SHORTER ARTICLES AND NOTES

GROUPING STRATEGIES WITH SIMULTANEOUS STIMULI

BY

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Broadbent (1956) reports that two lists of digits, each presented to one ear separately so that the items in the two series coincide in time, are grouped together according to the ear-of-arrival, and that these two lists are accordingly recalled separately, one after the other. To ascertain whether such a tendency reflected some built-in mechanism or whether it was due to an optional tactic, adopted through success in making sense of message sequences in other situations, an experiment was designed in which a meaningful message would emerge for the subject if the ear-of-arrival cue was *ignored*. In this experiment, words broken up into syllables, and phrases broken up into their monosyllabic constituent words were presented to the subject, with the constituents alternating between the two ears. At the same time lists of digits were presented to whichever ear was unoccupied. The results show that recall by meaning rather than by ear-of-arrival, when these are in conflict, can occur and is no less efficient.

Introduction

Broadbent (1956 and 1958) has reported that when two lists of three digits are presented simultaneously to separate ears at a speed of two digits a second on each ear, "in the vast majority of cases . . . all the information from one channel appeared in response before any of the information from the other channel" (p. 212, 1958). This finding is peculiarly interesting because grouping by temporal order, which is the normal phenomenon at slow speeds, seemed to be unobtainable. However his material, single digits, offered no further cues for grouping other than the ear on which each item arrived. It is not clear, therefore, whether the preference shown by subjects for grouping in this way reflects some built-in mechanism, or is simply an optimal strategy for the situation—i.e. a bias on the basis of past success in classifying the input of one ear as a continuous message, when other coincident cues (e.g. message sense, voice, pitch, etc.) also fit into this classification.

If grouping-by-ear is an acquired bias, the presence of other cues *in conflict with* the ear of arrival should be able to disrupt it, and some other strategy of recall will be used.

In the following experiments, such cues were provided by (1) 3-syllable words broken up into syllables and presented to alternate ears, and (2) 3-word phrases used in the same way.

Experiment I

Equipment

A Brenell Mark IV 2-channel tape-recorder, with each channel feeding into a separate headphone, was used throughout. Subjects recorded their own responses on cards at the end of each list.

Subjects

Ten male and 5 female university undergraduates, naïve in dichotic listening situations, were given preliminary practice with one series of digits only, under the same overall conditions as in the subsequent experiment.

Material

Ten lists of digits and syllables, arranged as in the following examples, orders (1) and (2) alternating throughout:—

(1)	*Left*	*Right*	(2)	*Left*	*Right*
	EX-	6		1	CYC-
	2	TIR-		LO-	7
	PATE	9		3	STYLE

The other words used were: fol-i-o, le-pre-chaun, ob-jec-tive, mas-ter-ful, se-man-tic, cad-mi-um, ri-vu-let, hy-dro-gen. The digits were taken from a table of random digits, though no list contained any digit twice.

Procedure

The interval between the onset of each simultaneous pair was half-sec., and the lists were 13 sec. apart, which gave ample time for subjects to record their results.

Subjects were divided into two groups. Group 1 (7 subjects) was given neutral instructions, to expect syllables and digits, and to write down exactly what was heard at the end of each list. They were not told that the syllables formed words. Subjects in Group 2 (8 subjects) were told in addition that the syllables formed three-syllable English words, and were instructed to listen for these words as a unit, as well as the three digits. Both Groups were asked to write down what they recalled immediately at the end of each list, and not to "reshuffle" the items on paper, nor, as far as possible, in their heads. The second Group was also asked not to attempt to infer or reconstruct a word if they had failed to hear it as a word. Subjects were watched throughout to ensure that they did not re-order the items as they wrote them.

Results

The results are given in Table I. The low mean scores indicate that all subjects found the task difficult, except Group 1 with the digits, and overall comparison of the grouping used was impossible owing to the number of ambiguous responses containing gaps and reduplicated items.

TABLE I

(*a*) Per Cent. Items Recalled

	Digits	*Syllables*	*Mean*
Group 1	78	49	64
Group 2	55	36	46

(*b*) Grouping of All-correct Lists

	Ear	*Meaning*	*Indeterminate*	*Total*
Group 1 . .	4(1.S)	—	1	5/70
Group 2 . .	1	8 (4.S)	—	9/80

But despite their higher score on individual syllables, Group 1 never made a whole word, and only had 5 lists with all 6 items correct, 4 being grouped by ear, and only the fifth one being free of phonetic approximations. Of the 9 all-correct lists of Group 2, 7 were perfectly recalled, and one had the syllables collected with a slight distortion, (CAT-ME-UM for CAD-MI-UM) without the word being recognized. Here plainly transition probabilities between syllables were not being utilized, but the differentiation between syllables and digits was alone sufficiently strong as a cue to break down the tendency to group-by-ear.

Two of the words ("leprechaun" and "rivulet") were never reported at all, perhaps owing to unfamiliarity.

We can conclude from this experiment that Group 2, owing to the greater difficulty of the task set to them, showed lower overall efficiency (fewer *items* recalled), but were more completely successful (more all-correct *lists*) when they achieved the technique of grouping-by-meaning.

Experiment 2

The second experiment was done by all subjects, in the same two Groups, immediately after Experiment 1.

Material

Ten lists of words and digits, arranged as in the following examples, orders (1) and (2) alternating throughout:—

(1)	*Left*	*Right*	(2)	*Left*	*Right*
	Mice	3		2	who
	5	eat		goes	3
	cheese	4		9	there

The other phrases used were: What the Hell, did you see, my old flame, it's in there, there she goes, tea is laid, not my sort, dear Aunt Jane.

Procedure

The timing and instructions were, *mutatis mutandis*, the same as in Experiment 1. Group 1 were told that they would hear digits and words, Group 2 that they would hear digits and words forming 3-word phrases or sentences.

Results

Higher means (Table III*a*) permit a more complete analysis of the data. First, each list was categorized for scoring as "Ear," "Meaning," or "Indeterminate" according to strict conventions. Cases where mixed strategies occurred were allotted to "Indeterminate," as were lists reported with ambiguous gaps, guesses, or reduplications. (One subject specialized in mixed strategies, e.g. "Tea 3 1 is laid 7," achieving 3 all-correct lists and the second highest total overall score in Group 1. It is noteworthy that this is exactly the strategy of temporal sequence that Broadbent's subjects found impossible.)

TABLE II

Efficiency of Performance in Relation to Method of Grouping

Method of grouping	*Number of subjects*	*Per cent total lists so grouped*	*Per cent. correct items*		
			Digits	*Words*	*Mean*
Group 1 (7 Subjects)					
Ear	4	21	80	56	68
Meaning	6	37	74	65	70
Indeterminate	—	42			
Group 2 (8 Subjects)					
Ear	5	18	71	60	66
Meaning	8	56	81	93	87
Indeterminate	—	26			

Column 2 shows the preferred method of subjects; some subjects used both methods. Column 3 shows the proportion of the total *lists* in each category. The last three columns give the percentage of individual *items* correctly recalled in each method; this provides a measure of the relative efficiency of the two methods.

Table II gives the percentage lists clearly grouped-by-ear and grouped-by-meaning, and the number of subjects using each of these methods. The *percentage success* of grouping-by-ear versus grouping-by-meaning was computed by calculating the percentage of individual items correctly reported out of the total possible within these categories; this is given for digits and words separately. It can be seen from this table that both Groups preferred grouping-by-meaning, though most subjects used both methods, and that both Groups (especially Group 2) were more successful when using this preferred method. This suggests that subjects were acting intelligently in the situation.

TABLE III

(*a*) Per Cent. Items Recalled (including "Intermediate")

	Digits	*Words*	*Mean*
Group 1	72	53	63
Group 2	72	74	73

(*b*) Grouping of All-correct Lists

	Ear	*Meaning*	*Indeterminate*	*Total*
Group 1 ..	5 (1.S)	1	4 (1.S)	10/70
Group 2 ..	1	21 (8.S)	—	22/80

Finally in Table III, the two Groups are compared for overall efficiency (including here the "Indeterminate" category), and for the number of all-correct lists, and their method of grouping. The overall efficiency for Group 1 is not significantly different from their score in Experiment 1; for Group 2 it is much higher on both digits and words. Every subject in Group 2 achieved at least one all-correct list in the second experiment.

Discussion of Results

It is clear from these results that the tendency to group simultaneously presented dichotic signals according to the ear to which they are presented can be overcome, given sufficiently strong cues favouring some other mode of grouping. This is apparent in Experiment 1, and clearly established in Experiment 2, even in the Group without instructions to follow meaning.

This system of grouping is if anything more efficient in this situation (see Tables I(*b*), II, and III(*b*)). If then we assume that the situation should require "switching attention," two possible alternatives have been suggested by Broadbent. (1) "It is possible to take a more passive attitude, and wait till after the stimuli have all arrived before beginning to deal with them successively," but "such an attitude is inefficient" (Broadbent 1957). (2) When some of his subjects did achieve immediate alternation of channels to a limited extent, he suggests "that it was done by a preliminary response to the information in some other order followed by a transposition of this order into the required one before the digits were reproduced publicly. Such a transposition is known from intelligence testing to be possible though more difficult than normal memory span" (Broadbent, 1958, p. 212). If we equate "more difficult" with "less efficient," this alternative is also ruled out here. So either our subjects were "switching," or the suggested alternatives are wrongly judged to be less efficient; or the "switching of attention" is not necessarily involved at all.

A further possibility is that subjects were utilizing transition probabilities between syllables and between words to guess at the third member of the word or phrase. We can distinguish between two ways in which this could happen. If subjects were guessing at the syllable or word they heard *last*, they must already have heard the first two syllables/words, as meaningful units, although this involved signals arriving at opposite ears. In this case, then, grouping-by-ear has already broken down before guessing can take place.

If, secondly, they were guessing at the middle syllable/word, this need not involve attention to both ears at all, as the first and last meaningful units always arrived on the same ear. However this would not account for those cases where subjects successfully recalled the *three digits* as well in the required order, for there was no way of inferring from one to another of these.

Moreover we should expect guessing to show itself in *semantic* substitutes for the correct word/syllable. Though this did occur five times in all, there were more substitutions of a word/syllable *phonetically* similar to the correct signal (nine cases), e.g. "not my salt" for "sort"—showing that the correct signal had been heard, even if imperfectly.

A final point requiring explanation is the greater difficulty for Group 2 of the task set in Experiment 1 as compared with Experiment 2. The difference is probably due to the fact that words are heard from the first as meaningful units, whereas syllables only become meaningful when the whole word is known, and are therefore less useful as immediate cues-for-grouping.

Conclusions

In terms of our original question, these results suggest that the ear-of-arrival is only one possible cue-for-grouping, although it is often dominant, especially in otherwise undifferentiated messages, as was the case for Broadbent's subjects. But by biassing the material so that meaning-cues must be followed for maximum payoff, this skill can be displaced; the odd idiosyncratic variations, not reflected in the quantitative results, support our view that subjects are searching for an optimal strategy, and if helped by instructions, readily adopt it. Subjects are simply using whatever cues are available to interpret sensory events.

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References

Broadbent, D. E. (1956). Successive responses to simultaneous stimuli. *Quart. J. exp. Psychol.*, **8**, 145–52.

Broadbent, D. E. (1957). Immediate memory and simultaneous stimuli. *Quart. J. exp. Psychol.*, **9**, 1–11.

Broadbent, D. E. (1958). *Perception and Communication*. London.

COMBINATION OF DRIVE AND INCENTIVE*

BY

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This experiment was designed to investigate the combination of drive and incentive as determinants of performance. Nine groups of rats were trained to press a bar under three levels of food deprivation (12, 24 and 36 hr.) and three incentive conditions (1, 2 and 3 pellets). Response strength was estimated by counting the number of responses with a latency of 1 sec. or less during five 20 trial sessions. The results indicated that response strength increased with hours of deprivation and with amount of food reward. Significant interactions between sessions and drive, and sessions and incentive provided additional support for the multiplicative combination of H (habit) and D (drive) and H and K (incentive). The lack of significant interaction between D and K was interpreted as supporting the hypothesis that D and K combine additively rather than multiplicatively.

This experiment was designed to investigate the manner in which the theoretical motivational variables drive (D) and incentive (K) combine with habit (H) to determine response strength (E). Evidence for the multiplicative interaction of H and D is provided by several investigations (Passey, 1948; Perin, 1942; Ramond, 1954; Williams, 1938) in which the number of reinforced trials and hours of deprivation or intensity of the unconditioned stimulus were varied. Response measures, including frequency, latency and number of responses to extinction, plotted against the number of trials show with one exception (Campbell and Kraeling, 1953) diverging curves for the different drive groups. Consequently the bulk of the evidence indicates that $E = f(H \times D)$. When D is held constant but amount or delay of reward is varied and a response measure is plotted against number of trials diverging curves are also obtained (Crespi, 1942; Dufort and Kimble, 1956; Fletcher, 1940; Grindley, 1929; Heyman, 1957; Perin, 1943) indicating that $E = f(H \times K)$. These conclusions require the assumption made by Hull (1951, 1952) and others that H is a function of the number of reinforced trials but is not affected by variations in D or K. Although there is some evidence against this assumption (Eisman, Asimow and Maltzman, 1956), more evidence is in support of it (Brown, 1956, Deese and Carpenter, 1951; Heyman, 1957; Hillman, Hunter and Kimble, 1953; Kendler, 1945; Strassburger, 1950; Teel, 1952). The limited generalization that $E = fH(D, K)$ seems permissible. Lacking experimental evidence concerning the combination of D and K, Hull (1943, 1951, 1952) speculated that they combined in a multiplicative manner. Reynolds, Marx and Henderson (1952) using resistance to extinction as a measure of response strength obtained evidence in favour of Hull's hypothesis. Recently, Spence, (1954, 1956) suggested that D and K might combine additively. An experiment by Loess (1952) may be interpreted as favouring this suggestion. Sufficient data are not available to evaluate the alternative hypotheses.

This experiment was designed to evaluate the additive and multiplicative hypotheses for the combination of D and K. Each of drive (hours of deprivation) and incentive (pellets of food) were varied three ways in a simple learning situation. If the effects of D and K on performance are unrelated, the additive hypothesis would be supported. If there is an interaction between the effects of D and K the multiplicative hypothesis would be supported.

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