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A. A GENERAL CONSTRAINT: SOME EVIDENCE FROM NEGATION

Chomsky[1] has tentatively proposed the following as a general constraint on rules of grammar:

(1) No rule can involve a pair X, Y in the context $\ldots X \ldots [\ldots Z \ldots Y \ldots]_{\alpha}$ where Z is the lexically specified "subject" of α, and α is an S or NP.

Such a constraint accounts for a variety of syntactic facts. For example, if the various synonymous positions of <u>each</u> arise from a transformation moving that lexical item,[2] and if that transformation were constrained by (1), the indicated grammaticality judgments on the following pair of sentences would be correctly predicted.

(2) The candidates wanted each other to be buried by an avalanche.

(3) *The candidates wanted an avalanche to bury each other.

For if the underlying structures contained <u>the candidates each...</u> the movement transformation would block in (3) where there is a lexical subject between the underlying and transformed positions of <u>each</u>.

Similarly, in the following NP's, the correct results would be obtained:

(4) The men read books about each other.

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(5) *The men read John's books about each other.

Here α is an NP and Z – John's – is the lexically specified subject of α.[3]

Another apparent instance of constraint (1) can be seen in the distribution of reflexives. If reflexives are to be transformationally derived along the lines suggested in Helke,[4] then the following pair can be explained if the transformation in question (in this case, a copying transformation) is constrained by (1).

(6) The men expected themselves to be run over by a truck.

(7) *The men expected a truck to run over themselves.

Chomsky has suggested that constraint (1), or something like it, constrains not just syntactic processes, but semantic processes as well. In this report I shall present an example of a semantic process whose operation, at least in a certain set of cases, seems to be constrained by (1). I have proposed[5] that the interpretation of negation can be explained in terms of a surface structure rule of interpretation depending upon linear order and phonetic information. The rule relates in interpretation a negative element and any one of a large class of elements including certain quantifiers, if certain structural and phonetic conditions are met. Its operation gives two possible readings for the following sentence, one where many is understood as "negated" and one where it is understood as "non-negated."

(8) I couldn't do many of the problems.

The two readings can be roughly paraphrased by (9) and (10).

(9) There are not many of the problems that I could do.

(10) There are many of the problems that I couldn't do.

Notice that in general, the not can be related to a quantifier within a noun phrase; that is, that the following sentence seems ambiguous in the same way that (8) is.

(11) I couldn't understand the proofs of many of the theorems.

Both (12) and (13) seem to be available as readings for (11).

(12) There are not many of the theorems whose proofs I could understand.

(13) There are many of the theorems whose proofs I couldn't understand.

If a subject is introduced into the NP in (11), however, there is no longer a reading available in which many is understood as negated; that is, (11') has no reading analogous to (12).

(11') I couldn't understand Euclid's proofs of many of the theorems.

There does seem to be a reading (13') analogous to (13).

(13') There are many of the theorems whose proofs by Euclid I couldn't understand.

If, as I have suggested, the unmarked condition for <u>many</u> is non-negated, and the negated reading arises out of the operation of a negation interpretive rule, the absence of a reading for (11') in which <u>many</u> is understood as negated can be explained in terms of constraint (1), for the presence of a subject – Euclid's – in the NP would block the normal application of the rule.

The following set of sentences represents a similar example.

(14) You didn't understand the proofs of enough of the theorems for me to be justified in giving you an A.

(15) *You didn't understand Euclid's proofs of enough of the theorems for me to be justified in giving you an A.

An examination of the meaning of (14) shows that <u>enough</u> has to be understood as being negated for the sentence to make sense, i.e., the content is something like "You understood the proofs of some theorems but not enough ...". If this analysis is correct, the unacceptability of (15) is explained by constraint (1), for the presence of a subject – Euclid's – in the noun phrase would block the semantic rule that would give the required negation (semantically) of <u>enough</u>.

H. B. Lasnik

References

1. Class Lecture, December 1970, and personal communication. All credit for the ideas behind the constraint discussed here and its applications is due to N. A. Chomsky. Any error in the statement of the constraint or the examples, however, is solely my responsibility.
2. For the motivation for such a transformation, see R. Dougherty, "A Transformational Grammar of Coordinate Conjoined Structures," Dissertation, M.I.T., 1968 (unpublished).
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B. WHAT INITIAL CLUSTERS TELL US ABOUT A CHILD'S SPEECH CODE

1. Introduction

Implicit in previous developmental studies is the idea that a child's phonological system is basically that of the adult. This idea can be blocked out as follows:

Child Language = Adult Language + Rules

(Henceforth, the A&R POSITION)

That is, child language is like adult language, except for certain regular differences that can be described by rules. If we take this position, we need only specify the systematic ways in which the child's output differs from that of the adult. This is the general pattern that psycholinguistic studies have followed in treating phonological acquisition. But does this approach really get at the problem? For example, What determines the child's representational system?

Within the current theory, there are at least two possible answers: (i) The child perceives speech in terms of adult phonological distinctions, but has motor problems in producing a phonetic copy of adult speech. This would mean that he perceives as the adult, but produces imperfectly – there is a mismatch between perception and production. (ii) The child perceives and produces in his own system. His phonological distinctions may not be the same as those of the adult. Furthermore, his system does not necessarily have to bear some simple relationship to the adult's.

Answer (i) is consistent with the A&R POSITION, as defined above; it is also the view that dominates the literature of the subject (cf. Leopold,[1] Velten,[2] Albright,[3] Smith,[4] and Moskowitz[5]). Answer (ii), on the other hand, is an alternative hypothesis that has been implicitly rejected in previous studies.[1]

2. Initial Clusters

The differences in the two positions can be best illustrated if we look at a particular problem in child phonology. Initial clusters provide just this kind of test case. Sequences of more than one consonant at the beginnings of words present obvious motor difficulties to young children, even up to the age of three years. Thus it is not surprising that children's pronunciations of clusters are "different" from those of adults. If the A&R POSITION is right, these "differences" could be explained as the child's "distortions" of adult speech. But if the alternative position is right, differences would be the result of distinctions in the child's own system, and not necessarily in the adult's.

3. Preliminary Studies

With the aim of getting data that would decide between these two positions, we have designed a long-term study of two-year-old speech. During the past seven months, we have sampled spontaneous speech from a group of 13 children, aged 1 1/2 to 2 1/2, all having monolingual parents living in the Boston area. Once every three weeks, each child was brought to a laboratory "playroom," where his speech could be recorded. Transcriptions were made at each session. Tapes of all relevant words and phrases were later analyzed spectrographically.

4. Results

Thus far, our transcriptions and spectrograms have shown the following regularities:

(a) Clear transitions between segments of children's clusters that adults accept as "accurate," e.g., swɪmĩ for SWIMMING (see Fig. X-1).

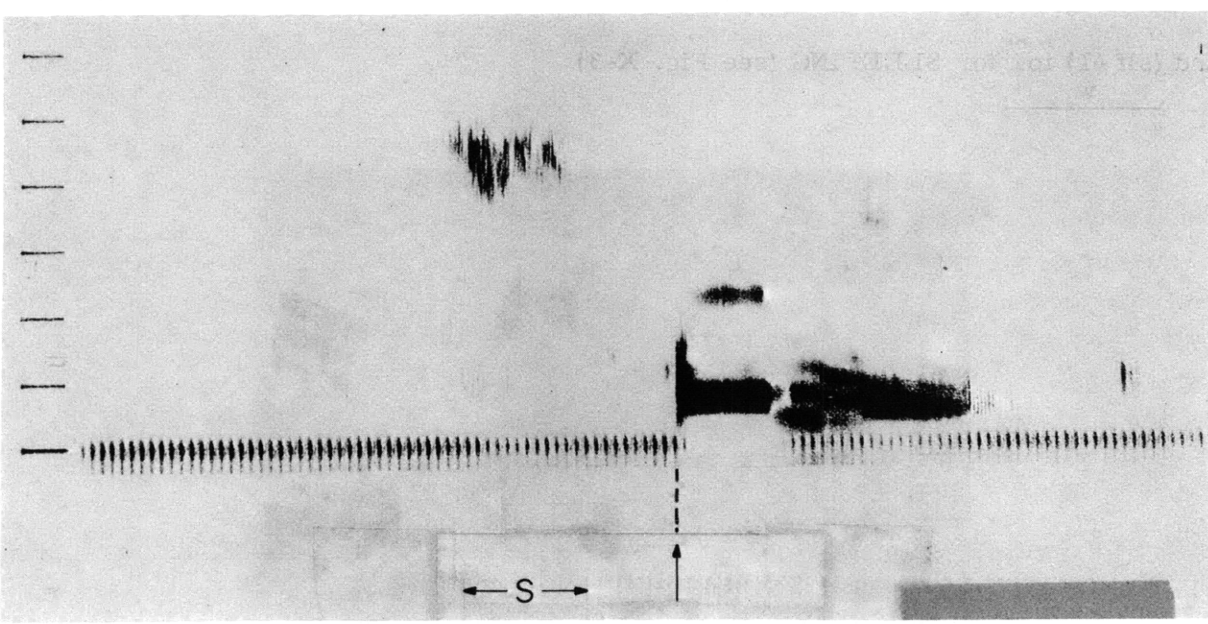

Fig. X-1. Spectrogram of 26-month-old child saying SWIM.

(b) Ill-defined transitions between segments of children's clusters that adults hear as "inaccurate" or "substituted" clusters, e.g.. f (w) i: for THREE (see
r
Fig. X-2),

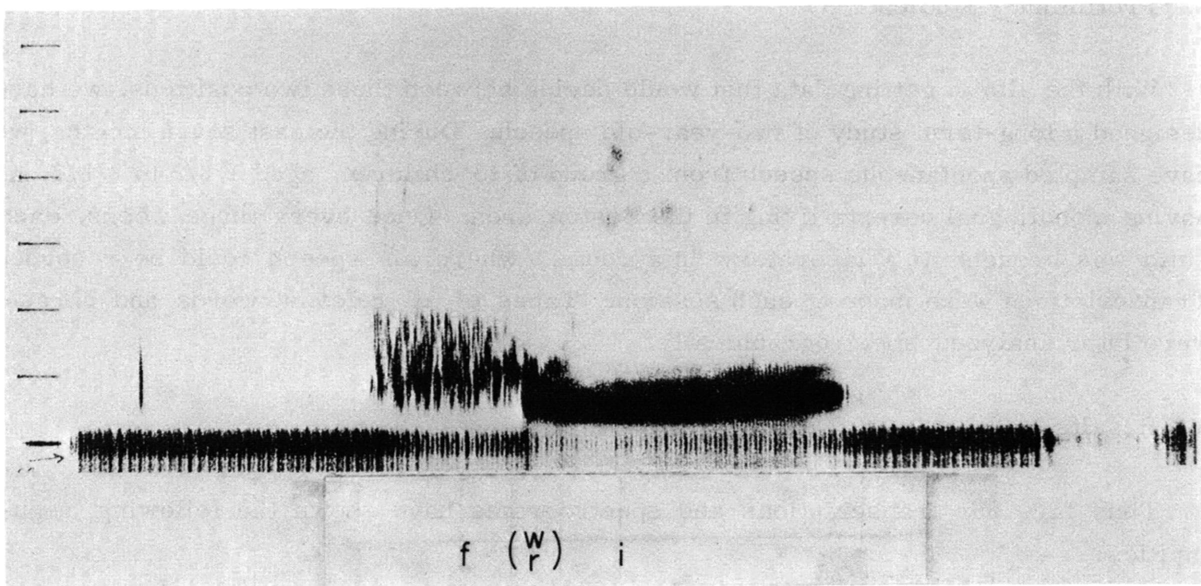

Fig. X-2. Spectrogram of the same subject as in Fig. X-1 saying THREE, transcribed as $\underline{f\ \binom{w}{r}\ i:}$.

and $\underline{(s)f\ \binom{l}{w}\ ip\tilde{i}}$ for SLEEPING (see Fig. X-3).

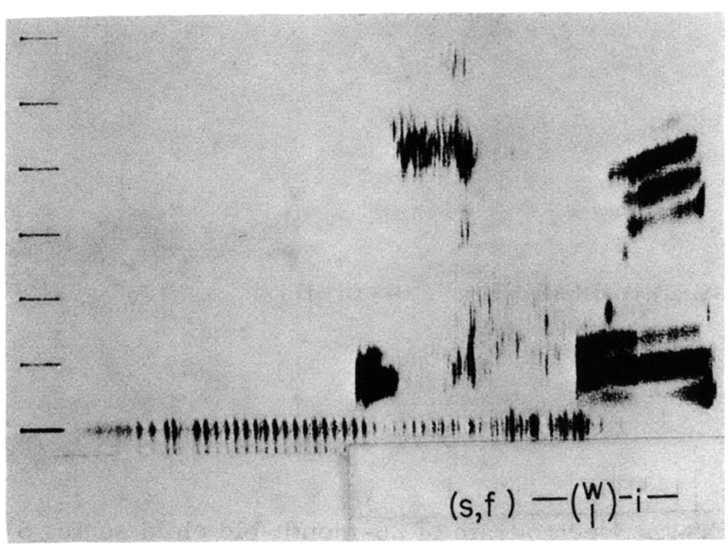

Fig. X-3. SLEEPING, transcribed as $\underline{(s)f\ \binom{l}{w}\ ip\tilde{i}}$.

(c) Ill-defined consonant-liquid transition for obstruent-liquid clusters, like GLASS and GRASS. Both words sounded the same to the adult ear and appeared as [g^{w}əes] in transcription, yet spectrograms showed consistent differences for the w that a child made for the liquid in GRASS and the w that he made for the one in GLASS. (Differences were in terms of F2 locus and duration of the "glide" segment.)

5. Conclusions

The results of this early study suggests that children mark the "same" phonological distinctions as adults do, but may not use the same process for making such distinctions. When the children produce distinctions in their speech (like /gl/ vs /gr/), these are not distinguished by adults (who perceive both clusters as g^w). This evidence gives us some reason to question the predominant (A+R) view. Without more extensive spectrographic analysis and perceptual testing, it is difficult to use our evidence to reject one of the two hypotheses given above. Future work should enable us to decide between the two.

Judith R. Kornfeld

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C. ON THE SEGMENTAL NATURE OF TONE IN THAI

It is often assumed that tone is a suprasegmental feature, i.e., that it is an underlying property of some linguistic unit larger than the segment, such as the syllable or the morpheme. This does in fact seem to be the case for many languages (cf. McCawley,[1] Leben[2]). Woo[3] has argued that there exist languages such as Mandarin in which phonological tone is represented as a feature on segments.[4] The following facts, taken from Henderson,[5] seem to indicate that Thai is one of those languages in which tone must be treated as a segmental feature.

The following tone patterns are given for Thai:

(1) Mid

(2) Low

(3) High-Low (=Falling)

(4) High Rise-Fall

(5) Low-High (=Rising).

It is safe to assume that (4) is phonologically a level high tone. Without this assumption, the tone system would be unnecessarily complex; furthermore, the acoustic data in Abramson[6] indicate that phonetically the pitch of (4) is just as "level" as that of (1) and (2), and Abramson in fact calls tone (4) a high tone. An additional reason for regarding (4) as a level tone will emerge from the discussion of its behavior in compounds.

There are two styles of speech: the isolative style, in which syllables are articulated slowly as more-or-less isolated units; and the combinative style, which, in compounds, causes distinctions in tone and vowel length to be neutralized to a considerable degree. I shall assume that the representations in the isolative style are underlying forms, and will attempt to formulate a rule for deriving from them the corresponding compounds in the combinative style. The symbols H, M, and L beneath the forms stand for High, Mid, and Low, respectively.

(6)

Isolative		Combinative		
thi: HL	nai LH	thi' M	nai LH	'where?'
thi: HL	ni: H	thi' M	ni: H	'there'
si: LH	kha:u LH	si' M	kha:u LH	'white'

In each case the tone of the first element becomes Mid, and the vowel of the first element shortens somewhat. (In my treatment, I assume that the vowel simply becomes short.) In the second element, there is no change at all.

The same applies to compounds in which the first element contains a long vowel and is closed by a consonant or glide:

(7)

Isolative		Combinative		
sa:u LH	sa:u LH	sau M	sa:u LH	'young girls'
wa:ŋ HL	wa:ŋ HL	waŋ M	wa:ŋ HL	'at your leisure'

One apparent exception to this is the behavior of a compound whose first element has tone (4), which Henderson described as a high rise-fall, and which I am calling an underlying high tone:

(8)

Isolative		Combinative		
na:m	tɕha:	nam	tɕha:	'tea'
H	M	H	M	
na:m	ta:n	nam	ta:n	'sugar'
H	M	H	M	

Here, the vowel shortens as expected, but the tone of the first element does not change to Mid. If we regard tone (4) as high level, a fairly plausible account of the data is possible: the vowel of the first element shortens, and a complex tone is simplified to Mid.

We might ask at this point if there is any connection between the vowel shortening and tone simplification; the two remaining forms provided by Henderson suggest that there is:

(9)

Isolative		Combinative		
tɔŋ	ka:n	tɔŋ	ka:n	'want'
HL	M	HL	L	
thau	rai	thau	rai	'how much'
HL	M	HL	L	

There is a change in tone from Mid to Low on the second element; there is nothing in the data to suggest why this is the case. What is significant, however, is that in these two words neither Vowel Shortening nor Tone Simplification applies. The behavior of the last two examples ceases to seem exceptional if we take the view that Tone Simplification occurs as a result of Vowel Shortening.

Actually, one could imagine a formulation that would generate the data presented above without connecting Tone Simplification with Vowel Shortening. (Given the sketchiness of the data, it might be unwise to insist on connecting the two processes.) The following rules might apply to the first element of a compound in the order given:

(10) a. $$\underset{\begin{bmatrix}\text{+Long} \\ \text{+Complex Tone}\end{bmatrix}}{\text{V}} \longrightarrow [\text{+Mid Tone}]$$

b. $$\underset{[\text{+Long}]}{\text{V}} \longrightarrow [\text{-Long}]$$

The first rule changes a complex tone to Mid on a long vowel; the second shortens a long vowel. Aside from the use of the feature [Complex Tone], an ad hoc invention, the formulation in (10a) leaves unanswered the question of why short vowels do not undergo Tone Simplification.

A much simpler and more plausible formulation is possible if we view Tone

Simplification as a result of Vowel Shortening. Morris Halle[7] has suggested that the result of collapsing two segments into one is in some sense a "compromise" between the two original segments. For example, e and o in Sanskrit result from the collapsing of /ai/ and /au/, respectively; these collapsed forms are composed of some of the features of each of the segments underlying them. Similarly, the nasal vowels in French, which, on one view at least, derive from the sequence Vowel + n by a singulary process, inherit in some of the features of each of their underlying segments.

This view, if adopted for Thai, would involve treating long vowels as sequences of two short vowels, and regarding tone as a segmental feature that may appear on vowels and on the coda of short syllables ending in a voiced segment (it would seem unnatural to posit underlying tones on voiceless segments); one of the effects of Vowel Shortening, then, would be the melding of two tones into one. In the case of (8), the two underlying level high tones would yield a single level high tone in the first syllable of the combinative form; in the other cases, the formation of the Mid tone would be the result of a compromise between the underlying sequence of low tone plus high tone, or high tone plus low tone – a result that seems quite natural. In place of (10) we would have a single rule:

$$(11) \quad VV \longrightarrow V$$

The seemingly exceptional tonal behavior of the first elements of (9) is, on this analysis, a direct consequence of the inapplicability of (11) in these cases. Furthermore, this analysis correctly predicts the nonoccurrence of complex tone on syllables containing a short vowel, with no voiced segment following. Since the complex tones are simply sequences of level tones, they cannot appear on syllables that have only one segment capable of bearing a tone – the vowel. (The nonoccurrence of the Mid tone on such syllables remains a mystery, however.)

W. R. Leben

References

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D. PERFORMANCE CONSTRAINTS ON SENTENCE FORM

Fodor, Garrett, and Bever[1] have demonstrated that one exploits the lexical information contained in the main verbs of (1) and (2)

(1) The man whom the child knew carried a box.

(2) The man whom the child met carried a box.

by showing that performance on both paraphrase and anagram tasks was lower on (1) than on (2). They suggested that this decrement resulted from knew being lexically coded to allow both complement and direct object constructions, while met is coded only for direct object. Because two candidate structures may be entertained for knew, and only one for met, performance is lower on tasks involving the former – presumably because the sentences containing it are more difficult to perceive.

In these cases, the context containing the critical word (knew) constrains the interpretation of the sentence to one reading. Thus, while the perceptual mechanism may entertain two projections for the structure in which knew occurs, only one is consonant with the string at hand.

But consider the case exemplified by (3) and (4), which contain the categorically ambiguous word base.

(3) The comedian's skit, which was neither stupid nor base, was attacked all night.

(4) The comedian's skit, which was neither base nor stupid, was attacked all night.

Since the underlying analyses of the two sentences probably do not differ in complexity because each contains base and stupid in conjunction, one would predict no differences in the ability to recall such sentences. Gleidman[2] demonstrated, however, that sentences like (3) are harder to recall than those like (4). He claimed that the difference should be attributed to a surface phenomenon; i.e., the separation of the categorically ambiguous word, base, from a context in which the inappropriate category could be used in projecting partial analysis of the string. He concluded that the representation of such sentences in memory is best characterized by their surface form, rather than by some underlying form.

Similarly, he suggested that the separation of words belonging to identical categories (and, therefore, presumably confusable) would aid recall. Indeed, he found that sentences like (6), in which forgetting which verb goes with which phrase has disastrous effect on the meaning of the sentence, were harder to recall than those like (5). Again, both sentences

(5) The man whom the woman watched often kissed the child.

(6) The man whom the woman often watched kissed the child.

have underlying analyses of nearly identical complexity.

Differences in performance on such memory tasks do not necessarily arise from memory processes alone. If sentence perception is in part assigning structure to a string of words, then strings that permit the assignment of inappropriate substructures or are difficult to segment structurally might be more difficult to perceive than strings of the same words in arrangements that lower the chances for misassignments of structure. Unless special procedures were adopted during learning sessions, these perceptual difficulties would persist as a memory deficit.

Whether the task at hand be memory or perception, sentence processing depends in part on using the lexical information contained by words in order to determine which structures contain those words. Therefore, strings containing categorically ambiguous words would, on the whole, be harder to process if these words occur in contexts that may be misinterpreted when the wrong category is assigned to the ambiguous word. In sentences (3) and (4) the potential misinterpretation can be avoided by choice of word order. On the other hand, the order of verbs in (5) and (6) has no effect on processing difficulty; consequently, there is no reason to suppose that one or another is preferred. To test these possibilities, subjects were asked to complete such sentences in which the critical phrases were replaced by a blank and a list of words to be used in filling the blank. They more often changed list order to the "easier" version of (3) and (4), but they did not favor either order of verbs in (5) and (6).

This finding leaves open the question whether the subjects were choosing to avoid difficulty in remembering, in perceiving or in both. But it is clear that they only constrained structure so as to minimize processing complexity. As we have remarked, the underlying structures of (3) and (4) must be identical; therefore, it seems equally clear that "complexity" is confined to surface form in this case. That is, one apparently imposes constraints on the surface form of sentences that are dictated by performance.

E. C. T. Walker

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E. EXPERIMENTS ON THE PERCEPTION OF AMBIGUOUS SENTENCES

Several recent psychological experiments have focused on the possible perceptual consequences of ambiguity. The results of these experiments have been varied. In a "verification task" (the subject's task is to determine the truth value of a sentence by reference to an immediately following picture), Foss, Bever, and Silver,[1] for example, found only "garden path" effects for ambiguous sentences. Mehler, Carey, and Bever[2] have recently obtained a similar result with a slightly different paradigm. In these experiments the reaction time in the verification task is compared for ambiguous sentences and their unambiguous control counterparts. Verification time was greater for the ambiguous sentences than for their unambiguous counterparts only in circumstances that required the "unexpected" reading of the ambiguous sentence (where expectancy is manipulated by the experimenter through changes in context, or where expectancy is determined by pre- or post-test of the ambiguous sentences). These experiments have been interpreted as showing that in normal sentence comprehension listeners immediately select only one reading for a sentence, even when there are multiple possible interpretations; it is only when the posterior context shows that the wrong selection was made that consequences of ambiguity are found.

On the other hand, MacKay[3] found a significant difference between ambiguous sentences and their unambiguous control counterparts in a sentence completion task, in which subjects are presented with an initial fragment of a sentence and are required to provide a grammatical and meaningful completion. Subjects in this experiment were not aware of the ambiguity but, nonetheless, showed an apparent effect of interference from the "unused" meaning in the facility with which they performed the completion task. More recently Foss[4] has found an effect of both terms of lexical ambiguities in a phoneme monitor task, in which the subject's task is to indicate the point of occurrence of a particular speech sound during the aural presentation of a sentence. Both of these experiments indicate that the processing of ambiguous sentences differs from the processing of unambiguous sentences. At this point two things are needed: first, additional evidence that the presence of an ambiguity affects computation, and second, some account of the computational process which will rationalize the different outcomes of the several experiments mentioned above. Two experiments are reported here that provide some information on each of these points.

1. BIASING THE INTERPRETATION OF AMBIGUOUS SENTENCES DURING DICHOTIC LISTENING

We assume that the structural description for a sentence is computed by its hearer during its input and, further, that the interpretation of a sentence is complete within at most a few hundred milliseconds following its termination. Given such a circumstance, we may inquire what computational procedures are followed when the hearer is confronted with an ambiguous sentence. Roughly there seem to be three possibilities: (i) the hearer can compute both (all) the structural descriptions for the sentence; (ii) he can hold computation in abeyance for some period, using posterior as well as prior context in the decision; (iii) he can choose one structural option and compute that, accepting the possibility of error. Experiments using the verification task appear to argue for (iii); experiments with the monitor task and the sentence completion task appear to argue for (i) or (ii). In all three cases, of course, it is assumed that "ultimately" one reading is selected. The question is, What computational processes underlie that selection and at what point do they occur? We report the first in a series of experiments aimed at a choice among these possibilities; we use a paradigm quite different from those previously employed to investigate the effects of ambiguity.

The experimental situation uses the dichotic presentation of an ambiguous sentence and a disambiguating context sentence. Thus, a subject in the experiment might be presented with an ambiguous sentence such as (a) in one ear, and at the same time be presented with a biasing context sentence such as (b) in the other ear.

(a) The spy put out the torch as a signal to attack.
(b) The spy extinguished the torch.

The subject is told to attend to the ear that receives the ambiguous sentence, and his task is to provide as quickly as possible a paraphrase of the stimulus sentence. Subjects are led to believe that the test is one of ability to resist distraction. They do <u>not</u> know that the materials presented to the two ears are related, nor do they know that one of the sentences is ambiguous. The disambiguating context sentence is presented during the presentation of the ambiguous sentence, but slightly delayed, so that the occurrence of the disambiguating context never precedes the occurrence of the ambiguous portion of the ambiguous sentence.

In the presentation of the ambiguous sentence and the biasing context sentence the level of the two sentences is adjusted so that the biasing sentence is approximately 5 dB down from the level of the ambiguous stimulus sentence. The level of the biasing context sentence is quite understandable in monaural presentation; that is, when the ambiguous sentence channel is turned off, the context sentences are readily understandable. When both the context sentences and the ambiguous sentences are presented simultaneously, the context sentences (the weaker channel) were difficult to follow consistently, even when our pilot subjects attempted to do so. Under the conditions of the experiment, however, subjects were instructed to attend to the stronger of the two channels; they were told to ignore the material in the less intense channel over which the context sentences were presented.

There are assumptions that must be made concerning this experimental situation.

The fundamental one, however, is that the possibility of influencing a subject's interpretation of the ambiguous sentences through the biasing material presented in the "unattended" ear rests on whether more than a single structural description for the ambiguous sentence is computed. If (iii) of the computational possibilities mentioned above is true, there should be no effect of the biasing context sentences in this situation, since choice is made before the occurrence of the bias. If bias in the interpretation of the ambiguous sentence should occur as a function of the context sentences, this would argue for computational strategy (i) (or possibly (ii)). That is, it is difficult to see how the material in the "unattended" biasing ear could affect the ambiguous material, unless the structural description relevant to the biasing context were computed.

A further inference is possible: if option (iii) (subjects pick a single reading of an ambiguous sentence and compute that) is correct, it should be the case that in certain conditions, subjects will become aware of the ambiguity of the stimulus sentences more frequently. When the two readings for the ambiguous sentence are of unequal probabilities (the usual case) and where the biasing context sentence is appropriate to the less probable meaning, subjects will quite often be in the position of having picked a description of the sentence which is at variance with the biasing context. If they do pick up information from the biasing context sentence, this incongruity may bring the ambiguity to their notice.

Procedure

Sets of stimulus sentences and appropriate biasing contexts were constructed for several types of ambiguities: lexical ambiguities (e.g., "the sailors enjoyed the port their captain recommended"); bracketing ambiguities (e.g., "John greeted the boy with a smile on his face"); deep structure ambiguities (e.g., "the mayor ordered the police to stop drinking after midnight"). There were 20 lexical ambiguities (half of these were verb-particle ambiguities), 10 bracketing ambiguities, and 10 deep structure ambiguities.

The ambiguous sentences were recorded and three copies of each sentence were made. The three copies were "paired" (i.e., ambiguity on channel 1, and context on channel 2), respectively, with a bias for reading one (R1), a biasing sentence for reading two (R2), and a neutral context control sentence. (The designation of the readings as R1 and R2 was arbitrary, with the proviso that high and low probability readings be about equally represented in the R1 and R2 sets.) These pairs were then sorted into three stimulus tapes so that each tape contained one-third ambiguous sentences with R1 context, one-third with R2 context, and one-third with the neutral context. The set of three stimulus tapes thus contained a representatior of each ambiguity with bias for both of its readings and a control condition.

The biasing contexts were pre-tested; those biasing sentences selected were such that 100% of the pre-test subjects chose the intended reading in the presence of that bias. Base probabilities for the ambiguities were taken in the presence of the neutral context sentence.

Following warm-up and practice trials, three sets of 15 subjects were presented with the 3 stimulus tapes; thus, there were 15 observations for each ambiguous sentence in each of the 3 conditions. The presentations were counterbalanced for right and left ears. The effect of bias was assessed by subtracting the proportion, for example, of R1 that occurred in the neutral context condition from the proportion of R1 that occurred in the R1 base condition; and similarly for R2. Thus direction and magnitude of the biasing effect could be assessed.

Results

Wilcoxon matched pairs signed ranks tests were run across the sets of stimulus sentences; for both R1 bias and R2 bias all ambiguity types showed a significant effect ($p < .05$, two tails). The biasing contexts were extremely effective in influencing the reading assigned to the ambiguous stimulus sentence in every condition. There is some indication that the bracketing ambiguities were affected less than the other types. No effect of the "ear" to which bias was presented was observed.

Discussion

Evidently, both readings of the ambiguous sentence are in some sense available during the computation of the structural description for the sentence. Can we interpret this result as evidence for simultaneous processing of more than a single reading for ambiguous sentences? Post-test interviews of subjects did not discover <u>any</u> subject who was aware of the ambiguous nature of the stimulus sentences. Subjects were also questioned about the nature of the material in the "unattended" ear. No subject could report even approximately the materials in the unattended ear; many of the subjects were, in fact, surprised when informed that the materials in the unattended ear were sentences. None reported a relation between the material in the unattended ear and that in the attended ear.

Nonetheless, many of the reports of the ambiguous sentences obviously incorporated information from the unattended channel. How are we to account for this? We do not believe that this is a case of the mythical beast "subception." What we think occurs is that the subject <u>does</u> obtain material from the unattended channel but is simply mistaken about which ear he heard it in. When the material in the unattended channel is appropriate to an interpretation of the ambiguous sentence, the subject simply integrates it into the material from the attended channel without ever becoming aware of doing so.

The fact that there is a very strong effect of the biasing context under conditions in which the subjects were not aware of the ambiguity and under conditions where such effects take place during the interpretation of the ambiguous sentence seems to argue strongly for a view of the analysis of ambiguous sentences which involves at least partial computation of both structural descriptions. In subsequent experiments we intend to more systematically manipulate the temporal relation between disambiguating context and ambiguous sequence, and to investigate further the effect of clause boundaries on the possibilities of bias.

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2. AMBIGUITY INCREASES THE COMPLEXITY OF PERCEPTUALLY INCOMPLETE CLAUSES

If the presence of an ambiguity results in an increase in the perceptual complexity of a sentence (e.g., by reason of the computation of both structural descriptions), it does not do so overtly. That is, we are seldom aware of the ambiguity of ambiguous sentences. A selection of one of the readings is almost invariably made, regardless of how many interpretations may be unconsciously computed. Whatever vexation ambiguity may bring to the 'unconscious sentence processor,' the conscious mind of the hearer proceeds in splendid indifference to the ambiguity so frequently encountered in normal conversational interchange. How is this accomplished?

The experiment discussed in Section E.1 suggests that one aspect of the process may involve the computation of more than a single reading for an ambiguous sequence. This condition of "uncertainty" does not persist for long, however, as the verification task experiments of Foss, et al.[1] and Mehler, et al.[2] attest. In the experiment reported here we find evidence that the point beyond which disparate structural options are not pursued is the clause boundary. A resolution of the apparent incompatibility of the results, for example, of verification task and monitor task experiments may lie in the observation that the complication attributable to ambiguity is internal to the sentence, or more precisely, internal to the particular clause containing the ambiguity. Once the sentence or clause is terminated, no further effect of the presence of the ambiguity is measurable; thus the results of the verification task. Measures taken during the computation of the structure of clause or sentence <u>may</u> show effects of an ambiguity; thus the effects of the monitor task experiments.

In an effort to evaluate these views, we considered the sentence completion paradigm of MacKay.[3] MacKay set subjects the task of providing as quickly as possible a grammatical and semantically acceptable completion to a fragment of a sentence. For example, a subject might be presented with the fragment

"Although the solution seemed clear in chemistry class..."

The efficiency of subject's completion of this fragment was compared with completions for control fragments like

"Although the answer seemed clear in chemistry class..."

In MacKay's experiments it was the case that fragments containing an ambiguity showed significantly longer completion times than their control counterparts. MacKay had a variety of types of fragments. Some were like the examples given above which terminate at a clause boundary. Others terminated internal to a clause boundary, for example,

"Although the solution seemed clear in chemistry class, I..."

and

"Although the solution seemed clear in..."

A reanalysis of MacKay's published data revealed that the significance of his results was primarily attributable to cases in which an incomplete clause was presented as the test fragment. Thus initial support for the view that the clause marks the termination of the effect of an ambiguity was provided. The present experiment uses a sentence completion paradigm similar to MacKay's, but with the variable of clause completion manipulated.

Procedure

Six incomplete sentence fragments 5 to 12 words in length of each type of ambiguity mentioned above were constructed. Each fragment had three ambiguous and three nonambiguous versions: in one ambiguous version the fragment was an incomplete clause, e.g., (a); in a second version it was a complete clause, e.g., (b); and in the third version it was a complete clause with the addition of the first word of a second clause, e.g., (c). There were parallel versions for the unambiguous control fragments, e.g., (d), (e), and (f).

(a) After taking the right turn at the
(b) After taking the right turn at the intersection
(c) After taking the right turn at the intersection, I
(d) After taking the left turn at the
(e) After taking the left turn at the intersection
(f) After taking the left turn at the intersection, I

In this study we used only one of the possible nonambiguous interpretations as the control for each ambiguous fragment.

The fragments were typed on 6 × 8 file cards. Six experimental groups were prepared so that each group contained one fragment of each type from the 18 different types (ambiguous vs unambiguous control × 3 types of ambiguity × 3 fragment types = 18 stimulus types).

Forty-eight paid volunteer subjects (native English speakers) were run, 8 in each of 6 groups required for counterbalancing. A subject was instructed to turn over the card (which was presented face down), read the sentence fragment to himself, and then read the fragment and a completion aloud as soon as he was able. Responses were tape-recorded and timed from presentation of the fragment. S was instructed to make his completion as well formed and relevant to the sentence as possible. In post-tests S was asked whether he noticed it was ambiguous during the experimental session. The very few responses where an ambiguity was noticed were excluded from analysis.

Results

The scores computed were delays from presentation of the fragment to the onset of vocalization for the completion attempt (i.e., "thinking time"). Overall, ambiguous sentence fragments do require longer "thinking" times to complete than do their corresponding unambiguous counterparts ($p < .001$, two-tail Wilcoxon matched pairs, signed ranks test across subjects). Most interesting, however, is the fact that all of the relative effect of ambiguous fragments was due to those fragment types that ended internal to the first clause (example (a) above). Only for such fragments is the difference between ambiguous responses and their controls significant (there is not even a trend in the other cases).

Discussion

If an ambiguous fragment is broken off before the clause completion, then two interpretations are both still available and involve added processing complexity. If the fragment is broken off at or just after its completion, then the fact that more than one meaning was originally possible makes no effective difference – after a complete interpretation is assigned by the subject to the string, the fact that it was originally ambiguous does not affect subsequent performance (so long as either meaning is situationally acceptable as it was here).

Further research is required on certain aspects of this study. Response times varied greatly among S's; it is unlikely that fast and slow responding subjects are using the same strategies. Second, there was great variability among individual fragments; thus the findings must be supplemented with larger varieties of sentences and different response techniques. Most important, however, is the apparently paradoxical result that some fragments with underlying structure ambiguities were responded to faster than their controls: just those underlying structure fragments which terminated at a clause boundary, i.e., were perceptually complete units (example (b) above) ($p < .01$ for thinking time). This effect, which did not appear for the other kinds of ambiguities, argues that ambiguity is coped with by parallel computation of both interpretations rather than by holding computation in abeyance. More direct experimental testing of this possibility is being carried out.

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