

THE INTERACTION OF PERCEPTION AND LINGUISTIC STRUCTURES: A PRELIMINARY INVESTIGATION OF NEO-FUNCTIONALISM

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1. INTRODUCTION AND SUMMARY

We can all agree that the capacity to symbolize and communicate with language has powerful effects on how we think and behave, but how does the way we think and behave affect the structure of our language? The present paper explores the ways in which specific properties of language structure and speech behavior reflect certain perceptual laws.

Recent investigations of language have made an important simplifying assumption: the primary subject for linguistic description is linguistic *knowledge*, as opposed to linguistic *behavior*. This heuristic strategy has facilitated progress in the formal description of the 'abstract' structure of language, but has left open the question of how such structures are learned by children and utilized by adults. Previous attempts to integrate linguistic structure and speech behavior have been to find direct mappings of abstract linguistic structures onto language learning, speech perception and speech production. Although the details of these mappings differ, the basic postulate is the same: actual speech behavior is some describable function of the abstract linguistic structure originally isolated in linguistic investigations. That is, grammar rests at the epicenter of all language behavior, with various different functions of grammatical structure accounting for different kinds of behaviors (e.g. talking, listening, memorizing, etc.).

This paper begins an exploration of an expanded approach to the study of language; as a conceptual and communicative system which recruits various kinds of human behaviors, but which is not exhaustively manifested in any particular form of language behavior. That is, the concept of 'language' is like the concepts of 'species' or 'organ' as they are used in biological science. In the study of language, there is no aspect of language which can be specified as *the* uniquely central aspect. This is true even of linguistic grammars, which at first have been taken as *the*

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essential structure inherent in language behavior. Yet grammatical structure 'is' the language only given the child's intellectual environment provided by a society and the processes of physiological and cognitive development which are the basis for language behavior.

Language has various manifest subsystems, each of which draws on and contributes to structural constraints on the structure used by every other linguistic subsystem. During the first decade of his life, a child simultaneously learns all these systems — primarily how to talk in sentences, how to understand sentences, and how to predict new sentences in his language. These and other skills can mutually influence each other as the child acquires them and as they are integrated in adult language behavior. Consequently our first task in the study of a particular regularity in adult language behavior is to ascertain its source rather than immediately assuming that it is *grammatically* relevant.

Recent attempts to construct linguistic 'grammars' are intended to describe our ideal knowledge of a language (as revealed by our intuitions about potential sentences) rather than how we can use that knowledge. Accordingly, in recent considerations of language learning, attention has been focussed on the acquisition of linguistic competence as isolated in linguistic investigations of grammar. This view of language 'structure' and its development in children isolated from the rest of cognitive development has been too narrow. Many aspects of adult language are due to the interaction of grammar with the processes of actually learning and using language in the child. Certain ostensibly grammatical structures may develop out of other behavioral systems rather than being inherent to them. That is, linguistic structures that appear are partially determined by the learning and behavioral processes which are involved in acquiring and implementing linguistic capacity.

The main example of such an interaction discussed in this paper is the effect of perceptual strategies in the child and adult on both linguistic structure and the relative acceptability of certain kinds of sentences. Since adult linguistic ability includes the ability to talk in sentences, to listen to sentences, and to produce intuitions about sentences, the child must simultaneously acquire 'concrete' behavioral systems for actually talking and listening as well as an 'abstract' appreciation of linguistic structure itself. It is clear that the child tends not to learn sentence constructions which are hard to understand or say: some formally simple linguistic structures will never appear in any language because no child can use them. In this way the child's systems for talking and listening partially determine the form of linguistic structure even as the structure is being learned and used by the child. Thus, the way we use language as we learn it can determine the manifest structure of language once we know it.

The demonstration of this thesis proceeds in several steps. First, I outline a study of the relations between perceptual mechanisms and conceptual structure in the child and adult; the capacity to judge relative numerosity of visual arrays. Adults can make such judgments using three different kinds of mechanisms, de-

pendence on basic perceptual mechanisms (e.g. numerosity detectors), dependence on superficial perceptual strategies, or dependence on an internalization of the structure of integers. In acquiring these capacities, children pass through three stages, each of which is successively dominated by one of the modes of adult functioning (in the order just given).

Second, I show that language is processed by adults in the same three modes and that, in acquiring language, children are relatively dependent on each of the three successive modes. In particular, speech comprehension in the child from 3-4 is relatively dependent on behavioral strategies rather than primitive mechanisms or sophisticated structural knowledge.

Third, I suggest that the properties of the perceptual system for speech affect adult linguistic structure, since the young child may learn certain linguistic structures only *after* he has acquired many perceptual mechanisms. Finally, I show that, in fact, many linguistic structures in adult language are clearly determined by the behavioral systems of speech perception in the young child and adult. This demonstration may be viewed as an attempt to specify the dynamic interaction between structural aspects and communicative functions of language.

It would be tempting to argue that these investigations reduce the extent to which language can be viewed as peculiarly innate, since they show that certain aspects of linguistic structure are direct reflections in language of our general cognitive structure and its development. However, this would be like arguing that the physiological structure of joints and of reciprocal muscular inhibition *explains* the fact that we can walk upright. While it is true that our walking capacity depends on certain anatomical structures, the mere presence of the structures themselves does not explain why we walk, nor does it even explain how the anatomical structures are recruited by walking behavior. In each case in which we discover neurophysiological substrata involved in specific behavior systems, the problem is merely made more precise: how do the behavioral systems recruit and organize such neurophysiological capacities? The argument in this paper, that language structure and behavior are the joint product of both linguistic and psychological structures, leaves us with the analogous question: how does the instinct to communicate integrate the distinct components of perception, cognition and motor behavior into human language?

2. JUDGMENTS OF RELATIVE NUMEROSITY

In our research we have distinguished three aspects of cognition for separate study: basic capacities, behavioral strategies and epistemological structures (see Mehler and Bever 1968b; Bever 1969). First we investigate the *basic capacities* which appear in young children without obvious or specific environmental training. Consider, for example, the two-year-old's capacity to judge numerical inequalities (Mehler and Bever 1968a; Bever, Mehler, and Epstein 1968), or his ability to pre-

dicate actions with verbs in speech (Bever, Mehler, Valian, Epstein and Morrissey, in preparation). Second, in both perceptual and productive behavior children and adults utilize many systems of *behavioral strategies* to shortcut the internal structure implied by the regularities in their behavior. For example, to make relative judgments of large numbers, we may suspend our knowledge of integers and counting, and simply use the perceptual rule that an array that 'looks' larger has more components; or if we hear a series of words with only one reasonable semantic connection (e.g. 'dog bite cracker') then we suspend any further perceptual analysis of the speech signal and assume that the sentence follows the usual semantic constraints on the relations among the words ('dog', 'bite', 'cracker'). Finally, as adults, we have a set of *epistemological structures* — systematic generalizations of our intuitions about the regularities in our own behavior. Consider, for example, the theoretical concept of an integer and counting which we can use in justifying our judgments of quantities; or the intuition of relative 'grammaticality' that a parent uses to guide a child's speech and a linguist depends on for the isolation of linguistically relevant data.

All three aspects of cognitive behavior are simultaneously present in the adult. Consider first the case of number: when presented with an array such as that in example 1 and asked to judge which row has more circles in it we can either count the circles in each row and see which number is larger, use the generalization that a row that looks larger has more components in it, or depend on elementary capacities to come to an immediate decision. Which of these strategies we deploy will depend on the clarity and duration of the stimuli, the penalty for an incorrect answer, and so on.

1 o o o o o
 oooo

Children do not appear to have the choice among these three strategies that adults have. Our research into the acquisition of the ability to judge numerical inequalities in arrays like 1 shows that at different periods the child's behavior appears to be dependent on one or another of the strategies. For example, children of 2/0 to 3/0 make correct judgments on which row has more circles in example 2, although they do not count the number in each row. It is not the case that they are choosing on the basis of density in 2a and 2b since at the same age they have no tendency to pick the denser of the two in a situation like 3 as having 'more'.

2	o o o o o o o o oooo
	oooooo o o oo oo o o o o o
	a b c
3	o o o o oooo

The children are not merely choosing the longer row as having 'more' since they

choose correctly in **2a** as well as **2c**. Thus, we must conclude that young children have a primitive capacity to appreciate the relative numerosity of small arrays even though they cannot count and do not have an (explicit) notion of integers. Six-year-olds, on the other hand, also perform correctly on judging the more numerous row in the arrays in **2**, but they generally count the two rows in each case, or they perform a 1-1 matching operation to see which row has some circles left over after the matching. Both of these operations depend on a psychological notion of integers (or 'countable units') and their relation to external objects. (Note that it is not necessary to claim that these children understand the concept of integer in any deep mathematical sense.)

Between the ages of 3 and 5 the child appears to depend on the generalization that larger arrays have 'more' components. For example, their performance is worse on **2a** than that of younger and older children (Fig. 1) while their tendency to choose the longer row as having more in **3** goes up from 60% at age 2 to 100% at age 3.

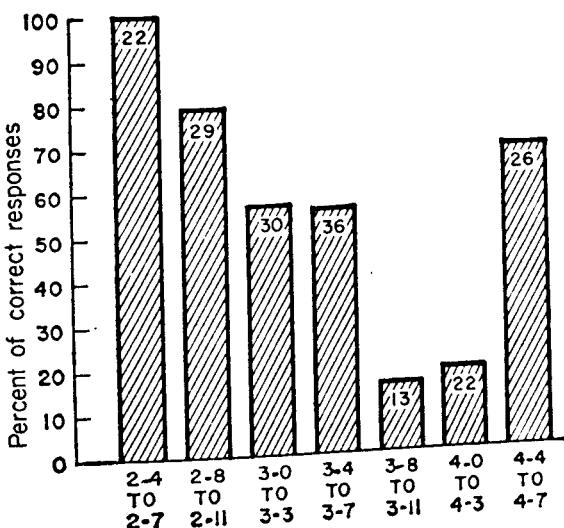


Fig. 1. The proportion by age of responses choosing the row with more members in **2a** (numbers inside bar indicate the number of children interviewed at that age) (see text; taken from Fig. 2 in Mehler and Bever 1967).

It is an open question at the moment whether such perceptual strategies are learned as inductions across experience (since it is probably true that most things which 'look' larger do have more parts) or whether the strategies appear as a result of internal maturation. On either interpretation the child successively displays dependence on the three types of thinking: use of basic mechanisms, behavioral generalizations, and epistemological systems. Thus, the study of the child at different ages can isolate and lay bare the operation of the different types of thought processes which are often integrated inextricably in adult thinking.

3. THREE ASPECTS OF LANGUAGE BEHAVIOR

We have been able to pursue the same sort of combined study of adult behavior and its development in children with respect to language. In this section, I first explore the interaction of three linguistic systems analogous to those for the adult's perception of numerosity, and then demonstrate that the child's behavior depends primarily on each of three systems at different points in his development.

3.1 *Basic Linguistic Capacities and Epistemological Structures*

In this discussion, I shall largely take for granted the fact that *basic linguistic capacities*, and *linguistic intuitions* are relatively clear concepts, while *perceptual strategies* of speech require more careful exposition. In the first place, it is clear that all adults have the *basic capacity* to understand that words refer to objects and actions, and to understand the basic relational concepts of 'actor, action, object' (as grammatical relational concepts). It is (almost as) clear that adults can make sophisticated phenomenological judgments about the sentences in their languages. Thus, adults can recognize that 4a is a sentence and 4b is not; that 4d-e are ambiguous but in different ways; that while 4f and 4g mean the same they are not related in the way that 4g and 4h,i are; that unacceptability of 4k is because of what it says, but the unacceptability of 4l is because of how it says it, and so on. All of these judgments require that the adult have the concept of the language as a system independent of any actual use, that he be able to consider the potential usability of

- 4 a) He kicked the can
- b) Can the kicked he
- c) The file is on the floor
- d) He read carefully prepared papers
- e) The missionary is ready to eat
- f) The cockroach died from the poison
- g) The poison killed the cockroach
- h) The cockroach was killed by the poison
- i) It's the poison that killed the cockroach
- j) Did the poison kill the cockroach?
- ?k) The cockroach then wrote me an unwritten letter complaining about the poison
- *l) I be replying politely please for not to bug me

a sentence, and the relations among potential sentences. It is in this sense that the capacity to have linguistically relevant intuitions is an example of the kinds of phenomenological systems we can construct to capture and extrapolate on the regularities implied by our own actual behavior.

A generative grammar attempts to provide a description of the structural basis or intuitions about sentences like the above. The basic intuitions of *sentencehood* (e.g. that 4a is part of the language and 4b is not) is accounted for if the grammar provides a description only for those sequences that are accepted as sentences. The structural descriptions are correct insofar as they provide the basis for intuitions about the relations among sentences such as the different types of ambiguity in 4c-e or relations between specific classes of sentences such as those represented by 4g ('active'), 4h ('passive'), 4i ('cleft sentence'), or 4j ('question').

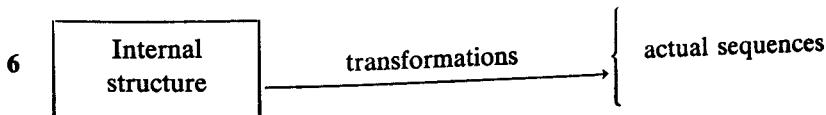
Current transformational grammars represent the traditional notion that sentences have two structural levels of description, the basic internal grammatical relations among phrases, 'actor, action, object, modifier', and the explicit relations among adjacent phrases in the actual appearance of the sentence. For example, sentences 4g-j all have the basic relations outlined in 5, while the superficial relations are obviously different. A transformational grammar represents the relations

5 actor ('instrument') = the poison

action = kill

object = the cockroach

between the internal and external form of a sentence with a set of rules ('transformations') which map abstract internal structures such as that represented in 5 onto actual sequences.



For example, a passive transformation applies to 5 to place the internal object at the front of the actual sentence and the actor at the end of the actual sentence; a question transformation inserts a form of the auxiliary verb 'do' at the beginning of the sentence. Accordingly, the variety of transformations can account for the fact that a variety of actual sequences (e.g. 4g-j) can share the same internal structure (e.g. 5).

The fact that every sentence has an internal and external structure is maintained by all linguistic theories — although the theories may differ as to the role the internal structure plays within the linguistic description.

3.2 Strategies of Speech Perception

Talking involves actively mapping internal structures onto external sequences, and comprehension involves mapping external sequences onto internal structures. In addition to basic linguistic capacities and systematic sets of structural intuitions,

adult language behavior of talking and listening depends on behavioral inductions. Our most intensive research has been devoted to exploring the role of these inductions in speech perception. In a recent paper, Fodor and Garrett (1966) reviewed the experimental evidence in favor of the working hypothesis that the perceptual operations which map external sequences onto internal structures are themselves directly related to the grammatical transformations specified within a grammar, i.e. the view that for every linguistic transformation involved in the linguistic analysis of the relation between the internal and external structure there corresponds one perceptual 'decoding' operation. Fodor and Garrett argue that this view leads to an empirical prediction that the psychological complexity of a sentence is proportional (or at least monotonically related) to the number of transformations involved in the grammatical description of that sentence. On this view the passive construction is harder to understand than the active because one more rule is used in the grammatical derivation of the passive sequence than the active sequence. Fodor and Garrett review the evidence for the general claim that the relative number of rules predicts perceptual complexity and conclude that the evidence is unconvincing. There are cases in which added transformations do not involve added behavioral complexity. First, transformational rules which delete internal structures do not necessarily involve added complexity; e.g. 7a is not more complex than 7b; in fact, 7a is *less* complex psychologically, although more complex grammatically.

- 7 a) The dog was called
 b) The dog was called by someone

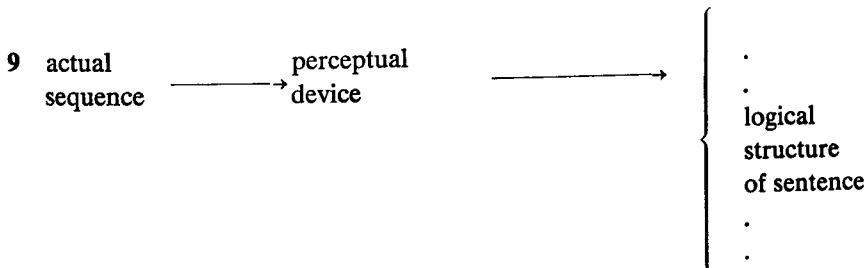
The second type of failure of added grammatical transformations to predict added psychological complexity is in certain recording transformations. Thus 8a is obviously not more complex to understand than 8b, 8c is not more complex to understand than 8d and 8e is not more complex than 8f.

- 8 a) The small cat is on the grass mat
 b) The cat that is small is on the mat that is made of grass
 c) The operator looked the address up
 d) The operator looked up the address
 e) It amazed Bill that John left the party angrily
 f) That John left the party angrily amazed Bill

Fodor and Garrett conclude from such examples and their review of the experimental literature that the relation between grammatical rules and perceptual operations is 'abstract' rather than direct. This negative point has clarified many issues for us but has left open what the actual nature of the operations of speech perception is. In the following section, I outline the positive evidence which bears on the processes of speech perception and the role of perceptual strategies in mapping external sequences onto internal structures.

3.21 Segmentation strategies

Recently, a great deal of attention has been given to the 'psychological reality' of the structures and rules postulated in transformational grammars. The most notable success has been to show both by experiment and appeal to intuition that the form in which sentences are understood and memorized corresponds closely to the logical structure internal to them (see Miller 1963; Mehler 1963; Mehler and Bever 1968b). Thus, any model for speech perception proposed in this tradition includes a device which isolates the internal structure corresponding to each lexical sequence.



For such a perceptual device to operate efficiently, the actual sequence of words in a speech utterance must be segmented into those subsequences which correspond to a full sentence at the internal structure level. For example, if one hears the sequence represented phonetically in 10, one must decide that it has two distinct sentences corresponding to it at the underlying structure level, and not more nor less.

10 *ðəboylayksgarlzgarlzlavboyz* (i.e. '*the boy likes girls girls love boys*'')

Failure to find the correct basic segmentation into sequences which do correspond to underlying structure sentences would seriously degrade comprehension. For example, suppose that a listener assumed that the second instance of 'girls' above was actually a spurious repetition: then he would be faced with finding an underlying structure for the following: *The boy likes girls love boys*. The problem is that this sequence has no single underlying syntactic structure.

There is no known automatic procedure which insures the proper segmentation of actual sequences. In cases like the above, however, pronunciation often provides many cues which indicate where the segmentation into basic sentences should occur. The operation of this segmentation strategy to separate sentences in a discourse like 10 can utilize many situational, semantic and pronunciation cues. The segmentation problem is much more complex, however, for sentences embedded within other sentences. Consider 11a for example:

11a *when he left everybody grew sad*

This has two deep structure sentences, each one corresponding to one of the 'clauses' in the apparent sequence: ('*when he left, everybody grew sad*'). I shall

represent this structure division into clauses at the surface structure level with parentheses '()' and the corresponding internal structure segmentation with brackets '[]', e.g. 11b.

11b ([when he left]) ([everybody grew sad])

If the wrong perceptual segmentation were attempted, then further perceptual analysis of the sentence would be impossible. For example, the listener might initially segment the first four words into a sequence bound together by an internal structure (i.e. 'when he left everybody...'), but would then have two words left over ('grew sad') with no possible segmentation deriving from another internal structure sentence.

A recent series of experiments have given initial support to the postulation of a perceptual strategy of isolating lexical sequences which correspond directly to underlying structure sentences (Fodor and Bever 1965; Fodor, Garrett, and Bever 1966; Bever, Fodor, and Garrett 1966). These investigations have studied the perception of non-speech interruptions in sentences with two clauses. The basic finding is that subjects report the location of a single click in a sentence as having occurred towards the point between the clauses from its objective location. For example, Fodor and Bever found that in sentence 12 a click objectively located in 'yesterday' or in 'the' was most often reported as having occurred between those two words. Fodor and Bever argued that the systematic displacement of the click towards the point between clauses showed that the clause has relatively high psychological coherence, since it 'resists' interruption by the click.

12 because it rained yesterday the picnic will be cancelled

Several experiments have shown that this systematic effect of the syntactic segmentation is not due to any actual pauses or cues in the pronunciation of the sentence. First, Fodor, Garrett, and Bever used materials in which the exactly identical acoustic sequence was assigned different clause structures depending on what preceded. (Consider the sequence '... eagerness to win the horse is quite immature'. If it is preceded by 'your...', then the clause break immediately follows 'horse'. But if that sequence is preceded by 'In its...', then the clause break immediately follows 'win'. The authors cross-recorded one initial sequence or the other and tested subjects on their ability to locate clicks in the different sentences.) The results showed that the clause structure assigned each sequence 'attracted' the subjective location of the clicks. Bever and Abrams (1969) found similar results with sentences constructed by splicing words from a random list.

Scattered through the materials in these experiments were sentences which did not consist of two entirely separate clauses in the external structure, but which had one clause embedded within another. For example, in the sentences 13a,b, there are two sentences at the level of internal structure, but they are not literally re-

- 13 a) ([the man ([who nobody likes]) is leaving soon])
 b) ([nobody likes the man ([who is leaving soon])])

flected in an organization into distinct uninterrupted sequences in the actual sentence. Nevertheless, Fodor and Bever found that the points at the extremes of the embedded clauses are as effective in attracting the subjective location of clicks as they are in sentences with two entirely separate clauses.

In certain cases in the previous experiments, two internal structure sentences corresponded to a sequence in which the division into two clauses was even less obvious in the actual structure. Consider 14a:

- 14 a) ([[the reporters assigned to George] drove to the airport])
 b) ([the reporters ([who were assigned to George]) drove to the airport])

The sequence '... assigned to George ...' does not have the same distinctiveness as a clause in the surface structure of 14a as in 14b. Nevertheless, sentences in which the surface structure does not obviously reflect the underlying structure, like 14a, were found to affect the subjective location of clicks (e.g. clicks were displaced perceptually to the point following 'George').

These data suggest that a fundamental reflection of the perceptual organization of a string of words is the isolation of those adjacent phrases in the surface order which together could correspond to sentences at the level of internal structure (Strategy A). This perceptual strategy would generate the experimental prediction 15 for the location of clicks.

Strategy A: Segment together any sequence X ... Y, in which the members could be related by primary internal structural relations, 'Actor action object ... modifier'.

- 15 Errors in location of clicks presented during sentences are towards those points which are external reflections of (potential) divisions between internal structure sentences.

Various further experiments indicate that 15 is correct. First, some negative experiments which indicate that within-clause minor phrase structure divisions do not affect perceived click location. Bever, Kirk and Lackner (1969) used the same technique of click location in which they systematically varied the within-clause surface phrase structure of 25 sentences. They found no tendency for the number of errors into a break to be correlated with the relative depth of that break in the surface phrase structure. Bever, Lackner and Stoltz (1969) found no difference in the effect on click location of three kinds of within-clause structures; adjective-noun ('red ball'), verb-object ('hit ball'), and subject-verb ('ball hit'). Finally, Bever, Fodor and Garrett (1966) investigated the relative effectiveness of pairs of surface structure transitions which were superficially quite similar, but which differed by having or not having an 'S' node in the surface phrase structure tree. Consider the two sentences in 16:

- 16** a) they watched ([the light turn green])
 b) they watched ([the light green car])

The relevant difference between the two structures just after the verb is the presence of a S-node in the surface structure of the first sentence. Bever, Fodor, and Garrett found that this difference of a single node had profound effect on the pattern of errors in click placement. Together with the negative results from the other experiments, this finding supports the following initial conclusion: a relative increase in the number of surface structure nodes defines a perceptual unit only if the increase is due to an explicitly marked sentence-node in the surface structure.

Although negative experimental findings are always inconclusive, these experiments do indicate at least that within-clause structural breaks have far less effect on click location than breaks between clauses. More recent investigations have demonstrated that within-clause breaks do attract clicks if the listener has prior experience with the sentence or more time to retain the sentence before writing down the click (cf. Bever 1970). Several other experiments indicate that points in the surface which correspond to underlying structure divisions do attract clicks, even in the absence of major division between apparent clauses. Bever, Kirk, and Lackner found several instances among their 25 sentences in which a within-clause phrase structure break corresponded to a division between sentences in the internal structure. These breaks did attract the subjective location of clicks. In a second experiment, they found that subjects locate clicks subjectively between a verb and its complement object significantly more for 'noun-phrase' complement verbs (e.g. 17a) than for 'verb-phrase' complement verbs (e.g. 17b).

- 17** a) 1[they desired 2[the general to fight]2]
 b) 1[they defied 2[the general₁] to fight]₂

These results demonstrate that prediction 15, and by assumption Strategy A, are correct. Perceptual segmentation proceeds primarily in terms of internal structure organization into sentences. However, there are various difficulties with each of the experiments we have reviewed and further work is necessary. Furthermore, it is not clear whether *every* internal structure division has an effect on perceptual segmentation, or whether this effect is limited to those underlying structure sentences whose order is literally reflected in the surface structure (or which are marked by a sentence node in the surface structure) — for example, it is not clear that both the first and second italicized sequences below will be treated as a perceptual unit; they both derive from the same underlying sentences (reflected in *my steak is rare, my steak is tender*), but only the first preserves this order in the surface structure.

- 18** a) I like *my steak rare and tender*
 b) I like *my rare and tender steak*

Whatever the outcome of further experimentation, it is clear that the internal, logical relations are a major determiner of perceptual segmentation in speech processing. As we hear a sentence we organize it perceptually in terms of internal structure sentence units with subjects, verbs, objects, and modifiers.

Consider now the relation between Strategy A and a transformational grammar. Clearly Strategy A presupposes a distinction between internal and external structural relations. But there is no obvious way in which the grammatical transformations may themselves be transmuted into subcomponents of Strategy A. Rather, Strategy A is implemented on the basis of the knowledge of the possibility that a particular external form-class sequence could correspond to an internal structure. The possible external sequences are, of course, enumerated by the transformations, but not necessarily in a way which can be directly utilized in the process of perception. In fact, several experiments demonstrate that the application of the segmentation Strategy A is directly sensitive to knowledge of the potential internal/external relations which individual lexical items *can* have, as opposed to their actual deployment in a particular structure.

First, Kaplan and Kaplan showed recently (personal communication of pilot work) that subjects respond to the interruption of a sentence following an adjective like 'hard' (19a) faster than they responded to the interruption of a sentence ending with an adjective like 'eager' (19b).

- 19 a) the old general was hard . . .
 b) the old general was eager . . .

I suggest that this is because immediately following 'eager' the listener is processing an internal structure unit; while following 'hard' he is not. This is presumptively due to the fact that the listener makes immediate use of his knowledge that 'eager' *must* terminate an internal structure sentence, while 'hard' may or may not terminate such a unit. Consider the examples of the possible continuations of the sentence fragments in 19.¹ (Internal structural sentence boundaries are marked with brackets.)

- 20 a) The old general was [*hard to please*]
 b) [The old general was hard] and [wouldn't give up]
 c) [The old general [*was eager*] to please]
 d) [The old general was eager], and [wouldn't give up]

A second example of the use of knowledge of internal/external potentialities in applying Strategy A appears in Bever, Lackner, and Kirk's experiment on click

¹ There are many facts which motivate the distinction between the internal analyses of 20a and 20c. For example, consider the fact that 20a is related to 'it was hard to please the old general' while 20b is not related to * 'It was eager to please the general'. That is, the abstract sentences internal to 20a can be directly reflected in the actual sentences 'It was hard', or 'somebody pleased the general', while the sentences internal to 20c are reflected in 'The general was eager' or 'The general pleased someone'.

location (see above). Clicks were also placed in the noun phrase following the verbs for other groups of subjects. The numbers in sentences 21a,b below indicate the different objective click positions which were used. The experimenters found that the difference in subjective click location for the constructions in 21a,b was

- | | |
|---|---|
| 1 | 2 |
| 21 | |
| a) that general desired soldiers to fight | |
| 1 | 2 |
| b) that general defied soldiers to fight | |

primarily due to responses to clicks objectively in the verb (position 1). The previous studies of click location had shown that clicks following and preceding a clause break are reported as occurring in the clause break equally often — that is, it is not the case that pre-clause break clicks are more sensitive to structural effects. Bever, Lackner, and Kirk suggest that their results show that the listener segments the sequences by using information inherent to the potential internal structure/external structure pairs which each complement verb can have. Verbphrase complement verbs characteristically must have a direct object (e.g. 'soldiers') that is simultaneously subject of a complement sentence. In contrast to this, nounphrase complement verbs can have at least the following kinds of objects:

- 22**
- a) direct object which is also the subject of a complement sentence
 - b) a complement sentence as direct object
 - c) direct object which is also the direct object of a complement sentence
(e.g. if the complement sentence is in the passive)
 - d) direct object without any complement sentence
 - e) direct object which is a nominalized complement
 - f) complement sentence which has the same subject as the main verb

Thus, many of the possible constructions following a nounphrase complement verb begin a new sentence at the level of internal structure, while this is *never* the case with a verbphrase complement verb. The fact that in structurally homonymous sentences, clicks objectively in the verbs are located differently shows that listeners use the information contained in the verb to predict the internal structure segmentation. When a listener hears 'defy' he *knows* that a direct object must follow; when he hears 'desire' he knows that many constructions which follow begin a new internal structure unit. Accordingly, listeners establish segmentation following nounphrase complement verbs (e.g. 'desire'), but wait for the predictable object following verbphrase complement verbs (e.g. 'defy'). (By the time the listener reaches the following nounphrase (position 2), there is no further difference in the potential internal structure organization of the sentence, so there is no subjective difference in click location for clicks in that location.)

3.22 Relations between clauses

The need for Strategy A follows from the fact that most sentences have more than one internal clause. Not only must the different clauses be segregated from each other, but the internal relation between the two clauses must be marked. There are two basic types of relations, coordinate 23a and subordinate 23b-d. In coordinate constructions both clauses are structurally and conceptually on the same level, while in subordinate constructions the subordinate clause is embedded within a higher, 'main' clause: the main clause of such sentences expresses the primary

- 23 a) Wars are distasteful and politicians are always in favor of peace.
 b) Wars are distasteful although *politicians are always in favor of peace*.
 c) Wars *that are distasteful* are a source of political power.
 d) Everybody wants *wars to be distasteful*.

content of the sentence while subordinate clauses either modify that main content (as in 23b), supplement it (as in 23c), or express a presupposition underlying it as in 23d (e.g. the information reflected in the sentence, 'some wars are distasteful'). The clearest principle is that *ceteris paribus* the first N...V...(N) is taken to be the main clause (Strategy B).

Strategy B: The first N...V...(N)... clause (isolated by Strategy A) is the main clause, unless the verb is marked as subordinate.

In English, there are many specific morphemes which mark an initial verb as subordinate, and in such cases Strategy B does not apply.² However, various facts demonstrate the relative complexity of sentences in which the first verb is a subordinate verb. Consider first the sentences with a clause as subject 8e,f. The less complex version is clearly 8e in which the subordinate verb ('left') is not the first verb in the sequence. In a general study of subjective preference, Bever and Weksel (1967) found that subjects indicate a stylistic preference for sentences in which the subordinate clause (marked by a conjunction) follows the main clause (e.g. 24a as opposed to 24b). Clark and Clark (1968) found that sentences in which the sub-

- 24 a) The dog bit the cat because the food was gone
 b) Because the food was gone, the dog bit the cat

ordinate clause occurs first are relatively hard to memorize.

These observations do not bear directly on perceptual complexity. In an independent perceptual experiment, Savin found that sentences in which the first verb is in a relative clause (e.g. 25a) are more complex than sentences in which the first verb is the main-clause verb (e.g. 25b). In Savin's experiment fewer random words

² Note that such strategies capture generalizations which are *generally* true, but not necessarily always true. That is, there are exceptions to every strategy. The validity of each perceptual strategy is based on its contingent probability (given the perceptual decisions determined by preceding strategies).

- 25** a) The boy who likes the girl hit the man.
 b) The boy hit the man who likes the girl.

are recalled when preceding sentences like 25a and 25b.

Strategy B accounts for actual mistakes made in other comprehension experiments as well as accounting for the relative complexity of sentences in which the first verb is not the main verb. For example, Blumenthal (1967) examined the nature of errors which subjects make in attempting immediate recall of center-embedded sentences (37a). His conclusion was that the main strategy which subjects use is to assume that the first three nouns are a composed subject and that the three verbs are a compound action (as in 26b). That is, they impose a general 'subject-verb' schema onto what they hear.

- 26** a) The man the girl the boy met believed laughed
 b) *The man the girl and the boy met believed and laughed

In immediate comprehension I found that subjects cannot avoid assuming that an apparent 'NVN' sequence corresponds to a clause even when they are given explicit experience and training that this interpretation is incorrect. Subjects reported immediate paraphrases of center-embedded sentences with apparent NVN sequences (e.g. italicized in 27a).

- 27** a) *The editor authors the newspaper* hired liked laughed
 b) The editor the authors newspapers hired liked laughed

Even after eight trials (with different sentences) the subjects understood the sentences with this property less well than the sentences without it (e.g. 27b). That is, the 'NVN' sequence in 27a is so compelling that it may be described as a 'linguistic illusion' which training cannot readily overcome.

3.23 Functional labelling strategies

Not only must listeners isolate internal structure clauses and assign their relations to each other, listeners must also assign the internal structural relations which bind the constituent phrases in each internal sentence. To do this, listeners use a set of labelling strategies which draw on semantic information, probabilistic structural features and knowledge of the potential structure underlying specific lexical items.

3.231 Semantic strategies. A basic strategy for functional assignment is to combine the lexical items in the most plausible way. That is, we use Strategy C whenever possible to assign the correct internal relations within a potential unit independent of syntactic structure. For example, the three lexical items 'man' 'eats' and 'cookie' are internally related as in 'the man eats the cookie'. If Strategy B applies indepen-

Strategy C. Constituents are functionally related internally according to semantic constraints.

dently of the actual syntactic structure we might expect that sentences in which the semantic relations are unique are relatively easy. Schlesinger (1966) supported this prediction by showing that center-embedded sentences are easier to comprehend when the semantic subject-verb-objects are semantically constrained. That is, 28a is easier than 28b. Clark and Clark (1968) demonstrated that if the superficial order

- 28** a) the question the girl the lion bit answered was complex
 b) the lion the dog the monkey chased bit died

of a complex sentence reflects the actual order of described events, then the sentence is relatively easy to retain. That is, 29a and 29b are easier than 29c and 29d.

- 29** a) he spoke before he left
 b) after he spoke he left
 c) he left after he spoke
 d) before he left he spoke

There is some evidence that the presence of unique semantic constraints allows syntactic factors to be bypassed entirely. For example, Slobin (1966) found that the passive construction is no more difficult to verify (vis-a-vis pictures) than the active sentence when the semantic relations are unique. That is, 30a is no harder to verify than 30b, while 30c is harder than 30d. This finding was extended by

- 30** a) the cookie was eaten by the dog
 b) the dog ate the cookie
 c) the horse was followed by the cow
 d) the cow followed the horse

Turner and Rommetveit (1967). They showed that children (even in the first grade) respond correctly to a sentence like 30c only 50% of the time when they have to choose a picture appropriate to the sentence. Even at age 4, however, they respond correctly to semantically-constrained sentences like 30a.

In an ingenious experiment, Mehler and Carey (1968) collected further evidence that subjects may process meaning simultaneously with the processing of syntactic structure. They presented subjects with appropriate and inappropriate pictures followed by a single sentence; the task of the subjects was to indicate whether or not the picture was appropriate for the sentence. Two kinds of superficially similar sentences were used; progressive tense 31a and the participial construction 31b. They found that the latencies (i.e. response times) were relatively high for inappropriate pictures, and relatively high for the participial construction, which was assumed to have a relatively complex syntactic structure. On this basis one would

- 31** a) they are fixing benches
 b) they are performing monkeys

expect the following order of latencies (in order of increasing time to decide about the picture):

<i>construction</i>	<i>picture</i>	<i>predicted</i>	<i>observed</i>
PROGRESSIVE	appropriate	fastest	fastest
PROGRESSIVE	inappropriate	intermediate	all . . .
PARTICIPLE	appropriate	intermediate	the . . .
PARTICIPLE	inappropriate	slowest	same

However, they found that whether a sentence had the more complex syntax or the picture was inappropriate, or both, the reaction time was delayed the same amount. This suggests that subjects process meaning and structure *simultaneously* rather than in sequence; either a relatively complex structure or a complex meaning can add decision time, but since they are processed in parallel, having both a complex structure and a complex meaning doesn't add any extra time.

3.232 *Semantic strategies — Conclusion.* The preceding experiments demonstrate that the most likely semantic organization among a group of phrases can guide the interpretation of sentences, independently of and in parallel (at least functionally) with perceptual processing of the syntactic structure. The semantic constraints utilized in the previous experiments were necessarily removed from any natural context, so the effects of generic probability (e.g. men usually eat cookies, as opposed to the reverse; if one event precedes another we tend to talk about the first event first and in the main clause, etc.). In the actual application of language, specific contexts must provide far stronger immediate constraints and basis for prediction of the most likely meaning of a sentence independent of its form. Thus, much normal perceptual processing of sentences is probably carried out with little regard to actual sequence or structure; rather the basic relational functions (actor-action-object-modifier) are assigned on the basis of temporary ('contingent') and generic ('constant') semantic probabilities. Strategy C is clearly another perceptual process in which the knowledge of the linguistically defined syntactic derivational structure assigned to a particular sentence is not utilized actively in actual perception. Rather, as in the case of perceptual segmentation, listeners depend heavily on their knowledge of the properties of individual words and groups of words.

3.24 *Sequential labelling strategies*

However, we are capable of understanding sentences in which there are no differential semantic probabilities. Accordingly, a complete account of the mechanisms of speech perception must also include the capacity to analyze the structural relations within a sentence from pure sequential and syntactic information. There is a primary functional labelling strategy, based on the apparent order of the lexical items in a sentence, which applies in the absence of specific semantic information (Strategy D).

Strategy D. Any Noun-Verb-Noun (NVN) sequence within a potential internal unit in the surface structure corresponds to '*actor-action-object*'.

There is some recent experimental evidence which demonstrates the presence of this labelling strategy. The primary finding is that the passive construction is more complex to comprehend than the active (in the absence of semantic constraints, see above). For example, Slobin (1966) found that children verify pictures which correspond to active sentences more quickly than pictures corresponding to passive sentences. Also, McMahon (1963) (replicated by Gough 1966) found that generically true 33a, b or false 33c, d passives are harder to verify than the corresponding actives. Finally, Savin and Perchonock (1965) showed that the number of unrelated words which can be recalled immediately following a passive sentence is smaller than if the test words follow an active sentence. The passive construction

- 33 a) 5 precedes 13
 b) 13 is preceded by 5
 c) 13 precedes 5
 d) 5 is preceded by 13

specifically reverses the assumptions in Strategy D, which is the presumed explanation for the perceptual difficulty of the passive. Of course, the fact that the passive construction is relatively complex perceptually might also be due to its increased length, rather than to its increased transformational complexity. However, the facts pointed out above show that transformational complexity is itself not a *general* explanation of perceptual complexity. Only the explanation in terms of its violation of Strategy D is consistent with the following experiments.

In the picture-verification experiment by Mehler and Carey discussed above, it was found that the progressive form is significantly easier to understand than the superficially identical participial construction: the participial construction fails to preserve the NVN = *actor-action-object* property in its surface structure.

Recall that in both the experiment by Blumenthal and by me (see above), subjects' errors involved the assumption that the first noun or series of nouns in an apparent N . . . V . . . N . . . sequence is not only the grammatical subject in the external structure but also the actor in the internal structure. That is, listeners impose the 'actor-action (object)' organization on what they hear as part of the basis for segmentation of clauses.

Bever and Mehler (1969) found another example of this constructive tendency in an immediate recall experiment referred to above: listeners change a sentence they just heard to conform to an 'NVN' sequence. For example, in 34a the NVN sequence is maintained while in 34b it is interrupted:

- 34 a) Quickly the waiter sent the order back.
 b) The waiter quickly sent back the order.

In immediate recall, 87% of the syntactic order errors involved changing stimulus sentences like 34b to sentences like 34a rather than the reverse.

3.241 Lexical ordering strategy — Conclusion. These different experimental results converge on one common explanation: any NVN sequence in the surface structure is assumed to correspond directly to *actor-action-object* in the underlying structure. Like the semantic strategies, this process may reflect a statistical preponderance in actual utterances — although little is known about the actual frequencies of construction types at the moment.

3.242 Particular lexical strategies. However, there must be other strategies which supplement sensitivity to surface order and semantic constraints, since we can understand sentences which are not uniquely constrained semantically and which do not maintain this particular 'canonical' order of the internal structure in the surface structure implied by Strategy D. Recent experimental work has brought out the fact that there is a heterogeneous set of strategies attached to specific lexical items, primarily function words and verbs.

It is a linguistic truism that inflectional endings and function words can represent the underlying structure relations directly in the surface structure of sentences. For example, the difference in functional labelling of the nouns in 35a, b and 35c depends entirely on the change in the preposition.

- 35**
- a) the laughing at the hunters was impolite
- b) the laughing of the hunters was impolite
- c) the laughing near the hunters was impolite
- a) John rode with Mary
- b) John rode to Mary
- c) John rode by Mary

A recent series of experiments indicates that listeners utilize the intersection of the potential internal structures which adjacent lexical items can have to guide sentence perception. Fodor and Garrett (1967) showed that center-embedded sentences with relative pronouns included (36a) are simpler to paraphrase than the same sentences without the relative pronouns (36b). They interpreted this as due to percep-

- 36**
- a) the boy who the man who the girl likes saw laughed
- b) the boy the man the girl likes saw laughed

tual strategy based on the use of the relative pronoun, 'who': $N_1 \text{ wh } N_2$ corresponds to $N_2 \text{ verb } N_1$ in the underlying structure. However, again the following theory of perceptual complexity would make the same factual predictions: 'more transformations = more psychological complexity'. In sentence 36b a pronoun deletion transformation has applied to transform it from 36a. Consequently, several additional studies have been used to increase the evidence for the argument that listeners project deep structure organization directly from the possible internal constituent structure/external structure combinations associated with the particular lexical items.

A series of experiments have shown that sentences with verbs which take complements (e.g. 'see') have more psychological complexity than simple transitive verbs (e.g. 'hit') even when the complement verbs are used transitively. This finding supports the contention that perceptual processing is guided by the potential internal role that each lexical item *could* play. Thus, complement verbs involve more complexity even when they are employed as simple transitive verbs. Fodor, Garrett, and Bever (1968) showed that center-embedded sentences are harder to paraphrase when they contain a complement verb (37a) than when they have a transitive verb in the same position (37b). (Both visual and auditory presentations were used.)

- 37 a) the box the man the child *saw* carried was empty
 b) the box the man the child *hit* carried was empty

The preceding experiments involve sentences with two center embeddings — which are inordinately difficult constructions in any case. Fodor, Garrett, and Bever also found that the anagram solution for sentences presented in a scrambled order is harder and less accurate if the sentence has a complement verb (38a) than a simple transitive verb (38b). (Subjects were presented with a randomized array of words on cards and asked to make a sentence out of them.) (See also Hakes 1972.)

- 38 a) The man whom the child *saw* carried the box.
 b) The man whom the child *hit* carried the box.

The results of these last two experiments might be due to non-structural differences between pure transitive verbs (e.g. 'hit') and complement verbs (e.g. 'see') rather than the fact that complement verbs have more potential internal structures: for example, the complement verbs we used characteristically require animate subjects, while the pure transitives do not require animate subjects. To test directly the hypothesis that the relevant independent variable was the number of potential internal structures a verb can express, I compared the results for complement verbs which can take several kinds of complements with those that can take only one kind of complement.³ Each complement verb used in the two experiments was classified according to how many kinds of complements it can take. For example, 39 shows that 'like' can have three kinds of complements, while 'see' and 'decide' have two and 'remark' has only one. An analysis of the data in both experiments shows

³ Notice that the potential 'kind' of complement I use is defined in terms of the potential deep structure relations rather than the external form of the complementizer. Thus, the three relevant types of potential complement for each verb are:

John _i liked	<table border="0"> <tr> <td>(it) that we left</td><td>(it) that S</td></tr> <tr> <td>to kick the bottle</td><td>for-to</td></tr> <tr> <td>kicking the bottle</td><td>poss-ing (John_i-deleted)</td></tr> <tr> <td>Bill's kicking the bottle</td><td>V NP object</td></tr> <tr> <td>Bill to kick the bottle</td><td>NP (= John_i) V NP</td></tr> <tr> <td></td><td>object</td></tr> </table>	(it) that we left	(it) that S	to kick the bottle	for-to	kicking the bottle	poss-ing (John _i -deleted)	Bill's kicking the bottle	V NP object	Bill to kick the bottle	NP (= John _i) V NP		object
(it) that we left	(it) that S												
to kick the bottle	for-to												
kicking the bottle	poss-ing (John _i -deleted)												
Bill's kicking the bottle	V NP object												
Bill to kick the bottle	NP (= John _i) V NP												
	object												

that complement verbs with three possible complement types are more complex than verbs with only one or two complements (see Tables 1A, B).

- 39 a) John liked it that we slept a lot.
 b) John liked to kick the bottle.
 c) John liked Bill to win the race.
 d) John saw that we slept a lot.
 e) *John saw to kick the bottle.
 f) John saw Bill to be a fool.
 g) John decided that we slept a lot.
 h) John decided to kick the bottle.
 i) *John decided Bill to be a fool.
 j) John remarked that we slept a lot.
 k) *John remarked to kick the bottle.
 l) *John remarked Bill to be a fool.

TABLE IA

Mean Relative Number of Subject-Verb-Object Triples Correctly Recovered per Sentence for Auditory Presentation Relative to Corresponding Transitive Non-Complement Verbs (Analyzed from data in Fodor, Garrett, and Bever, 1968, Table 1)

Number of Potential Complements/Verb	1	2
Number of Cases	4	8
Relative Number of SVO triples Recovered	.89	.25

TABLE IB

Relative Number of Errors in Visual Presentation (from Fodor, Garrett and Bever, 1968, Table 2)

Number of Potential Complements/Verb	1	2	3
Number of Cases	5	15	9
Relative Number of Errors	.2	1.2	2.0

I have presented the perceptual strategies of segmentation, semantic labelling, and sequential labelling separately for purposes of exposition. It is obvious that the operation of one of the strategies can simultaneously aid the operation of another strategy. Thus, in actual perception the strategies combine simultaneously to isolate potential internal *actor-action-object ... modifier* sentence units and to assign correctly the functional relations within those units. It seems reasonable to suggest that semantic cues are dominant, since structural factors (such as the reversal of the canonical actor-action-object order in passive sentences) do not affect psychological complexity when the semantic relations are unique (according to Slobin). The structural strategies, in turn, project segmentation and inter-

nal structural labelling on the basis of general sequential properties of actual sequences (e.g. 'NVN' in the surface structure corresponds to underlying 'SVO'), or on the basis of the particular internal/external structural potential of individual lexical items.

The strategies used in speech perception to discover internal structures from external sequences are distinct both from basic linguistic capacities and from the system of intuitions which are described by a grammar. As in the case of the perceptual strategies of numerical judgments it is not clear whether these linguistic strategies are derived by passive induction over actual experience or whether they are due to autonomous internal developments. In either case, it is clear that the perceptual strategies accord closely with experience, particularly strategies B, C and D. Furthermore, the deployment of the knowledge of specific lexical internal/external potentialities in perception could come about without an accumulation of experience of the lexical potentialities. In this sense the strategies constitute behavioral inductions over actual speech behavior. Thus, just as in the judgments of numerosity, speech behavior can also be described in terms of three aspects: basic capacities, behavioral inductions and epistemological systems. Of course, in adult speech behavior these three systems are ordinarily merged together: the presence of the behavioral strategies is brought out in experimental conditions such as those reviewed above; our primitive linguistic capacity (e.g. for reference) is directly revealed in our speech production while the structural intuitions relevant for linguistic analysis appear only in our conscious epistemological considerations of sentences.

3.3 The Development of Perceptual Strategies of Speech in the Child

As in the case of numerical judgments, the child appears to pass through different phases in which his linguistic behavior is successively dominated by each one of the three kinds of cognitive functioning. Consider first the expression of the basic linguistic capacities at age 2 years. It has been traditionally recognized (cf. McCarthy 1956) that children of this age have the basic capacity to recognize (and often to say) the names of some objects and actions — that is, the capacity for *reference* is already developed, although not widely extended. (Of course, it is not clear whether the two-year-old understands the arbitrary nature of the acoustic-referential relations or whether he believes that the names of objects and actions are intrinsic and indivisible from the objects and actions themselves.)

A more abstract linguistic notion is the capacity to recognize explicitly the concept of predication as exemplified in the appreciation of the difference between subject-action, and action-object relations. Recently, we have tested this capacity in young children with a task in which they are requested to act out simple active sentences with toy animals (40a, b). The results of our first experiment in which

- 40** a) The cow kisses the horse.
 b) The alligator chases the tiger.

each child received a total of six sentences of different kinds are presented in Figure 2.⁴ Even the children in our youngest age group did extremely well on the

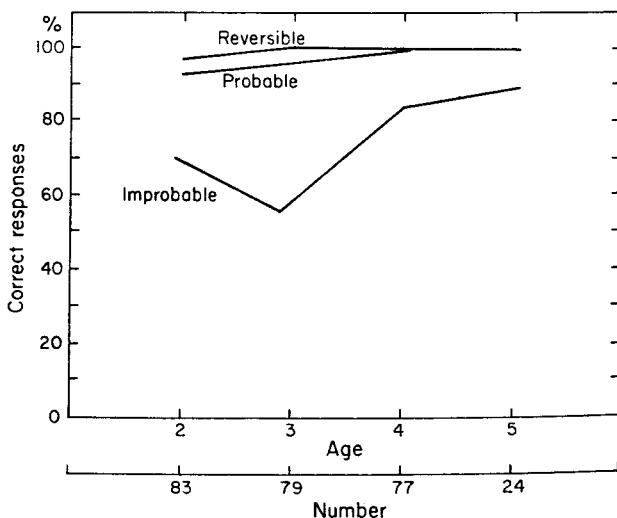


Fig. 2. The proportion by age of correct responses to reversible active sentences like 40a and probable active sentences like 43a and improbable active like 43b; each child received only one active sentence of each kind.

simple active sentences. The significance of this simple result (obvious to any parent) is that even the very young child distinguishes the basic functional relations internal to sentences. Furthermore, he appears to be able to distinguish different syntactic construction types, as opposed simply to interpreting the first noun of *any* type of sentence as the actor and the last noun as the object. The evidence for this is that while children from 2/0 to 3/0 act out simple active sentences 95% correctly, they also do far better than 5% on simple passives like 41a, b. (See Figure 3 for the performance on passives.) If children at this age always took the first noun as the actor then they would systematically do as

- 41** a) the horse is kissed by the cow
 b) the tiger is chased by the alligator

poorly on passives as they do well on actives (cf. R. Bates 1969 for a discussion of this). Since they perform near randomly on passives we must conclude that they can at least distinguish sentences they can understand from sentences they

⁴ The responses include some cases in which the child refused to act out the sentence at all himself, but chose the correct alternative acted out for him by the experimenter. The number of such cases was less than 15% at all ages, and did not materially change the results. Only responses in which there was a clear differentiation of actor and object are counted.

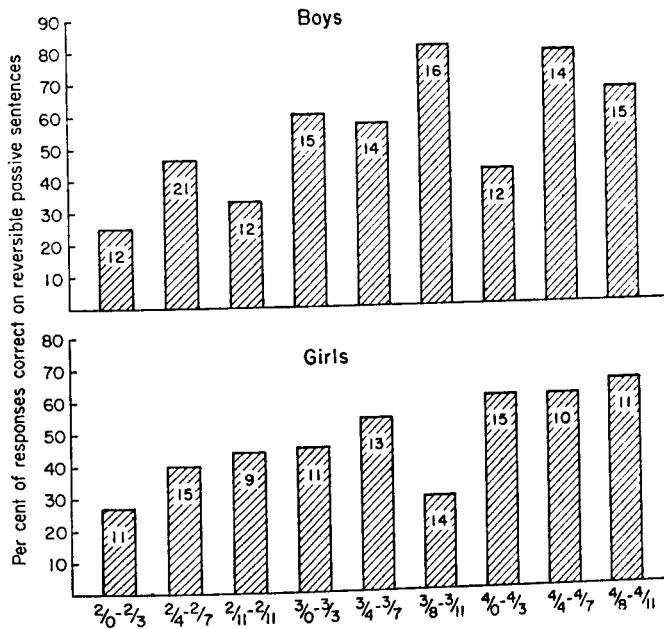


Fig. 3. The proportion by age and sex of correct responses to reversible passive sentences (e.g. 41a). Each child received only one reversible passive sentence. (The numbers in each bar indicate the number of children interviewed at that age. The data is broken down by 4-month age groups for purposes of the discussion below.)

cannot understand. Thus, the basic linguistic capacity evidenced by the two-year-old child includes the notion of reference for objects and actions, the notion of basic functional internal relations and at least a primitive notion that there are different sentence structures.

Beilin and Spontak (1969) used the emergence of the capacity to recognize the relationship between the active and the passive construction as a measure of the development of the child's capacity to produce linguistic intuitions. (I should emphasize that while the facts are due to Beilin, the interpretation is not necessarily his.) Beilin shows that the child does not appear capable of appreciating the regularity of the relationship between active and passive sentences until about age 7-8, which is also the age at which the child is alleged to have developed the integer concept. Indeed it is support for my claim that the adult numerical and linguistic phenomenologies are the same type of cognitive phenomena that Beilin finds a correlation between the child's ability to deal correctly with numerical and linguistic transformations (e.g. recognizing that changing the array in 2a to that of 2b doesn't change the number of circles in any of the rows, or recognizing the relation of the active and passive).

As in the case of the development of the child's capacity to make judgments of relative numerosity, the linguistic behavior between the ages of 2 and 6 displays

a period of relative dependence on perceptual generalizations. Consider first the early appearance of the basis for Strategy B, that the first N...V...(N) sequence is the main clause. In a recent study we have asked young children to act out sentences like 42a. Presumably because of memory limitations children often

- 42 a) *The cow that jumped* walked away.
b) The cow jumped and walked away.

act out only one of the two clauses of such sentences. Which clauses they act out gives us a measure of which clauses they consider the most important when they hear it. Our results show that children between $1\frac{1}{2}$ and $2\frac{1}{2}$ who perform poorly on acting out both actions in 42b act out only the first action (the subordinate verb) in 42a; children who do well on sentences in 42b act out the second action (the main verb) in 42a. That is, children at the beginning of language comprehension pick the first 'N...V' sequence as the most important part of a sentence; they follow Strategy B completely; more advanced children learn to discriminate the main verb from the subordinate verb and consider the main verb to be the most important action.

Consider now the development of the basis for a semantic strategy like Strategy C, involving probabilistic constraints. We examined the development of this in the course of the same experiment outlined above by including simple active sentences which either followed 43a or did not follow 43b probabilistic constraints. Figure 4 shows the relative sensitivity to the semantic constraints at each age (i.e. the percent correct performance on sentences like 43b subtracted from the percent

- 43 a) The mother pats the dog.
b) The dog pats the mother.

correct on sentences like 43a — a large number indicates a high dependence on semantic constraints). Figure 4 shows that this dependence undergoes a marked increase during the third year. These results were found initially with only 2 sentences of each type, but have been replicated in a second experiment with five sentences of each type (Figure 5). A similar result is reported by Sinclair and Broukhardt (1972). These experiments show that the two-year-old child is relatively unaffected by semantic probabilities. The implication of this is to invalidate any theory of early language development which assumes that the young child depends on contextual knowledge of the world to tell him what sentences mean, independent of their structure.

It is obvious why the very young child cannot make use of contextual probabilities: he does not have enough relevant experience to know what the probabilities are. For example, the young child may know the meaning of the word 'pat' but may not have heard it enough, or done it enough, to know that usually people pat dogs and not the reverse. Thus, it is not until the third year of life that the kind of contextual probabilities which provide the basis for Strategy C in adult perception develop as guide for sentence comprehension.

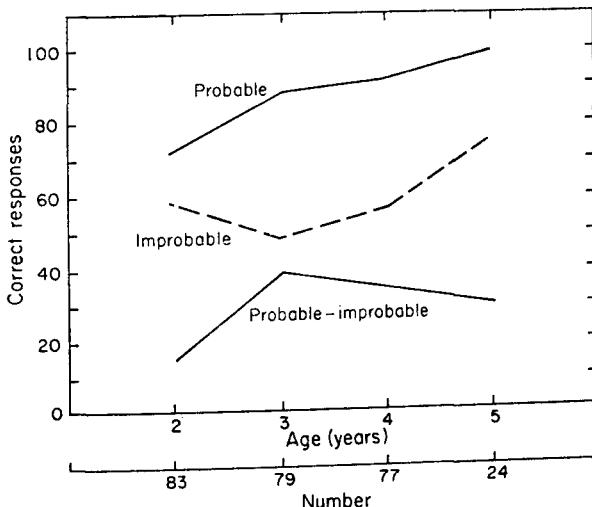


Fig. 4. The proportion by age of correct responses to probable and improbable sentences, in which each child received one sentence of each kind (roughly half the children at each age received one probable and one improbable active sentence and roughly one-half received one probable and one improbable passive sentence). The bottom line represents for each age the difference in correct responses between the probable and improbable sentences, and thus is a measure of the children's dependence on probability as an aid to correct performance.

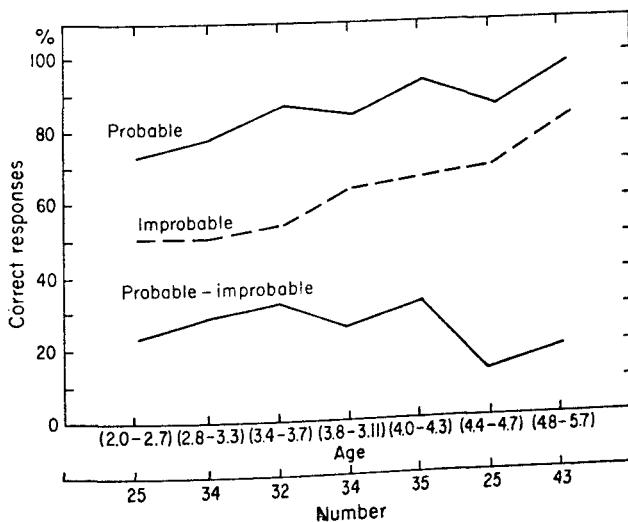


Fig. 5. The same data display as in Fig. 4 except from a different experiment with different children in which each child received three probable sentences (balanced within each age group so that the same number of actives and passives of each kind were responded to).

Shortly after this development the child goes through a phase in which he depends relatively heavily on something like Strategy D for the comprehension of sentences which do not have semantic constraints. This is brought out by his performance on acting out passive sentences like those in 35 (see Figure 3). The most important feature of these results is the steady increase in performance until age 3/8 for girls and 4/0 for boys when there is a sharp (temporary) drop in performance. These results were obtained with only four sentences (of which each child acted out only one) so a larger experiment was run (again by a different experimenter and in a different city) in which twelve reversible passive sentences were used (of which each child acted out three). The results for the passive sentences in this group are presented in Figure 6. Again the same brief decrease appears at the same ages (although in these materials, the decrease starts at the same time for boys and girls, but lasts to a later age in boys than in girls). Finally, in a separate experiment we have studied the performance of the child on cleft-sentence con-

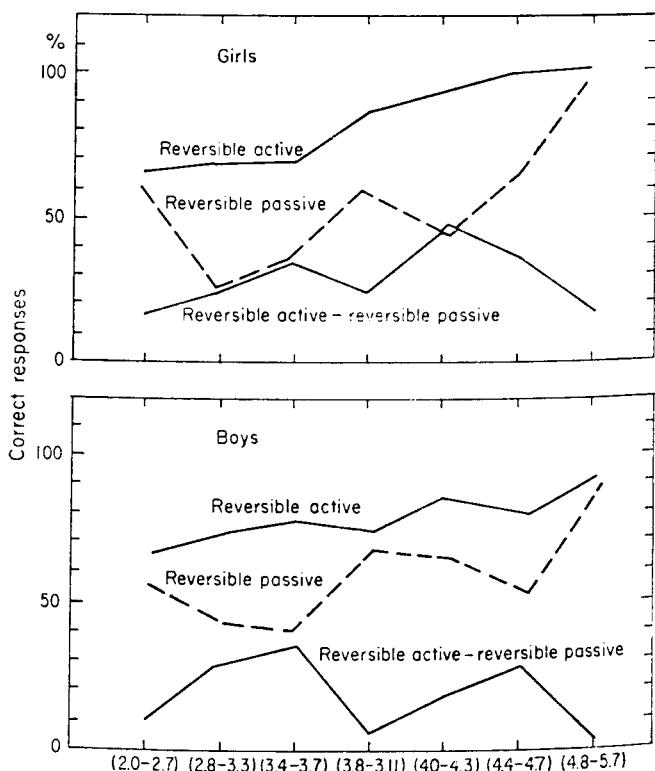


Fig. 6. The proportion of correct performance by age and sex to reversible active and passive sentences in which each child acted out three sentences of each kind. The bottom line in each graph represents the difference between the performance on actives and passives and thus is a measure of the children's dependence on the 'actor-action-object' order as an aid to correct performance.

structions which can reverse the subject object relation without reversing subject verb order, as in 44a,b.

- 44 a) It's the cow that kisses the horse (actor first)
 b) It's the horse that the cow kisses (object first)

Figure 7 presents the tendency to perform correctly on sentences like 44b. Again, the same decrease in performance appears at about age 4.

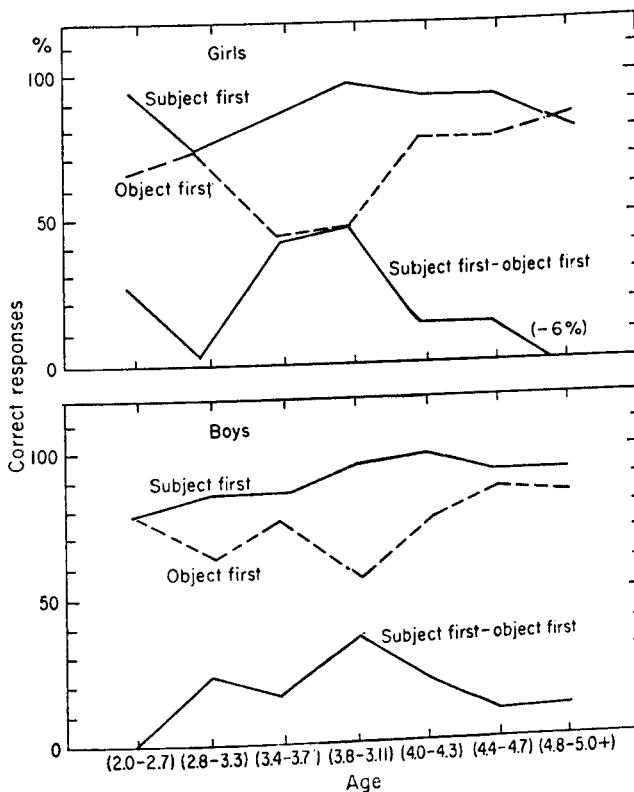


Fig. 7. The same data display as in Fig. 6 except for responses by different children to reversible cleft sentences with subject first (analogous to actives in Fig. 6, e.g. 44a) and object first (analogous to passives, e.g. 44b) in which each subject received three sentences of each kind.

While any one of these results alone might not be convincing, the constant re-appearance of the effect across different experiments with different materials (and different experimenters) indicates the reliability of the phenomenon (since our first presentation similar findings have been reported by Sinclair (1972) and DeVilliers and DeVilliers (1972)). Since each experiment averages across large numbers of children, it is not clear whether the period of the decrease in performance is due to the active development of a perceptual strategy like D or simply the failure to apply

the earlier capacity to understand passives and object-first sentences. Of course in both girls and boys in the experiment in Figure 6, the performance on passives is worse than random at the critical age, which indicates an active tendency to use a strategy like D. Similarly when the reversible passive sentences in the larger experiment are looked at in pairs by overall difficulty (as measured by success overall during the first three years), the performance on each pair of sentences goes below 50% (although at slightly different times). Only longitudinal research can resolve the question as to whether all children pass through a phase of over-generalizing Strategy D or of simply losing their earlier competence and lapsing into random behavior on those semantically reversible sentences which do not conform to the SVO pattern. However, the fact that we obtain decreases below 50% even when averaging across children, suggests strongly that all individual children pass through periods of actively applying Strategy D, and always reversing those sentences in which the first noun is the object rather than the actor.

It is an open question how the child acquires Strategies A, B, C, and D. It could be argued that the strategies are formed in response to natural probabilities in the actual speech that the child experiences: in actual speech sentences may tend to have pauses between internal structure units (the basis for Strategy A); sentences may tend to place subordinate clauses second (Strategy B); sentences do usually conform to some sort of contextual constraint (Strategy C); the active actor-action-object order probably predominates in what mothers say to children (Strategy D). Thus, one could argue that these perceptual strategies are formed by the child as inductions over his experience, as opposed to being due to internal cognitive developments independent of specific experience. However, just as in the case of the acquisition of the strategy of assuming that a relatively large array has a relatively large number of components, one must be prepared to explain *why* it is the case that the perceptual strategies A, B, C, and D are the ones that the child recognizes as fruitful rather than the many other generalizations which may be equally justified by his limited experience. Thus even an empiricist view of the acquisition of such perceptual generalizations must include a nativist component which selects certain possible generalizations and rejects others.

In any event, we have been able to explore in language the way in which the child may display relative dependence on basic mechanisms, perceptual generalizations and systematic intuitions as he grows up. This is further support for the distinction between these separable aspects of language behavior which are integrated in adult capacity.

3.31 *The enumeration of possible perceptual strategies*

I have suggested that the child may extract particular perceptual strategies by selective induction over his early linguistic experience; different topics, different speakers and different situations justify different perceptual strategies (or at least different relative importance of the strategies). Thus, part of what a child learns

when he adapts to the 'linguistic style' of a situation is a particular configuration of the perceptual strategies which the language used in that situation justifies. Since the number of potential strategies (like the number of sub-languages and of sentences) is infinite, the child must have both a characterization of the set of possible perceptual strategies as well as a routine for the extraction of such strategies from his particular linguistic experience. Analogously, a recognition routine must have a priori limits on the kinds of recurrent information it treats as relevant for the formation of perceptual strategies, and a system for the distillation of that information into particular strategies.

All we can do at the moment is to define the problem of the specification of possible perceptual strategies. It is clear that probabilistic information about the internal structure and internal/external structure pairs is the basis for certain psychological strategies which are developed. But it is not clear that all perceptual strategies are based on experience in this way, nor is it clear which additional linguistic structures are manipulated by strategies. That is, just as the general study of linguistics seeks to define language universals in terms of the basic structures and universal constraints on possible rules, the study of speech perception must be stated in terms of the basic form of the perceptual mechanism and universal constraints on possible perceptual strategies. Just as certain linguistic structures may be 'innate' and some learned, certain perceptual strategies may be basic to all perceptual processes, and some derived from linguistic experience.

4. THE INFLUENCE OF THE CHILD'S PERCEPTUAL SYSTEM ON LINGUISTIC STRUCTURE AND LINGUISTIC BEHAVIOR IN THE ADULT

A grammar provides the basis for the *prediction* of new possible sentences from the ones that have already been uttered and heard. That is, the system of grammatical rules which relate internal and external structure is the finite structural basis for the expression of linguistic creativity. While the grammatical rules make possible the extrapolation of new sentences from the old ones, the system of behavioral strategies makes more efficient the *perception* and *production* of sentences.

The preceding sections have demonstrated the interdependence of the perceptual and grammatical internal and external structures of sentences. These systems manifest themselves as partially independent systems in the adult and are learned at least partially independently in the young child. However, there is one obvious connection between the two systems in the child: the child will learn the grammar for those sentences which he can understand (at least partially). Conversely the child will have difficulty in learning the putative grammatical structure underlying sentences that he has difficulty in understanding. Thus, the child's system of speech perception constrains what he can understand and consequently restricts the kinds of grammar he can learn. To put this another way: the child will

learn those grammatical structures most easily which are most consistent with his perceptual system — those cases in which the theory of grammar offers alternative grammars the child will tend to learn only those that describe perceptually simple sentences. The structural aspect which is the vehicle for the mutual influence of perception and grammar is surface structure/deep structure pairs. That is, the child will accept as linguistically relevant data, those surface sequences for which he can understand the internal structure, and he will isolate perceptual inductions over those internal/external structure pairs. The perceptual constraints are observed and formed across internal/external structure pairs rather than the intervening structural derivations which describe in transformational terms the derivation from the internal to the external structure. Thus, it is not surprising that studies of the perception of speech in adults do not bring out any behavioral evidence for the transformations themselves. Furthermore, the perceptual strategies might themselves account for certain general formal constraints on internal/external structure pairs, but not account directly for the presence or absence of any particular transformation. For this reason the child's acquisition of the perceptual constraints may be viewed as motivating structural constraints on entire derivations, but not on any particular derivational step. (We shall return to this question below. See Section 5.1.)

In brief then, the child is simultaneously acquiring (at least) two kinds of linguistic systems, which can modify each other. It is clear that the structures allowed by the grammar of a language restrict the kinds of perceptual strategies that are learned. Obviously it is rare that perceptual strategies are acquired for the perception of sentences which are not grammatically predictable (or nearly so). However, it is also presumably rare that rules are learned whose applications produce only sentences that are impossible to understand. Thus, we can expect that certain aspects of sentence structure reflect the perceptual constraints placed on it by the child as he learns the structure and by the adult as he uses the structure.

The following sections present examples of syntactic rules which appear to be acquired in conformity with the perceptual strategies in the child and adult. There are two kinds of perceptual effects: first, certain systems of rules are determined by perceptual constraints; second, potential sentences may be incorrectly judged as 'ungrammatical' because of their perceptual complexity.

5. SOME SYSTEMS OF ADULT LANGUAGE STRUCTURE AND BEHAVIOR DETERMINED BY PERCEPTION

5.1 *Some Syntactic Rules*

5.11 *The integrity of main clauses in external structure*

Consider the perceptual strategies A and B. These combine to form the perception of an initial 'N . . . V . . . (N)' sequence as comprising the main independent

clause of the sentence. Above, I presented evidence showing that the very young child's habits of speech perception are dominated by such a strategy: in those sentences with more than one clause the first 'N...V...(N)' sequence is taken by the young child as the most important clause. Certain facts of adult English syntactic structure appear to accommodate this perceptual strategy: for example, R. Kirk (personal communication) has observed that a subordinate clause verb which precedes its main verb is generally marked as subordinate by the end of its verb phrase. The most obvious device is the subordinate clause conjunction, as in 45.

- 45 a) *Although* the research was secret, the liberated files revealed that it actually concerned the metabolization of sauce Bearnaise.
 b) *Because* the demands were non-negotiable nobody wanted any.
 c) *If* the system corrupts itself, the thing to do is to take it over.
 d) *While* this conference was not attended by any Americans of African antecedence, that fact was obviously an accident.

In each case the first verb is marked by the subordinate conjunction as subordinate.

Subordinate conjunctions are specific lexical items which accommodate to Strategy B by acting as specific markers of those cases in which a subordinate clause occurs before its main clause. There are also certain syntactic verb systems which appear to have formed in response to Strategy B: restrictions on the 'syntactically' allowed deletion of words which mark functional relations among clauses. The sentences in 46 and 47 exemplify a heterogeneous set of grammatical restrictions

- 46 a) The fact that the door was discovered to be unlocked amazed the tenants.
 b) That the door was discovered to be unlocked amazed the tenants.
 c) The fact the door was discovered to be unlocked amazed the tenants.
 d) *The door was discovered to be unlocked amazed the tenants.
 e) The door was discovered to be unlocked and that amazed the tenants.

on the stylistic deletion of 'that' or 'the fact' in initial position. For example, 46a can be reduced to 46c by deletion of one of the initial noun phrases, but not to 46d in which *both* noun phrases are deleted. The cases in 47 show that so long as some noun which marks the first clause as a nominalization is in initial position before the clause, both 'that' and 'the fact' may be deleted. Stated in this way, the

- 47 a) The discovery of the fact that the door was unlocked amazed the tenants.
 b) The discovery that the door was unlocked amazed the tenants.
 c) The discovery the door was unlocked amazed the tenants.

facts in 46 and 47 exemplify a constraint on internal/external structure relations which requires initial subordinate verbs to be uniquely marked. Notice in 46e that

strategies A and B do not apply if the sentence has more than one clause so long as the first clause is an independent clause (in the traditional grammarian's sense of 'independent'). The facts in 47 show that this constraint does not apply to the deletion of complementizers when they do not precede an initial noun.

Strategies A and B also predict certain facts about the deletion of relative pronouns on subject nouns. Consider the grammatical facts in 48.

- 48 a) The man who/that came to buy the giraffe forgot his money.
 b) *The man came to buy the giraffe forgot his money.
 c) The senator who was in the saddle shot from the hip.
 d) *The senator was in the saddle shot from the hip.
 e) The senator in the saddle shot from the hip.
 f) The monkey who was running after the bus slipped on a banana.
 g) *The monkey was running after the bus slipped on a banana.
 h) The monkey running after the bus slipped on a banana.
 i) The monkey who was scared by the dog slipped on a banana.
 j) The monkey scared by the dog slipped on a banana.
 k) The acid that was dissolved in the water became colorless.
 l) ?The acid dissolved in the water became colorless.

It would appear from 48a and 48b that there is a general syntactic restriction of the deletion of relative pronouns modifying initial nouns. This restriction follows from Strategies A and B, since the deletion of the relative pronoun would make the relative clause verb appear incorrectly to be a main verb of an independent clause. However, there are certain cases in which Strategy B predicts that the relative pronoun can be deleted. For example, the deletion of only the pronoun in 48c to produce 48d is blocked, but if the verb 'was' is optionally deleted as well, then the pronoun must be deleted to produce 48e. Strategy B allows this, since the subordinate clause verb 'was' is already deleted.

In certain cases the relative pronoun can be deleted even in the presence of a following verb. Thus, 48h can be derived from 48f even though the verb from 'running' directly follows the nounphrase 'the man'. However, the suffix '-ing' at the end of the verb marks it independently as a subordinate clause verb.

In a small number of cases of relative pronoun deletion, the form of the verb suffixes do not uniquely determine the verb as subordinate. Thus 48j can be derived from 48i, even though the past participle verb form 'scared' is homonymous with the simple past form of the verb (i.e. to produce the apparent clause 'the man scared somebody'). However, the following participle, 'by', marks the verb 'scared' as not having a direct object in the external structure and therefore as subordinate. Similarly in 48l the preposition 'in' marks the verb 'dissolved' as not having a following direct object in the external structure, and therefore either as intransitive or as a subordinate verb. Thus, Kirk's observation can be elaborated into a principle for the relations between the internal clause relations from their

external form; it is clear that this principle accommodates to the perceptual Strategy B on the one hand and that it constrains the form of the syntactic rules which relate the internal and external structures on the other hand.

Kirk's Claim:

If the first nounphrase in a sentence is followed by a verb form not marked as a subordinate verb, by a preceding subordinate conjunction, by inflexion (e.g. '-ing', or by an immediately following word (e.g. 'by' in 48j and 'in' in 48d then the verb is a main verb of an independent clause (of which the nounphrase is the external structure subject).

This principle predicts that certain sentences are unacceptable in which the subordinate verb suffixes are homonymous with main verb suffixes. For example, 49a is not acceptable (at least at first) although it is related to 49b, in the same way as 49c is to 49d. The difficulty of 49a is due to the fact that the verb 'race' can occur as an intransitive or as a transitive (unlike 'stumble' (pure intransitive) as in 49e

- 49 a) ?The horse raced past the barn fell.
 b) The horse sent past the barn fell.
 c) The horse that was sent past the barn fell.
 d) The horse stumbled past the barn and fell.

or 'send' (pure transitive) as in 49c, d). In 49a this facilitates the incorrect assumption that 'horse' is the subject of 'raced' as a main verb. Notice that if Strategy B and Kirk's Claim were always true, 49a should be *ungrammatical* as opposed to merely unacceptable since it also violates Strategy B. However, to formally block constructions like 49a with verbs that can both act transitively and intransitively, all constructions with pure transitives (e.g. 49c) and pure intransitives (e.g. 49e) would be blocked in a grammar. The alternative is selectively to restrict deletion of 'that (was)' to subordinate clauses with verbs that are not potentially phonologically homonymous with intransitive forms. Not only is such a restriction difficult to state but it is also inadequate. Consider the relative acceptability of 50a over 50b and 50c over 50d. In each of these pairs the less acceptable sentence (the 'NP... VP' sequence created by deleting nominal 'that was' between the NP and VP) is relatively likely as an independent 'subject verb' sentence (italicized in the

- 50 a) *The light airplane pushed past the barn* crashed into the post.
 b) *The pushing bulldozer pushed past the barn* crashed into the post.
 c) *The door slammed by the storm* splintered.
 d) *The door slammed during the storm* splintered.

examples). That is, *any* feature of an initial NP... VP sequence which makes it appear relatively plausible to the listener as a sentence interferes with perception if the NP... VP is not actually a sentence.

Thus Strategy A and B and Kirk's Claim are not offered as grammatical rules themselves but as constraints to which otherwise optional rules may respond when the knowledge of the speaker/listener of individual exceptions does not make them irrelevant.

There are some principles that are implicit which explain certain other syntactic phenomena of English:⁵

In an 'N...V' sequence in which 'V' is appropriately inflected, 'N' is the (external structure) subject of 'V', unless some preceding noun is so marked.

An initial 'N' is the external subject of the first appearing 'V' (unless blocked for a particular verb by principle B).

This explains the fact that the restrictions on relative pronoun deletion also apply to relative clauses in object position. Thus 51b cannot result from 51a in modern English,⁶ although 51d is an acceptable variant of 51c.

- 51 a) I ate the apple pie that was yummy.
 b) *I ate the apple pie was yummy.
 c) I saluted the apple pie that my mom made.
 d) I saluted the apple pie my mom made.
 e) The flag that was waving above *mom's apple pie* was groovy.
 f) The flag waving above *mom's apple pie* was groovy.

Notice that in 51e, f, Strategy B has marked 'the flag' as the subject of the first verb after 'wave' so the apparent 'NVN' sequence (italicized) is allowed (although of course it may cause perceptual difficulties).

5.12 Syntactic restrictions on pronominalization

The structure of coreferential pronominalization is another example in which general perceptual principles appear to constrain formal grammatical structures. Indeed, some authors have recently questioned whether pronominalization is a syntactic phenomenon at all, since all attempts to provide a complete account in syntactic terms have failed up to now. However, certain general constraints are statable within syntax. First, whenever two nouns with the same reference appear in one clause, one of them must be transformed into a pronoun. Thus we cannot say 52a unless there are two distinct 'George's in mind, rather we must say 52b:

- 52 a) ?George spoke to George.
 b) George spoke to himself.

⁵ Principles like these must apply recursively as exemplified by sentences like 'Max couldn't believe that the flag waving above mom's apple pie was groovy' in which the principle applies to the embedded sequence after 'Max couldn't believe that . . .'.⁶

⁶ However, see Bever and Langendoen (1970) in which it is argued that sentences like 51b were grammatical in Old English because the object ('pie') was marked by inflection as an 'object' and therefore would not lead to a false declarative sentence with the object as subject.

In 52b the first instance of 'George' is said to 'govern' the pronominalization of the second instance. It is immediately clear that the 'government' of pronominalization always proceeds from *left to right* within clauses. Consequently, the second instance of 'George' in 52a cannot govern the first. If it did, the ungrammatical sentence 52c would result (on the interpretation that 'he' and 'George' are coreferential):

- 52 c) *He spoke to George.

(Note that sentence 52c can be grammatical if 'he' and 'George' are different people, but not if they are intended to be the same person.)

This *left-right* constraint on pronominalization also obtains in certain sentences with a main ('independent') clause and a subordinate ('dependent') clause, e.g. 53a must be transformed to 53b:

- 53 a) *George was late although Mary spoke to George.
b) George was late although Mary spoke to him.

As above, pronominalization cannot proceed right to left, thus 53c is not a correct version of 53b:

- 53 c) *He was late although Mary spoke to George.

However, pronominalization can proceed right to left if the main clause is to the right of the subordinate clause. In 53a the 'George' on the right can govern pronominalization of 'George' on the left (to yield 54b), as well as the reverse (to yield 54c).

- 54 a) Although Mary spoke to George, George was late.
b) Although Mary spoke to him, George was late.
c) Although Mary spoke to George, he was late.

In general, the only cases in which the left-right constraint can be violated are those in which the governed noun is in a clause subordinate to the governing noun (Ross 1968; Langacker 1967). Thus, there are two independent constraints on the government of pronominalization: either it proceeds from left to right (to yield 52b, 53b, 54c), or from main clause to subordinate clause (as in 53b, 54b). At least one of the constraints must be met; if *neither* is met, an incorrect sentence like 53c can result from 53a.

Such a complex system appears at first to be an example of a 'pure' linguistic law. However, there is an intuitively clear general principle of all experience which could underlie such complex linguistic constraints. First, for one object to 'stand for' another, like a pronoun for a noun, a connection must already be established between them. For example, a picture of a leaf cannot be used to represent a tree unless the viewer already knows the connection. Analogously, in 52e above, 'he' cannot refer to 'George' since the listener does not yet know who 'he' is. The con-

straint which allows a superordinate clause noun to govern the pronominalization of a subordinate clause noun may also be interpreted as a linguistic reflection of an obvious regularity of experience: presentation of a whole includes a presentation of its subordinate part but not vice-versa. For example, a picture of a tree also presents a leaf to view since it includes a leaf, but in a picture a leaf does not present a tree (without prior knowledge of the connection, as above). Analogously, a pronoun can appear, even preceding its governing noun, if it is explicitly marked as in a subordinate part of the sentence. Since every sentence has at least one main clause, the listener can predict that a pronoun in a subordinate clause will be governed by a main-clause noun. But a pronoun in an initial main-clause does not necessarily have a following subordinate-clause governing noun since there may be no subordinate clause at all. (Recall Kirk's observation that subordinate clauses in English are always identifiable as such by the end of the verbphrases.)

To put it another way, the general perceptual principle is:

A symbol 'S1' can stand for 'S2' if (a) the prior connection is known or (b) there is an indication that a connection is about to be established.

The constraint on pronominalization would conform to this principle. (It should be noted that more recent linguistic investigations (e.g. by Lakoff) have brought out some counterexamples to the proposals by Langacker and Ross for the syntactic treatment of pronominalization. Further research is necessary to see if further psychological considerations could account for the new examples.)

There are many considerations which show that many of the restrictions on coreferentiality are perceptual as opposed to structural in any case. Consider first a clearly ungrammatical sequence 55a:

- 55** a) *John the hit Bill.
b) *John the hit ball.

No manipulation of the semantic constraints (as in 55b), or of the way in which the sentence is pronounced, or the gestures accompanying its utterance can affect the unacceptability of a form-class sequence like 55a. This is characteristic of sequences which are unacceptable on syntactic grounds — semantic or behavioral changes do not reduce their unacceptability.

However, semantic manipulations do affect the acceptability of certain sentences with coreferential pronouns which indicates that pronominalization constraints are not purely syntactic. Consider 56a and 56b in which the italicized nouns and pronouns are coreferential.

- 56** a) *The shovel* broke the rake *it* fell on.
b) The shovel *it* was below broke *the rake*.

While each of these sentences is acceptable, they cannot combine as in 57a or 57b-d. Notice that the unacceptability of 57a is not directly due to the difficulty

of grasping its content: even after careful consideration of the content as clarified in 56a, b, 57a is still nearly incomprehensible. Furthermore 57a is not unacceptable

- 57 a) **The shovel*₁ *it*₂ was below broke the *rake*₂ *it*₁ fell on.
 b) *The shovel that was above it broke the rake it fell on.
 c) *The shovel it was below broke the rake that fell on it.
 d) *The shovel that was above it broke the rake that fell on it.

because of the actual syntactic relations: consider the acceptability of 58a and 58b which have the same syntactic structure as in 57a without having two coreferential relations which cross each other from one clause to the other.

- 58 a) The shovel I was below broke the rake it fell on.
 b) The shovel it was below broke the rake I fell on.

Thus, the unacceptability of 57a-d appears to be due to a restriction on having two referential relations crossing over each other. However, if the relations between the nouns and verbs are uniquely determined semantically, coreference relations can cross over between clauses, as in 59

- 59 The box it rolled out of scratched the ball it had contained.

(i.e. it is semantically predictable that *the box had contained the ball* and *the ball rolled out of the box*).

Coreference also can cross over between clauses without unique semantic constraints so long as the pronouns differ superficially. For example, 60a and 60b can combine into 61a, a perfectly acceptable sentence:

- 60 a) The boy deserved the girl he kissed.
 b) The boy she pleased deserved the girl.
 61 a) The boy she pleased deserved the girl he kissed.
 b) The boy that wanted her deserved the girl he kissed.
 c) The boy she pleased deserved the girl that kissed him.
 d) The boy that wanted her deserved the girl that kissed him.

The conclusion from these facts is clear: so long as the referential relations are kept distinct from each other, by general semantic restrictions or by unique referential possibilities of the pronouns, coreferential relations may cross each other: that is, the unacceptability of the sentences in 57 are *not* due to a syntactic restriction, but a behavioral one.

Certain examples bring out even more clearly the effect of non-structural behavioral variables on the acceptability of sequences with coreferential pronouns. Thus, 62a and 62b are unacceptable while 62c and 62d are acceptable, since the

- 62 a) *He and he liked the cannabis juice.
 b) *Him and him liked the cannabis juice.
 c) Her and him liked the cannabis juice.
 d) She and he liked the cannabis juice.
 e) ?He and him liked the cannabis juice.

two pronouns obviously refer to different people because of the difference in sex. In fact, 62e is almost acceptable even with pronouns of the same sex: the difference in the external form of the pronoun is sufficient to make the sentence acceptable. The dependence of such pronominalization restrictions on nonstructural variables is brought out even more markedly by special execution of 62a,b: these sentences are completely acceptable when spoken with accompanying gestures, e.g. first pointing to one (male) person and then another.

Thus, many of the factors which govern pronominalization are clearly the linguistic reflection of behavioral constraints on symbols which 'stand for' other symbols; those syntactic mechanisms which are involved in the partial description of pronominalization clearly are grammatical responses to the behavioral constraints.

5.13 *Syntactic restrictions on prenominal adjective ordering — stop me if you can.*

The previous two examples of the effect of general psychological principles on structure would appear to be extremely general, if not universal; they both bear on the relation between subordinate and superordinate clauses, which is itself a putatively universal structural distinction. Certain perceptual strategies are language-specific, in that they depend on particular properties of a language which themselves are not universal. Consider, for example, the strategies involved in the immediate perceptual segregation of major phrases. The implication of perceptual strategies like A and B is that understanding a sentence involves a marking of the internal relations between the phrases in each clause. This assumes that the phrases themselves have been (or are being simultaneously) isolated from each other. It is easy to see the importance of such segregation. For example, in 63a, the perceptual segregation of words in the verb must end (and begin) with 'called' while in 63b it must include the particle, 'up'. Or in 63c the subject nounphrase must end with the word 'snow' while in 63d it must end with the following word, 'catches'.

- 63 a) I called up the not very well painted stairs.
 b) I called up the not very well painted Indian.
 c) The heavy snow catches the mountain travellers.
 d) The heavy snow catches saved the mountain travellers.

If such perceptual segmentation into major phrases is not achieved, the internal relations themselves cannot be assigned. Of course in many instances the semantic relations and unique lexical classifications in English can themselves determine the

segmentation. Thus, there is no doubt (even temporarily) about the segmentation of the verb in **64a** or the first nounphrase in **64b**.

- 64 a)** I called from the not very well lighted stairs.
b) The powerful snow barriers saved the travellers.

Furthermore, in many instances stress and intonation patterns can provide the necessary clues. (Consider the relatively high stress on 'up' in **63a** or on 'catches' in **63c**.)

In English the presence of certain function words at the beginning of a phrase can uniquely determine what kind of phrase it is and therefore what to look for at its termination. For example, the determiners, 'the, a, someone, many . . . etc.' all signify the beginning of a nounphrase. A putative perceptual strategy (E) could be based on this fact:

Strategy E: 'determiner . . .' begins a nounphrase.

Consider sentence **64a**. This principle leads a listener to expect a noun terminating the nounphrase begun by 'the': in **64a** the form-class possibilities of 'pencil' and 'fell' uniquely determine the interpretation that the nounphrase is 'the ball' and that 'fell' is the verb. In addition, there are certain classes of morphemes and words which

- 64 a)** The pencil fell.
b) The pencils fell.
c) The pencil (that) { Sam }
 { the boy } found fell.
d) The nice pencil fell.
e) The plastic pencil fell.

uniquely identify the boundary of a head nounphrase: in **64b** the plural morpheme 's' (given that a noun doesn't follow it) and in **64c** the function word 'that' or proper noun 'Sam' or the determiner 'the', all signal that the immediately previous noun was the head noun of its nounphrase. That is, there is a perceptual strategy (E').

Strategy E': The first uninflected (except for plural) noun after 'Determiner . . .' is the head noun which terminates the nounphrase (independent of relative clause modifiers). (Or the first noun with a following morpheme which marks the beginning of a new nounphrase.)

Strategy E' operates correctly in cases like **64d** where an adjective intervenes between the determiner and the noun. However, since the adjective 'nice' is not a noun, Strategy E' would operate incorrectly in cases like **64e** in which one of the prenominal modifiers is itself lexically marked as a noun. Since 'plastic' is the first noun after 'the', Strategy E' would establish the following segmentation to sentence **64e**:

65 (The plastic)_{np} (pencil)_{np}

which is incorrect. To block this kind of premature NP segmentation the Strategy E' must be restated so that it does not establish segmentation of a nounphrase until there is a word which is relatively *less* noun-like.⁷

Strategy E''. After 'determiner . . .' the boundary of the head noun of the nounphrase is marked by a subsequent lexical item which is less uniquely a specific noun, by a set of morpheme classes which signal the end of a nounphrase (e.g. 's') or immediately subsequent morphemes which signify the beginning of a new nounphrase (e.g. 'the' proper nouns) or a relative clause (e.g. 'that').

E'' yields the correct segmentation for **64e** (and indeed covers most of the cases in **64**). However, it is not clear whether principle E'' extends the nounphrase to be as long as is possible, or whether it establishes segmentation at the earliest possible point. If the former is true then **66a** should be more complex than **66b**: in **66a** the word 'marks' would be incorrectly included within the nounphrase because while it is a verb, it is homophonous with a noun (as in **66b**).

- 66** a) The plastic pencil marks easily.
- b) The plastic pencil marks were ugly.
- c) The plastic rose fell.
- d) The plastic rose and fell.

On the other hand, if principle E'' applies at the first possible point, then **66c** should be more complex perceptually than **66d**: the word 'rose' would *not* be included within the nounphrase because while it is a noun it is homophonous with a verb (as in **66d**). Future experimentation is necessary to decide this question. In any case, the problems raised by the sequences in **66** are usually resolved by normal intonation and stress patterns.

However, nuances of stress do not resolve the segmentation problem exemplified in **64e**, so Strategy E'' is required for the segmentation of nounphrases with prenominal modifiers. This strategy appears to act as a constraint on the external order of prenominal modifiers that might otherwise be freely ordered. Consider the constraints on the order of adjective classes exemplified in (67).⁸

- 67** a) The red plastic pencil. . . .
- b) *The plastic red pencil. . . .
- c) The large red pencil. . . .
- d) *The red large pencil. . . .
- e) The large plastic pencil. . . .

⁷ I am indebted to M. Halle for this suggestion.

⁸ Notice that these examples refer to the 'neutral', non-emphatic adjective order in which the prenominal adjectives are conjoined (semantically) rather than nested.

- f) *The plastic large pencil. . .
- g) The large red plastic pencil. . .
- h) *The plastic red large pencil. . .

Notice first that any two-adjective prenominal sequence is acceptable if the first adjective is given contrastive stress. (E.g. in 67b, the phrase would have to be in a contrasting context like 'not the *métal* red pencil, but the *plástic* red pencil . . .'). However, with neutral stress the order of prenominal adjectives is constrained. Several recent theories (Vendler 1963; Martin 1968; Ertel 1970) agree that adjectives are ordered according to the extent to which an adjective is related lexically to a noun (Vendler), or to which it refers to a 'substantive, concrete' quality of an object (Martin), the less 'variable' the quality of the adjective is (Ertel) the more 'nounlike' or definite an adjective is (on any of these two measures) the closer to the noun it must be. Thus, for example, following Vendler, we can argue that a substance adjective like 'plastic' is more like a noun than a color adjective like 'red' in the sense that it occurs in more kinds of constructions as a noun than does 'red' (see 68); similarly color adjectives like 'red' occur in more constructions as nouns than do size adjectives like 'large' (see 69). Martin has recently suggested a more semantic basis for a scale of 'noun-likeness' of adjectives; substance words ('plastic') refer to the concrete, 'inner', structure of the noun they modify; color words ('red') refer to the exterior of the object they modify; and size words ('large') refer to qualities of the objects they refer to which must be assessed by the speaker relative to other objects of that type. Ertel's main proposals are closely related although they are more based on context and reference than on semantic sentences. A substance word like 'plastic' refers to a specific substance with little variability; 'red' includes a range of colors and some subjective judgment, while 'large' is completely variable, being dependent on the specific context.⁹

⁹ I have summarized the arguments of Vendler, Martin and Ertel in vastly abbreviated form. The reader should consult their highly original work on this problem. Notice that a general 'semantic' account of adjective ordering like Martin's or Ertel's is incorrect. If adjectives are postposed, then the order is free, as in, *I like my pencils red and plastic* or *I like my pencils plastic and red*. That is, the ordering constraint only applies to prenominal ordering: this is inconsistent with an explanation couched in terms of those qualities which are most easily closely associated with the noun, since these constraints would presumably apply postnominally as well. Furthermore, prenominal comparatives are freely ordered, as in 'I never saw a redder larger brick' or 'I never saw a larger redder brick'. A semantic theory of ordering would not predict this freedom. On my interpretation prenominal comparatives are freely ordered because the suffix '-er' marks all the adjectives as non-noun in English. It might be argued that languages with unique adjectival inflections should not show the same ordering restrictions since each adjective is marked by the ending as a non-substantive. Indeed Ertel argues that German is just such a language and that his theory of 'variability of reference' is necessary. However, principle E" includes changes in relative 'semantic substantivity' as well as syntactic 'nounness' as the basis for NP contour formation. Also German adjectives are inflected with the same endings as the nouns and so inflections do not set them apart. Finally adjectives can be nominalized into nouns with the same inflections, thus reducing further the utility of inflections in marking adjectives.

- 68 a) Red is a color; redness is nice.
 b) Plastic is a substance; plasticity is nice.
 c) *That is made out of red.
 d) That is made out of plastic.
 e) *The red broke.
 f) The plastic broke.
 g) ?Reds are of variable quality.
 h) Plastics are of variable quality.
- 69 a) Red is my favorite color.
 b) *Large is my favorite size.
 c) He splattered some red on me.
 d) *He splattered some large on me.
 e) Red and blue and green are colors.
 f) ?Large and enormous and tiny are sizes.

Whichever metric of 'specific noun-likeness' is used the syntactic constraints on prenominal adjective ordering principle is expressed the same way: *in a series of prenominal adjectives, the more specific and noun-like adjectives are ordered to be closer to the head noun they all modify*. The perceptual strategy for the segmentation of nounphrases developed in Strategy E" can explain this otherwise strange grammatical constraint. If more substantively specific adjectives preceded less substantively specific adjectives, then Strategy E" would produce premature segmentation. For example, principle 2 of Strategy E" would incorrectly segment the phrase in 67b as shown in 70 as opposed to the correct segmentation of 67a as in 71. This follows from the fact that 'red' is less noun-like than 'plastic'. Thus, se-

70 (The plastic)_{np} (red pencil)_{np}

71 (the red plastic pencil)_{np}

quences which violate the general constraint on noncontrastive prenominal adjective order are incorrectly segmented by Strategy E".

If the above arguments are correct then the restriction on prenominal adjective ordering is an example of the effect of perceptual strategies on 'grammatical' structure. I suggested above that perceptual strategies affect grammatical structures in those cases in which the child acquires the strategies before he acquires the particular grammatical structures: grammatical structures acquired after he learns the strategies are affected by the strategies. Suppose that the child acquired Strategy E" before acquiring the ability to process more than one prenominal adjective at a time; this strategy could be expected to constrain the preferred adjective order that he eventually acquires – given that adjective order is otherwise syntactically free (which is indicated by the fact that with contrastive stress *any* order of two adjectives is possible – see above). Recently we have tested this view of the ontogenesis of prenominal adjective constraints with children between 2 and 5 years of age. We present the child with phrases like those in 67, some of which follow the adult

constraints (e.g. 72) and some of which do not (e.g. 73), and ask him to say back to us what we say (see Bever, Freedle, Hall, and Sumner (forthcoming) for details). The crucial result is that younger children perform better than older children on the

72 The large red plastic pencil fell from the table.

73 The plastic large red pencil fell from the table.

repetition of sequences which do not follow the ordering constraints: the age at which the child's performance deteriorates on these tasks is just the age at which our other research shows him to be acquiring strategies for speech perception. This is consistent with our proposal that the constraints on prenominal adjective ordering are basically due to perceptual strategies.

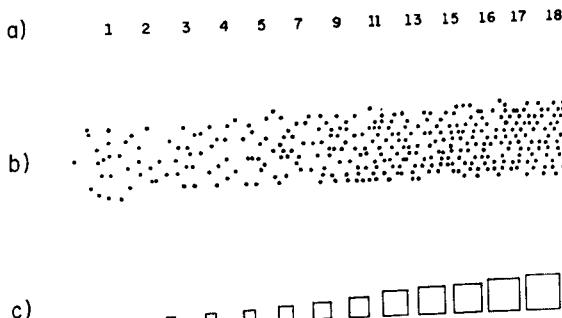


Fig. 8. Examples of different kinds of perceptual segmentation. In each case there are two main segments with an intermediate transition.

The details of a strategy like E'' are obviously language-specific since there are many languages without explicit determiners, or without prenominal adjectives. However, it is also clear that Strategy E'' is a special instance of an extremely general principle of perceptual grouping (F). This principle articulates the fact that perceptual segmentation tends to be established only at points in a stimulus where a discontinuity of relations is perceived (although not at all such points).

Strategy F: In an ordered array of adjacent items ... XYZ..., if XR_iY is the same as YR_iZ, then the array is grouped together. If YR_iZ is different from XR_iY, then the stimulus is segmented (XY) Z.

Consider first the application of Strategy F to non-linguistic stimuli. If asked to segment the sequence of numbers in Fig. 8a into groups, there would clearly be two main groups 1-5 and 13-18 separated by a transition 5-13. The first and third segments are grouped by unit increases, the middle transition segment by increases of 2.¹⁰

¹⁰ Notice that it is ambiguous which group '5' and '13' belong to uniquely. This is again a special case of the question as to whether segmentation is established at the earliest or latest possible point in a sequence. See the discussion of example 66 above.

Similarly in Fig. 8b and Fig. 8c each are made up perceptually of two segments with a transition Fig. 8b. The first and third groups are ordered by slightly increasing density while the middle group is transitional between them. In Fig. 8c the first and third segments are ordered by slightly increasing size, while the middle segment is ordered by radically increasing size. Notice that cases like Fig. 8c are special instances of all edge boundaries. A visual edge is defined according to Strategy F as point where R_i between two adjacent points differs from R_{i-1} .

The constraint on a prenominal adjective ending in a sequence of adjectives is that the second must be more 'noun-like' than the first. That is, in a sequence of prenominal adjectives, ' $Adj_1 R_i Adj_2 R; Adj_3 \dots$ ' both R_i and R_j are partially described as 'less noun-like than'.

Consider now the application of Strategy F to the segmentation of cases that are directly analogous to the prenominal adjective ordering constraints within nounphrases (Fig. 9). The natural segmentation in each of these cases is following the fifth segment, and at no point preceding it. (In Fig. 9 the noun-likeness of the adjectives corresponds to the largeness of the numbers in Fig. 9a, the size of the figures in Fig. 9b, and the intensity of the shading in Fig. 9c.) Suppose that the sequential visual and numerical relations were analogous to a sequence which violates the adjective ordering constraints, as in Fig. 10d.

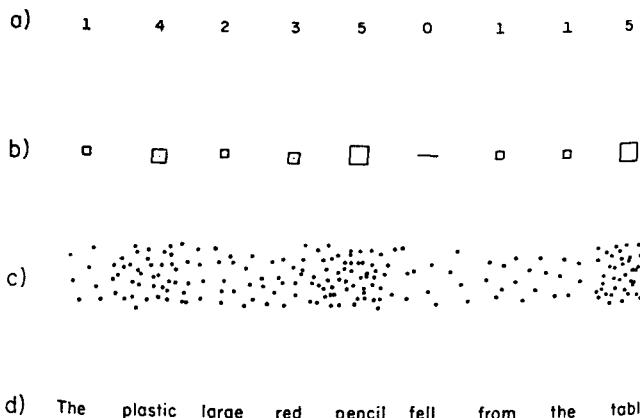


Fig. 9. Examples of the perceptual segmentation corresponding to correct adjective orderings. In each case the first major segment terminates after the fifth item.

While a perceptual boundary following the fifth segment remains (just as in the case of the linguistic sequence) there is some uncertainty as to an additional boundary following the second segment in each array. It is exactly this perceptual uncertainty as to perceptual grouping that I claim as the basis of the ordering constraints on prenominal adjectives.

Every specific strategy of speech perception is a special case of a general

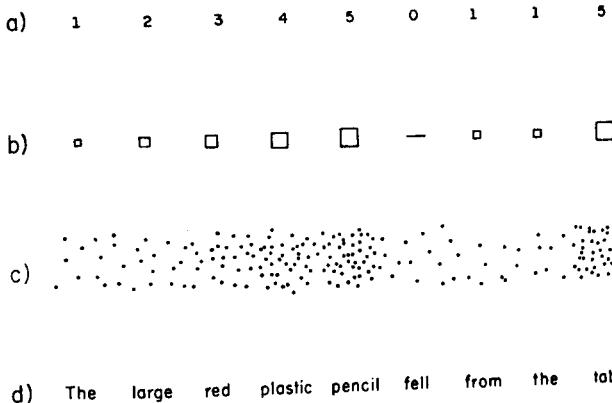


Fig. 10. Examples of the perceptual segmentation corresponding to incorrect adjective orderings. In each case the first major segment terminates after the second item.

principle of perception, at least in the sense that no general perceptual laws may be violated by a language-specific strategy. For example, the fact that Strategy E" is a linguistic reflection of Strategy F is not an *explanation* of Strategy E"; rather it simply is a classification of the linguistic strategy in terms of the general principles that it utilizes.

5.2 *The Influence of Sentential Perceptual Complexity on Acceptability Intuitions*

During the course of this discussion I have emphasized the ways in which linguists depend on intuitions about sentences as the basic source for data which must be described by a grammar. The demonstration of the tripartite nature of speech behavior raises the possibility that such intuitions about sentences also are of three basic kinds. For example, it is perfectly clear that the unacceptability of 74a is due to the violation of the basic linguistic property of reference (i.e. there is no reference for 'bruck'), while 74b lacks an action. These sequences may be said to be unacceptable as sentences due to violations of basic (universal) linguistic properties. In contrast with this type of violation the sequences in 75 are unacceptable as sentences due to violations of the rules governing the specific syntactic rules of English.

74 a) *Please pass me the bruck.

b) *Tom, Dick and Harry.

75 a) *I hoped it for you to win the loot.

b) *The group are better than you think.

That is, these sequences violate the most sophisticated systematic properties of

English. (Notice that the sequences in 74 and 75 could all be uttered and understood in ordinary speech.)

I pointed out above that the primitive basic capacities and sophisticated epistemological systems are both easier to isolate in adult behavior than the inductive systems of actual behavior. Correspondingly unacceptable sequences which are due to the failure to meet some basic property of all sentences (e.g. 74) are easy to distinguish from unacceptability due to the failure to maintain higher order properties specific to the language (75). However, sequences which are unacceptable due to the violation of perceptual strategies are relatively hard to identify. Yet, identification of such cases is crucial for linguistics — otherwise linguists may construct grammars that exclude grammatical sequences. For example, it is not immediately clear whether the ungrammaticality of sentence 76a is due to linguistic properties of English or due to the mechanisms of speech perception. At first blush it might appear that sentences like 76a should not be generated by a grammar of English since they are not immediately acceptable; however, it is possible to argue that there is a near-continuous scale of acceptability between 76a and 76j in which the independent variable is the complexity of the sequence which separates the verb ('call') and the particle ('up'). Thus, it is plausible to argue that the apparent unacceptability of 76a is due to the length of the phrase intervening between the verb and its particle. That is, 76a is classified as acceptable syntactically, but complex perceptually, because of the load it places on immediate memory of the material between the verb ('called') and its particle ('up'). (Notice that the acceptability of 76k shows that the unacceptability of 76a is not due to the length of the sentence per se, but the length of the sequence interrupting the verb and its associated particle.)

- 76 a) *John called the not very well liked but quite pretty girl on the next block where Jack has lived for years up.
 b) *John called the not very well liked but quite pretty girl who lives on the next block where Jack lived up.
 c) ?John called the not very well liked but quite pretty girl who lives on the next block up.
 d) ?John called the not very well liked but quite pretty girl who lives on the block up.
 e) John called the not very well liked but quite pretty girl up.
 f) John called the very well liked and quite pretty girl up.
 g) John called the well liked and quite pretty girl up.
 h) John called the pretty girl up.
 i) John called the girl up.
 j) John called up the girl.
 k) John called up the girl who is not very well liked but quite pretty and who lives on the next block where Jack has lived for years.

5.21 Sequences which interrupt each other — save the hardest for last

To generate the acceptable sequences 76h-k, the formal grammar must also generate the less acceptable sequences 76a-g. That is, there is no natural way in which 76a-g can be blocked by a grammar which also generates 76h-k. However, there is a general perceptual rule (Strategy G) which can be used to explain the unacceptability of 76a on behavioral grounds, and thus explain why it is simultaneously grammatical and unacceptable.

Strategy G. Sequences with constituents in which each subconstituent contributes information to the internal structure of the constituent are complex in proportion to the complexity of an intervening constituent.

Notice that immediate memory may be exhausted either by the length of an intervening sequence or by the perceptual complexity of that sequence. Thus, 77a is more acceptable than the equally long but more complex 76a while 77b is less acceptable than the equally long but simpler 76g.

- 77 a) John called Jane, Mary, Marsha, Sally, Joan, Melissa, Erica, Felicia, Irma, Urania, Galacia and all the other girls in his class up.
 b) John called girls seen by the sailor he met up.

There are various other linguistic phenomena covered by Strategy G. Recently Ross (1968) has suggested that there is a general constraint on postposition in English which orders 'heavier', or more complex, nounphrases toward the end of a sentence. For example, 78a is more acceptable than 78b; 78c more acceptable than 78d, and so forth. These cases are all characterized by the sequence

- 78 a) John called up the girl in the white dress.
 b) John called the girl in the white dress up.
 c) John showed the girl the book that I like a lot.
 d) John showed the book that I liked a lot to the girl.

'...Verb X Y...' where X and Y both have some unique internal relation to the verb (e.g. 'particle, direct object, indirect object'). Ross's relative complexity constraint may be viewed as a special extension of Strategy G. Consider the sequence '...Verb X Y...' in which Y is less complex than X and both X and Y are related to the verb in the internal structure (i.e. X and Y are dominated by VP). Suppose the complexity of the Verb-X relation taken independently is assigned a value of 'x' and Y is assigned a value of 'y' where $y < x$. Then the complexity of the relations (taken separately) in a sequence 'V X Y' is the quantity $(x+y)$: assume that the interaction with short-term memory is defined as a factor 'm' which is proportional to the complexity of what must be remembered. The overall complexity (including the ordering) of '...Verb X Y...' in which X must be held in memory would be $(x + y + m x)$ and of 'Verb Y X' would be $(x + y + m y)$. Since by assumption $y < x$, the complexity of 'V X Y' is greater

than that of 'V Y X'. That is, in those cases in which the syntax provides free ordering between X and Y, the preferred order is one which places the more complex nounphrase so that it does not interrupt the relation between the verb and the less complex nounphrase: this ordering yields the simplest overall complexity of the sequence.

This principle also accounts for the relative acceptability of post-verb adverb ordering. The basic rule is that more complex adverbs are ordered towards the end of the sentence. Thus, 79a is more acceptable than 79b while 79c is more acceptable than 79d. Strategy F would explain these facts, since in 79a and 79b the more complex adverbial phrase comes after the less complex phrase, while both modify the verb.¹¹

- 79** a) John walked briskly in a slightly more northerly direction.
 b) ?John walked in a slightly more northerly direction briskly.
 c) John walked north at a slightly brisker pace.
 d) ?John walked at a slightly brisker pace north.

Strategy G also accounts for certain stylistic preferences which indicate that the more complex of two modifiers appears later in a sequence of two. For example, a is preferred over b in the pairs of examples below:¹²

- 80 PRENOMINAL CONJOINED ADJECTIVES OF THE SAME CLASS**
 a) The steel and artificially strengthened fibre plastic tube broke.
 b) ?The artificially strengthened fibre plastic and steel tube broke.

¹¹ In 79 the adverb categories (e.g. direction or manner) are held constant so the ordering constraints are not due to constraints on the order of semantic adverb categories. The fact that relatively complex adverb phrases are always displaced towards the end of the clause allows us to investigate category-restrictions on adverb order, by holding complexity constant and equal between any pair of adverbs. Such comparisons indicate that the canonical English post-verb adverbial order is, DIRECTION MANNER PLACE DURATION FREQUENCY TIME PURPOSE. Thus, (a) is correct, while (b) is not. Or to give an example with all categories, (c) is correct and (d) is appalling. The reader is invited to test my intuitions adverb pair by adverb pair.

- a. John walked north fast.
 b. John walked fast north.
 c. Georgeal Cough rode north fast in the park briefly often yesterday for fun.
 d. Georgeal Cough rode for fun yesterday often briefly in the park fast north.

The source for these constraints is unclear to me at the moment, although it does appear that the direction and manner adverbs modify the verbs while the rest are sentence modifiers. Furthermore, the order 'Place... Purpose' appears to be in the direction of increasing abstractness, and (consequently) of increasing psychological complexity. If this observation is true then Strategy G can account for these ordering constraints as well: The relatively complex adverb is ordered relatively late. To test the reality of the constraints themselves, M. Garrett and I played sentences like (a) and (b) to subjects with an accompanying task (click location) to increase errors. We found that subjects tend strongly to reverse adverb sequences which violate the canonical order stated above.

¹² I am indebted to G. Miller for suggesting some of these examples.

CONJOINED PREDICATE NOMINALS

- a) The machine is bulky and incredibly hard to operate without the appearance of at least one malfunction.
- b) ?The machine is incredibly hard to operate without the appearance of at least one malfunction and bulky.

POSTPOSITION OF COMPLEMENT SUBJECT (when the object is not complex)

- a) It amazed Bill that John left early in the morning to catch the usually late train.
- b) ?The fact that John left early in the morning to catch the usually late train amazed Bill.

CONJOINED CLAUSES

- a) It rained while the dog barked at his master's voice mysteriously coming out of a big black funnel.
- b) ?The dog barked at his master's voice mysteriously coming out of a big black funnel while it rained.

5.22 *Sequences with two simultaneous functions — three's a crowd*

Unfortunately it is not the case that the perceptual source of the relative unacceptability of a syntactically allowed sequence is always so easily identified and precisely described. Consider 81a, a so-called 'double embedding'. It must be generated formally by a contemporary linguistic grammar which also generates 81b. It is not possible to restrict the number of embedded subordinate clauses to one, because of sentences like 81c which have two embeddings, but are perfectly acceptable. Indeed, since the internal structures of 81a, 81c and 81d are identical and only 81a is unacceptable, no restriction on the form of internal structures themselves can account for the unacceptability of doubly-embedded sentences. Rather, it is a function of the way in which the internal relations are presented in the external structure. Fodor and Garrett (1967) imply that it is the density of the number of internal structure sentence units per word in the external structure which exceeds some critical threshold ('density' = 3/12 for 81a; 'density' = 3/14 for 81c). This proposal is intriguing since it would suggest that at least one dimension of perceptual complexity is quantifiable. However, the proposal is incorrect as shown by the fact that the density of internal structures per word is even higher in 81d. Yet 81d is entirely comprehensible and acceptable. Thus, the complexity of center-embedded sentences cannot be easily explained away by appeal to any obvious perceptual principle. This creates a dilemma — either we must accept the current form of generative grammar as incorrect since it cannot avoid generating center embedded sentences in a natural way, or we must appeal to an unspecified perceptual strategy to account for its difficulty.

- 81 a) The dog the cat the fox was chasing was scratching was yelping.
 b) The dog the cat was scratching was yelping.

- c) The fox was chasing the cat that was scratching the dog that was yelping.
- d) The fox was chasing the cat scratching the yelping dog.

Chomsky and Miller (1963) have attempted to define such a perceptual principle. They argue that any perceptual rule may not interrupt its own operation more than once. In the case of a sentence like 81b (represented schematically in 82b) the perceptual assignment of the 'actor'-action relation to the first noun and last verb is interrupted by the same assignment to the second noun and first verb. In 81a (represented in 82a) the perceptual assignment of actor-action to the first noun and last verb is interrupted by the assignment of the same relation to the second noun and the second verb which is in turn interrupted by the assignment of the same function to the last noun and the first verb. (Upper lines in 82 represent subject-verb relations. Lower lines represent verb-object relations.)

82 a)



b)



It is intuitively clear that a self-interrupting operation is more complex than one which does not interrupt itself. However, it is not theoretically motivated that one interruption be acceptable (as in 81b) and two interruptions are entirely unacceptable (as in 81a).

It is possible to subsume the relative unacceptability of double embedded sentences under a general perceptual principle (H) which simultaneously accounts for the perceptual difficulty of a superficially heterogeneous number of types of sentences.

Strategy H. A stimulus may not be perceived as simultaneously having two positions on the same classificatory dimension.

Strategy H merely articulates the unavoidable fact that a stimulus cannot be perceived in two incompatible ways at the same time. This principle combines with the view of speech perception as a function of direct mapping of external sequences onto internal structures to predict the difficulty of any sequence in which a phrase has a 'double function' with respect to such a mapping operation. Before applying Strategy H to explain the difficulty of center-embedded sentences, consider first some well-known facts.

Miller and Selfridge (1950) found that sequences with low-order probability approximations to English are difficult to perceive, e.g. a sequence like 83 is more difficult than 84.

83 he went to the newspaper is in deep (2nd-order approximation)

84 then go ahead and do it if possible (7th-order approximation)

(A '2nd-order approximation' is generated by giving a subject two words (e.g. 'he went') and asking him to produce the next word of a sentence ('to'); the next subject is given the last two words of the sequence ('went to') and produces the next word ('the'). A '7th-order approximation' is generated by giving each subject the last seven words of the sequence and asking for the next word.) The relative ease of perceiving sentences as they increase in order of approximation was taken by Miller and others as evidence for the organizing role of syntactic structure at levels higher than a single word. For example, in sequence 84 the sequence forms a sentence, while in 83 they do not. However, this did not explain the exact psychological nature of the behavioral difficulty of low orders of approximation. In fact, if forming a sentence makes word strings easy to perceive, it might be predicted that sequence 83 should be psychologically simpler since it simultaneously forms *two* sentences (as in 85 and 86).

85 he went *to the newspaper*

86 *the newspaper* is in deep

The real basis of the psychological difficulty is clear: the italicized portion of the sequence is vital to each sentence — that is, it has a 'double function'. There is a general cognitive restriction which results in psychological complexity whenever such double functions appear. As a visual example, consider the representation of the two adjacent squares in Fig. 11. The line labeled 'y' is simultaneously shared by the right and left squares. As a result, Fig. 11 is generally perceived as a divided rectangle rather than two adjacent squares.

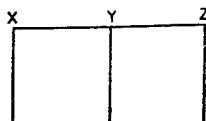


Fig. 11. Figure most easily seen as a rectangle with one division at 'y', rather than two squares joined at 'y'.

Often such double functions in vision can produce 'impossible' figures from the combination of two possible figures, e.g. Fig. 12.

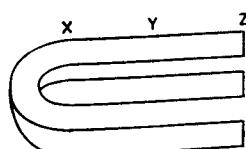


Fig. 12. Figure that is 'impossible' because of combination of 2- and 3-dimensional projection at point 'y'.

The general psychological principle which governs these visual examples is a special case of Strategy H: *in a closed system a component of a stimulus cannot serve two opposite functions at the same time.* For example, in Fig. 11 line 'y' cannot both end one square and begin another; or in Fig. 12 the segment labeled 'y' cannot both end one kind of figure (the 3-dimensional 'u' opening right in the segments labeled x-y) and begin the other (the three poles in the segments labeled y-z).

There is a related explanation for the psychological difficulty of 'center-embedded' sentences. Phillips and Miller (1966) noticed that part of the complexity of center-embedding may be due to the fact that in a sentence like 81a the second noun is the subject of one clause and the object of another (see 82). If understanding a sentence involves labeling each word for its logical function in the underlying structure, then the second noun in 81a could be interpreted as having a 'double function' with respect to a strategy which maps external noun sequences onto internal structures in which the first noun is the object of a verb of which the second noun is the subject. With respect to the preceding noun it is a subject while it is an object with respect to the following noun. The general double function hypothesis for perception following from Strategy H is this:

Strategy I. In a sequence of constituents x, y, z, if x has an internal relation R_i to y and y has the same internal relation to z, and x, y, and z are superficially identical, then the stimulus is relatively complex, due to y's double function in the perceptual strategy, S_i

$$S_i : x \ y \xrightarrow{S_i} x \ R_i \ y$$

Notice that the prediction of the perceptual difficulty of center-embedded sentences from Strategy I depends on the existence of strategies for the direct perception of the internal structure relations from the external sequence which define the relations (R_i) which adjacent phrases bear to each other. One relevant strategy is presented in J.

Strategy J. In . . . $NP_1 \ NP_2(VP)$. . . sequence in the external structure, NP_1 is the internal object of an internal structure sentence unit of which NP_2 is the subject.

Of course, Strategy J (like A, B, C) is not *always* true as in 87, but it is probably

87 *the boy the girl was seen by* is here.

true of external sequences most of the time. The same is true of Strategy K.¹³

¹³ Note that it is not crucial to this explanation that strategies J and K exist independently – only that the external/internal relations they describe are utilized as listeners hear sentences which justify those strategies (e.g. 81a).

Strategy K. In . . . $V_1 V_2 . . .$ (in which the verbs are finite), V_2 corresponds to the main verb of a sentence with V_1 as the subordinate verb.

The relations assumed by Strategies J and K combine to make single-embedded sentences like 81b quite simple to perceive. But the same strategies make doubly-embedded sentences difficult because of Strategy I. With respect to the internal relation set up by J, NP_2 is simultaneously the left hand and right hand member of that strategy in double-embeddings, while V_2 is simultaneously the right and left hand member of Strategy K. Notice that the superficial identity of the three NP 's and V 's in an embedded sentence increases the difficulty since it makes the relation between the first and second and second and third constituent *absolutely* identical. Thus, if N_2 or V_2 differ superficially from their surrounding phrases, sentences like 81 should become easier. I have not tested this, but it seems to me that 88, in which N_2 and V_2 do differ superficially from their adjacent constituents, is relatively comprehensible (compared with 81a). (Note that the semantic constraints have not changed from 81a.)

88 The dog the destruction the wild porcupine produced was scaring will run away fast.

There are other kinds of examples in language explained by the double function principle I. Consider the complexity of the sentences in 89:

- x y z
89 a) They did not want me not to promise not to help them.
 b) They did not want me to promise not to help them.

- x y z
 c) John is not not available for no charge at all.
 d) John is not available for no charge at all.

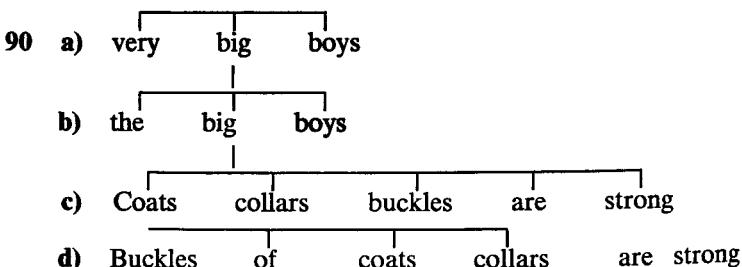
89a and 89c are examples of triple negation, which has often been recognized as extremely complex, if acceptable at all. Like the embedded sentences 81a, b, sentences with two negation markers are perfectly comprehensible and acceptable (as in 89b, d). Strategy I applies to predict both the difficulty of sentences with three negations and the relative ease of sentences with two negative markers. Consider the perceptual Strategy L which defines the perceptual operation signalled by a negative marker. L operates to place the second 'not' in the above sentences as both the scope of the first negation and simultaneously the operator

Strategy L. Negation markers (not, un, etc.) apply the operation of semantic negation to their syntactically defined scope.

on the third negation. According to Strategy I any sequence with such a double perceptual function is perceptually complex.

This principle also explains the difficulty of many so-called 'left-branching'

structures. Yngve (1963) has proposed that phrases with a left-branching external hierarchical organization (e.g. 90a) place a greater load on immediate memory than phrases with a right-branching organization (e.g. 90b).¹⁴ According to this view (as elaborated by Johnson 1965) 'left-branching' involves greater load on temporary memory than 'right-branching'. This is allegedly due to the number of hierarchical phrase structure 'commitments' for the rest of the sentence that are made by the words in a left-branching structure. For example, the word 'very' in 90a allegedly 'commits' the talker to an adjectival phrase modifying a noun, while the word 'the' in 90b makes no such commitment. Presumably structures involving more commitments are harder to produce, because they require a greater memory load, to ensure that commitments made earlier in a sentence are fulfilled. This model of speech processing is intended to account for the relative difficulty of sentences like 90c as compared with 90d:



This proposal is coherent as a model of complexity in speech production. But for speech perception it appears that one could argue that left-branching structures should be *simpler* to understand if there is any effect at all, just because the increased number of structural 'commitments' that the speaker makes early in a sentence should make it easier (i.e. more redundant) for the listener to predict the latter part of the sentence. Thus, even on formal grounds it is not clear that the amount of left-branching in a sentence should correspond to its perceptual complexity. Furthermore, there are many convincing counter-examples. For example, consider the perceptual simplicity of the highly left-branching sentence in 91a:

- 91 a) After a quite severe appendicitis attack the not very well dressed man fell over.
 b) Buckles of collars of coats are strong.

Thus, left-branching as such cannot be used to predict or explain perceptual complexity. Strategy I, however, does account for the perceptual complexity of the cases which appeared to support the left-branching hypothesis 90c. Sentences 90c and 91b are predicted to be relatively more difficult than the other sentences

¹⁴ It should be noted that the conceptual spirit of Yngve's article was similar to that of the present one: to show that certain language universals are based on the mechanisms of speech processing. The present article differs in its acceptance of the concept of underlying syntactic structure and of a perceptual theory that can recover it from the surface structure.

in 90 and 91 because of the double function of at least one phrase. (Note that 90c becomes immediately comprehensible if the word 'coats' is changed to 'fur' as in 92a, that 91b becomes comprehensible if the word 'collars' is changed to 'containers', as in 92b.)

- 92 a) fur collars' buckles are strong.
 b) buckles of containers of coats are strong.

That is, while the superficial appearance and phrase structures in 92a, b are identical with the incomprehensible sentences 90c, d, Strategy I does not apply to them because the internal relations between the three phrases now differ — the phrase in the middle is not both the left and right hand member of the same external/internal perceptual mapping strategy because of the changes in the internal relations.

Strategy I also predicts previously unexplored classes of perceptual complexity which are intuitively of the same sort as the preceding examples. Consider the sentences in 93. In each case there is a phrase (indicated by 'y') which is related to a previous phrase in the same way that it relates to a following phrase, and in each case, the sentences are extremely difficult to understand, if they are acceptable at all. As in the case of double-embedding, triple-negation and left-branching, the complexity of these sentences is a function of the presence of three super-

- x y z
 93 a) They were tired of discussing considering producing toys.
 x y
 b) They were tired of the discussion of the consideration of the
 production of toys.
 z

cially identical phrases in which the second phrase is modified by the first phrase in the same way in which it modifies the third phrase in the internal structure. Consider the relative perceptual ease of these sentences if only two phrases occur:

- 94 a) They were tired of discussing producing toys.
 b) They were tired of the discussion of the production of toys.

The sentences in 93 also become much easier to understand if the internal relations among the three critical phrases are varied:

- x y z
 95 a) They were tired of discussing ceiling producing toys.
 x y z
 b) They were tired of the discussion of the evolution of the production
 of toys.

(Note that in 95a y is the internal structure object of z while x and y are not directly related. In 95b y is the action carried out by z, but the object of x.) Finally, the sentences in 93 become perceptually simpler if the superficial form of

the critical phrases is varied, even while the internal relations are held constant (96):

- 96 a) They were tired of discussing the consideration of producing toys.
 b) They were tired of the discussion of considering the production of toys.

In brief, I have tried to show that if speech perception is viewed (at least in part) as a direct mapping of external sequences onto internal structures, then the tautology in H predicts the principle in I, which in turn predicts the relative perceptual complexity of double embedding, triple negatives, left-branching sentences among others. Thus, such sentences may be generated as syntactically (and semantically) acceptable, but hard to understand nevertheless.¹⁵

6. SOME CONCLUSIONS

These discussions of the role of language behavior in determining language 'structure' lead to several modifications of current views of the study of language. First, we must reassess the distinction between 'grammatical structure' revealed in a particular linguistic grammar and its 'actual use' which places emphasis on the independent primariness of 'abstract linguistic knowledge' isolated through linguistic investigations. Second, we must consider whether the acquisition of language systems is best interpreted in terms of the primary acquisition of a series of grammatically-defined rules or in terms of the development of the psychological systems underlying perception and memory. Finally, the demonstration that the structural and behavioral systems of language are often special expressions of cognitive universals should expand rather than limit our conception of the innate components of language acquisition: we now must focus on the problem of how the different innate components are linked together in the course of language learning and how the learned aspects are incorporated in adult language behavior.

6.1 *The Distinction Between Linguistic Competence and Performance in the Adult*

6.11 *Ideal grammar and candidate grammar*

The goal of a model of speech perception is to specify how listeners understand

¹⁵ Notice that the notion of 'double-function' in I does not refer to all cases in which a given word may both be a subject and an object in the internal structure. That is, it is not clear that sentence (a) is more complex perceptually than sentence (b), even though 'boy' in (a) is both a subject and an object while in (b) it is only a subject.

- a) the boy that the girl likes hit the man.
- b) the boy that likes the girl hit the man.

Principle I says nothing about such cases, although it does appear to imply that (a) should be more complex. However, the view that internal structures are projected directly from the surface structure predicts that sentences in which a word has a different function with respect to two different internal structure sentences is less complex rather than more so, since the two internal sentences would be kept entirely distinct from each other in perception.

the internal structures of sentences from their external form. The review of experimental work in the first part of this discussion was devoted to explorations of the role in speech perception of the structures originally isolated in 'linguistic' investigations. The conclusion drawn from these studies was that behavioral processes manipulate linguistically-defined internal and external *structures* but do not mirror or directly simulate the grammatical processes that relate those structures within a grammar. Such a conclusion invalidates any model for speech recognition which attempts directly to incorporate grammatical rules as an isolable component of recognition processes.

The first attempts to integrate transformational grammar with speech behavior were largely concerned with the 'psychological reality' of the linguistic rules proposed by linguists (reviewed in Miller 1962; Miller and McNeill 1969). Many psychologists viewed transformational grammar as a novel and radical challenge to their experimental skill. They were particularly unwilling to accept the concept of an 'abstract' underlying structure because the current psychological theory could not account for its existence. Thus, the conflict between 'behaviorism' and 'mentalism' reappeared in discussions of language behavior and motivated many 'psycho-*linguistic*' experiments.

One product of this conflict has been the distinction between 'linguistic theory' on the one hand and 'speech behavior' on the other. Linguists defended themselves from the accumulation of inexplicable psychological facts about speech by invoking the distinction between what we know and what we do. In this view, 'psycho-*linguistics*' was a logical adjunct to 'linguistics' according to the following kind of formula:

$$97 \text{ Grammar} + \text{'performance principles'} = \text{actual speech behavior.}$$

'Grammar' was taken to be an idealized account of our knowledge. The psychologists' problem appeared to be to find general performance principles which would describe how that grammar is used in behavior.

At first it appeared that many of the processes and structures postulated in Transformational Grammar would provide direct accounts of behavior. For example, Miller and McKean (1964) found that the time to match pairs of sentences with the same internal structure is a function of the transformations which differentiate their external structures: this result appeared to justify the claim that 'one linguistically defined transformation corresponds to one psychological operation'. Further research at first appeared to back up this simple competence-performance equation, but more recent research (reviewed in section 2 above) shows that this is incorrect. In point of fact, grammatically-defined *structures* may be reflected in experiments on speech behavior, but not grammatically-defined *processes*. Thus we seem to be in a dilemma: how do we account for the psychological validity of linguistic processes which define those structures and their interrelations?

This dilemma is actually an illusion created by the indeterminacy of the distinc-

tion between 'competence' and 'performance' in grammatical analysis as carried out by individual linguists. It is important here to distinguish two uses of the term 'grammar'. 'Ideal Grammar' refers to the actual structure of our knowledge of language; 'candidate grammar' refers to the attempt of a particular linguist to represent the Ideal Grammar in a particular grammatical description. Thus, candidate grammar does not, in fact, start with an abstract linguistic world as data, but rather a set of intuitions about 'grammaticality' held by native speakers. For example, the transformational grammarian appeals to an intuition shared by most of us about our language when he claims that he will consider only facts which pertain to complete sentences. We all agree roughly on what a sentence is, and no doubt, we could define psychological tests which would identify most sentences most of the time. However, even if the agreement on what is (or is not) a sentence were much weaker than it is, the point would remain the same; the linguist uses an introspective criterion to choose among his intuitions about a language. He assumes that some of the structural distinctions inherent to ideal grammar are consistently reflected in his intuitions about sentencehood, structural relations, ambiguities, and so on. He uses these consistent reflections in his own behavior to decide what data about the language he must describe in his candidate grammar.

However, even if our linguistic intuitions are consistent, there is no reason to believe that they are uniquely direct behavioral reflections of linguistic knowledge in ideal grammar. The behavior of having linguistic intuitions may introduce its own 'performance' properties; that is, there is no guarantee that a candidate grammar itself is a *direct* representation of the linguistic structure in ideal grammar. I have emphasized that the discovery of the linguistically pertinent data which a candidate grammar describes is itself a poorly understood psychological process. Therefore, a candidate grammar is *not* necessarily a unique, basic, 'non-psychological' representation of ideal linguistic structure; it is merely a description of the most direct and available of all behavioral reflections of ideal grammatical structure.

In short, for the past ten years some have taken the stability of linguistic intuitions for granted and have used those intuitions as data relevant to the construction of a universal linguistic grammar. Our apparent problem has been to put candidate grammars and psychology back together again. We are finding that it is impossible to do this *directly* according to the simple equation in 97. Instead we find that we have developed two formulae for the interaction of ideal grammar and speech behavior in grammatical analysis:

- 98** a) ideal + behavioral principles = 'linguistic data
 grammar of having 'linguistic relevant to Li
 of Li intuitions' (e.g., the facts in 4)'
 b) 'linguistic + formal grammatical = 'candidate generative grammar
 data of Li' Universals of Li'

Thus a candidate linguistic grammar may have formal properties which reflect the study of selected subparts of speech behavior (e.g. having intuitions about sentences), but which are not reflected in other kinds of speech behavior. Other kinds of speech behavior may bring out additional aspects of the ideal linguistic structure, and they undoubtedly have laws of their own, independent of the ideal linguistic structure; but all the formalizations of whatever kind of systematic speech behavior including candidate grammar must exemplify at least part of the ideal linguistic structure.¹⁶

This conclusion is in conflict with recent claims about the relationship of a linguistic grammar and behavior. For example, the current view has been expressed in the following quotations from a recent conference (Lyons and Wales 1966).

A theory of linguistic knowledge attempts to account for our 'intuitions' concerning the language. . . . (A theory of performance) is a theory of how, given certain linguistic competence we actually put it to use, realize it, express it. (Wales and Marshall, pp. 29-30)

If language were a game, 'competence' would be the rules of the game, while the actions of its players would constitute 'performance'. (Blumenthal, p. 81)

A search for an analysis of the connection between the way the structural description is specified by the grammar and the way it is 'specified' by speakers and hearers . . . is one way of formulating the psycholinguistic problem; the abstract nature of this connection between grammar and recognition is (to be) emphasized . . . the problem (is) which aspects of the structural description are relevant to explanations of particular performance tasks. (Garrett, in the discussion of Fodor and Garrett, p. 175)

These authors agree that there is a linguistic grammar which accounts for our basic linguistic intuitions of sequence acceptability, structural relations, and so forth. It is the psychologists' problem to explore the 'behavioral' relevance (if any) of the structures internal to a candidate grammar.

I have argued that a proper understanding of the behavioral and phenomenological nature of 'basic linguistic intuitions' forces us to reject as obvious the claim that a candidate linguistic grammar is in any psychological sense internal to such linguistic performance as talking and listening. To quote Jonkheere in the same volume:

It does not necessarily follow that the characterization of the rules a person is following in some form of rule-conforming behavior has to go into the explanation of how he follows these rules or performs behavior in conformity with them.

The relationship between a candidate linguistic grammar based on intuition on the one hand and the description of other kinds of language performance on the other hand may not just be 'abstract' (as maintained by Fodor and Garrett) but may be *non existent* in some cases. First, certain 'linguistic' intuitions about the

¹⁶ Note that to take one external capacity as the underlying structure for another is to make the same mistake as those linguists and psychologists who argue that one actual sentence form (e.g. 'the active') is central to other sentence forms (e.g. 'the passive').

relative acceptability of sequences may themselves be functions of one of the systems of speech behavior (e.g. perception) rather than of the system of structurally relevant intuitions. Second, the behavior of producing linguistically-relevant intuitions about potential sentences may reveal some properties which are *sui generis* and which appear in *no* other kind of language behavior.

In this paper I have considered examples of the first kind in which perceptual mechanisms underlie what initially appear to be idiosyncratic syntactic rules and examples in which the unacceptability of 'grammatically acceptable' utterances is due to perceptual mechanisms. An example of the second kind, in which an aspect of grammar is relevant only to prediction of potential sentences may be linguistically-defined transformations themselves, since they do not play a direct role in sentence perception. If they also play no role in speech production they will remain an example of grammatical mechanisms which are revealed directly *only* in the behavior of having intuitions about potential sentences.

Once we accept the possibility that ongoing speech behavior does not utilize a candidate linguistic grammar, it is no surprise that the mechanisms inherent to ongoing speech behavior do not manifest transformations or any operations directly based on them. But, one may ask, if transformations are not utilized in speech perception (and production) why do they appear to be so important in the description of linguistic intuitions? An explanation of why producing conscious intuitions about potential sentences elicits transformations which are not utilized in other aspects of speech behavior awaits a full theory of the phenomenology of linguistic intuitions. However, there are some aspects of such intuitions which provide an initially plausible basis for the importance of transformations in candidate grammars based on those intuitions. Candidate grammars are constructed mainly on the basis of two kinds of intuitions, intuitions of sequence acceptability and of relations between sentences. For example, the fact that active and passive constructions are felt to share the same basic grammatical relations and are sensed as somehow corresponding to one another is taken as a motivation for describing both as instances of a common internal structure (see the facts in 4). Furthermore, most cases of acceptability judgments involve judgments about *potential* sentences, in which one is asked to extrapolate his linguistic knowledge onto imagined situations, which often stimulates the linguist-informant to aid his 'grammaticality' judgment about a particular sequence by thinking of other sequences to which it is closely related. *Thus the formal description of a language using transformations depends in part on intuitions which are irrelevant to most ongoing speech behavior but which emphasize transformational relations between sentences.* On this interpretation it is no wonder that transformations appear in candidate grammars but not clearly in descriptions of other speech behaviors.

6.12 *Some so-called 'output conditions', derivational constraints and/or interpretive semantic rules are formalizations of behavioral constraints*

Output Conditions. Recent linguistic theorists have attempted to come to grips with the kinds of facts about sentences discussed in section 5. For example Ross (1968) discusses a constraint on the post-position of so-called 'heavy' nounphrases which would be part of the principle discussed in 5.21 that complex phrases follow simple ones. Stated informally, Ross's constraint requires that a 'complex' nounphrase be ordered to follow a 'less complex' nounphrase. For example 99a must be reordered to appear as 99b but 99c may not be reordered to appear as 99d. There

- 99 ?a) Sam showed the letter Max lost to Mary.
 b) Sam showed Mary the letter Max lost
 c) Sam showed the letter to the girl Max likes a lot
 d) Sam showed the girl Max likes a lot the letter

are several difficulties with these proposals that Ross makes explicit. First the relative acceptability intuitions are not as strong as for many grammatical differences; it is not clear that *any* of the sentences in 99 are ungrammatical. Rather, the 'complex nounphrase constraint' provides the rationale for a relative stylistic ordering, in which sentences at the extreme end of that ordering (e.g. 76a) are so poor stylistically that they are phenomenologically indistinguishable from 'ungrammatical' sequences.

Ross terms such constraints on the surface appearance of phrase sequences 'output conditions' in order to distinguish those constraints from actual transformational rules or direct restrictions on the type of transformations which are possible. Rather, such conditions set constraints on the order of phrases in an external sequence, regardless of the transformational operations involved in deriving that external order from the internal structure. Various examples of potential output conditions have been explored since the original discussion by Ross (in particular see Perlmutter 1969). In some of these cases, violations of the conditions appear to lead to ungrammatical surface phrase orders as opposed to orders that are merely poor stylistically.

I would suggest 100 as an obvious proposal (in the light of the present paper at any rate).

- 100 *Output conditions are the formalizations of behavioral constraints on language use.*

Thus we can view the heterogenous restrictions that mark the first verb if it is not the main verb, the relative ordering of complex phrases and the restrictions on the 'neutral' order of prenominal adjectives as structural reflections of the operation of the perceptual system. As we have discussed, violation of certain of these conditions results in ungrammatical sequences and in other cases only stylistically poor sequences. The explanation for such differences in the power of the effect of the perceptual constraints is presumably to be found in the relative importance and timing of the various perceptual rules as the child learns his language. The early

dependence in the child on the assumption that the first *noun . . . verb* sequence corresponds to the (surface structure) *subject action* of the main clause may explain why that restriction has many heterogenous effects on different transformations. In contrast the perceptual constraint of 'saving the hardest for the last' may be relatively weak, late-appearing and not specific to language, and thus have little effect on grammatical structure itself. A clear understanding of these possibilities requires careful ontogenetic studies of the simultaneous development of the system of speech perception, speech production and structural knowledge.

'Derivational Constraints' and 'Interpretative Semantic Rules'. I pointed out above that the perceptual strategies develop as generalizations about internal/external structure pairs of sentences: one might expect that certain grammatical restrictions which are conditioned by the perceptual system might be statable only in terms of such pairs, rather than in terms of restrictions on transformations. Certain perceptual constraints, that is, might be formally reflected as *constraints on possible derivations* between internal and external structures. Recently Postal (1969) and Lakoff (1969) have argued that there is a class of such restrictions within each grammar. For example, Lakoff points out that the nature of the restrictions on pronominal reference discussed in section 5.12 are not revealed (if statable at all) in terms of restrictions on particular transformations. Rather the restriction requires that a derivation may not destroy *both* the left-right pronominalization relationship *and* not have the superordinate-subordinate clause relation in the left-right order of the external sequence, regardless of the particular transformations that might apply. That is, certain external structure forms are not admissible as representatives of certain internal forms, and are marked as ungrammatical if any (independently motivated) transformations derive them. In this way certain transformations can generate internal/external pairs which are then marked as ungrammatical by derivational constraints on possible internal/external structure pairs. Not only are the restrictions on pronominalization statable in such terms but one might also suggest that the unacceptable sequences in 5.22 be marked as such by a derivational constraint based on the Strategy I. This would provide an apparently grammatical solution to the unacceptability of center-embedded sequences (e.g. 81a). Such sequences would be marked as 'ungrammatical' whenever generated, by Strategy I (now strengthened to mark double function sequences as 'ungrammatical' rather than merely 'perceptually complex').

Of course the formal power of such constraints is enormous¹⁷ and it may seriously be claimed that including such rules as part of grammar reduces the interest of study of universal grammar. It would be no surprise that such powerful constraints can be used to describe all languages — they probably could describe

¹⁷ Transformations are more powerful than phrase structure rules since they are sensitive to entire (single) phrase structure trees rather than to single nodes or strings. Similarly, derivational constraints are more powerful than transformations since they are sensitive to sequences of phrase structure trees rather than to one tree at a time.

anything. Thus, it may be that to include such constraints in the formal repertoire of universal grammar would reduce the study of grammar to an unrevealing taxonomy.

It would appear that phenomena describable by internal/external structure constraints and that the full description of language must include such structural devices. However, the existence of such constraints does not lead necessarily to the conclusion that they must be included within grammar itself. One could argue that sentences which violate the constraints are grammatical, but unacceptable for perceptual reasons, or semantically anomalous. For example, center-embedded like 81a would be marked as perceptually complex, and sentences like 52c would be described as grammatical but semantically anomalous on the interpretation of co-reference of the two nounphrases. In this way grammatical simplicity and purity would be purchased at the expense of descriptive power granted to other aspects of sentence description.

Chomsky (1969), Jackendoff (1969) and others have recently argued that this is the correct course. In particular Jackendoff proposes that the analysis of pronominal co-reference be treated (at least in part) by the system of semantic analysis rather than syntactic derivation. He argues from independent cases that certain semantic information can be extracted only from an examination of the surface structure of sentences. Thus, semantic interpretive rules have the power to examine both the internal structure and external structure in order to assign certain aspects of the semantic interpretation of each sentence. Accordingly, the semantic assignment of reference relations in sentences with pronominalization can be stated (where necessary) by referring to the internal/external relations of each sentence. On this interpretation sentences like 52c are grammatical but semantically anomalous if 'George' and 'he' are co-referential.

It is clear that a linguistic description which contains syntactic internal/external derivational constraints makes different claims about the basis for sequence acceptability from a grammar which has no such syntactic constraints, but uses semantic rules which are sensitive to both internal and external structures. A sequence which is marked as *ungrammatical* by the first type of grammar would be marked as *semantically anomalous* by the second type. Even if this is the only difference between the two grammars it should not be concluded that the differences are trivial — the claims about the etiology of the acceptability of a particular sequence are a crucial empirical test for any candidate grammar.

Whatever the outcome of this theoretical question, it is clear that certain types of constraints on internal/external structural relations must be included within some component of the description of language. I have argued that since the child forms his strategies for speech behavior across such internal/external structure pairs, many (if not all) derivational constraints of this sort can be shown to be derived from non-linguistic 'behavioral' principles.

6.13 What is the science of linguistics a science of?

Linguistic intuitions do not necessarily directly reflect only the structure of a language, yet such intuitions are the basic data the linguist uses to verify his grammar. This fact could raise serious doubts as to whether linguistic science is about anything at all, since the nature of the source of the critical data is so obscure. However, this obscurity is characteristic of every exploration of human behavior. Rather than rejecting linguistic study, we should pursue the course typical of most psychological sciences; give up the dependence on an 'absolute' intuition about sentences and study the laws of the intuitional process itself.

This course of action has been fruitful in other areas of psychology. Consider the subjectivity of astronomical star-transit judgments, which (according to E. Boring) was one of the first problems to arise in the context of what we know today as psychology. For a time, astronomers believed in the 'absolute' constancy of their judgment of the instant at which a star crossed a certain reference point. However it was noticed that different observers produced different judgments, so each pair of astronomers were related by a 'personal equation', which specified the relative delay in their judgments. Ultimately it was observed that even an individual's judgment delay was not constant, and could vary from situation to situation.

These observations could have been used to justify rejection of any facts based on personal reaction time, and indeed astronomers turned to other timing techniques as soon as they became available. However, the study of reaction time itself became one of the main areas of experimental psychology. Given that reaction times are not absolute or free of the context in which they occur, psychologists have explored systematically the interaction between reaction-time and its context.

The effect of stimulus context on absolute judgment of the stimulus has become a part of almost every branch of psychology. One of the most basic laws governing the interaction between stimuli is the *law of contrast*; for example, the well-known phenomenon of feeling that the ocean is cold on a hot day, while the same ocean at the same temperature feels warm on a cold day. That is, one's 'absolute' judgment of a stimulus can be exaggerated by the difference between the stimulus and its context. This influence by contrast clearly can occur in 'intuitions' about grammaticality. For example, **101b** preceded by **101a** may be ungrammatical, but contrasted with **101c** it will probably be judged as grammatical.

- 101** a) who must telephone her?
- b)? who need telephone her?
- c)* who want telephone her?

That is, not only are there several reasons for the unacceptability of sequences, but even the notion of structural grammaticality is itself subject to contextual contrast.

Often the nature of contextual influences on absolute judgments is less clear than in cases of contrast. For example, the perception of an unsaturated spot of color is

greatly influenced by its surroundings. Surrounded by a yellow background, a pale green spot may appear blue, while the same green spot appears deep green if it is surrounded by red. These differences in judgment are quite stable, in the sense that even with conscious instruction about the nature of the situation the perception of the colors is still influenced by the surrounding context in the same way.

Cases like this cannot be described as mere 'contrast' effects: in what *a priori* sense does red contrast more directly with green than yellow does? Human observers themselves *contribute* this notion of contrast even in the absence of obvious physical parameters to be contrasted (unlike the case of the influence of hot or cold on the perception of luke-warm in which the differences and contrasts have an objective contrasting measure). In the case of color perception, it is in the nature of our visual system to contrast red and green in one dimension and blue and yellow in another dimension.

It is quite possible that there are similar situations that obtain between sentences, in which judgments of the grammaticality of one sentence are affected by the other sentences among which it is placed, even when the other sentences do not appear to contrast with the stimulus sentence in as direct a manner as in 99. This proposal is subject to demonstration, for which I propose the following experiment (in a Gedanken-state at the moment). Take all the example sentences from several linguistic articles (excluding those sets that contrast directly, analogous to the situation in 99) and present them to subjects either in the original sequence, taken separately from each article, or entirely shuffled from all the articles. Subjects must simply indicate which sentences they think the original articles assumed to be grammatical and which were labeled ungrammatical. It would not be surprising if subjects replicate the judgments of the original articles much more consistently when presented with the examples in their original order than when presented all the sentences from the different articles in some random order. If this is true, it will demonstrate that the judgments of 'absolute' grammaticality are illusory and that a science of the influence of context on acceptability judgments is as necessary in linguistic research as in other areas of psychology.

Such a criticism does not invalidate linguistics, even without experimental reform. Many intuitions about sentences appear to be strong enough to resist contextual effects, and we can expect that these intuitions will remain constant even when we have developed an understanding of the intuitional process (e.g., the relationship between actives and passives; the fact that 'John hit the ball' is a sentence of English, etc.). However, recent trends in linguistic research have placed increasing dependence on relatively subtle intuitions (c.f. Lakoff 1968, 1970; Kiparsky and Kiparsky 1971, Ross 1968 and MacCawley 1968) whose psychological status is extremely unclear. Since there are many sources for intuitional judgments other than grammaticality and since grammaticality judgments themselves can be influenced by context, subtle intuitions are not to be trusted and certainly not used until we understand the nature of their interaction with factors which are irrelevant

to grammaticality. If we depend too much on such intuitions without exploring their nature, linguistic research will perpetuate the defects of introspective mentalism as well as its virtues.

6.2 *The Acquisition of Grammar*

Ideally, a model of language learning should specify how the child discovers the systematic relations between internal and external structures of language used in talking, listening, and predicting potential sentences. This review has explored the effects of the system of listening (and presumably talking) in the young child on the system of predicting potential sentences in the adult. The existence of this interaction shows that it is not the case that the predictive grammar is learned independently from the use of language, rather it is learned in the course of its use.

However, many recent studies have been devoted to exploring the child's acquisition of language in terms of his acquisition of linguistic rules, independent of their use. A standard methodology is to observe the child's utterances at a given stage and to then write a 'miniature grammar' for his utterances; language development is then described as an ordered series of such 'grammars'.

There are several methodological difficulties with such a program. First, adult grammars are based on a variety of linguistic *intuitions* about sentences, not actual utterances. The 'grammar' for what an adult actually says (and what he understands) would undoubtedly look quite different from the grammar that accounts for his intuitions about sentences *in vitro*. Thus, while a description of the maturation of the child's productive (or perceptual) system for language is interesting, it does not bear directly on his acquisition of a system of linguistic knowledge. Second, any finite set of linguistic data about specific sequences justifies an infinitude of candidate grammars. Which candidate grammar is used to generate a particular corpus of data depends on intuitions *about* the acceptable sequences (like the notion of relations between sentences) as well as *a priori* decisions by the linguist as to what theoretical form a grammar must have, and what kinds of intuitions are relevant to his description. Since young children do not present us with their intuitions *about* sentences and intersentential relations we cannot narrow the range of possible grammars implied by any finite set of their utterances. Furthermore, we cannot use preconceived notions about the form of grammar underlying a child's utterances (such as the assumption that it is initially non-transformational) because this would prejudge the sort of fact which we are trying to ascertain by collecting his utterances in the first place.

Suppose, however, that these difficulties with writing grammars for utterances of pre-schoolers were somehow overcome by finding a way of eliciting 'linguistically-relevant' intuitions from young children. One would then be able to study the development of the systems for predicting potential sentences. At each point in the

child's development one would still have to examine the structure of his other systems of language behavior to assess their interaction with his allegedly 'linguistic' intuitions. Thus, like an adult (as in sentence 81a), a child may reject a particular sequence as ungrammatical simply because he cannot understand it. Of course the situation would be more complex than for an adult, even in the study of a child who could articulate his 'linguistic' intuitions, since his perceptual and productive systems for language behavior would themselves be evolving and presumably would interact with each other and with the system of predicting new sentences from old.

This paper has concentrated on the interactions between 'linguistic' structures and perceptual mechanisms in the child and adult, although it is clear that mechanisms for *learning* a language affect the eventual structure of a language even more dramatically than the perceptual system. I have said little about the effects of general principles of learning on linguistic structure because I do not know anything about how language (or anything else) is learned, while I do have some initial understanding of the mechanisms of perception. There is no doubt, however, that as we understand more about the learning of language we will be able to account for even more of the structures that we find in our adult ability to make predictions about potential sentences.

The claim that languages are learned via a series of sub-grammars of the adult language remains to be demonstrated. However, there are certain non-grammatical behavioral variables which we know to affect the learning of language, even though we do not yet understand the learning process itself. The most obvious behavioral constraint on language acquisition is the development of memory in the young child. The child's immediate and long-term memory must constrain his language ability in vocabulary size, utterance length and amount of material in the external structure of sentences deleted from their internal structure. The fact that the child starts out with a small vocabulary and short utterances is well-attested. Recent research by Brown and Hanlon (1970) demonstrates further that the child also has some difficulty with constructions which depend on active reconstruction of the internal structure.

6.3 *The Unity of the Universals of Language and Thought in the Mind*

Recent discussions of language and linguistic theory have emphasized the extent to which the capacity for language is innate in human beings. The formal articulation of innate language structures is contained in the *universal grammar*, which represents all the formal characteristics and constraints which a grammar for each language must reflect. For example, the putative universal grammar states that every language has an internal structure, an external structure and a set of transformations which map the former onto the latter, that there are distinct categories for 'noun' and 'verb', and so on. Chomsky (1965) suggested that we must distinguish between

formal and *substantive* universals. Formal universals describe the *types* of rules which are possible (e.g. that there are transformations) while substantive universals describe the universally available stock of terms used in languages (e.g. that 'noun' and 'verb' are possible syntactic categories). Many substantive linguistic universals appear to be derivable from more general psychological universals. For example, the universality of the noun/verb distinction in language might be explained as the linguistic reflection of the general cognitive distinction between objects and relations between objects (cf. Chomsky 1965 : 28). Thus the concept of 'noun' would not have to be taken as a linguistic universal in itself but merely the linguistic expression of such a cognitive universal. The formal universals are also susceptible to immediate explanation as special instances of general cognitive structures. For example, one could argue that there are transformational systems in other areas of behavior; e.g. the systematic set of transformations involved in interpreting a 3-dimensional object from a 2-dimensional projection of that object.¹⁸

This paper has explored the way in which behavioral systems affect all linguistic structures. There are many instances in which the structure of adult linguistic intuitions about potential sentences is influenced by the mechanisms of language perception and learning. The isolation of such cases suggests that there are universal constraints on the form of ideal grammar which are not inherent to the statement of universal grammar itself, but rather to the way in which ideal grammar is learned and the use to which it is put. One possible example of this sort is a universal constraint on the amount of ambiguity of internal structural relations in sentences. Many languages represent the internal relations by the order of the words in the external structure and a few selected function words (as does English). Other languages allow relatively free ordering but have a rich system of inflections (e.g. Russian); some languages have both ways of representing the internal relations to some extent. However, languages which have neither and languages which have both systems to a great extent appear to be very infrequent (if they exist at all). The relevant constraint appears to be that a language may not have *too much ambiguity of the internal relations* in the external forms of sentences. This condition is difficult to state formally as part of the universal grammar because it cannot be phrased unequivocally — that is, all languages have *some* internal-structure ambiguity, so the universal grammar cannot rule out such ambiguous derivations entirely. On the other hand, the frequency of such ambiguities must be restricted. Such a restriction can be interpreted as coming about as a natural function of the fact that a language in which every sentence has an indeterminate internal structure (except from context) will not be learned by children. However, such a restriction

¹⁸ For a clear example of a formal universal which reflects general cognitive structures consider Chomsky's proposal that it is a formal linguistic universal that '... proper names... must designate objects meeting a condition of spatiotemporal contiguity and that the same is true of other names designating objects' (1965: 29). Surely one could argue that the same principle applies to the visual apprehension of objects, independent of their name, and that the principle pervades all behavior.

is not a part of universal grammar but a statement about the universals of language learning.

The distinction between language structure and speech behavior is reflected in two approaches to the description of language within linguistic theory, 'structuralism' and 'functionalism'. The structuralist approach is most developed in the current work in generative grammar, while the functionalist analysis has been associated with the writings of A. Martinet. The structuralist attempts to enumerate the sentences and their interrelations; the functionalist views 'structure' as a kind of epiphenomenon whose real basis is in the use of language as a communicative instrument. The problem has been that these approaches beg each other's questions: the pure structuralist has no way of describing the structural effects of the communicative function of sentences; the functionalist has no available analytic basis for a description of their communicative function. The present paper attempts to combine these approaches by consideration of a theory of speech behavior as one aspect of the use of language as a communicative tool which can be related to linguistic structure. In a sense, we are embarking on a kind of 'neo-functionalism' — an investigation of the mutual interaction of systems of speech as a communicative instrument and linguistic structure internal to it. Presumably as our understanding of the mechanisms of speech production and learning increases, more extensive insights will be available into the interaction between structure and communicative function.

One might be tempted to conclude from such investigations as these that our problem is now to 'subtract out' general cognitive structures from linguistic structures in order to isolate the 'pure' linguistic universals, as depicted by the formula in 102. Indeed the arguments in this paper might be taken as demonstration that

$$102 \quad (\text{Apparent Linguistic Universals}) - (\text{Cognitive Universals}) = \text{Real Linguistic Universals}$$

there is not as much innate structure to language as we had thought if the 'universal grammar' is stripped of those aspects which draw on other psychological systems (cf. McNeill 1969 for considerations of just this possibility).

However, such an enterprise fails to take into consideration the fact that the effects between language and cognition are mutual; one cannot consider one without the other. The isolation of cognitive mechanisms which are utilized in language does not explain them away as linguistic structures any more than the fact that we can name abstract (non-linguistic) concepts explains how we come to have such concepts. The discovery that certain aspects of language are based on mechanisms of perception, learning and cognition only increases our puzzle, since we must now explain how they are all integrated in human communicative behavior.

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