of the passive construction. Many examples appeared of sentence constructions in which more grammatical transformations resulted in sentences which were in fact *simpler* to understand, as in the examples (b) in (26).

26. (Sentence pairs in which (b) has more transformations than (a) but is perceptually simpler)

    a.   The dog was called by someone.
    b.   The dog was called.

    a.   The cat that is small is on the mat that is made of grass.
    b.   The small cat is on the grass mat.

    a.   That John left the party angrily and quickly annoyed Bill.
    b.   It annoyed Bill that John left the party angrily and quickly.

While everybody was willing to agree with the claim that sentence perception involves in part the discovery of the internal, 'logical' relations inherent to each sentence, it was not at all clear how the grammatical structures used to describe intuitions about sentences are themselves deployed in actual sentence processing (Fodor and Garrett, 1968). Such an observation raises the general question: which linguistically-postulated structures are primary in actual speech behaviour and which are abstracted from behaviour?

There are three structures which are manifest in most linguistic theories (even those that are not 'generative'), the phoneme, the external phrase structure, and the internal 'logical' structure. Our current research suggests that these three structures are the residue of an internal abstraction process, rather than structures which are themselves actively used in all normal speech processing. There is strong empirical *linguistic* evidence for the 'reality' of each of the three linguistic structures: each structure is necessary for the description of certain indisputable facts about sentences. However, observational and experimental investigations indicate that the role of these structures in speech behaviour is dependent on the particular activity. In general, these linguistic structures appear in behaviour as organising concepts rather than as primary behavioural entities.

(a) THE NONPERCEPTUAL AND NONARTICULATORY REALITY OF THE PHONEME. Consider first the phoneme, the basic sound unit in language. The word *bats* is made up of four such units, which correspond (in this

case) to the individual letters in the spelling of the word. There is a great deal of intuitive confirmation of such a subdivision of the acoustic stream of speech: the presence of spoonerisms in speech, of alliterative and rhyming folk poetry, and the natural development of phonemic alphabets. In formal linguistic study the phoneme is the basic segment for analysis of the sound patterns unique to each language. In English, for example, the rule for the regular formation of the plurals is as stated in (27).

27. To the singular form add
    (a) /s/ if it ends in a voiceless consonant except those in (c)
    (b) /z/ if it ends in a voiced consonant or vowel except those in (c)
    (c) /ehz/ if it ends in a sibilant or fricative consonant

For example, after the word *bet* (case (a)) the plural ending is pronounced '-s' as in *bets*; after the word *bed* (case b) it is '-z' as in *bedz*; if the singular form of the word ends in a vowel (eg, *bay*, case b) then the plural is also pronounced '-z' (as in *bayz*). Finally, after the word *bush* (case c) the plural ending is pronounced '*ehz*' as in *bushehz*. ('Fricative sounds' are phonemes that involve a marked turbulence of air in their production; eg, the last sound in 'bush, butch, budge, rouge, bus, buzz'.)

These three rules account for all the regular plural forms in English in an elegant and straightforward manner. The large number of acoustic-articulatory phenomena in languages that are equally well described in terms of phonemes is the basic descriptive motivation for postulating their existence. Unfortunately, attempts to determine the acoustic (or articulatory) definition of the objective constancies associated with each phoneme have been frustrating and unsuccessful. The physical realisation of each phoneme is modified by the surrounding phonemes. The acoustic (or articulatory) definitions must take into account sequences of several phonemes at the same time so that the interdependencies can be included in the description.

A more natural unit for objective definition of the basic units of speech perception and articulation is the *syllable*. Not only do we feel that we talk in syllables (rather than stringing phonemes together) but it is also possible objectively to describe the physical properties of the articulatory and acoustic boundaries of syllables. Such boundaries are marked by changes in articulatory movements and corresponding changes in the acoustic intensity of the speech signal. The relative clarity of the objective definitiveness of the syllable is also reflected in

the fact that it is possible to speak all syllables in isolation, but impossible to speak most phonemes in isolation.

Unfortunately the description of linguistic phenomena such as plural formation cannot be naturally described in terms of unsegmented syllables, but must depend on the subdivision of the syllable into phonemes. There are approximately 5,000 unique syllables in English. The rule for plural formation would have to list the different kinds of syllables that take the different plural forms (in $/-s/$, $/-z/$ and $/-ehz/$) in the rule like (28).

28. To the singular form add
    (a) $/s/$ if it ends in '-bet, -bat, -but, . . . -sip, -sap, -sup . . .'
    (b) $/z/$ if it ends in '-bed, -bod, -bud, . . . -sib, -sab, -sub . . .'
    (c) $/ehz/$ if it ends in '-bef, -baf, -buf, . . . -sis, -sas, -sus . . .'

While such a representation in terms of syllables would be slightly more economical than listing all the singular words themselves, the major generalisation would be lost that it is the sound *at the end* of the syllable that determines the sound of the plural. This fact could be captured by describing syllables in terms of the sounds that they end in, and stating the rules as listed for the phonemic analysis, as above. But this description would be equivalent to the phonemic analysis itself since it would merely be a circuitous way of referring to the phoneme in question as 'the last sound of the syllable'. Of course, rule (28a) and (28b) would in fact be impossible to state in an unsegmented syllabic system: neither $/s/$ nor $/z/$ are themselves syllables, and therefore could not be used as theoretical terms. One would actually have to list separately the pluralisation process as the formation of a new plural syllable from each singular syllable as exemplified in (29). That is, using unsegmented syllables, plural formation would be a process made up of thousands of rules.

29.
singular form	plural form
-bet	-bets
-bat	-bats
-bit	-bits
.	.
.	.
.	.
.	.

Thus we appear to be in a dilemma. While the syllable is the natural unit for the description of linguistic data, the phoneme is the natural unit for the description of linguistic regularities. This dilemma can be

converted into an empirical question about the relative role of the phoneme and syllable in actual speech behaviour. To examine this, Harris Savin and I (Savin and Bever, 1970) compared the amount of time it takes for a person to react discriminatively to a syllable beginning in a particular phoneme depending on whether or not he knows the entire syllable to listen for or just the first phoneme of the syllable. We found that it takes about a fifteenth of a second *longer* to identify the syllable when only the first phoneme is known than when the entire syllable is known. Yet all the responses are completed before the middle of the vowel. Listeners are conscious primarily of syllables, and secondarily of the phonemes. We take this result as an empirical reflection of the fact that phonemes are themselves entities which are abstracted out from speech perception and production. The role of such units is to 'mediate' the acoustic and articulatory regularities in the language. Phonemes are 'psychologically real', but their level of conscious reality is *derived* from the primary acoustic/articulatory speech unit, which is the syllable.

(b) THE ABSTRACTNESS OF SURFACE PHRASE STRUCTURE. Another theoretical structure postulated by all linguistic theories is the external phrase structure (or 'parsing structure') which ascribes a hierarchical analysis to the relations between adjacent words and phrases. The phrase structures in (30a) and (30b), indicated by parentheses, represent such hierarchical relations among sequences. Like the phoneme, phrase structure organisations of sentences are critical to the formulation of linguistic rules which capture generalisations about sentence organisation. The phrase structure analysis of sentences is behaviourally reflected in our perception and production of the placement of relative pauses, as well as agreeing with our intuitions about the relative closeness of the associations between adjacent words. Analyses like those in (30) represent empirical data in language behaviour. Phrase structure hierarchies are also indispensable to linguistic analysis; they represent the notion of *phrase type*, which is the theoretical term referred to in linguistic rules (eg, 'noun phrase, verb phrase, adverbial phrase', etc). Each phrase type subsumes a wide variety of distinct constructions, each of which is treated as the same by grammatical rules.

30. a. (they (fed him (dog biscuits)))
      b. (they (fed (his dog) biscuits))

31. $NP_1 \ V \ NP_2 \ \rightarrow \ NP_2$ be $V+$ed by NP_1