Journal of Experimental Psychology
1974, Vol. 102, No. 5, 893–896

EFFECTS OF TWO TEMPORAL VARIABLES ON THE LISTENER'S PERCEPTION OF READING RATE

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Apparent rate grows much more rapidly for the speaker than for the listener as words per minute increase (exponents 2.6 vs. 1.6). The rate of speaking comprises three variables, however: the number of pauses, articulation rate, and the durations of the pauses. When a speaker doubles his rate (as it seems to him) he halves the number of pauses, altering the other variables only slightly. Conversely, the listener is much more impressed by changes in articulation rate than in pausing (exponents 1.5 and −.23). Thus, the perceptual processes of speaker and listener are somewhat complementary, and changes in the two variables have more comparable effects on the listener when expressed in units of apparent magnitude for the speaker. The net effect of mapping autophonic into extraphonic magnitudes in the transmission of speech rate is one of compression, both for overall rate (exponent .6) and for the component articulation rates (.44) and pause frequencies (.21).

A speaker may alter his rate by changing the number of pauses, the articulation rate, or the durations of pauses, in various degrees. The autophonic scale that describes the speaker's perception of his own rate has a slope of 2.6 when expressed as a function of words per minute (in log–log coordinates) and slopes of −1.1, 3.4, and −4.3 when plotted as a function of the respective components of these overall rates (Lane & Grosjean, 1973). It follows that when a speaker varies his rate of reading a known passage, he primarily adds or subtracts pauses (at strategic syntactic locations); he alters articulation rate and pause duration much less. The same is true for spontaneous speech: "Increase of speed in talking is due largely to the closing of gaps and to the heightened continuity with which movements performed at relatively constant rate succeed each other [Goldman-Eisler, 1968, p. 26]." An equivalent way of describing the relative importance of these variables for autophonic rate is to point out that as reading rate increased by a factor of 2.7 (close to the total operational range for reading sentences), the three component variables changed by factors of 10.3, 2.1, and 1.6, respectively.

How the three components of rate control the listener's perception is unknown. We do know from the autophonic study (Lane & Grosjean, 1973), in which a representative speaker's productions were also played back to listeners for numerical estimates, that apparent rate grows much more slowly for the listener than the speaker as words per minute (wpm) increase (slopes of 1.5 vs. 2.6). This difference in slopes indicates that the speaker's perception of his own rate is not based solely on auditory cues. Therefore, pause frequency, articulation rate, and pause duration may not have the same relative importance for the listener's perception of rate as they do for the speaker; it may matter a great deal whether it is your own tongue that is wagging. In the present experiment, then, the two variables that proved most salient in the perception of autophonic rate were decoupled, and each was varied systematically in a 5×5 array of rates presented to listeners. We examined the relative contributions of pause frequency and articulation rate to the listener's extraphonic perception of rate, the invariance of the cue hierarchy across

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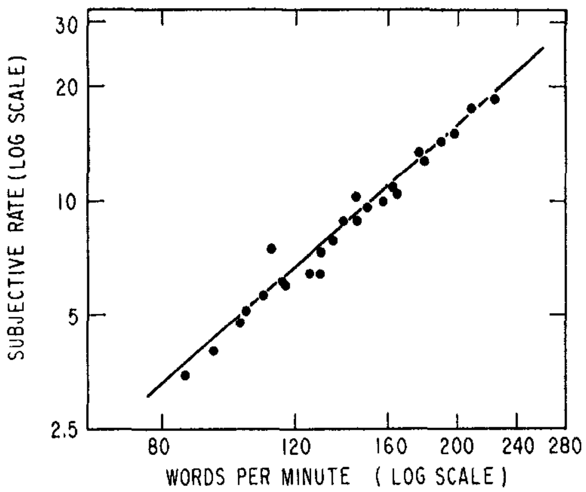

FIGURE 1. The extraphonic scale of reading rate. (Each point is the geometric mean of 68 rate estimates, 4 by each of 17 listeners. The 25 values of words per minute reflect 5 levels of articulation rate at each of 5 levels of pause frequency.)

modalities, and the reproducibility of the extraphonic scale with somewhat different procedures and stimulus ensembles.

METHOD

Seventeen graduate students, native speakers of English with no reported speech or hearing defects, served in groups of three or four, while seated in an audiometric room for 1½ hr. They wore Opelem binaural headsets supplied in parallel by an Opelem 2M-70 studio tape recorder.

The method of magnitude estimation (Stevens, 1956) was used to measure the perception of speech rate. The *E* played a recording of the experimental passage, read with a midvalue of number of pauses (7 pauses or 9.4 syllables/run) and of articulation rate (4.5 syllables/sec). The *E* assigned the numerical value 10 to this standard rate (146 wpm). Next, he played 100 recordings of the passage, and the listener assigned to each a number proportional to its apparent rate. In all, 25 rates of reading by the same speaker, ranging from 85 to 225 wpm, were presented four times, in irregular order. Each rate corresponded to a combination of a level of articulation rate and a level of number of pauses, shown on the coordinates of Figure 2. (The length of the pauses was held constant, with tape splicing, at a mean value of .56 ± .01 sec. Each articulation rate was constant within 1% over the five levels of pause frequency.) The same passage employed in the extraphonic study and comparable ranges of the variables measured there were adopted in the present study. However, the rates presented here are somewhat lower (average wpm 146 vs. 165), thus higher pause frequencies (9.6 vs. 6.3) and lower articulation rates (4.5 vs. 4.8 syllables/sec) are naturally encountered.

The experimental passage contained the following 51 words of text (including contractions), comprising 75 syllables (the number at each pause emplacement shows the lowest pause frequency that entailed pausing there; all higher pause frequencies also used that emplacement):

> as far /24/ as I know /7/ I'm a fairly /24/ normal /13/ fifteen year old /3/ neither a complete /13/ psychological /24/ case /7/ nor a cut /13/ above /24/ the others /1/ I listen /24/ to Radio /24/ Luxembourg /7/ my hair /24/ falls forward /13/ in the fashionable /24/ style /3/ and I wear /13/ polo neck /24/ sweaters /7/ but I don't /24/ consider myself /13/ a great /24/ pop fan.

The hierarchy of pause emplacements is that observed in the autophonic experiment of Lane and Grosjean (1973).

RESULTS AND DISCUSSION

The extraphonic scale of reading rate is shown in Figure 1. The magnitude estimations are well fit by a straight line with a slope of 1.7, in logarithmic coordinates. (The mean and *SD* of the 17 individual slopes are 1.7 and .56., respectively.) The scale is substantially the same as that obtained with five rates of reading in which pausing and articulation rate were normally coupled, not varied independently (slope = 1.5, *SD* = .37; Lane & Grosjean, 1973). A slope of 1.6 is found in the latter study over the range of words per minute employed here; moreover, moderate levels of the two variables in the present experiment (3 × 3 subensemble) yield a slope of 1.62. We conclude that the extraphonic scale of reading rate is reasonably invariant over these differences in stimulus array and procedure, with a slope (exponent in linear coordinates) of 1.6.

The contributions of pause frequency and articulation rate to perceived reading rate may be examined in three different ways, all of which give the same general picture. The perceived-rate solid in Figure 2 suggests that the two components of overall rate contribute about equally over the ranges employed (approximately those encountered by Lane & Grosjean, 1973, in actual productions). An analysis of variance of rate estimates confirms that pause frequency and articulation rate are equally important: the two mean squares are 3,255

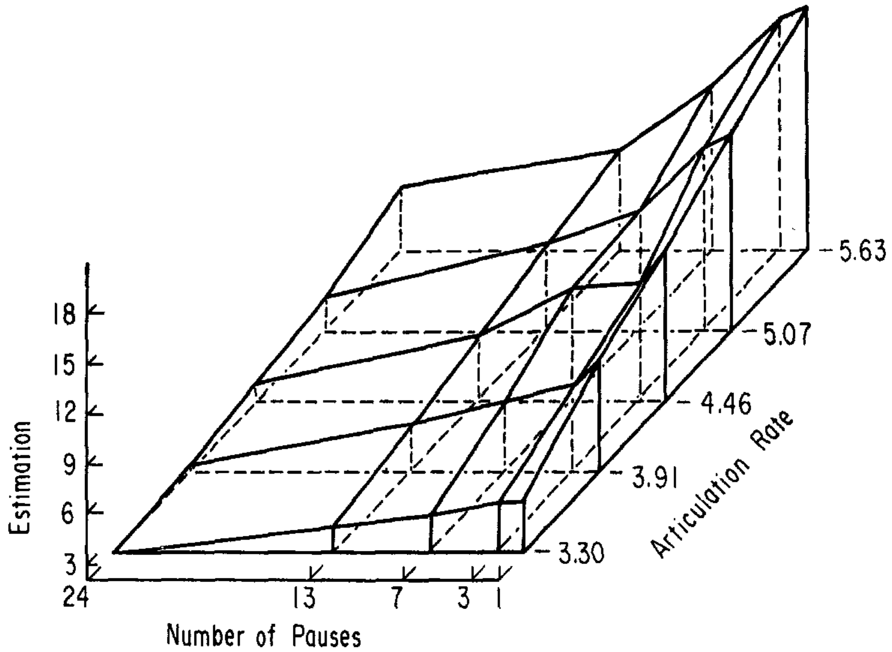

FIGURE 2. Numerical estimates of apparent rate as a function of two component variables, pause frequency and articulation rate. (The 25 line intersections plot the geometric means of 68 rate estimates, 4 by each of 17 listeners.)

and 2,919, respectively; F (4, 64) = 98 and 109, $p < .01$. The between-*S*s mean square is 136, *ns*. The interaction of pause frequency and articulation rate, evident in the graph, is statistically significant, mean square = 136; F (16, 256) = 23, $p < .01$. Eighty-four percent of the interaction sum of squares is associated with the one *df* corresponding to the bilinear component.[2] This suggests that the two cues combine multiplicatively to yield the net impression of overall rate. Thus, an increase in articulation rate may amplify the effects of pause frequency on apparent rate. The same result would be obtained, however, if the listener combines the two cues linearly under conditions in which the estimates are not linearly related to apparent rate, or if the weights assigned to the cues for integration vary as a function of stimulus magnitude.

A third way to evaluate the relative contributions of pause frequency and articulation rate, and to compare their importance for the speaker and the listener, is to examine the rates of growth of autophonic and extraphonic perceived rate as a function of the two components and overall words per minute. A speaker instructed to double his apparent rate will change pause frequency by a factor of 2, articulation rate by 1.2, and overall rate by 1.3 (since the autophonic slopes are −1.1, 3.4, and 2.6). A listener would estimate, however, that the changes were, in fact, 1.2, 1.3, and 1.5 to 1, respectively (since the extraphonic slopes found in this study are −.23, 1.5, 1.6). Consequently, equal changes in pause frequency and articulation rate have more comparable effects on the listener when those changes are measured in psychological units along the autophonic scale. Extraphonic rate grows approximately six times faster as a function of articulation rate than pause frequency, expressed in physical units. However, the rates of growth as a function of the corresponding apparent (autophonic) magnitudes are more similar: .44 and .21, respectively (absolute values). Thus, the perceptual processes of speaker and listener are somewhat complementary. The net effect is one of compression: extraphonic rate grows as the 1.6/2.6 = .6 power of auto-

[2] The authors are grateful to Norman H. Anderson for calling this aspect of the results to our attention and for aiding us in applying his theory of functional measurement (Anderson, 1973).

phonic rate. It follows that speakers and listeners will not agree on what constitutes a doubling of rate (or halving, tripling, etc.), and that speakers will always fall short when trying to imitate the rate changes of a model.

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(Received May 31, 1973)

Journal of Experimental Psychology
1974, Vol. 102, No. 5, 896–898

AROUSAL AND RECALL: EFFECTS OF NOISE ON TWO RETRIEVAL STRATEGIES[1]

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In a test of the notion that arousal affects the retrieval strategy of pigeonholing by decreasing the separation between risky and cautious criteria, 75 *S*s heard short meaningful stories accompanied by either No, Medium, or High noise and were asked to recall the characters' names. Common names were better recalled than rare names in each noise condition. Using a decision theory analysis it was found that, in the No Noise condition, *S*s employed a risky criterion for common names and a cautious criterion for rare names. In noise, however, *S*s employed a similar criterion for recall of both common and rare names, but sensitivity increased for common names. The results were interpreted as supporting the hypothesis that arousal affects the accessibility of information for retrieval. A possible mechanism for arousal's action, as well as the theoretical implications of these findings, was discussed.

Drawing on his work in perception, Broadbent (1971) has identified two memory retrieval strategies—filtering and pigeonholing. According to Broadbent, filtering occurs when one adopts a "stimulus set," choosing items to be recalled on the basis of some common feature (e.g., acoustic similarity) and ignoring those items in memory without this feature. Filtering, therefore, involves the grouping of input on the basis of physical characteristics. Pigeonholing, on the other hand, occurs when one adopts a "response set" selecting from a large number of items (e.g., a list of words), those constituting a subvocabulary (e.g., the names of colors). Thus, filtering leads to stimulus selectivity, whereas pigeonholing results in response selection. When an operating characteristic is derived relating the probability of a correct response to the probability of an incorrect response (false alarm), pigeonholing produces an increase in the number of correct responses as the false-alarm rate increases, whereas filtering produces a change in the number of correct responses with a constant false-alarm rate. In decision-theory terms, filtering affects d', the difference between the correct response rate and the false-alarm rate, whereas pigeonholing affects β, the critical value of likelihood ratio above which S responds positively.

Despite recent interest in applying decision-theory measures to memory, the effects of arousal on d' and β as estimated from recall data have not been explored. On the basis of vigilance research, however, there is reason to believe that arousal affects pigeonholing but not filtering. Broadbent and Gregory (1965) found that, in a vigilance situation, arousal results in a change in the number of responses assigned to intermediate confidence levels. That is, aroused *S*s were more certain that a signal was presented or more certain that no signal was presented than unaroused *S*s. Such a mechanism may produce contradictory effects on pigeonholing.

[1] The author is indebted to D. E. Broadbent for his constructive criticism and to a number of students and colleagues whose comments greatly improved this article. Any errors in the final product are, of course, the responsibility of the author.

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