FUNCTIONAL CLAUSES AND SENTENCE SEGMENTATION

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In two experiments subjects listened to a sentence containing a brief tone, then wrote out the sentence and marked the location of the tone. The experimental sentences were biclausal with the tone placed before or after the clause break. The initial clause was either functionally complete or functionally incomplete. Functionally complete clauses contain a complete set of fully specified grammatical relations, while functionally incomplete clauses do not. In Experiment 1 tones were mislocated toward the clause break and the final word of the first clause significantly more often for functionally complete clauses. Experiment 2 replicated this finding holding deep- and surface-structure variables constant. The results indicate that functionally complete clauses are better segmentation units during sentence perception than functionally incomplete clauses. Purely structural theories of the units of sentence perception cannot account for this finding.

A central concern of psycholinguistic research is to specify how listeners process large segments of speech, like sentences. In physical terms, speech consists of a complex and essentially continuous patterning of acoustic energy. Spoken sentences can be several seconds long and the listener's processing capabilities are limited. Several investigators have proposed that the listener segments the speech signal at various points, treating the material between points of segmentation as a unit in perceptual processing (Fodor and Bever, 1965; Bever, Lackner, and Kirk, 1969; Chapin, Smith, and Abrahamson, 1972; Caplan, 1972). According to the model of sentence perception presented by Fodor, Bever, and Garrett (1974), when the listener encounters the end of a segmentation unit, the preceding sequence is integrated and recoded into a more abstract holistic unit, thus freeing the processor for further analysis.

An initial step in the project of studying sentence segmentation must be a careful characterization of what sort of linguistic sequences can serve as segmentation units. Several studies addressing this question have used the click location paradigm. Fodor and Bever (1965) reported that brief bursts of noise superimposed on recorded sentences tended to be subjectively mislocated into linguistic constituent boundaries. They suggested that clicks are deflected into constituent breaks because linguistic constituents tend to be segmentation units in sentence perception. Bever, Lackner, and Kirk (1969) reanalyzed Fodor and Bever's data and found that only constituent boundaries corresponding to linguistic deep-structure sentoids attracted clicks. In two further requirements, they first demonstrated that minor constituent boundaries did not attract clicks, and second, that clicks were mislocated toward the boundaries of both surface-structure clauses and deep-structure sentoids that did not correspond to surface-structure clauses. Since in the linguistic theory Bever et al subscribe to (Chomsky, 1965), all surface-structure clause boundaries correspond to deep-structure sentoids but not conversely, they concluded that listeners organize linguistic materials into units corresponding to deep-structure sentoids. Chapin et al (1972) challenged Bever et al's conclusions, arguing that the segmentation unit corresponds to the surface-structure constituent (such as, noun phrase, verb phrase). They demonstrated that, for certain constructions, major surface-structure constituent boundaries are more likely to attract clicks than deep-structure clause boundaries.

Although the primary motivation for the construct of segmentation in sentence perception is functional (for example, limitations on working memory), hypotheses about the nature of segmentation units have been couched in purely structural terms. Ignoring functional variables has led these structural theories to make some implausible predictions about sentence perception. For example, a deep-structure sentoid or constituent theory of sentence segmentation would predict that segmentation will occur just after the word *fleeing* in (1), because *fleeing* is both a major constituent and a surface clause corresponding to a deep-structure sentoid. However, the single word *fleeing* certainly seems an implausible source of processing load.

(1) *Fleeing* was John's favorite strategy, but many called it cowardice.

And indeed, that the word *fleeing* corresponds to a coherent linguistic clause or constituent can only become apparent to the listener in light of the material that follows it in (1). The deep-structure sentoid position encounters additional difficulties in sentences such as (2). For many linguists (for example, Stockwell, Schachter, and Partee, 1973), the adjective *tall,* in Sentence (2) corresponds to the deep-structure sentoid S_2 in (3),

(2) *The tall* man ordered a Scotch-on-the-rocks.
(3) S_1 [The man S_2 [the man is tall] S_2 ordered a Scotch-on-the-rocks.] S_1,

which presents a deep structure bracketing of (2). Thus, the sentoid theory predicts that the sequence *the tall* should be parsed as a perceptual unit.

Structural theorists are aware that their claims need to be weakened. Bever et al, in a footnote, cautioned that all deep-structure clause boundaries might not equally be capable of stimulating segmentation. Conversely, they acknowledged that factors other than clausal structure might stimulate segmentation.

Recent work (Carroll, 1976; Tanenhaus and Carroll, 1975), more strongly suggests that purely structural conceptions of segmentation units in speech perception are not adequate. The term functional clause was introduced to distinguish sequences that are effective processing units from those that are not. Several factors were proposed that could be instrumental in determining whether a linguistic sequence would be treated as a segmentation or processing unit.

The primary factor we have developed is functional completeness. Sequences that contain a complete set of grammatical relations (subject, verb, and object) will be better segmentation units than sequences with unspecified or deleted grammatical relations. According to Fodor, Bever, and Garrett's (1974) model, segmentation units are recoded and dismissed from working memory. Thus, it is essential that the linguistic material comprising a segmentation unit be recodable into an independent memory structure. Current views of memory identify such memory units with propositional structures (such as, Fredricksen, 1975; Kintsch, 1972; Lindsay, Rumelhart, and Norman, 1972). Our definition of the functionally complete clause is closely related to these notions of proposition: A well-formed proposition must include a coherent set of nominal and predicate elements just as a functionally complete clause must include a complete set of grammatical relations.

Clauses such as *John hit Harry* in (4) and *after John left school,* in (5) exemplify functionally complete clauses.

(4) *John hit Harry* when Harry called him fat.
(5) *After John left school* he went swimming.

Both sequences explicitly represent the subject, verb, and object of the verb that together define their corresponding propositions. Functionally incomplete clauses fail to do this. For example, consider so-called "headless" nominalizations like (6) (and (1) above).

(6) *After falling* John went to the hospital.

Sequences like *after falling* explicitly indicate the main verb but not the subject noun of the deep-structure sentoids to which they correspond. Hence, they are incomplete vis-a-vis the functional (that is, grammatical) relations which comprise a functional clause. As a second example, consider noun phrases like *the tall man* in (2). This sequence can be associated with the proposition corresponding to S_2 of (3). Because *the tall man* explicitly represents the subject noun and the predicate adjective of S_2 but not the copula verb, it is also a functionally incomplete clause.

Now consider the factor of clause marking. As the elements of a clause must be integrated and recoded as a whole, the various clauses comprising a sentence must also be integrated. Thus (7) and (8) are distinct sentences.

(7) *Since Joan is sick* Harry is upset.
(8) *Harry is upset* since Joan is sick.

Listeners must be sensitive to the occurrence of complementizing and subordinating markers, because these grammatical formatives specify the relations between clauses. In a sentence like (7) the listener is warned from the outset that the *underlined* initial clause is an adverbial modifier of the following main clause. However, in (8) there is no such marking on the initial clause. Thus, the processing that occurs around the clause break in (7) (that is, between *sick* and *Harry*) might be different (for example, less complete) than the processing that occurs after the initial clause in (8). Clause marking indicates dependencies and therefore should delay or reduce segmentation in sentence processing.

The factors of functional completeness and clause marking together predict a hierarchy of clause types that should be more or less effective as functional clauses, that is, as segmentation units in sentence processing. (For additional discussion of the clausal processing hierarchy, see Tanenhaus and Carroll, 1975.) Sentence-initial independent main clauses, like the one in (8), should be strong functional clauses. Subordinate initial clauses, such as (7), because they are clause marked, should be less strong. However, both of these should be stronger functional clauses than any type of functionally incomplete clause. Among functionally incomplete clauses, clause marking also orders clause types. Thus, headless gerundive nominalizations like *fleeing* in (1) above contain the affix *-ing* in the clause-initial deverbal noun. Noun phrases like *the tall man* in (2) contain no such marking element. These considerations predict the following hierarchy of clause types:

(9) (a) Main Clauses
(b) Subordinate Clauses
(c) Noun Phrases
(d) Headless Nominalizations

Finally, consider clause length. The sheer number of words comprising a linguistic sequence would certainly be expected to contribute to overall processing load for the listener, and therefore to the determination of segmentation units. A long surface clause may overtax short-term memory capacity and stimulate early segmentation, even if it is not functionally complete. Conversely, a very short sentence-initial surface clause may be parsed along with following material even if it is functionally complete.

Experiment 1 used the location technique of Fodor and Bever (1965), Bever et al (1969), and Chapin et al (1972) to test these three parameters of the definition of functional clause. In particular, it tests the hypothesis that functionally complete clauses are better segmentation units than functionally incomplete clauses. Also, the effects of clause marking and clause length on the segmentation of different clause types were examined.

EXPERIMENT 1

Method

Subjects. Sixteen undergraduate students enrolled in an introductory psychology course served as subjects to satisfy a course requirement.

Materials. Thirty-eight sentences were used in the experiment. The sentences were read in a monotone to avoid effects of intonation on segmentation (Wingfield and Klein, 1971). They were recorded on the left channel of a Sony stereo tape recorder (Model 2C-252D). The filler sentences varied in length and syntactic structure to discourage the formation of task-specific strategies by subjects. The 16 experimental sentences were all biclausal. The word immediately preceding the clause break and the word immediately following the clause break were both monosyllables. The first clause of the experimental sentences was either functionally complete or functionally incomplete. Two types of functionally complete clauses, main clauses and complete subordinate clauses, and two types of functionally incomplete clauses, headless nominalizations, and noun phrases with modifiers were used as initial clauses in the experimental sentences. Examples of the four clause types are:

Main Clause: *I felt very sorry for the old bum* so I gave him a dime.
Complete Subordinate: *After the crook stole the woman's bag* he ran for safety.
Headless Nominalization: *Meeting the pretty young girl* was the highlight of Peter's trip.
Noun Phrase with Modifiers: *The old painted wooden pipe* was on display at the local museum.

Two initial clause lengths were used. Short clauses contained five words and seven syllables, and long clauses contained eight words, and 10 syllables. Clause length and clause type were varied orthogonally. Thus, there were four sentences beginning with each of the four clause types. Within each clause type two sentences began with long clauses and two with short clauses.

The 16 experimental sentences and 22 filler sentences were combined in the following way. The first six sentences were filler sentences. The remaining filler sentences and the experimental sentences were arranged randomly with one restriction; one long and one short clause of each clause type appeared in the first and second halves of the list (Sentences 7–22, and 23–38, respectively.) Two copies of the 38 sentences were then made.

A 35-msec, 500-Hz tone was placed in each of the experimental sentences in 16 of the filler sentences. (Tones were not placed in all the sentences for reasons outlined in Abrams, 1973.) The tones were placed using the following procedure. Trigger tones were manually placed on the right channel opposite the appropriate location for each sentence. The sentences were then cross-recorded with the right channel played through a Grason-Stadler voice-operated relay (Model C 700-1A). The tone triggered the relay, which in turn closed a contact across a Hunter digital timer gating the output of a General Radio oscillator (Type 1304-A) through a Grason-Stadler electronic switch (Model 1287) for 35 msec. The 40-msec lag introduced by the contact closure in the voice-operated relay was controlled by placing the trigger tones 0.76 cm before the desired final location.

Two tone locations were used for the experimental sentences. Position 1 was immediately preceding the word before the clause break, and Position 2 was immediately following the word after the clause break. Tone position was balanced across the two tape copies for the experimental sentences. The tones in the filler sentences were placed either near the beginning or near the end of the sentence. The position of the tone was the same for the filler sentences on both tape copies. Thus, the two copies differed only in the position of the tone for each of the experimental sentences. Within each tape copy, both tone positions occurred four times in each half of the list. Tone position was also balanced across clause type and clause length.

Procedure. Eight subjects were run on each tape copy. The sentences were presented on a Uher stereo tape recorder (U400). The output of both channels of the tape recorder was connected to a Shure solo-phone. The output of the solo-phone was adjusted so that the sentences and tone were judged to be equally loud.

The subjects heard the sentences binaurally through Sony stereo headphones. The headphones were altered to mix both channels. After each sentence, the subjects first wrote out the sentence from memory in a booklet, and then marked the location of the tone with a slash. The subjects were told that tones could occur either in or between words. Sentences that did not contain tones also were written out.

The scoring procedure was modified from that of Bever et al in light of subsequent research with the click methodology (see Fodor et al, 1974). Bever et al counted mislocations of clicks toward the clause boundary as confirming the hypothesis that the clause is a segmentation unit. Mislocations an equal distance (or less) away from the clause boundary were scored as disconfirmations. This procedure is consistent with their model of click location, namely that the perceptual integrity of the clause resists its interruption by a click or tone and phenomenally pushes the interruption into the clause break.

Subsequent research (see Abrams and Bever, 1969; Seitz, 1972; Holmes and Forster, 1970; and Bever and Hurtig, 1975) indicates that the click location effect is most likely a result of processing load and shifts of attention that occur in the vicinity of the last word of the first clause and the clause break. Brief interruptions seem to be mislocated toward this processing zone where listeners produce greater reaction times to clicks, are poorer at detecting clicks, and show depressed auditory evoked responses to clicks. This revised interpretation is also more fully consistent with the processing model outlined in Fodor et al (1974), which asserts that segmentation, integration, and recoding operations must take place in and around the ends of clauses.

We have therefore modified the scoring procedure to take this new interpretation into account. All mislocations into or toward the critical processing zone, including the clause break and the monosyllabic clause-final word of the initial clause, were counted as confirming the hypothesis that the clause break represents a segmentation boundary. Any mislocation away from the clause break was scored as disconfirming the hypothesis. Correct subjective locations and overshoots (mislocations that go toward the clause boundary and beyond it out of the processing zone) were not scored. This procedure is more conservative than that of Bever et al in that it considers all mislocations away from the clause break as disconfirming the segmentation hypothesis. Bever et al counted as disconfirmations only mislocations that went a distance equal to the distance from the objective click location to the clause boundary (or less) in the wrong direction.

Several methodological investigations of the location measure have appeared subsequent to the Fodor and Bever (1965) experiment. Our design controls for positional response biases that have been identified (Ladefoged and Broadbent, 1960; Reber and Anderson, 1970). Any systematic preposing or postponing location bias will be expected to cause as many disconfirming location errors vis-a-vis one tone position as it will be expected to cause artifactual confirming location errors vis-a-vis the other tone position. Actually, we overcorrect because subjective locations of Position 1 tones in the initial word of the second clause are scored as overshoots. Furthermore, there was no systematic difference in the experimental sentences in the positioning of the clause break with respect to the sentence-medial position for the different clause types. Thus, we control for any medical position location bias.

Some of these methodological studies point to the possibility that obtained patterns of subjective locations actually conflate several different location phenomena, involving memory, attention, perception, the direction of graphic writing, and so forth (Bertelson, 1972; Bever, 1973; Dalrymple-Alford, 1976; Ladefoged, 1967; Reber and Anderson, 1970). Unfortunately, each study has confounded its intended manipulation with idiosyncrasies of method and procedure (Levelt, in press). Therefore, we presently have no way of knowing which controls and analyses are particularly relevant to a given application of the location technique. In light of this confusing state of affairs, we simply note the possibility that the interpretation of our results may have to be elaborated when and if separate factors contributing to location patterns are reliably isolated and identified.

Results

Our subjects yielded 256 location responses for the experimental sentences of which 89.5% were errors; 21 responses were correct locations, and six responses were lost either because a subject failed to indicate any location for the tone or because a subject failed to recall the sentence correctly. A total of 25 responses were overshoots, leaving 204 location responses in the analysis.

Before analyzing the data from Experiment 1, we checked the actual tone