In search of ambiguity

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A study of the time required for Ss to perceive the two meanings of ambiguous sentences, supports the following conclusions: (1) Perception time (PT) is a function of the type of ambiguity, three of which are defined in this study. (2) A similar relative function was obtained for the PT in sentences with more than one ambiguity and for sentences with only a single ambiguity. (3) The PT for finding a single ambiguity in such multiply ambiguous sentences was significantly longer than in singly ambiguous sentences. (4) When one of the interpretations of certain types of ambiguous sentences is less likely than the other (where likeliness is defined in terms of the number of Ss perceiving that interpretation first) PT is high. (5) Complexity of the surface and underlying structures (which are defined in transformational grammar) is an important determinant of the PT for surface and underlying structure ambiguities, respectively.

This research involved an extensive search for ambiguous sentences by the authors, and an intensive search for two interpretations of each of these ambiguous sentences by subjects. Gleason has pointed out (1965) that the term "ambiguity" is itself ambiguous. For the present paper the following definition resolves this: *any stimulus pattern which is capable of two and only two distinct interpretations is ambiguous.*

Some ambiguities in sentences are more difficult to discover than others. For example, the preceding sentence contains (at least) one ambiguity which is hard to discover: the word "sentences" could refer to the typewritten objects or to the legal pronouncements of judges. The first aim of the present research was to study some of the factors influencing the ease of perception of the two interpretations of various kinds of ambiguous sentences.

The major variable was the linguistic differentiation of sentential ambiguities. Transformational grammarians have recently developed a theory which defines three levels at which ambiguity in sentences may occur. These three levels (and the corresponding types of ambiguity) are termed the "lexical," the "surface structure," and the "underlying structure" levels. (See Chomsky (1965) for formal discussion of linguistic levels, since only the general nature of the different levels of ambiguity will be discussed here.)

The meanings and sounds of individual words are represented at the lexical level. A sentence is lexically ambiguous if a word or sequence of words has two distinct meanings and no differences at the other grammatical levels. For instance, the sentence *The soldiers like the port* is lexically ambiguous since the lexical item "port" can mean either "wine" or "harbor."

The manner in which words can be grouped into phrases is represented in the surface structure of sentences. Ambiguity at the surface structure level involves the possibility of two distinct groupings of adjacent words. Consider the sentence *Small boys and girls are frightened easily.* If the word "small" is grouped with "boys and girls" then both the boys and the girls are small. But if "small" is grouped only with "boys" then only the boys are small (see Fig. 5).

The underlying structural level of sentences represents the essential "logical" relations between words and phrases. For instance, the logical relation between "police" and "drinking" is quite different in these two sentences: *The mayor will ask the police to forbid drinking. The mayor will ask the police to cease drinking.* Ambiguities at the underlying structure level involve neither a change in meaning of individual words, as in lexical ambiguity, nor a change in the apparent grouping of words, as in surface structure ambiguities, but *only a change in the logical relations between words.* For example, consider the sentence *The mayor will ask the police to stop drinking.* In this sentence are the police doing the drinking, or is somebody else? This sentence is ambiguous at the underlying structure level since only the logical relations between *police* and *drinking* is altered in the two interpretations.[2]

Our second reason for studying linguistic ambiguity was the hope that by determining how subjects go about discovering two meanings of a sentence, some insight could be gained as to how subjects go about discovering the one meaning of non-ambiguous sentences. Linguists have postulated that the logical way to process sentences, either in understanding them or speaking them, is to start with an appreciation of the underlying structure, then the surface structure, and finally the lexical level (Chomsky, 1965). Now if the actual understanding of sentences requires the processing of the three levels in this order, and if a sentence contains an ambiguity at one of these three levels, then the ambiguity should be easier to discover if it involves the underlying constituent structure than if it involves the derived, or lexical level. So the second purpose of this paper was to determine whether the *logical* order of processing of levels, postulated by linguists, corresponds to the *actual* or "psychological" order in which these levels are processed, on the assumption that ambiguities

at those levels which are processed first, should be discovered first, and ambiguities at those levels processed later should be discovered later.

METHOD

Materials

Eighty ambiguous sentences were typed on 5 x 3 in. index cards. Fifty-six of these had one ambiguity. The other 24 sentences contained two independent ambiguities, or could be interpreted in at least four possible ways. Of these 80 sentences, 45 (shown in Appendix A) fell into the categories of ambiguity discussed in the introduction, and the remaining 35 sentences either contained other types of ambiguity or were eliminated from the sample, because one of their interpretations turned out to be much more probable than the other (see results and footnote 2).

Since inability to immediately recall the entire sentence would differentially affect the perception time (PT) for certain types of ambiguity, all of the sentences were constrained to eight (plus or minus one) words, which was well within the immediate memory span of the subjects.

Procedure

The subjects were 20 undergraduates at Harvard University, paid for their participation in the 1-hr. experiment. E read the following instructions to each individual:

> "This is an experiment in psycholinguistics, dealing with ambiguity. The purpose of this experiment is to determine the time it takes you to see two meanings of various types of ambiguous sentences.
>
> So I have here a set of ambiguous sentences on cards. That is, each of these sentences has at least two meanings or interpretations. The two meanings of each sentence are grammatical or logical, and either meaning would be possible in normal conversation.
>
> Your task will be to find two meanings of each sentence as quickly as you can. So, as I hand you each card, you are to turn it over and read the sentence as rapidly as possible without misreading it, and remember the first meaning that you see. Then as soon as you see the second meaning of the ambiguity, say "yes" immediately, and I will stop the first watch.
>
> You are then to tell me the two meanings which you saw in the sentence. Do this as concisely and quickly as possible, since your verbalization of the two meanings will also be timed. There should be no pause between saying yes and reporting the two meanings.
>
> Since the order in which you see the two meanings is also of interest, please tell me the two meanings in the order that you saw them, the first meaning first and the second meaning next.
>
> Finally, if you fail to find a second meaning of the sentence, continue searching until I stop you, which will be after a minute and a half. You are then to tell me the meaning you saw, and I will tell you what the other possible interpretation was."

Thus E told the subjects that each sentence contained at least one ambiguity. E instructed the subject to say "yes" as soon as he saw two meanings for a sentence and then to describe these two meanings as rapidly as possible in the order in which he noticed them. E presented each sentence on a card face down to the subject. When the subject turned the card over, E started a stopwatch. The subject read each sentence until he saw two meanings and said "yes," whereupon E simultaneously stopped the first watch and started the second. The subject then described the ambiguity; when the subject finished, E stopped the second watch. After each trial E recorded the *Perception Time* (PT), the time it took the subject to say "yes," and the *Verbalization Time* (VT), the time it took the subject to describe the two meanings. E also recorded the order in which the meanings were described and the trial number for the sentence. The 80 cards were presented in a different random order for each subject. E noted if one of the interpretations was ungrammatical, extremely idiosyncratic, or based on a misreading of the sentence. The number of such cases was small (15 out of 1600), and these data were not analyzed further. Where the subject was unable to see more than one meaning within 90 sec. (as occurred in 15 out of the remaining 1585 trials), only this time was recorded, along with the one meaning that he saw. The subject was then told the other interpretation of the sentence.

RESULTS

The median perception time (PT) for the three types of ambiguity is shown (in ascending order) in Fig. 1b. Here it can be seen that lexical ambiguities

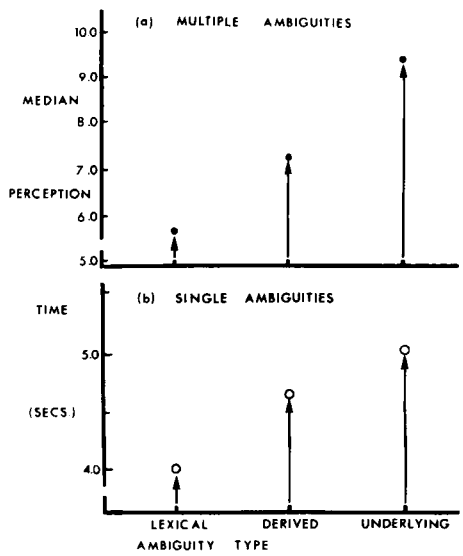

Fig. 1. The median Perception Time for lexical, derived and underlying structure ambiguities in (a) Multiply ambiguous sentences, (b) Singly ambiguous sentences.

were discovered faster than surface structure ambiguities and that underlying structure ambiguities required the longest time to be discovered. All differences in PT between the three types of ambiguity were significant at the .01 level using a two-tailed sign test.[3] The relative order of PTs for the three types of ambiguity in multiply ambiguous sentences (shown in Fig. 1a) was the same as for the singly ambiguous sentences. However, the time required to see a single ambiguity in sentences containing two ambiguities was significantly longer than the time required to see the corresponding level of ambiguity in singly ambiguous sentences ($\alpha < .01$ using a Mann-Whitney U test).

Controls

A major variable in the materials was the context in which an ambiguity occurred. One interpretation of a set of ambiguous words may be much more obvious in one sentential context than in another. For example, the interpretation of, *In sentences some ambiguities are more difficult to discover* as referring to the legal pronouncements is rather obscure, but not if the sentence were, *In their sentences, state judges tend to be hard on criminals.* Discovering such ambiguities involves reading the sentence, understanding one meaning, and then looking for the other meaning. It is possible that seeing the more obscure meaning for the particular context on the first reading could make discovering the ambiguity easy since perception of the second meaning is relatively probable. Seeing the more likely meaning on first reading should make discovering the ambiguity take more time since the perception of the second meaning is less probable and presumably more difficult. To test this hypothesis, the *bias* for a meaning, defined as the percent of the subjects who reported seeing that meaning first, was calculated for each sentence. For example, a sentence where 18 of the 20 subjects report seeing one meaning first and two report the other first, would have a 90% bias for one meaning and a 10% bias for the other.

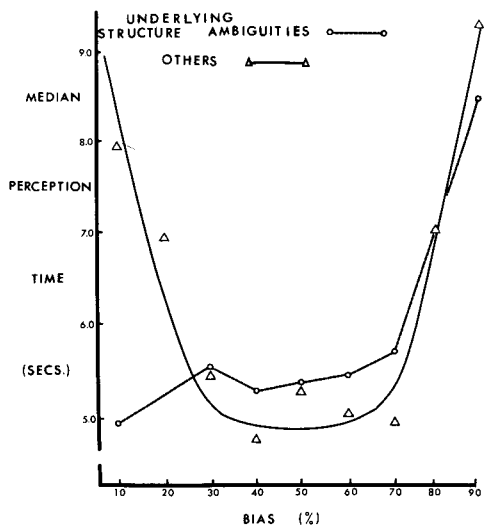

Fig. 2. The median Perception Time for lexical and derived structure ambiguities (indicated with solid line) as a function of "bias" or the per cent of the subjects seeing one meaning first. That for underlying structure (UCS) ambiguities is shown with the broken line.

Table 1. Median bias, position and sentence length for the three types of ambiguity

Type of Ambiguity	Number of Sentences	Median bias (%)	Median Position	Median Length
Lexical	14	38	4	10.5
Derived Structure	18	37.5	4.5	10.0
Underlying Structure	12	43.0	5.3	9.0

The data for underlying structure ambiguities supported the hypotheses that the bias of the meaning which is discovered first is directly related to the PT. The PT for these ambiguities increased as the relative probability of the first discovered meaning increased. However, this was not true of other types of ambiguity. The relation between bias and PT for each meaning of all other sentences (including sentences with more than one ambiguity) is shown in Fig. 2. Examination of Fig. 2 shows that PT was very high for lexical and surface structure ambiguities in which there was a marked imbalance in the probability of seeing one of the two meanings first. In these cases the PT is long, *regardless of whether the more or less probable meaning was seen first.* What is important as a control, however, is the fact that there was a range of bias for the first discovered meaning over which the PT function is relatively flat for all ambiguities (from 30-70 to 70-30 bias in Fig. 2). The 12 sentences falling outside this range of bias were excluded from all data analysis (as well as from Appendix A, which lists the 54 sentences discussed in the remainder of this paper). Furthermore, there were no systematic differences in bias between the three kinds of ambiguities which could account for the major results for the remaining sentences (see Table 1).

The function relating PT and experimentally located position of the ambiguities is shown in Fig. 3. (In a control study, 10 subjects located where in each ambiguous sentence the ambiguity seemed to occur. Location of an ambiguity is defined as the median position of the ambiguity located by the 10 subjects in that written experiment.) If the perceived ambiguity is in the last two words of the sentence, the PT is quite long and if in the first word, quite short. This finding was not true of underlying structure ambiguities; underlying structure ambiguities located at the beginning and at the end of a sentence had longer PTs

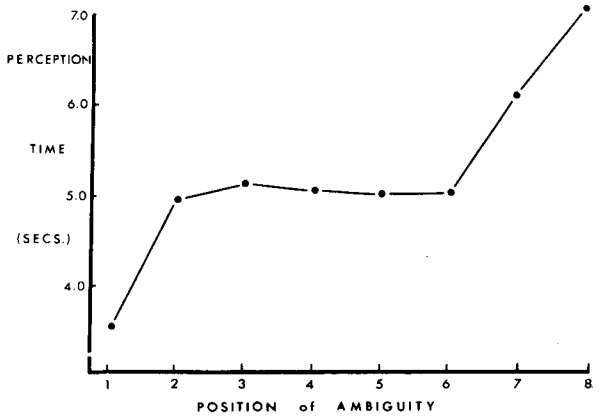

Fig. 3. Median Perception Time as a function of the position in the sentences of lexical, derived structure and multiple ambiguities.

than those in the middle of a sentence. In any case, differences in the median position of the three types of ambiguities could not account for the major results (see Table 1).

It might be the case that PT was actually a function of the time it takes to explain the ambiguity (VT). To check this, the PT and VT were correlated. VT was consistently higher than PT (see Fig. 4a) and there were warm-up effects in both functions. However, the rank order correlation was only .05 which was nonsignificant at the .5 level.

There were practice effects in the experiment. However, the functions relating PT and VT to trial number for the three ambiguity types reached asymptote after 30 trials (shown in Fig. 4b) (out of a total of 80). If asymptote is the limit beyond which further practice with an ambiguity type cannot improve the PT, then it is clear that the major results cannot be attributed to differential practice effects since the PT ordering of the types of ambiguity is the same for the last 50 trials as for the first 30. Furthermore, the different types of ambiguities were equally distributed over the experimental session so that the consistency of the ordering cannot be due to practice.

Although the number of words per sentence was roughly constant, the number of syllables per sentence varied from seven to 19. The rank order correlation between PT and number of syllables was .84, significant at the .001 level. However, syllable length was evenly distributed over the three types of ambiguity and so could not account for the results (see Table 1).

Subsidiary Results

(1) It is intuitively clear that lexical ambiguities can be divided into two types based on the nature of the relation between the two meanings of the ambiguous lexical item (Bever & Rosenbaum, 1965). Some lexical ambiguities have two meanings which seem to bear no relation to each other. For example, in *The bark frightened him*, the *bark* of a tree has no obvious connection to the *bark* of a dog. For other lexical ambiguities, the two meanings appear to be related. For example, in *The marine captain liked his new position*, the two meanings of *position* are conceptually related. The first four lexical ambiguities in Appendix A were classified as related or "systematic" lexical ambiguities, and the remaining 10 as unrelated or "unsystematic" lexical ambiguities. The PT data supported this intuitive dichotomy of lexical ambiguities, since significantly more subjects had lower PT for systematic than non-systematic lexical ambiguities ($\alpha < .01$ using a two-tailed sign test).

(2) A second subsidiary question was the effect

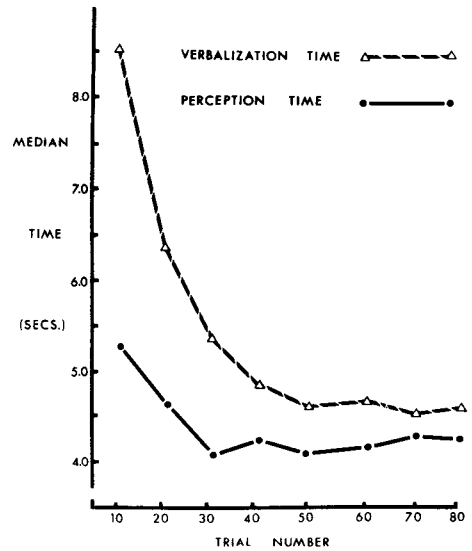

Fig. 4a. Median Verbalization Time (VT) and Perception Time (PT) as a function of trial number for all sentences.

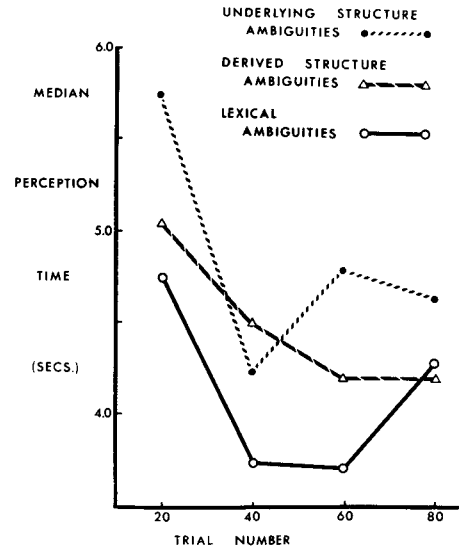

Fig. 4b. Perception Time for the three main types of ambiguity as a function of trial number.

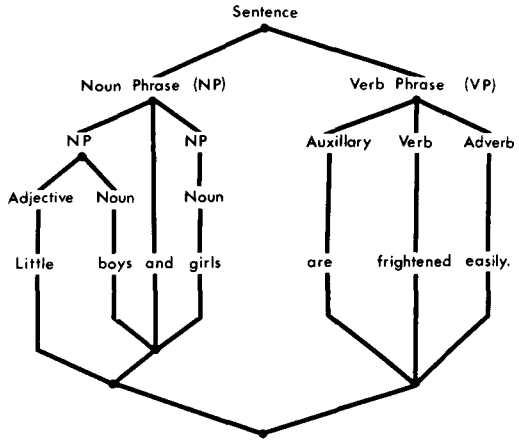

Fig. 5. Diagrams of the two derived structures of an ambiguous sentence, taken from Katz and Postal, p. 24.

of the complexity of the derived structure on PT. Our measure of derived structure complexity was the node to terminal node (N/TN) ratio, described by Miller and Chomsky (1963). The N/TN ratio of an ambiguous sentence is defined in terms of tree diagrams of its two interpretations, such as for the two interpretations of the ambiguous sentence shown in Fig. 5. It is the ratio of the total number of nodes in a tree diagram to the number of terminal nodes in the sentence. For the interpretations of the example in Fig. 5 the N/TN ratio is $\frac{12}{7}$ or 1.71 and for the lower interpretation it is $\frac{11}{7}$ or 1.57.

One question was whether subjects would take longer to perceive the two meanings of derived structure ambiguities when the N/TN ratio of the two interpretations differed, than when both interpretations had the same N/TN ratio. The data showed that those derived structure ambiguities involving equal N/TN ratios for both interpretations were perceived faster than those derived structure ambiguities with unequal N/TN ratios ($\alpha < .01$), even though there was no bias in the number of subjects seeing the putatively less complex meaning first.

Another question was whether the ambiguity in sentences with more complex surface structure would be more difficult to discover than in less complex sentences, regardless of the type of ambiguity. The functions relating N/TN to PT for all three types of ambiguity were essentially linear, with longer PT for sentences with high N/TN ratios.

(3) The two meanings of underlying structure ambiguities can also be considered to differ in complexity. For example, in *The idea of the natives was dreadful*, the relation of *idea* to *natives* can be expressed as *The natives had the idea* for one interpretation, and for the other interpretation the relation is expressed in *Someone had an idea about the natives*. In the one case, *natives* is the subject in its underlying relation, and in the other case, natives is an object, being replaced by an unspecified "someone" as subject. In most of the underlying structure ambiguities in Appendix A, one interpretation involved an apparent subject and the other an implied "someone." When the "implied someone" interpretation was seen first, the PT was lower than when the "apparent subject" interpretation was first to be seen ($\alpha < .01$). This suggests that initial perception of the presumably more complex, implied-subject interpretation makes the less complex, apparent-subject interpretation easier to see, and initial perception of the presumably simpler underlying structure, involving no additional implied components, makes the more complex structure harder to see.

(4) The part of speech in which the ambiguity in our sentences occurred was either subject, verb, object, adjective or adverb. Ambiguities involving verbs, subjects and objects had relatively low and almost identical PTs. However, ambiguities in adjectives and adverbs had significantly longer PTs ($\alpha < .01$).

DISCUSSION

The first purpose of the present paper was to investigate some of the factors involved in perception of ambiguous sentences in general. Four types of findings relating to this purpose will be discussed here. First the effect of position of ambiguous words on PT: For derived structure and lexical ambiguity, the relation obtained was the nearer the ambiguity to the end of the sentence the higher the PT. This finding suggests support for the hypothesis that sentences are processed from left to right in the search for ambiguity. This finding did not hold for underlying structure ambiguities, however. This suggests that lexical and derived levels are processed from left to right but the underlying structure is processed in a different (but not yet understood) manner.

Another factor influencing PT was the part of speech of the ambiguous words. The fact that ambiguity in subjects, verbs and objects was easier to discover than in adverbs or adjectives was not surprising. Other investigators have found that adjectives and adverbs are less prominent features of sentences than nouns and verbs. For example, Blumenthal (in press) found that subjects, objects and verbs are more effective in prompting recall of sentences than adjectives and adverbs. Clearly, any model of sentence processing must weight some parts of speech more than others, since verbs, subjects and objects appear to be more dominant than adjectives in the perception and in prompted recall of sentences.

A third factor influencing PT is the probability or likeliness of the two meanings of ambiguous sentences (bias). For underlying structure ambiguities, the relation between PT and bias was both positive

and linear as might occur if both meanings were independent, and the time to discover the second meaning was a direct function of its probability.

However, the lexical and surface structure ambiguities with one meaning much less probable than the other, had a high PT regardless of which meaning was seen first. This implies that the meanings for these ambiguities were not independent, but coupled, with the degree of interaction between the two meanings dependent on their relative probability.

A fourth factor influencing PT is the surface structure complexity of a sentence. The fact the N/TN ratio was directly related to PT for all three types of ambiguities suggests either that the three levels of language are processed intermittently, or that the discovery of the two meanings of ambiguous sentences is influenced by surface structure complexity. The importance of surface structure complexity was again demonstrated by the difficulty in perception of surface structure ambiguities whose interpretations had unequal N/TN ratios as compared to those that had equal N/TN ratios.

Our second interest in the search for ambiguity was to gain some insight into the manner in which subjects discover one meaning in the normal processing of sentences. Although the order of processing of levels postulated by linguists is the *logical* order (underlying, derived, and then lexical levels), it is not necessarily the *psychological* order in which people *actually* process and understand sentences.

We found that lexical ambiguities were discovered faster than derived structure ambiguities, which in turn were discovered faster than underlying structure ambiguities. The relative order of median PTs for multiply ambiguous sentences being the same as for singly ambiguous sentences both confirms and extends this finding. These results could be interpreted to suggest that the lexical level is processed first since ambiguity at this level was discovered first, and that the underlying structure level is processed last since ambiguities at the underlying level were most difficult to uncover.

Such an interpretation of our results rests on the assumption that the normal procedure in finding the first meaning of sentences is identical to that of finding the second meaning of ambiguous sentences, an assumption for which there is no experimental evidence. In fact, normally we try to avoid ambiguities in processing sentences instead of searching for them (MacKay, 1966) so that the usual manner in which we process and understand sentences may be quite different from the way we search for ambiguities in them.

This issue becomes ever sharper when we consider our results for multiple ambiguities. We expected that subjects would be able to discover a single ambiguity with greater ease, as the number of ambiguities in the sentence increased, i.e., lower PT for multiply than for singly ambiguous sentences. We found the exact opposite. Our subjects took significantly longer to find two meanings for multiply ambiguous sentences than for singly ambiguous sentences, even though they saw only one of the ambiguities in the multiply ambiguous sentences. Clearly our subjects cannot be processing first one structural level, and then the next, and stopping as soon as they find an ambiguity in one of the levels.

Further, we must assume that the presence of an unperceived ambiguity in a sentence can influence the time to perceive another ambiguity. Thus the search for ambiguity is not a simple process of discovering one meaning, with differences in perception time reflecting the ease of discovering the second meaning only, as we have tacitly assumed until now.

Rather, ambiguous sequences may be treated differently from non-ambiguous sequences in the process of understanding sentences. Specifically, let us assume that when we encounter an ambiguous set of words, we delay the interpretation of these words until we can disambiguate them on the basis of the remaining, non-ambiguous context, since only after we process the total context of the sentence can we determine which meaning of ambiguous words is more appropriate. Often one of the meanings of an ambiguous word will not be appropriate or grammatical once the entire sentence is processed, as for example the interpretation of *one* as an adjective in the immediately preceding sentence. If we normally assign meaning to ambiguous words only after consideration of its grammatical relations in the sentence, we would only infrequently perceive the ambiguity in many sentences, even though most of the words in these sentences may, by themselves, be ambiguous (as is often the case; see Gleason, 1965).

It thus seems reasonable that we should withhold interpretation of ambiguous words, until we can feed back a bias for one of the interpretations derived from our understanding of the remainder of the sentence. Granting this interpretation of processing ambiguous sentences, the extra difficulty of discovering a single ambiguity in multiply ambiguous sentences becomes clear. For if one encounters an ambiguity in a multiply ambiguous sentence, the remaining context of the sentence is also ambiguous. Consequently it would be very difficult to feed back a bias for one of the meanings of the ambiguity on the basis of the remaining context of the sentences, which is also pending disambiguation. The remaining context in a singly ambiguous sentence, however, is unambiguous, so that determining the first meaning for these sentences would be easy. Consequently, discovery of the first meaning for multiply ambiguous sentences would be more difficult than for singly ambiguous sentences, and the over all PT for multiply ambiguous sentences would thus be longer than for singly ambiguous sentences as was found. One of the predictions

which follows from this interpretation is that once the first two meanings of multiply ambiguous sentences are seen, perception of their third and fourth meanings will take less time than finding the two meanings of singly ambiguous sentences, since discovery of the third meaning is already under way. Similarly, the reason that lexical ambiguities were easier to discover than surface and underlying structure ambiguities may lie in the differences in the ease of discovery of the first meaning of these types of ambiguity. A task in which the subjects are aware of only one of the meanings of ambiguous sentences could then be expected to show that lexically ambiguous sentences take *less* time to process than surface and underlying structure ambiguities. (Experimental evidence for this view has been provided using a sentence completion task in MacKay, 1966.)

SUMMARY

A study of the time required for subjects to perceive and explain three linguistic types of ambiguous sentences supports the following conclusions:

(1) Perception time (PT) is a function of the linguistic type of ambiguity, three of which are defined. PTs for ambiguities within the meanings of words (lexical ambiguities) are shorter than those within phrases (surface structure ambiguities). The longest are for ambiguities which have differences only in their underlying syntactic structure (underlying structure ambiguities).

(2) These results were not due to position or number of words in the ambiguity, length of ambiguous sentence, or the amount of time to explain the ambiguity.

(3) A similar relative function was obtained for the PT of the three types of ambiguities in sentences with more than one ambiguity. However, the PT for these sentences was always higher than for singly ambiguous sentences, even though subject noticed only one of the ambiguities.

(4) For lexical and surface structure ambiguities the PT was high if the first interpretation seen was either very likely or very unlikely. For underlying structure ambiguities, when a less likely meaning was seen first, discovery of the likely meaning was easy; when the more likely meaning was seen first, discovery of the unlikely meaning was relatively difficult.

References

Bach, E. *An introduction to transformational grammar.* New York: Holt, Rinehart and Winston, Inc., 1964.

Bever, T. G., & Rosenbaum, P. Syntactic and semantic lexical structure. Paper delivered to the Linguistic Association of America, December, 1965.

Blumenthal, A. Prompted recall of sentences (in press).

Chomsky, N. *Aspects of the theory of syntax.* Cambridge: The Massachusetts Institute of Technology Press, 1965.

Gleason, H. A., Jr. *Linguistics and English grammar.* New York: Holt, Rinehart and Winston, 1965.

Katz, J., & Postal, P. *An integrated theory of linguistic description.* Cambridge: The Massachusetts Institute of Technology Press, 1965.

MacKay, D. G. To end ambiguous sentences. *Percept. & Psychophys.*, 1966, 1, 426-436.

Miller, G., & Chomsky, N. Finitary models of the language user. In R. D. Luce, R. R. Bush & E. Galanter (Eds.), *Handbook of mathematical psychology.* New York: John Wiley, 1963. Pp. 419-492.

Notes

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2. Notice that even the smallest surface structure ambiguities involve some differences in the linguistically-analyzed underlying phrase structures. For example in "They fed her dog biscuits", the underlying structure either contains "dog" as modifying "biscuits" or as being modified by "her". But the subject-verb relation between "they" and "fed", and the verb-object relation between "fed" and "biscuits", remains constant, whichever interpretation of the sentence is made. These basic relations are characteristically at issue with underlying structure ambiguities. Thus for this experiment an "underlying structure ambiguity" involves a change in the basic subject-verb and/or verb-object relations between words in the main clause of the sentence, and has no surface structure differences. A "surface structure ambiguity" does have surface structure differences, but also relatively insignificant differences at the underlying structure level.

3. These results exclude 12 sentences that were not functionally ambiguous, that is, one meaning was perceived first more than 70% of the time. See the controls section below, for a discussion of this. The small differences between the types of single ambiguities may appear disturbing in view of the possibility of variation in measurements with a stop watch. However, the total reaction time in starting or stopping a stop watch was approximately one-tenth of a second with a range of variability of about one fiftieth of a second (E's reaction time was tested in a separate experiment). Further, the possibility of systematic mistiming for different types of ambiguity was unlikely since E did not know the type of ambiguity contained in the sentence the subject was reading on any given trial. For multiple ambiguities, there was absolutely no way of knowing which ambiguity would be seen, so that biased timing was impossible.

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Appendix A

The median perception time for the three types of unbiased singly ambiguous sentences.

I. Single Ambiguities

Sentence	Ambiguity Type	Median Perception Time (sec.)
1. The office of the president is vacant.	Lexical (Systematic)	3.55
2. The truck driver was a very solid person.	"	3.85
3. The students saw Professor Smith in this office.	"	5.3

Sentence	Ambiguity Type	Median Perception Time (sec.)
4. The marine captain liked his new position.	Lexical (Systematic)	2.5
5. The young boys ran out of the boxes.	Lexical (Unsystematic)	
6. We are confident that you can make it.	"	3.95
7. He wears a light suit in the summer.	"	4.0
8. She could not bear children after the accident.	"	3.25
9. The soldier put the gasoline into the tank.	"	7.4
10. On top of everything there was a tarpaulin.	"	4.0
11. The salesman wanted lots of that size.	"	4.0
12. Fred wrote the story of the year.	"	4.05
13. The soldiers took the port at night.	"	4.0
14. Everyone knew that they were making money.	"	7.3
15. He told me to go without any hesitation.	Derived Constituent Structure	4.0
16. The stout major's wife stayed at home.	"	3.8
17. The three masted British ships were sailing south.	"	4.7
18. The old men and women did not cooperate.	"	5.2
19. I gave the advice to the man with Jack.	"	6.6
20. They talked about the problem with the mathematician.	"	4.15
21. They sent the requisition over a week ago.	"	5.1
22. The eskimos soon learned how good meat tastes.	"	3.75
23. They claimed that he was quick to please.	Underlying Constituent Structure	6.05
24. The idea of the natives was dreadful.	"	4.35
25. Italians like opera as much as Germans.	"	4.50
26. John is the one to help today.	"	5.00
27. Those who play chess as well as Bill came.	Underlying Constituent Structure	5.45
28. The growing of the spring flowers was marvelous.	"	5.45
29. Mary and I approved of his cooking.	"	4.1
30. I just don't feel like pleasing salesmen.	"	6.5
31. The mayor requested the police to stop drinking.	"	5.0
32. They asked the men to stop fighting.	"	9.65

II. Multiply ambiguous sentences

1. The girls met the man in the orchard.	Lexical Surface	6.0 4.4
2. We were surprised at the colonel's appointment.	Lexical Underlying	4.8 5.2
3. How decent farmers looked was unknown to them.	Lexical	5.9
4. He unclogged the pipe in the bathroom.	Lexical Surface	7.5 4.0
5. He lectured on the new type of building.	Lexical Surface	4.9 7.2
6. I don't know how they remembered our turn.	Lexical	10.0
7. The jury heard the criminal lawyer's case.	Underlying	8.0
8. They took the plane to another city.	Lexical Surface	4.8 5.1
9. The secretary took the chair before the Board.	Lexical " " "	3.3 4.0 5.55 4.65
10. This bank was the scene of the crime.	Lexical "	12.0 14.1
11. They were powerless to analyze strictly agricultural conditions.	Lexical Surface	15.5 8.8
12. All with serviceable boats help the stranded soldiers.	Surface Underlying	15.5 11.3
13. The Spanish students worked on the translation together.	Surface Underlying	28.0 10.3