Locating clicks in sentences: Left, center, and right*

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There are currently two theoretical interpretations of the pattern of errors that Ss make in attempting to locate the position of a click in a message. One is based upon lexical sequences in the message (the *linguistic* hypothesis), and the other is based upon attentional priorities, memory factors, and response biases (the *attentional* hypothesis). This experiment was designed to differentiate between them. By orthogonally varying the temporal location of the major syntactic break and the position of the click, it was possible to control for effects of serial position and memory. In addition, a subliminal control group was run to evaluate Ss' response biases. Little evidence was found to support the linguistic hypothesis; considerable support was found for at least a qualitative version of the attentional hypothesis.

There seems to be little disagreement over the simple fact that, under the appropriate experimental conditions, mature speakers of English tend to mislocate a spot of interference (a "click") embedded in or superimposed upon a linguistic message. The unanimity, however, is quickly lost when it comes to describing the nature of the mislocations and the theoretical interpretations of what has come to be called "the click migration effect."

T. G. Bever and his coworkers (Bever et al. 1969; Fodor & Bever, 1965) have consistently stressed the role of linguistic variables, most recently those which reflect the deep structure of the sentential material. In particular, they argue that Ss tend to subjectively place clicks in or toward the break between major syntactic structures. The argument stems from the Gestalt suggestion that basic psychological units have a coherency that resists interference by extraneous stimuli. Thus, they conclude that a tendency to locate those clicks which are objectively *within* a linguistic unit in or near the point of closure *between* such units is evidence that such units have psychological reality.

Reber and Anderson (1970) have presented an alternative hypothesis which deemphasizes syntactic factors and suggests that the relocation errors are due primarily to attentional priorities and secondarily to memory factors and response biases. In brief, the hypothesis assumes that the sentential material and the click constitute two separate messages, only one of which is within the S's attentional focus at any one time. Using Titchener's (1909) law of prior entry, the hypothesis infers that the pattern and direction of errors reflects the attentional priorities at the time of occurrence of the click. If the click has priority, it will be perceived earlier than it occurred objectively; if the sentence has priority, the click will be perceived as occurring later.

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Given the relative paucity of data presently available, it seems unlikely that it can be shown that one of these interpretations is entirely correct. In point of fact, we maintain that to some extent many processes may be operating in these experiments. However, there are two clearly distinct theoretical foci here. The one argued for primarily by Bever et al is based on natural language factors in perception and is referred to hereafter as the *linguistic* hypothesis. The other, argued for primarily by Reber and Anderson (1970), is based on very general perceptual factors which can, but do not necessarily, relate to natural languages and is hereafter referred to as the *attentional* hypothesis. This experiment was designed to differentiate between these two orientations.

METHOD

Stimulus Items

The experiment was built around a set of 27 sentences. Each sentence was exactly 12 words long, all words were monosyllabic. There were two experimental factors, sentence type and click location.

Sentence Type

Sentence type refers here to the location of the major syntactic break. There were three types, with the major syntactic break located after the third word, the sixth word, or the ninth word. Examples of each are:

Left break:

Forced to choose ↓ most men will opt for youth and not wealth.

Center break:

The bark of that big dog ↓ is much worse than its bite.

Right break:

The boy and girl who walked arm in arm were in love. ↓

The arrow marks the location of the major break. In all cases, the major break was determined by the standard parsing procedure described in Fodor and Bever (1965).

Click location

The click positions used were balanced symmetrically around the three possible major break positions. If one counts each word and space between words, there are 25 possible click locations, i.e.,

1	2	3	4	5	6	7	8	9	10	11	12	13
THE	BOY	AND	GIRL	WHO	WALKED							
14	15	16	17	18	19	20	21	22	23	24	25	
ARM	IN	ARM	WERE	IN	LOVE							

Positions 6, 7, 8, 12, 13, 14, 18, 19, 20 were used. Note that Positions 7, 13, and 19 are the locations of the major breaks for left, center, and right sentences, respectively, and that they are the only clicks that occur in word breaks. The clicks themselves were produced by a .05-msec burst of broadband white noise. Intensity was set to match approximately the loudest parts of the linguistic message.

Design

Click location and position of the major break were varied orthogonally so that each of the nine click positions occurred with each major syntactic break position. Two separate recordings of the 27 sentences were made up, each with a different pattern of click locations. This procedure was used to control for any adventitious effects of particular combinations of sentence and click location. Each tape was played through twice, alternating order for each succeeding group of Ss, making a total of four runs, or 108 trials. (No differences were observed between the separate recordings, and they are analyzed together below.)

The sentences were recorded by an adult male using normal prosody on one channel of the tape; the clicks were put on the other. All stimulus items were presented to the Ss over centrally located loudspeakers, the sentence on one speaker, the clicks on the other. Three practice items were played before the actual experimental session began.

The Ss were run in small groups of three or four and were seated approximately equidistant from the two speakers. As in our previous work, Ss were not required to memorize or transcribe the sentences. Each S was presented with a booklet which had the items typed out in capital letters and without punctuation. Blank divider pages were used so that Ss could not see the item until after it was presented. The S's task was simply to mark on the typed sentence the exact position that the click was perceived.

Subliminal Control

A failing in much of the earlier work has been the lack of concern over the role that response biases may play in the Ss' attempts to locate the exact position of the click. The use of such statistics as "the proportion of clicks correctly located" or "the proportion of clicks mislocated toward the major syntactic break" can be defended only if one assumes a uniform distribution of responses with no linguistically or perceptually produced biases. Two studies (Ladefoged, 1967; Reber & Anderson, 1970) have, however, shown that the underlying response distribution is generally nonuniform; Ss often show a tendency to locate imperceptible clicks in and around the major syntactic break. In order to properly analyze click location responses, one must have either a theoretical or an empirical estimate of the overall response tendencies of the Ss in the experiment.

The subliminal control group was run to obtain an empirical measure of Ss' response biases. Ss were run in a fashion identical to that of the experimental group except that after the three

practice trials, the channel containing the clicks was disconnected. These Ss were told that the click was still there but that they would "not even be aware of hearing it" and that "experiments have shown that Ss under these conditions locate clicks with better than chance accuracy." They were asked to mark the position they thought the click "most likely occurred."

Subjects

There were 20 Ss in the experimental group and 9 in the subliminal control group. All were undergraduates in psychology courses who served as unpaid volunteers.

RESULTS

A total of 2,160 responses were made by the experimental Ss. Of these, 1,020, or .472, were correct locations; of the 1,140 errors, 752, or .660, were errors locating the click to the right of (or later in the sentence) where it actually occurred. These two statistics, probability of a correct response (P_c) and probability of an error to the right ($P_{e,r}$) were used as the main analytical tools.

Probability of a Correct Response, P_c

Figure 1 shows the probability of a correct response for each of the nine click positions and each of the three sentence types. The circled data points represent clicks which occurred in the major syntactic break. The important aspects of these results are:

(a) There are no meaningful overall differences between the three sentence types. This result is not unreasonable, since there is no current interpretation of the click location effect which would predict an overall difference.

(b) There is a marked overall effect of click position: clicks occurring later in the sentence are located with greater accuracy than those occurring earlier. This result was found in our earlier work (Reber & Anderson, 1970), and we consider it to be a simple consequence of loss from memory of the location of early clicks, since the Ss do not respond until the sentence is complete.

(c) Clicks occurring exactly in a major syntactic break (the circled data points) have a markedly higher P_c than clicks occurring in any other place. On the surface, this result would seem to lend strong support to the linguistic hypothesis since it alone predicts that clicks occurring *between* linguistic units are perceived differently from those occurring *over* linguistic units. However, final interpretation is dependent upon certain corrections for possible response biases.

(d) The values of P_c for clicks located over words (Positions 6, 8, 12, 14, 18, 20) are systematically higher than for clicks located between words—excluding, of course, those clicks in major breaks (.48 vs .36). This result is not in keeping with the linguistic hypothesis, particularly in that it predicts relatively low P_c values for clicks located over words adjacent to the major break (Positions 6 and 8 for left sentences, 12 and 14 for

Fig. 1. Probability of a correct response (P_c). Left, center, and right sentences plotted separately. The circled data points are those where the click position and the major syntactic break coincide.

center, and 18 and 20 for right). According to the linguistic hypothesis, the tendency should be to hear such clicks as occurring *in* the break itself. However, as above, these data are only meaningful when analyzed against possible response biases.

Thus, a simple analysis of the P_c data yields three clear effects: (1) the later a click is in a sentence, the more likely it will be correctly located; (2) clicks actually in major syntactic breaks are easier to locate than clicks elsewhere, and (3) clicks objectively over words are more likely to be located correctly than those in word gaps which are not also major syntactic breaks.

However, as was stressed before, a measure like P_c is a reliable measure of the S's perceptual accuracy only if there are no systematic biases in the data. A disproportionately high number of responses in any one position will result in a spuriously high P_c for that position. There are, however, reasons to suspect that Ss have strong response biases favoring major syntactic

breaks, words, and the latter half of sentences. Since these are also the three effects obtained, a new analysis was run using a weighted value of correct responding noted as P'_c . Values of P'_c were obtained simply by correcting the P_c for each click position by the total number of responses made in that position, i.e., $P'_c = P_c / (P_c + P_e)$.

The results of this correction are shown in Fig. 2. Note that the two most important effects "wash out." Clicks in major breaks are no easier nor more difficult to locate than clicks located elsewhere. The only effect that remains is the slight increase in accuracy with later occurring clicks. Our conclusion is: except for those effects produced by simple memory factors, the pattern of errors observed in this study is traceable to response biases. In the absence of similar corrections for response biases, there is no reason to assume that this conclusion is not applicable to other studies on the location of clicks in linguistic messages.

Fig. 2. Probability of a correct response corrected for number of responses per position (P'_c). Left, center, and right sentences plotted separately. The circled data points are those where the click position and the major syntactic break coincide.

Fig. 3. Subliminal control group. Normalized distribution of responses to left, center, and right sentences.

The Subliminal Control

Clearly, the impetus to perform the P'_c correction came from the previously observed tendency for Ss to guess the major syntactic break when clicks were actually not present (Ladefoged, 1967; Reber & Anderson, 1970). However, these earlier studies suffered from certain shortcomings. Ladefoged's "experiment" was actually little more than an informal, post hoc, check on possible guessing biases; Reber and Anderson's used only sentences which were symmetric around a centrally located major break. The purpose of this control group, then, was to establish a reliable estimate of the underlying response distribution and to evaluate the degree to which the effects of syntax could be separated from those of serial position.

Figure 3 presents the normalized distribution of the 972 responses made by the nine subliminal Ss with the three sentence types shown separately. The main points are as follows:

(a) There is a rather dramatic effect of syntax with the major syntactic break attracting a disproportionately large number of responses. In addition, those points surrounding the major breaks (Positions 6 and 8 for left, 12 and 14 for center, 18 and 20 for right) have higher than average response proportions. Clearly, Ss are much more likely to select the major syntactic break and immediately adjacent points than any others. In fact, these positions, which make up only .120 of the total response alternatives open to the Ss, attracted .338 of the responses. Thus, we find further evidence for Ladefoged's (1967) conclusion, "...part of the responses in ours and (others) experiments may have nothing to do with a subject's perception from the point of view of the way he scans incoming auditory data."

(b) The overall central tendency observed in our earlier studies is present here also. However, since

centrality and syntax are not confounded, it is now clear that serial position effects are more than offset by the syntax effects. That is, Ss will select positions as early as 6 and 7 and as late as 19 and 20 provided that the major syntactic break is in the vicinity.

(c) There is a pronounced tendency for Ss to select words as responses as opposed to the gaps between words. The breakdown is: proportion of responses over words, .604; in major syntactic word gaps, .338; in nonmajor word gaps, .058. In view of the general reluctance of Ss to select word gaps as responses, the attractive effects of the major syntactic breaks are even more striking.

(d) The last half of an item is more likely to receive responses than the first half; .522 of the responses were in Positions 14-25 and only .401 in Positions 1-12. This result is the only one not in agreement with our earlier work, where we found a slight tendency for Ss to select the earlier positions. The difference here may be due to the larger number of trials run in this study (108 vs 72), since we have previously observed an increase in the right directional bias with later trials. The point, however, is far from compelling.

The subliminal data make it quite clear that we are faced with nonuniform guessing probabilities in these experiments. We appreciate the fact that the subliminal procedure suffers from certain deficiencies, particularly in that it no longer deals directly with a perceptual process. Nevertheless, the effects shown in Fig. 3 are so compelling that the criticism is seemingly vitiated. Moreover, while it is certainly true that a subliminal control condition may not have direct implications for perception experiments, it does have important implications for the evaluation of response biases which may be present in perception experiments. Without such an evaluation, the earlier studies on click location have few implications for the study of speech perception. It is simply not possible to interpret unambiguously Ss' responses to clicks in sentences unless there is either a theoretical or an empirical measure of the underlying response distribution.

Probability of an Error to the Right, $P_{e,r}$

This analysis treats only error trials. The data are presented as the proportion of total errors to the right (toward the end of the sentence) of the actual click position. Figure 4 gives the values of $P_{e,r}$ for each click position and sentence type.

There are no significant differences between sentence types. Temporal location of the click dominates the pattern of directional errors to the extent that clicks in any given position are responded to similarly regardless of their proximity to the major syntactic break. This result is important insofar as the linguistic hypothesis predicts differences in directionality of errors as a function of proximity of the click to the major break. The attentional hypothesis makes no such predictions.

Fig. 4. Probability of an error to the right of objective click location ($P_{e,r}$). Left, center, and right sentences plotted separately. Circled data points are those where the linguistic hypothesis and the attentional hypothesis make different predictions.

Also note that the linguistic hypothesis focuses upon the major break, placing essentially no weight on its temporal location. Thus, the break is assumed to have similar attractive effects on clicks both before and after it regardless of whether the break occurs late or early in a sentence. Further, no directional bias is expected for clicks which occur in or distant from major breaks. The attentional hypothesis, on the other hand, focuses upon the temporal location of the clicks in the sentence and underplays the role of the major syntactic break. The direction of an error is assumed to be determined by the attentional priorities of the S at the point in time when the click occurs. Thus, the linguistic hypothesis predicts symmetry of directionality of errors surrounding all breaks; the attentional hypothesis predicts asymmetry of directionality of errors for early and late clicks.

As Fig. 4 shows, the data are in agreement with the attentional hypothesis. There is a systematic decrease in $P_{e,r}$ with later click positions, and this trend is found regardless of the location of the break. The circled data points are those which differentiate most clearly between the two hypotheses. Positions 8 in left sentences and 14 in center sentences should, according to the linguistic hypothesis, show a strong left bias roughly symmetrical with the right biases in Positions 6 and 12; the attentional hypothesis predicts right biases. The obtained values of $P_{e,r}$ were .74 and .75, respectively. Similarly, Position 18 clicks in right sentences, where the linguistic hypothesis predicts a right bias roughly symmetrical with the left bias found for Position 20, the value of $P_{e,r}$ reflects the systematic decrease predicted by the attentional hypothesis, .43. Clicks in and remote from major syntactic breaks reflect the same general trend. Early in a sentence, they have a right bias, and later in a sentence, they have a left bias. There is no evidence for the symmetry independent of serial position predicted by the linguistic hypothesis.

DISCUSSION

The overall picture is primarily negative with respect

to the linguistic hypothesis and is at least tentatively positive with respect to the attentional hypothesis. The P_c and P'_c data showed that effects seemingly attributable to syntax are, in fact, determined by general perceptual factors, memory processes, and marked response biases. Interestingly, when only the uncorrected P_c measure was examined, the values were roughly in accordance with those reported elsewhere (Fodor & Bever, 1965). That is, the position of the major syntactic break showed a higher P_c than did other positions. This result shows that this study is not incompatible with others.

The $P_{e,r}$ data were even more damaging to the linguistic hypothesis and lend further, at least qualitative, support to the attentional hypothesis. In general, the direction of error seemed to be determined primarily by temporal location of the click and not by proximity to a major syntactic break. Again, it should be emphasized that these data are also compatible with other research. Those who support the linguistic hypothesis often refer to "the proportion of clicks that are misplaced toward or into the major syntactic break." The overall value of this statistic in this study was .572, a value reasonably close to that reported elsewhere. However, as long as major breaks receive more than their share of guessing responses, this result is ambiguous at best.

The major problem with the attentional hypothesis at this point is its lack of precision. For example, the assumption is made that with progress through a sentence, the S would shift attention away from the channel containing the sentence to the channel containing the click. There seem to be at least two good reasons for making this assumption. First, since the click has not been heard yet, the S begins to actively anticipate it. Second, with progress through a sentence, the message becomes increasingly more determined, and the S may safely redirect attention to the other channel. While this line of argument leads to the prediction of a drop in $P_{e,r}$ with later occurring clicks, it is not possible to predict how high the initial bias should be, how large

Fig. 5. Best fit lines for the $P_{e,r}$ data from these different types of stimulus material.

a decrease to expect, at which point the directional bias should shift from right to left, and so forth. The attentional hypothesis seems to account for the gross effects observed in this study with relative ease; the fine grain is another story altogether.

In spite of these problems, it is possible to get some sense of the role that the stimulus material plays in the direction of error. Figure 5 shows the best fit lines for the $P_{e,r}$ data from three different experiments using three different types of stimulus materials: 12-word sentences, 6-word sentences, and a sequence of noise bursts. The 12-word sentences contain the most "information" and are the most variable in that the sentence structure changed from trial to trial. Thus, they are simultaneously the most attractive in terms of initial attentional priorities and the least determined in that the last few words still convey considerable content. The $P_{e,r}$ for these sentences starts high and decreases only gradually.

The six-word sentences (from Reber & Anderson, 1970) all had the exact same syntactic structure. Thus, they are somewhat less attractive of the Ss' attention and they are highly determined in that the last few words convey very little content (sample sentence: "Tiny compact autos consume cheaper fuels"). The $P_{e,r}$ for these sentences starts fairly high but decreases quite dramatically.

The noise bursts (also from Reber & Anderson, 1970) were a mockup of the six-word sentences. That is, they consisted of six 370-msec bursts of white noise whose

total duration matched that of the average six-word sentence. Since there is essentially no structure here, there is little effect of click location on $P_{e,r}$. The initial right bias is low and the decline in the $P_{e,r}$ is slight.

Thus, it begins to appear that the click migration effect is subject to the linguistic content of a message (or lack of it), but perhaps not in the way that the linguistic hypothesis suggests. Rather, the effects that sentential material have are primarily in the manner in which they control the Ss' attentional priorities, and these priorities determine the pattern of click mislocations.

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