too many transformations are applied, to yield a very compact, rich message, the computation involved in unravelling it to recover the expressed relationships may cause a processing overload, in which case comprehension fails altogether. Even if the processing does not cause a catastrophic overload, the rate at which new input can be accepted may be much lower than would be possible with a less tightly compacted message. Syntax provides a method of "impedance matching" between the language skills of the producer and receiver. The optimal

syntax for a sentence will depend on the capabilities of the receiver.

The foregoing argument leads to questions about the pragmatic value of syntax. What is a particular syntactic rule needed for? What relationships cannot be expressed -- or can be expressed only very clumsily -- without it? What determines that one syntactic rule is more appropriate than another in a particular context? Although everyone who has tried his hand at writing prose has intuitive answers to these questions, the answers have not been formalized (but see Fraser, 1972, for a useful preliminary attempt). Knowing the answers might make it easier to teach children both to use and to comprehend the combinations of syntactic rules used in adult language.

As an example of a fruitful application of this approach, consider the passive construction. The passive voice seems to be psychologically more difficult than the active. The passive form of a statement takes longer to verify than the active form, even when length is equated (McMahon, 1963; Gough, 1965). Also, children develop competence in the passive much later than in the active voice (Brown & Hanlon, 1970). Observations such as these were used to support early versions of the "derivational theory of complexity." Early generative grammar (Chomsky, 1957; now rather dated) proposed that the passive form of a sentence was derived from the same "kernel", or meaning-structure, as the active form,

but required an additional rule to be applied in its derivation. The extra rule used in deriving the passive form, it was claimed, accounted for the increased psychological difficulty of the passive. Since transformations were supposed not to alter meaning, the active and passive had the same meaning, but the passive was more complex. Why, then, should one ever use the passive, since it apparently adds to complexity without modifying meaning?

Two types of answers can be given. First, consider context. Very little communication takes place in single isolated sentences. In conversations, and in texts, the message usually proceeds by starting with knowledge common to both producer and receiver, and relates new information to this "given" information (e.g. Perfetti & Lesgold, 1976). The first concept presented in a new sentence is usually the "given" information, because then the new information that follows can be fitted in as it arrives. Otherwise the listener would have to store the new information until he found out where it should fit. When the given information of the new sentence is the object of the verb, rather than the subject, then the object rather than the subject should appear at the front of the sentence, if the sentence is to be easily understood. This "topicalization" is achieved by using the passive voice. In such a context, the passive voice is no longer harder or more complex than the active, and children can both

produce passives, and understand them, at a considerably younger age than had formerly been thought (Turner & Rommetveit 1968).

A second reason for using a passive is to avoid having a subject noun phrase widely separated from its verb by a long or complicated modifying phrase, such as a relative. If the sentence is converted into the passive form, the long modifier is placed at the end of the sentence, following the subject, instead of lying between subject and verb. This greatly reduces the memory load on the receiver, because now the subject need not be held in memory, awaiting union with its verb, while the intervening qualifying material is processed. We will return to this example later. The conclusions to be drawn are 1) that although there are some contexts where the active voice is "easier" than the passive, there are others where the reverse is true. Therefore 2) the one-sided evidence that the passive is more complex cannot be used to support the derivational theory of complexity.

SYNTACTIC COMPLEXITY

Readability

What is syntactic complexity? Why are some forms in which a message is expressed more difficult to understand than others, though the message is unchanged? This problem has been a central one in the study of readability. Studies of readability usually

take a set of passages that span a range of difficulty, and then try to find ways of predicting the difficulty from a variety of measures, such as average sentence length, number of subordinate clauses or prepositional phrases, proportion of concrete as opposed to abstract words, etc. Readability measures thus represent statistical rather than structural descriptions of complexity. Unfortunately, correlation does not imply causality, and although passages that are highly readable tend to have short sentences, and few prepositional phrases or clauses per sentence, it does not follow that writing short sentences with few prepositional phrases yields highly readable text. Recently, Bormuth (1966) has derived some new measures that are more related to structure, such as ratios of the frequency of occurrence of various parts-of-speech, such as the number of pronouns per verb, or the number of verbs per conjunction. But these measures too are statistical, and can hardly be used to predict the difficulty of a single sentence. Thus, although sentence length correlates with syntactic complexity, it cannot be used to explain it.

Surface Structure

A second approach to syntactic complexity grew out of work on how people memorize sentences. Even before the advent of generative grammar, psychologists had been interested in how subjects "chunk" materials they are asked to remember (e.g.

Miller, 1956), and in how this chunking is affected by the surface structure of the sentences. As an example of this interest, Johnson (1965) showed that transitional error probability (the probability that a word is not recalled, given correct recall of its predecessor) was much higher when the words spanned a boundary between different surface structure constituents, than when they were within the same constituent. Johnson concluded that when lists of sentences are learned, the surface structure clauses are treated as psychological units. The psychological reality of surface structure was further supported by Mehler and Carey (1967), who showed that a set to expect one sort of surface structure (e.g. They are buying gloves) could interfere with verification of a sentence with a structure that looked identical, but was in fact different (e.g. They are boxing gloves). Further support for the clause as a unit was obtained by Garrett, Bever, and Fodor (1966, and many subsequent studies). They asked subjects to report the location of an extraneous click in sentences in which the clause boundary was controlled by preceding context, as in the pair:

Your constant hope of marrying Anna is surely impractical.

In her hope of marrying Anna is surely impractical.

The initial two words determine whether the clause boundary precedes or follows Anna. There was a strong tendency for the clicks to be mislocated into the clause break, although the clause

break was not marked acoustically as a consequence of an ingenious experimental design. (In normal speech, of course, clause boundaries are marked by prosodic cues, and these are highly influential in controlling segmentation: see Wingfield & Klein, 1971). Both the interpretation and the methodology of the "click" experiments have been criticized (e.g. watt, 1970; Olson & Clark, 1976), but enough of the criticisms have been answered by now to justify tentative acceptance of the conclusions (Carroll & Bever, 1976).

Deep Structure Clauses

A surface structure clause boundary always coincides with a clause boundary in the deep structure, but the reverse need not be true. Therefore, all the foregoing results are equivocal between surface and deep clauses being psychologically important. Bever, Lackner, and Kirk (1969) found that clicks were mislocated into deep structure clause boundaries that were not marked in surface structure. For example, clicks migrated differently in pairs of sentences like:

I defied John to leave.

I desired John to leave.

which are identical in terms of surface structure, but whose deep clause boundaries fall in different places. Bever et al argued

that much of the variability of earlier clik data could be explained in this way (see Carroll & Bever, 1976, for more discussion). Blumenthal (1967; Blumenthal & Boakes, 1967) showed that surface structure could not account for all of the psychological organization found in sentence-memory tasks: deep structure relationships must be invoked too. They showed that the deep structure subject is a better prompt for recall than is a noun in an adverbial phrase, even though the surface structures look identical. Thus the word "tailors" was a better prompt for the sentence:

The gloves were made by tailors.

than the word "hand" was for the sentence:

The gloves were made by hand.

These results also suggest it is the deep structure clause, rather than the surface structure clause, that represents a psychological meaning unit.

Finally, the clause boundary appears to trigger recoding of the clausal material into deep structure form, and the surface form is then erased from working memory. Jarvella (1971) showed that when a continuous passage was unexpectedly interrupted, verbatim memory for earlier words showed a sharp drop at the preceding clause boundary. Memory for content, or meaning, showed

no such drop. Similarly, Caplan (1972) showed that reaction time to decide if a probe word had occurred in a preceding sentence was longer if the probe had occurred in the preceding, rather than the immediate clause. Results with similar implications were obtained in other studies by Sachs (1967), and by Johnson-Laird (1970). Forster (1970) showed that, with rapid serial visual presentation, sentences with only one deep sentoid yielded lower error rates than those with two sentoids, even though length and semantic plausibility were controlled. This would be expected if the deep structure sentoid is a perceptual unit, since sentences containing two units should be more complicated than those with only one.

Derivational Complexity

The first theory that attempted to model the psychological complexity of different syntactic constructions proposed that, in order to recover the deep structure, every transformation used in the derivation of the surface structure had to be undone during perception by an inverse transformation, like peeling an onion. This, simply stated, is the theory of derivational complexity. The briefer account we give below is intended to give just the flavor of the research performed to test this theory. More extensive coverage can be found elsewhere (Bever, 1970; Fodor, Bever, & Garrett, 1974; Watt, 1970; Carroll & Bever, 1976).

Several early experiments were interpreted as supporting the theory. For example, McMahon (1963; later replicated by Gough, 1965) read statements about the integers to subjects for verification, and measured reaction times. The statements were true or false, active or passive, affirmative or negative, and used the reciprocal verbs precede and follow, as in the following set:

- 5 precedes 7
- 7 follows 5
- 5 is followed by 7
- 7 is not followed by 5
- 7 is not preceded by 5

Filler words that did not add to derivational complexity were added to some sentences, to vary length independently of complexity. Passive and negative transformations lengthened reaction times, and the amount of lengthening produced by a particular transformation was remarkably independent of what other transformations had been applied. In other words the increment in reaction times in moving from an active affirmative declarative to an active passive was almost identical to the increment from a negative active to a negative passive. The implication was that a special operation was required to handle the passive, regardless of the context in which it appeared, and parallel operations to undo the other transformations.

Other studies have used the results of memory tasks to test the theory of derivational complexity (Miller, 1962). Mehler (1963) presented his subjects with simple and transformed sentences to memorize, and found that transformations are much more likely to be wrongly omitted than wrongly inserted, suggesting that subjects were, in fact, extracting the syntactically simple deep structures. He also found that the probability of a single transformation being omitted in recall was independent of the presence of other transformations. Here again, each transformation seemed to increase complexity by a fixed amount specific to that transformation. Savin and Perchonock (1965) pursued the idea that, when a sentence is memorized for verbatim recall, its content is stored separately from the transformations used in its derivation. They presented a sentence of variable transformational complexity, and followed it with a list of unconnected words, to fill up the subject's memory in a mental analogue of Archimedes law. The more complicated the syntax of the stored sentence, the less room there was for extra words. The results lent further support to derivational complexity, and the method seemed to be well suited to measuring complexity empirically. Although the result has been replicated, at least for the negative, passive, and question transformations (Bever, Fodor, Garrett, & Mehler, 1966), other researchers have noted the critical importance of the timing of events during a trial -- how long the delay is between test sentence and "filler"

words, and before recall begins (see Olson and Clark, 1976, for more detail).

The study of language development is a further source of evidence favoring the theory of derivational complexity. Brown and Hanlon (1970) looked at the emergence of transformations in a longitudinal study of three children. They were careful to consider only cumulative derivational complexity, arguing that simply counting the number of transformations applied makes the implicit (and empirically false) assumption that different transformations all yield the same increment in complexity. The only pairs of sentences that should be compared are those in which the second member differs from the first only by requiring one (or more) additional transformations. Thus passive+negative can be compared with passive or with negative but not with question. Brown and Hanlon found that the sequence of development indeed followed the order predicted by derivational complexity, including the deletion operations used in the truncation transformation, which yields We did from We had a ball. They also found that question, negative, and truncation transformations all appear at much the same time, which is interesting in view of the fact that all depend on mastery of the same transformations to handle the auxiliary verbs, such as do-support. (Do-support introduces do into the sentence in just those cases where "tense" is the only auxiliary element. Thus when negation is applied to I like it or

I liked it, do is introduced to yield I don't like it, or I didn't like it: see Brown & Hanlon, p23, for more detail.)

Brown and Hanlon were also able to reject sentence length as an alternative explanation of the developmental sequence they found. In twelve cases, multiplied by their three subjects, derivational complexity and length yielded conflicting predictions about which construction should appear earlier, for a total of 36 predictions. Only one of the predictions made by the length hypothesis was supported by the data, whereas 31 of the predictions from derivational complexity were supported.

Are there theories other than derivational complexity that could explain the results obtained with adult subjects? Brown and Hanlon (1970) have pointed out that, of the 17 predictions Savin and Perchonock made of the relative complexity of their transformed sentences, 13 would be made also on the grounds of length alone. Savin and Perchonock mention length as an alternative explanation, but dismiss it because one of the transformations they studied, the wh-question transformation, shortens the sentence, but also makes it harder to remember. A further explanation mentioned by Savin and Perchonock is that the effects might arise in retrieval rather than during storage. They were not disturbed by this possibility, since it did not conflict with their thesis that the content of a sentence was stored separately from its transformational history. Kempen (1976) has

recently presented evidence that the "chunking" of words into phrases in memory tasks, at least as revealed by probe-latency techniques, occurs during retrieval rather than during storage. If this finding is broad enough to subsume Savin and Perchonock's method, it means that their result, or any other result involving sentence memory, cannot be used to support derivational complexity. Further, the memory tasks in these and other studies can often be performed by strategies that do not involve comprehension. McMahon's results are the only ones considered above that do require comprehension.

Derivational complexity has been attacked on other grounds by Fodor and Garrett (1966). They pointed out that some transformations have the effect of decreasing rather than increasing the perceptual complexity of a sentence, which conflicts with derivational complexity. Their prime example was deletion transformations. They argue that a sentence such as The boy was given a book by someone becomes simpler, rather than more complex, when an additional transformation deletes the by someone. A counterargument to this example is that no information is being deleted, since full command of the verb give must include the fact that it can take up to three noun phrases: a subject, an object, and an indirect object -- or their case theory equivalents (Fillmore, 1968) -- and any unfilled slots must be understood as unspecified. Other counterarguments have been offered by Watt

(1970). The other transformations that reduce complexity perform reorderings of constituents, such as:

- 1) converting a relative predicate nominal to an adjective, to change The tree that is green ... into The green tree ...;
- 2) separating verb and participle to change She looked up her school friend, into She looked her school friend up, and
- 3) complement postposing, which changes That Tom cried amused Bill into It amused Bill that Tom cried.

Evidence that perceptual complexity is sometimes reduced when derivational complexity is increased was provided by Fodor, Jenkins and Saporta (reported in Bever, 1970), who demonstrated that some simple sentences are harder to perceive than derivationally more complex ones, when presented in a tachistoscope -- although the different time pressures in tachistoscopic presentation might well affect the strategy used by the subject.

The foregoing results conflicting with derivational complexity can be interpreted either as disproving the theory, or as a criticism of the particular formulation of the grammar used to determine the number of transformations applied in the derivation of a particular sentence. This is a formidable problem in psycholinguistics: the rate at which linguistic description

has been developing over the past 20 years, together with the lag before new developments in linguistics are taken up by psycholinguists, means that the formal descriptions psychologists seize on for testing are often obsolete before the testing begins (not to mention possible further delays before they reach educators).

Processing Models of Complexity

The set of transformations that combine two underlying sentoids into a single surface sentence is a much richer source of sentence complexity than are the so-called singulary transformations such as the passive, which deal with only a single deep sentoid.

The two resulting clauses may be in coordinate relation with each other, as occurs in conjunction, or one may be in a subordinate or embedded relation to the other, as in relatives and complements. The richness of the structure that can be produced by these constructions results from the fact that they are recursive: the embedded sentence can itself be a complex sentence, with an embedded clause, and so on indefinitely.

Since transformations that perform embeddings introduce a new sentoid every time they are applied, it would be surprising if the number of times the transformation was applied did not affect the

complexity of the resulting sentence. But there is a different, and probably more important source of difficulty. A common use of a relative clause is to modify the subject noun phrase in a sentence, which as a side effect separates the noun phrase from its verb. Since the noun phrase in the main clause must have a verb, the listener is forced to store that part of the noun phrase already identified, while decoding the modifying relative clause intervening before the verb. Wanner and Maratsos (1974) used a modification of Savin and Perchonock's Archimedean task to measure "on-line" memory load during sentence processing, and found that the more complicated, or the longer, the modifying material was, the heavier the load placed on memory. This model of syntactic complexity we will call the depth hypothesis, after Yngve (1961), who introduced it. Although Yngve's model was quickly overtaken by counterexamples, it recently received some belated support when Bormuth (1966) found that it makes fairly good predictions of readability.

The depth hypothesis drew attention to the processing demands placed on the receiver by language. Yngve's model was developed in part to explain why a syntactic procedure that involved recursion could, in some circumstances, be applied only a limited number of times before the sentence became incomprehensible. The best example is center embedding, in which the relative transformation is applied to qualify the subject noun phrase. The

sentences The dog chased the cat, The cat killed the rat, and The rat ate the malt can be combined to yield the nursery rhyme fragment:

(...This is) the dog, that chased the cat, that killed the rat, that ate the malt.

The right-branching structure is very easy to understand, and is enjoyed by quite young children -- it may well be their first introduction to recursively applied transformations. The same sentoids can be combined into a center-embedded, instead of a right-branching construction, to yield:

(...This is) the malt that the rat that the cat that the dog chased killed ate.

The center-embedded version is virtually unintelligible, although it was produced by applying the rules for relativization correctly. Several attempts have been made to explain the difficulty of such constructions. Miller and Isard (1964) tested an "interrupted subroutine" model, in which recursion caused the "return vector" to be lost if the subroutine was entered more than once. Subsequent research has been generally consistent with this model. In particular, as pointed out by Carroll and Bever (1976), it has drawn attention to listeners' attempts to identify the deep-structure sentoids, together with their grammatical relations. Blumenthal (1966) found that if the subjects were

unaware of the double-embedding construction, they simply treated the resulting sentences as ungrammatical. Schlesinger (1968) found that center-embeddings are much easier to understand if the underlying kernels are semantically constrained in such a way that the noun from one cannot be combined with the verb from another. Savin (quoted in Bever, 1970) showed that even single center embeddings are more complex than corresponding right-branching structures. Thus The boy who likes the girl thanked the man is more complex than The boy thanked the man who likes the girl (and also has a different meaning). As the complexity or length of the relative clause increases, the pressure grows to recast the matrix sentence (in which the relative clause is embedded) into a different form, to prevent the clause from separating the subject and verb in the main clause. This can be achieved by the passive transformation, as in The man was thanked by the boy who likes the girl ... that he met when he went to the party last Saturday with Aunt Sally... Fodor and Garrett (1967) found that center embeddings are easier to paraphrase when the relative pronouns that begin the relative clauses are retained in the sentence, instead of being deleted. Thus, The boy that the girl likes kicked the ball is easier than The boy the girl likes kicked the ball, although the latter is shorter.

Strategies in Perception

Observations such as these led to a new theory of how a listener decodes syntax. This theory implicitly incorporates a theory of syntactic complexity. In order to extract meaning, the listener must reconstruct the relations between the constituents that appear in the deep structure sentoids, as in the derivational complexity theory. The center embedded sentence from which the relative pronouns have been deleted is hard to understand because the deletion has removed a clue needed in recovery of the deep structure. Bever (1970) developed this position by suggesting a set of strategies the listener uses to recover deep structure. They are strategies, rather than algorithms, because they do not always give the correct answer. The first strategy is to look for a sequence that could correspond to subject-verb-object (S-V-O) of the deep structure. The second strategy is to assume that the first sequence consisting of noun-verb(-noun) must be the main clause of the sentence, except if the verb is marked by a subordinate conjunction, such as although, if, while, or because. When these words appear first in a sentence, they indicate that the subordinate clause precedes the main clause, as in so-called "cleft" sentences such as Although John was a bore, we invited him to the party. The third strategy is to allow semantic constraints to guide the assignment of syntactic function whenever possible -- in extreme cases, syntactic analysis may not be necessary at all.

Fourth, in the absence of semantic clues, an N-V-N sequence is assumed to correspond to the deep structure subject-verb-object (i.e. actor-action-object). Fifth, a determiner is assumed to mark the beginning of a noun phrase, which continues until the first word is encountered that is less "noun-like" than its predecessor. Bever found this description was able to account for several puzzling details about adjective-order in English, such as preference for The red plastic ball over The plastic red ball. (See Bever, 1970, and Ford & Olson, 1975, for more discussion). As we will see below, the description is also helpful in explaining the difficulty of garden path sentences like The old man the boats.

These five strategies have been revised slightly in the latest statement of the theory (Carroll & Bever, 1976), but the changes made are not critical to the discussion here. The crucial idea underlying all the strategies is the problem of recoverability -- that is, how the deep-structure sentoids can be recovered from the surface form of the sentence. Bever went on to show that the strategies are special language-related cases of a set of general perceptual principles closely related to the Gestalt rules of organization.

A highly similar set of conclusions had been reached quite separately by a group trying to write a parsing algorithm for English sentences (Thorne, Bratley, & Dewar, 1968). Their aims

were explicitly "to construct a device that will not only assign a syntactic analysis to any English sentence... but also, to some extent, simulate the way in which (a native speaker) perceives this structure." Three aspects of their model make it highly appealing as a model of the reader, at least as far as his syntactic abilities are concerned:

- 1) the parser uses a finite dictionary of "closed-class" words (function words, inflectional suffixes, and complement-taking verbs) to establish a syntactic context for all "open-class" words (nouns, verbs, adjectives) which do not appear in the dictionary. This can account for the "understanding" of nonsense passages like Jabberwocky.
- 2) the parser works left to right in a single pass, with each word being analyzed only once.
- 3) the parser simultaneously analyzes deep structure as well as surface structure, without appeal to context or meaning.

The reason for excluding meaning was similar to that offered by Chomsky (1957): it is bad strategy to introduce meaning before seeing how far one can get without it. In addition, there was no known way of incorporating meaning into a parsing algorithm.

The "closed class" dictionary used by Thorne et al did not include every word that would appear in the sentences used to test the parser. The dictionary listed three types of items, and contained only about 2000 entries. The three types of items were:

1) all words with fixed syntactic functions such as articles, prepositions, pronouns, and conjunctions; 2) a list of inflectional suffixes; and 3) a list of special verbs. The verbs included were those that take two objects or complements, or an object and infinitive, such as give, persuade, tell, ask, promise, etc. (The syntactic description of these forms has advanced considerably since then: see Carroll & Bever, 1976.) It is interesting that Thorne et al found it necessary to include the list of verbs in their dictionary, since Fodor, Garrett, and Bever (1968) showed, at about the same time, that sentence complexity varies considerably as a function of the number of different constructions in which the verb can take part. This problem has been approached in a different manner by case theory grammar (Fillmore, 1968), with similar implications. Thorne's parser was the first of the augmented transition network (ATN) parsers (Bobrow & Fraser, 1969; Woods, 1970). Kaplan (1972) has shown that the heuristic strategies described by Bever (1970), with the exception of the semantic strategy, can be directly translated into an ATN. The term ATN is used to refer to both the ATN formalism, which corresponds roughly to a class of finite state grammars that can incorporate calls on subroutines, and also to a particular implementation -- that is, to a specific grammar that is a member of the class.

A particularly appealing aspect of Thorne's model is that, in performing its single left-to-right pass through the input, it develops simultaneously all the possible parsings of the sentence. The model is thus predictive in that, at any instant, each possible parsing has only a limited range of possible continuations. The class of possible continuations can be considered to be predictions about what will come next in the input sentence. Such prediction clearly occurs in human listeners, as shown by the extremely short-latency shadowing experiments of Marslen-Wilson (1973, 1975).

In summary, most of the transformations that make recoverability more difficult, at the same time shorten the sentence to which they are applied. Thus their function can be seen as attempting to reach a balance between 1) overloading the temporal limitations of the listeners short-term memory, which is risked by using long messages with high recoverability, and 2) overloading his processing ability, by using short messages with low recoverability.

Ambiguity and Garden Paths

Recoverability is a central issue in ambiguity, also. One sort of ambiguity can be explained as the result of applying too many redundancy removing transformations, to the point where two (or more) deep structures can be recovered from a single surface

sentence. In other words, a sentence that is not ambiguous to a skilled receiver may be ambiguous to one less skilled, for whom too much deletion has occurred to allow unambiguous recovery. This is the reverse of the more obvious possibility that the skilled reader suffers the ambiguity, because of his more detailed word-knowledge.

Three sources of ambiguity can be distinguished. Lexical ambiguity arises when a word has multiple meanings, and it is not clear which is intended, as in The rest of the circus troupe was disturbed. Here, rest can refer to remainder or to sleep. Surface structure ambiguity occurs when a single string of words has two possible constituent structures, as in He came over a week ago, or The older men and children arrived (- were the children older too?). Thirdly, deep structure ambiguity results when there are two possible assignments of deep structure functions to surface constituents, as in The shooting of the hunters was awful, where it is not clear whether the hunters were shooters or snootees.

There have been many psycholinguistic studies of ambiguity (Mackay, 1966; Mackay & Bever, 1967; Carey, Mehler & Bever, 1970; Wanner, 1976). The aim of many of these experiments was to compare two theories of how ambiguous sentences are processed. One possibility is that the second and further parsings are developed only after the first is complete -- that is, the

alternative parsings are obtained sequentially. Carey, Mehler and Bever (1970) supported this position by showing that ambiguity did not increase reaction times in a picture verification task, so long as the subject did not notice the ambiguity. If the ambiguity was noticed, the reaction times were longer. The second possibility is that all parsings are developed in parallel, as the Thorne model would suggest. This position is supported by results such as those of Foss (1970), who found that phoneme monitoring reaction times were longer following an ambiguous word. Carroll and Bever (1976) in a detailed discussion, account for both sets of data by pointing out that all studies that appear to support the serial model involve tasks that follow presentation of the sentence, whereas those that support the parallel model interrupt processing of the ambiguous clause. They suggest that all possible parsings are developed within the ambiguous clause, but that only one of the possible meanings is selected and retained after the end of the clause. This interpretation also fits in well with semantic recoding of completed clauses, as described above.

Another phenomenon closely related to ambiguity is the "garden path" sentence, in which the listener is misled into an incorrect assignment of syntactic relations. Examples of garden paths are sentences such as The old man the boats, and the incomprehensible The man kicked the ball kicked the ball (Limber,

1976). The difficulties with these sentences can be explained as the result of deleting information that is vital to recovery, in a situation where the strategy of treating the first unmarked S-V-O sequence as the main clause can then apply. We have seen above that verbatim memory for earlier words in a sentence drops sharply for words in earlier clauses (Jarvella, 1971), presumably because whenever a clause is completed, it is recoded into a more semantic form, and is no longer held in working memory. As a result, when the first clause in the garden path sentence is wrongly analyzed as the main clause, the error is extremely hard to recover from, since this means bringing back for re-analysis the words that comprised the completed clause. Although memory for the meaning of an earlier clause can easily be recovered, the exact words used are not available after the successful parsing of the clause is complete. But it is essential that the exact words be recovered, if they are to be re-analyzed to yield a different parsing. (The second garden path sentence above can be parsed if "thrown" is substituted for the first "kicked", or "that was" is inserted after "man".)

Examples such as this rarely find their way into print, of course, except to prove a point. But ambiguity is far more widespread than is generally realized (Wanner, 1976). This raises the possibility that a sentence that adults find to be merely ambiguous may have been over-deleted to a point where a child

finds it totally incomprehensible, similar to the garden path examples quoted above. It is also possible, of course, for a sentence that is not ambiguous to an adult to be ambiguous to a child, owing to his less-developed ability to use context for disambiguation.

Syntax in Children

In this section, we will restrict our attention to studies that have something to say about the factors influencing recoverability, that also involve children. The course of language and syntax development up to age five has been extensively reviewed elsewhere (McNeill 1970; Menyuk, 1971; Dale, 1972; Brown, 1974; and many others), and Palermo and Molfese (1972) have provided a survey of the evidence that children of five still have much to learn in phonology, in syntax, and in semantics.

In an earlier section, we described some strategies for recovering meaning during sentence perception. In developing his account of these strategies, Bever was strongly influenced by the problems children face in learning language. Therefore, it is not surprising that the strategies developed to account for adult performance can be used to explain children's performance also. Strohner and Nelson (1974) studied comprehension in 2- to 5-year olds, and confirmed that 3 year olds rely heavily on the

search-for-meaning strategy. Almost all of the improbable sentences they used, such as The mouse chased the alligator, were interpreted by event probabilities rather than by syntax. Active improbables were misunderstood as often as passive improbables, suggesting that the search-for-meaning strategy overrode the search-for-SVO strategy, in conflict with Bever's result. However, Strohner and Nelson did confirm the use of the latter strategy, which was apparent in the high error rate in reversible passives (Slobin, 1966), where the search-for-meaning strategy produces equivocal assignment of subject and object. Strohner and Nelson also found, again in conflict with Bever, that the semantic strategy was strongly present in 2-year olds, in agreement with MacNamara's (1972) position, that "infants use meaning as a clue to language, rather than language as a clue to meaning."

The widespread use of the semantic strategy, at all age levels, can be used to support the argument that it is extremely dangerous to study language development and use, except in relation to general cognitive development (Donaldson 1966, and many others). Yet that is what many early studies of syntax effectively tried to do by eliminating meaning as a source of variability. The situation is a bit reminiscent of the revolution in the study of memory when meaning was allowed to play its part. Even with this example before us, studies frequently appear that

challenge earlier results on the grounds that they failed to control semantic factors adequately

A recent study by Lesgold (1974) provides a clear example. He set out to replicate an earlier finding by Bormuth et al (1970), who had established a difficulty-ordering for different forms of anaphora. For example, pro-verb forms such as Jane likes Jim. SO DOES Sue, and pro-clause forms such as Dan may come. If SO, we will have a party, were understood by 83% and 87% respectively of the 420 fourth grade subjects, whereas only 65% understood personal pro-noun forms such as Dick went to the store. HE bought an apple. Bormuth et al generated their task items by composing a sentence as the antecedent of the anaphora, and following it with a second sentence in which the anaphora occurred, as in the foregoing examples. The pair was embedded in a paragraph, and the subject had to answer a question such as "Who bought an apple?" Lesgold argued that three sources of variability must be controlled in such a task. First, it is obviously important, if a who-question is to be asked, to have more than one animate referent in the test paragraph, otherwise no comprehension or syntactic analysis is required. (Bormuth et al avoided this trap.) Secondly, the choice of content words for the paragraph may have undesired influences on the difficulty of the question. Thirdly, for the pro-clause forms, it is important to equate the complexity of the antecedent clauses for the two

exemplars of anaphora that are to be compared. As an extreme example, the following two sentence-pairs use the same type of anaphora, but the second should be much harder to understand:

Dan may come. If SO, we will have a party.

Dan told us he will try to get here soon after dinner if he doesn't miss his train. If SO, we will have a party.

When these three sources of variability were controlled, Lesgold obtained a difficulty ordering that was not only different from Bormuth et al's, it was significantly negatively correlated with it! Lesgold concluded that "syntax is not the basis of a hierarchy of comprehension skills that have not been completely acquired by...fourth grade.... There are very few syntax forms which children in the fourth grade cannot understand in at least some contexts." This raises again the point that syntax is used for a purpose, and testing syntactic difficulty in situations where the construction is divorced from that purpose is likely to produce misleading results. A large proportion of the studies that have been performed on children's comprehension of passive forms can be criticized on these grounds, as demonstrated by Turner and Rommetveit (1968). Lesgold goes on to propose two reasons for children failing to understand a construction in one context that they can understand in another: 1) The child may not know the interpretation rules required to understand the structure in the particular semantic context; or 2) He may lack

the real-time capacity for applying those rules. Lesgold concludes that

grammatical rules for 9-year olds are not abstract structures that apply mechanically. They are inextricably bound up with semantics (cf. Palermo & Molfese, 1972).. The potential reliability and validity of syntax tests with uncontrolled semantics is low."

Unfortunately, this indictment probably applies to a large proportion of all earlier work on syntactic complexity, including many of the studies on adults.

One encouraging trend obvious in recent syntactic work with young children is the increasing linguistic sophistication of the experimenters. As a result, more complex transformations (those which are widely used in adult language) are beginning to be studied. This trend was perhaps started by C. Chomsky (1969), in her well-known study of children's comprehension of pairs of sentences that share the same surface structure, but differ in deep structure. We have already seen that such sentences exist. In some cases, the meanings of the words in the sentences are sufficient to resolve the potential ambiguity, as in:

The customer is ready to eat.

The omelette is ready to eat.

Since children make heavy use of the semantic strategy, they should have little trouble with such examples. But what happens when the semantic strategy does not give a helpful answer? How would children interpret an ambiguous sentence like:

The missionary is ready to eat.

A general strategy for interpreting complement clauses of this sort is: whenever there are two noun phrases, the second is the subject of the complement verb, but when there is only one, then that one must be the subject. The strategy is called the "minimal distance principle", because when a missing subject has to be supplied, the nearest noun phrase is used. The strategy can be seen to work in such cases as:

John wanted Bill to leave. (Bill leaves)

John wanted to leave. (John leaves).

but it gives the wrong answer in such cases as:

John promised Bill to leave. (JOHN leaves)

Chomsky tested individual children aged five to nine in a variety of tasks, of which we will consider two here. The child was shown a blindfolded doll, and asked if the doll was easy to see. The younger children incorrectly used the minimal distance principle, as shown by the following example (Chomsky, 1969, p.30):

Q Is this doll easy to see or hard to see?

A Hard to see.

Q why?

A 'Cause she got a blindfold.

When asked to make the doll easy to see, the child typically removed the blindfold. Only 22% of Chomsky's five-year-olds interpreted the question correctly, this proportion increasing until all the nine-year-olds in her sample gave the right answer.

The second task we will consider from Chomsky's study showed explicitly how over-deletion can interfere with children's comprehension. The minimal distance principle was again involved, this time with the verbs tell and ask. Consider the pair of sentences:

John told Bill what to do.

John asked Bill what to do.

The minimal distance principle correctly assigns Bill as the do-er in the former, whereas it incorrectly assigns Bill as the do-er in the latter. Initial tests with sentences such as these showed that, surprisingly, children interpreted ask in such contexts as if it were tell, as the following exchange demonstrates (Chomsky, 1969, p.55):

Q Ask Eric his last name.

A Handel.

Q Ask Eric this doll's name.

A I don't know.

Q Ask Eric what time it is.

A I don't know how to tell time.

Yet, it is quite clear that the word ask itself is not the problem, because appropriate responses were given to questions such as: If you were going to ask your friend to dinner, what would you say? This sort of performance was the rule, rather than the exception, in five-year-olds. The children followed a clear developmental sequence in acquiring control of ask. The sequence consisted of differential mastery of three different syntactic forms:

Class 1 (wh-clause, with subject supplied):

1A Ask Laura what color this book is.

1B Ask Laura what you should feed the doll.

Class 2 (Noun Phrase):

2A Ask Laura the color of this book.

Class 3 (wh-clause, with subject omitted):

3A Ask Laura what to feed the doll.

Children fell into one of five ordered stages, those in the first making errors on all three classes, and those in the last showing mastery of all three classes. The third syntactic class was mastered in two stages: first the child would correctly produce a question, but would insert the wrong subject, and only later, at about age 10, choose the right subject. There are two particularly interesting pairs of sentences in the foregoing examples. Some children were able to respond correctly to 1A, but not to 2A. Others, at a slightly more advanced stage, were able to respond correctly to 1A and 2A, and to 1B, but not to 3A. The two sentences in each pair require exactly the same of the subject, and differ only in how much deletion has occurred. The conclusion is inescapable: in the second member of each pair, too much deletion has occurred for the deep structure clauses to be correctly recovered, and comprehension fails. The fact that performance on the easier of the two sentences is satisfactory, in each case, shows that there is nothing intrinsic to the task that is beyond the child's capacities.

The foregoing study illustrates very graphically the three points we are making in this chapter. First, semantics is of overriding importance. Second, children's ability to deal with syntactic complexity does increase with age. Third, at any age, there is some syntactic complexity that is best suited to the child's abilities, and this level of complexity will vary as a

function of how much support is available from the semantics of the context.

A recent thesis by Richek (1976-7) confirms several of the foregoing conclusions, and also those of Lesgold quoted above. Her study involved three different types of anaphora, as follows:

1. John saw Mary, and JOHN said hello to Mary. (Noun)
2. John saw Mary, and HE said hello to her. (Pronoun)
3. John saw Mary, and said hello to her. (Null)

In a carefully controlled and counterbalanced experiment, different children saw each of the three forms in an identical paragraph context. There was a consistent difficulty ordering of the three forms, within each context, with the noun form being easiest and the null form being hardest, as recoverability would predict. The third-grade children showed little understanding of the null form of anaphora, although it occurred with high frequency in their readers. There were major differences in difficulty between the same form in different contexts, illustrating the large effect played by context, and the importance of controlling it.

Many of the problems encountered in more advanced syntax are not purely syntactic, since they often depend on the case properties of particular words -- such as occur in the contrast between John is easy to please / John is eager to please, or in

the tell / ask example above. Verbs and some other words (easy, eager, ready) can be classified by the case forms they are associated with (e.g., Fillmore, 1968), and this classification can be used as the basis for ordering the words by complexity. A developmental study of how children acquire mastery of this sequence would be most helpful.

Further non-syntactic difficulties arise when the complement-taking verbs begin to qualify the meaning of the complementized sentoid, as occurs with factive, counter-factive, and non-factive verbs. The implications for Bill's health are quite different in:

John knows Bill is sick. (Bill is sick.)

John pretends Bill is sick. (Bill is not sick.)

John says Bill is sick. (Indeterminate.)

Comprehension of such complex sentences is not fully acquired until after sixth grade (Harris, 1975) -- however, the problems involved are probably not syntactic, and they are discussed in other chapters.

Another example where the problems are only partly syntactic is Ford and Olson's (1975) study of noun phrase elaboration and the acquisition of adjective ordering in 5- to 7-year olds. They found that even 5-year olds reliably used adjectives to distinguish a target item from the set of alternatives that might

be mistaken for it. A big black triangle was called the black one in the context of white triangles, but the big one in the context of small triangles. However, the differentiation was made relative to the set of inferred alternatives (all the blocks that had previously been presented in the experiment) rather than those in the immediate context. That is, the children's differentiations were more detailed than was required by the direct context. Ford and Olson suggest that perhaps children begin to restrict their elaborations to what is sufficient only when they start to take into account the needs of the listener. A consequent restructuring of their language output to allow for the listener's needs might well account for the sudden jump in syntactic elaboration and development that Palermo and Molfese (1972) report as occurring at this age.

A second interesting finding by Ford and Olson was that between the ages of 5 and 7, children apparently learn that one of the possible uses of conjunction is to release adjectives from the rules that govern their ordering within noun phrases (Bever, 1970). Adjective ordering is obligatory in The big red plastic ball . . ., but not in The ball, which was plastic and red and big The adjectives can then be ordered by their salience or utility in the particular task. This is another example of a construction being discovered when it begins to perform a useful function, since there is no need for a child to learn how to

release adjectives from ordering rules before those ordering rules themselves are acquired.

Two of the questions asked in the early part of this chapter were: What is a particular construction needed for? How does (or should) a language producer decide which of two alternative constructions is appropriate to express a particular proposition? An attempt to answer these questions, in part, was reported by Pearson (1974). Pearson composed a set of simple propositions, such as commonly occur in third and fourth grade texts. The propositions were then recast into several different syntactic forms, such as the following:

1. The tall man thanked the young woman.
2. The man who was tall thanked the young woman.
3. The man thanked the young woman. He was tall.
4. The man thanked the woman. He was tall. She was young.

QA. Who thanked the young woman?

QB. Which man thanked the young woman?

In a preliminary comprehension task, each syntactic form was read by a different subject, who was then asked one of the two questions QA or QB. Error rates were extremely low, and did not differentiate between the different syntactic forms. But a second task was much more interesting. The subjects (3rd and 4th graders, excluding poor readers) were asked to rank order the

different versions for their appropriateness as answers to one or other of the questions. The subjects showed a clear preference for the more compact form over the less compact forms. That is, they preferred the more complicated form. Pearson interpreted this result as disconfirming both the readability theory of complexity, and also the deep-structure theory. The latter conclusion unfortunately results from a misunderstanding of what deep structure theory would predict. Pearson wrongly assumed that, because extraction of a sentence's meaning requires the identification of deep structure sentoids, subjects should therefore prefer a form of presentation in which this identification has already been done for them, by presenting each deep structure sentoid in a single isolated simple sentence in the surface structure. This corresponds to the "long, thin message" described on page 14, which is unnecessarily long because it fails to make efficient use of the processing ability available to the receiver. Subjects should prefer the "long thin" message only if the more compact form strains their processing capacities, as might occur for the foregoing examples if the same task could be presented to infants.

Although Pearson's conclusions can be criticized, both the task and the results are very interesting. The result he obtained is exactly what would be predicted by the arguments made at the beginning of this chapter. The receiver should prefer the

shortest syntactic form that is compatible with his processing abilities. The less compact forms should be preferred only when the most compact forms begin to overload processing ability.

The experimental paradigm used by Pearson appears to have great potential, for several separate purposes. First, it could be used for collecting empirical data on the development of syntactic competence, at all ages, by studying how children's preference for one form over another changes as they grow older, and also how their preferences differ from adult preferences. Second, the task could be used for the complementary purpose of measuring the processing abilities of an individual child. A child faced with a syntactic form that is too complex for him to unravel either misunderstands the message, as a result of making the wrong syntactic decisions, or treats the message as ungrammatical -- as do many adult subjects when they are faced with double center-embeddings (Blumenthal, 1966). These two alternatives are distinguishable by a carefully designed set of questions. Finally, tasks such as Pearson's could easily be adapted for the purpose of teaching a complex new structure to children.

Conclusions

- 1) An attempt should be made to formalize the pragmatics of syntax. That is, answers are needed to questions such as:

what are the pragmatic reasons for using a particular construction?

- 2) Syntax can become too complex for a child to unravel for two separate reasons: either because the semantic relations expressed are too advanced for him to understand, yet require complex syntax for their expression; or because the syntax overloads his processing or memory abilities.
- 3) Therefore, more attention to the parallel development of children's other, non-linguistic processing abilities and cognitive capabilities is necessary.
- 4) Careful control of semantic and discourse factors is essential for all studies of syntax, if the results are to be meaningful.

References

- Bever, T. G. The cognitive basis for linguistic structures. In J. R. Hayes (ed.), Cognition and the development of language. New York: John Wiley, 1970.
- Bever, T.G., Fodor, J.A., Garrett, M.F., & Mehler, J. Transformational operations and stimulus complexity. Unpublished, M.I.T., 1966.
- Bever, T.G., Lackner, J.R., & Kirk, R. The underlying structures of sentences are the primary units of immediate speech processing. Perception and Psychophysics, 1969, 5, 225-231.
- Blumenthal, A.L. Observations with self-embedded sentences. Psychonomic Science, 1966, 6, 453-454.
- Blumenthal, A.L. Prompted recall of sentences. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 203-206.
- Blumenthal, A.L., & Boakes, R. Prompted recall of sentences, a further study. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 674-676.
- Bobrow, D., & Fraser, B. An augmented state transition network analysis procedure. In N. Walker & L. Norton (Eds.), Proceedings of the International Joint Conference on Artificial Intelligence, Washington, D.C., 1969, 557-568.
- Bormuth, J. R. Readability: a new approach. Reading Research Quarterly, 1966, 1, 79-132.
- Bormuth, J.R., Manning, J.C., Carr, J.W., & Pearson, P.D. Children's comprehension of between- and within- sentence syntactic structures. Journal of Educational Psychology, 1970, 61, 349-357.
- Brown, R. A First Language. Cambridge, Mass.: Harvard University Press, 1974.
- Brown, R., & Hanlon, C. Derivational Complexity and Order of Acquisition. In J.R. Hayes (Ed.), Cognition and the Development of Language. New York: Wiley, 1970.
- Caplan, D. Clause boundaries and recognition latencies for words in sentences. Perception and Psychophysics, 1972, 12, 73-76.
- Carey, P.W., Mehler, J. & Bever, T.G. Judging the veracity of ambiguous sentences. Journal of Verbal Learning and Verbal Behavior, 1970, 9, 243-254.

- Carroll, J.M., & Bever, T.G. Sentence Comprehension: A Case Study in the Relation of Knowledge and Perception. In Carterette, E.C. & Friedman, M.P. (Eds.), Handbook of Perception, Vol. VII: Language and Speech. New York: Academic Press, 1976.
- Cattell, N.S. New English Grammar. Cambridge, Ma.: M.I.T. Press, 1969.
- Chomsky, C. The acquisition of syntax in children from 5 to 10. Cambridge: M.I.T. Press, 1969.
- Chomsky, C. Reading, Writing, and Phonology. Harvard Educational Review, 1970, 40, 287-309, reprinted in F. Smith (Ed), Psycholinguistics and Reading. New York: Holt, Rinehart, and Winston, 1973
- Chomsky, N. Syntactic structures, The Hague: Mouton, 1957.
- Chomsky, N. Aspects of the Theory of Syntax. Cambridge, Mass. MIT Press, 1965.
- Chomsky, N. Reflections on Language. New York: Random House, 1976.
- Chomsky, N., & Halle, M. Sound pattern of English. New York: Harper and Row, 1968.
- Dale, P.S. Language Development. Hinsdale, Ill.: Dryden Press, 1972.
- Donaldson, M. Prepared comment on paper by D. McNeill. In Psycho-linguistics Papers, J. Lyons & R.J. Wales (Eds.). Edinburgh: Edinburgh University Press, 1966.
- Fillmore, Charles J. The case for case. In E. Bach & R. T. Harms (Eds.), Universals in linguistic theory. New York: Holt, Rinehart & Winston, 1968.
- Fodor, J.A., Bever, T.G., & Garrett, M.F. The psychology of language: an introduction to psycholinguistics and generative grammar. New York: McGraw-Hill, 1974.
- Fodor, J.A., & Garrett, M.F. Competence and Performance. In J. Lyons & R. Wales (Eds.), Psycholinguistic papers. Edinburgh: University of Edinburgh Press, 1966.
- Fodor, J.A., & Garrett, M.F. Some syntactic determinants of sentential complexity. Perception and Psychophysics, 1967, 2, 289-296.

- Fodor, J.A., Garrett, M.F., & Bever, T.G. Some syntactic determinants of sentential complexity, II: Verb structure. Perception and Psychophysics, 1968, 3, 453-461.
- Ford, w., & Olson, D. The Elaboration of the Noun Phrase in Children's Description of Objects. Journal of Experimental Child Psychology, 1975, 19, 371-382.
- Forster, K.I. Visual perception of rapidly presented word sequences of varying complexity. Perception and Psychophysics, 1970, 8, 215-221.
- Foss, D.J. Some effects of ambiguity upon sentence comprehension. Journal of Verbal Learning and Verbal Behavior, 1970, 9, 699-706.
- Fraser, B. Optional rules in grammar. 23rd Annual Round Table Monograph No 25, Georgetown University, 1972.
- Fromkin, V.A. The Formal Nature of Language and Linguistic Theories. In Carterette, E.C. & Friedman, M.P. (Eds.), Handbook of Perception, Vol. VII: Language and Speech. New York: Academic Press, 1976.
- Garrett, M.F., Bever, T.G., & Fodor, J.A. The active use of grammar in speech perception. Perception and Psychophysics, 1966, 1, 30-32.
- Goldman-Eisler, F., & Cohen, M. Is N, P, and NP difficulty a valid criterion of transformational operations? Journal of Verbal Learning and Verbal Behavior, 1970, 9, 161-166.
- Gough, P.B. Grammatical transformations and speed of understanding. Journal of Verbal Learning and Verbal Behavior, 1965, 4, 104-111.
- Grice, H.P., Implicature. In P. Cole and J. Morgan (Eds), Syntax and Semantics Volume 3: Speech Acts. New York: Academic, 1975.
- Harris, R.J. Children's comprehension of complex sentences. J. Exper. Child Psychol., 1975, 19, 420-433.
- Jarvella, R. Syntactic processing of connected speech. Journal of Verbal Learning and Verbal Behavior, 1971, 10, 409-416.
- Johnson, N.F. The psychological reality of phrase structure rules. Journal of Verbal Learning and Verbal Behavior, 1965, 4, 469-475.

- Johnson-Laird, P.N. The perception and memory of sentences. In J. Lyons (Ed), New Horizons in Psycholinguistics. London: Penguin Books, 1970.
- Kaplan, K. Augmented transition networks as psychological models of sentence comprehension. Artificial Intelligence, 1972, 3, 77-100.
- Kempen, G. Syntactic Constructions as Retrieval Plans. Br. J. Psychol., 1976, 67(2), 149-160.
- Kleiman, G.M. "Speech Recoding in Reading." Journal of Verbal Learning and Verbal Behavior, 1975, 14, 323-339.
- Lesgold, A.M. Variability in Children's Comprehension of Syntactic Structures. Journal of Educational Psychology, 1974, 66(3), 333-338.
- Limber, J. Syntax and Sentence Interpretation. In E.C.T. Walker & R.J. Wales (Eds.), New approaches to Language Mechanisms Amsterdam: North-Holland, 1976.
- Mackay, D.G. To end ambiguous sentences. Perception and Psychophysics, 1966, 1, 426-436.
- Mackay, D.G., & Bever, T.G. In search of ambiguity. Perception and Psychophysics, 1967, 2, 193-200.
- Macnamara, J. Cognitive basis of language learning in infants. Psychological Review, 1972, 79, 1-13.
- Marslen-wilson, W. Linguistic Structure and Speech Shadowing at Very Short Latencies. Nature, 1973, 244, 522-523.
- Marslen-wilson, W. Sentence Perception as an Interactive Parallel Process. Science, 1975, 189, 226-227.
- McMahon, L. Grammatical analysis as part of understanding a sentence. Unpublished doctoral dissertation, Harvard University, 1963.
- McNeill, D. The development of language. In P.H. Mussen (Ed.), Carmichael's Manual of Child Psychology. New York: Wiley, 1970.
- Mehler, J. Some effects of grammatical transformations on the recall of English sentences. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 346-351.

- Mehler, J., & Carey, P. Role of surface and base structure in the perception of sentences. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 335-338.
- Menyuk, P. The acquisition and development of language. Englewood Cliffs, N.J.: Prentice-Hall, 1971.
- Miller, G.A. The magical number seven, plus or minus two. Psychological Review, 1956, 63, 81-97.
- Miller, G.A. Some psychological studies of grammar. American Psychologist, 1962, 17, 748-762.
- Miller, G.A., & Isard, S. Free Recall of self embedded English sentences. Information and Control, 1964, 7, 292-303.
- Olson, G.M., & Clark, H.H. Research Methods in Psycholinguistics. In Carterette, E.C. & Friedman, M.P. (Eds.), Handbook of Perception, Vol. VII: Language and Speech. New York: Academic Press, 1976.
- Palermo, D.S., & Molfese, D.L. Language acquisition from age five onward. Psychological Bulletin, 1972, 78, 409-427.
- Pearson, P. D. The effects of grammatical complexity on children's comprehension, recall, & conception of certain semantic relations. Reading Research Quarterly, 1974-75, 10 (2), 155-192.
- Perfetti, C.A., & Lesgold, A.M. Discourse Comprehension and Sources of Individual Differences. Paper presented at 12th annual Carnegie Symposium on Cognition. Carnegie-Mellon University, Pittsburgh, Pa., May 1976.
- Ricek, M.A. Reading comprehension of anaphoric forms in varying linguistic contexts. Reading Research Quarterly, 1976-7, 12, 145-165.
- Sachs, J. Recognition memory for syntactic and semantic aspects of connected discourse. Perception and Psychophysics, 1967, 2, 437-442.
- Savin, H., & Perchonock, E. Grammatical structure and the immediate recall of English sentences. Journal of Verbal Learning and Verbal Behavior, 1965, 4, 348-353.
- Schlesinger, I.M. Sentence structure and the reading process. The Hague: Mouton, 1968.

- Simon, H. A. How big is a chunk? Science, 1972, 183, 482-488.
- Slobin, D.I. Grammatical transformations and sentence comprehension in childhood and adulthood. Journal of Verbal Learning and Verbal Behavior, 1966, 5, 219-227.
- Slobin, D.I. The ontogenesis of grammar: Facts and theories. New York: Academic Press, 1971.
- Stronner, H., & Nelson, K.E. The Young Child's Development of Sentence Comprehension: Influence of Event Probability, nonverbal Context, Syntactic Form, and Strategies. Child Development, 1974, 45 567-576.
- Thorne, J., Bratley, P., & Dewar, H. The syntactic analysis of English by machine. In Micnie, D. (Ed.), Machine Intelligence 3. New York: American Elsevier, 1968.
- Turner, E.A., & Rommetveit, R. Focus of Attention in Recall of Active and Passive Sentences. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 543-548.
- wanner, E. Garden Paths in Relative Clauses. Paper given at Convocation on Communication, sponsored by AT&T and M.I.T. in Celebration of the Centennial of the Telephone, 1976.
- wanner, E., & Maratsos, M., An augmented transition network model of relative clause comprehension. Unpublished paper, Harvard University, 1974.
- watt, w.C. On Two Hypotheses Concerning Psycholinguistics. In J.R. Hayes (Ed.), Cognition and the Development of Language. New York: wiley, 1970.
- wingfield, A., & Klein, J.F. Syntactic structure and acoustic pattern in speech perception. Perception and Psychophysics. 1971, 9(1A), 23-25.
- woods, w.A. Transition Network Grammars for Natural Language Analysis, Communication of the ACM, 1970, 13, 591-606.
- Yngve, V.H The depth hypothesis. Proceedings of the XII Symposium in Applied Mathematics. Providence, RI: American Mathematical Society, 1961.

CENTER FOR THE STUDY OF READING

TECHNICAL REPORTS

- No. 1: Halff, H. M. Graphical Evaluation of Hierarchical Clustering Schemes, October 1975.
- No. 2: Spiro, R. J. Inferential Reconstruction in Memory for Connected Discourse, October 1975.
- No. 3: Goetz, E. T. Sentences in Lists and in Connected Discourse, November 1975.
- No. 4: Alessi, S. M., Anderson, T. H., & Biddle, W. B. Hardware and Software Considerations in Computer Based Course Management, November 1975.
- No. 5: Schallert, D. L. Improving Memory for Prose: The Relationship Between Depth of Processing and Context, November 1975.
- No. 6: Anderson, R. C., Goetz, E. T., Pichert, J. W., & Halff, H. M. Two Faces of the Conceptual Peg Hypothesis, January 1976.
- No. 7: Ortony, A. Names, Descriptions, and Pragmatics, February 1976.
- No. 8: Mason, J. M. Questioning the Notion of Independent Processing Stages in Reading, February 1976.
- No. 9: Siegel, M. A. Teacher Behaviors and Curriculum Packages: Implications for Research and Teacher Education, April 1976.
- No. 10: Anderson, R. C., Pichert, J. W., Goetz, E. T., Schallert, D. L., Stevens, K. V., & Trollip, S. R. Instantiation of General Terms, March 1976.
- No. 11: Armbruster, B. B. Learning Principles from Prose: A Cognitive Approach Based on Schema Theory, July 1976.
- No. 12: Anderson, R. C., Reynolds, R. E., Schallert, D. L., & Goetz, E. T. Frameworks for Comprehending Discourse, July 1976.
- No. 13: Rubin, A. D., Bruce, B. C., & Brown, J. S. A Process-oriented Language for Describing Aspects of Reading Comprehension, November 1976.
- No. 14: Pichert, J. W., & Anderson, R. C. Taking Different Perspectives on a Story, November 1976.
- No. 15: Schwartz, R. M. Strategic Processes in Beginning Reading, November 1976.
- No. 16: Jenkins, J. R., & Pany, D. Curriculum Biases in Reading Achievement Tests, November 1976.
- No. 17: Asher, S. R., Hymel, S., & Wigfield, A. Children's Comprehension of High- and Low-Interest Material and a Comparison of Two Cloze Scoring Methods, November 1976.
- No. 18: Brown, A. L., Smiley, S. S., Day, J. D., Townsend, M. A. R., & Lawton, S. C. Intrusion of a Thematic Idea in Children's Comprehension and Retention of Stories, December 1976.

- No. 19: Kleiman, G. M. The Prelinguistic Cognitive Basis of Children's Communicative Intentions, February 1977.
- No. 20: Kleiman, G. M. The Effect of Previous Context on Reading Individual Words, February 1977.
- No. 21: Kane, J. H., & Anderson, R. C. Depth of Processing and Interference Effects in the Learning and Remembering of Sentences, February 1977.
- No. 22: Brown, A. L., & Campione, J. C. Memory Strategies in Learning: Training Children to Study Strategically, March 1977.
- No. 23: Smiley, S. S., Oakley, D. D., Worthen, D., Campione, J. C., & Brown, A. L. Recall of Thematically Relevant Material by Adolescent Good and Poor Readers as a Function of Written Versus Oral Presentation, March 1977.
- No. 24: Anderson, R. C., Spiro, R. J., & Anderson, M. Schemata as Scaffolding for the Representation of Information in Connected Discourse, March 1977.
- No. 25: Pany, D., & Jenkins, J. R. Learning Word Meanings: A Comparison of Instructional Procedures and Effects on Measures of Reading Comprehension with Learning Disabled Students, March 1977.
- No. 26: Armbruster, B. B., Stevens, R. J., & Rosenshine, B. Analyzing Content Coverage and Emphasis: A Study of Three Curricula and Two Tests, March 1977.
- No. 27: Ortony, A., Reynolds, R. E., & Arter, J. A. Metaphor: Theoretical and Empirical Research, March 1977.
- No. 28: Ortony, A. Remembering and Understanding Jabberwocky and Small-Talk, March 1977.
- No. 29: Schallert, D. L., Kleiman, G. M., & Rubin, A. D. Analysis of Differences Between Oral and Written Language, April 1977.
- No. 30: Goetz, E. T., & Osborn, J. Procedures for Sampling Texts and Tasks in Kindergarten through Eighth Grade, April 1977.
- No. 31: Nash-Webber, B. Anaphora: A Cross-Disciplinary Survey, April 1977.
- No. 32: Adams, M. J., & Collins, A. A Schema-Theoretic View of Reading Comprehension, April 1977.
- No. 33: Huggins, A. W. F. Syntactic Aspects of Reading Comprehension, April 1977.
- No. 34: Bruce, B. C. Plans and Social Actions, April 1977.
- No. 35: Rubin, A. D. Comprehension Processes in Oral and Written Language, April 1977.
- No. 36: Nash-Webber, B., & Reiter, R. Anaphora and Logical Form: On Formal Meaning Representations for Natural Language, April 1977.

- No. 37: Adams, M. J. Failures to Comprehend and Levels of Processing in Reading, April 1977.
- No. 38: Woods, W. A. Multiple Theory Formation in High-Level Perception, April 1977.
- No. 39: Nickerson, R. S., & Adams, M. J. Uses of Context in Speech Understanding and Reading, April 1977.
- No. 40: Brown, J. S., & Collins, A. Model-Based Versus Text-Based Reasoning, April 1977.
- No. 41: Anderson, R. C., & Pichert, J. W. Recall of Previously Unrecallable Information Following a Shift in Perspective, April 1977.
- No. 42: Mason, J., Osborn, J., & Rosenshine, B. A Consideration of Skill Hierarchy Approaches to the Teaching of Reading, April 1977.
- No. 43: Collins, A., Brown, A. L., Morgan, J. L., & Brewer, W. F. The Analysis of Reading Tasks and Texts, April 1977.
- No. 44: McClure, E. Aspects of Code-Switching in the Discourse of Bilingual Mexican-American Children, April 1977.
- No. 45: Schwartz, R. M. Relation of Context Utilization and Orthographic Automaticity in Word Identification, May 1977.
- No. 46: Anderson, R. C., Stevens, K. C., Shifrin, Z., & Osborn, J. Instantiation of Word Meanings in Children, May 1977.
- No. 47: Brown, A. L. Knowing When, Where, and How to Remember: A Problem of Metacognition, June 1977.
- No. 48: Brown, A. L., & DeLoache, J. S. Skills, Plans, and Self-Regulation, July 1977.
- No. 49: Goetz, E. T. Inferences in the Comprehension of and Memory for Text, July 1977.
- No. 50: Anderson, R. C. Schema-Directed Processes in Language Comprehension, July 1977.
- No. 51: Brown, A. L. Theories of Memory and the Problems of Development: Activity, Growth, and Knowledge, July 1977.
- No. 52: Morgan, J. L. Two Types of Convention in Indirect Speech Acts, July 1977.
- No. 53: Brown, A. L., Smiley, S. S., & Lawton, S. C. The Effects of Experience on the Selection of Suitable Retrieval Cues for Studying from Prose Passages, July 1977.
- No. 54: Fleisher, L. S., & Jenkins, J. R. Effects of Contextualized and Decontextualized Practice Conditions on Word Recognition, July 1977.

- No. 55: Jenkins, J. R., & Larson, K. Evaluating Error Correction Procedures for Oral Reading, August 1977.
- No. 56: Anderson, T. H., Standiford, S. N., & Alessi, S. M. Computer Assisted Problem Solving in an Introductory Statistics Course, August 1977.
- No. 57: Barnitz, J. Interrelationship of Orthography and Phonological Structure in Learning to Read, August 1977.
- No. 58: Mason, J. M. The Role of Strategy in Reading in the Mentally Retarded, September 1977.
- No. 59: Mason, J. M. Reading Readiness: A Definition and Skills Hierarchy from Preschoolers' Developing Conceptions of Print, September 1977.
- No. 60: Spiro, R. J., & Esposito, J. J. Superficial Processing of Inferences Presented in Text, October 1977.
- No. 61: Spiro, R. J., & Smith, D. Distinguishing Sub-Types of Poor Comprehenders: Overreliance on Conceptual vs. Data-Driven Processes, October 1977.
- No. 62: Spiro, R. J., & Rittenhouse, R. K. Attribute Clarity in Conservation Instructions and Horizontal Décalage in Normal Hearing and Deaf Children, October 1977.
- No. 63: Spiro, R. J., & Anderson, M. C. Theme and Subordination in Sentence Recall, October 1977.
- No. 64: Spiro, R. J., & Martin, J. E. Contextual Factors in the Recall of Alternative Surface Structures, October 1977.
- No. 65: Brewer, W. F. Memory for the Pragmatic Implications of Sentences, October 1977.

This page is intentionally blank.

