MEDIATED GENERALIZATION AND THE INTERPRETATION OF VERBAL BEHAVIOR: II. EXPERIMENTAL STUDY OF CERTAIN HOMOPHONE AND SYNONYM GRADIENTS¹

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In a previous paper (1), the writers presented a theoretical account of the conditioned response mechanism of mediated generalization, and suggested that many phenomena of verbal behavior might be understood in terms of mediated as well as non-mediated generalization. The present paper reports an investigation designed to determine whether some of the suggested theoretical relationships may be demonstrated experimentally.

In the above-mentioned report, it was pointed out that if generalization effects should operate as described, they might occur along any of several different dimensions. Thus, if a given word be reinforced, we should expect generalization effects to appear in its synonyms, homophones (1, Figs. 2 and 3), antonyms, and other classes of words which the subject has learned to associate with it in some way.² The present investigation is limited to certain synonym and homophone relationships. The study was designed specifically to discover whether generalization may be demonstrated to occur to (1) more than one homophone of a reinforced word, (2) a synonym of the reinforced word, and (3) a synonym of a synonym of the reinforced word which is not, however, itself a synonym (or other semantic relative) of the reinforced word. The first two problems involve generalization to stimuli directly related semantically or homophonically to the reinforced word, whereas the third problem involves semantic generalization to a stimulus only indirectly related to the reinforced word—two transformations removed from the original reinforced word, *cf.* (1).

The writers have previously (1) summarized the experiments directly concerned with generalization along synonym and homophone gradients. To our knowledge, all of these experiments have been limited to the demonstration of such generalization along a *single* synonym or homophone gradient from a given word, the synonym

¹ The present paper represents part of a research project being conducted by the writers under a grant-in-aid from the American Association for the Advancement of Science.

² For a list of certain of these possible gradients along which mediated generalization might be expected to occur, *cf.* (1).

gradient in each case being but *one degree* of transformation or 'mediation' removed from the original, reinforced word. The present study thus represents an extension of the concept of mediated and non-mediated generalization to include generalization along more than one homophone gradient from a given word and along synonym gradients two transformations removed from the original word.³ Attention is also called to the fact that additional data are reported in the literature which are relevant to the problem as studied by the method here employed, although no attempt will be made to summarize such material in the present report.

METHOD

Theoretically, if a given word is reinforced, *i.e.*, responded to in a particular stimulus situation, not only will its reaction potential be incremented, but the reaction potentials of all other words related to it will likewise be increased to some degree. This increased reaction potential of the other words constitutes a generalization effect, mediated and/or non-mediated, which should be experimentally demonstrable. As previously suggested (1), several methods might be employed to study this phenomenon,⁴ only one of which has been used in the present study.

1. *Materials*.—A list of 10 unrelated words (presentation or P-list) was assembled such that from each word two homophones and one synonym could be derived. In addition, each of the synonyms had a familiar meaning other than that of the original word, and thus a synonym of each synonym was available, although the second synonym was not a synonym of the word in the original list. In each case, care was taken to minimize other complicating semantic relationships.⁵ According to the hypothesis advanced by the writers, the repetition (reinforcement) of these derived or related words should increase the reaction potentials of the words in the original list; if this should occur, one should expect the latter to be more easily learned after the presentation of a related list than after the presentation of an unrelated (control) list. Thus, to test generalization along the above-mentioned gradients, four related and one unrelated reinforcement lists were constructed as follows: (1) the H_1 -R list was composed of 10 words each one of which was a homophone of one word in the original (P) list; (2) the H_2 -R list was composed of 10 words each one of which was a homophone of one word in the original (P) list (there were no words common to the H_1 -R and H_2 -R lists); (3) the S_1 -R list was composed of 10 words each one of which was a synonym of one word in the original (P) list; (4) the S_2 list was composed of 10 words each one of which was a synonym of a word in the S_1 -R list but not a synonym of any word in the original (P) list; (5) the C-R (control) list was composed of 10 words unrelated to the words in the P-list in any evident or formal way, directly or indirectly. These 5 lists, along with the P-list, may be found under the appropriate headings in Table 1.

In addition to the above lists two others were utilized. One consisted of 8 numbers (spelled out) which served as a 'buffer' or practice list. The other was a list of ten Christian names which was used to equate the subjects in different groups for 'learning ability.' The buffer and equation lists may be found in Table 1 under the headings 'B.' and 'E.L.', respectively. It might be added that numbers and names were used for these purposes so as to minimize the possibility of generalization effects from these sources.

³ Likewise, it would be theoretically important to investigate mediated generalization along more than one synonym gradient from the same presentation word, as well as along alternate or interlocking synonym and homophone gradients.

⁴ Four methods for studying the operation of mediated generalization in verbal behavior were outlined in the previous paper (1). In the present experiment the first of these methods was employed.

⁵ The writers recognize the possible existence of generalization gradients arising from the instructions as well as the possible existence of intra-serial, 'circular' gradients. Examples of the latter are *fruit-plum* (S_1 -R list) and *palm-reed* (C-R list).

TABLE 1

LISTS OF WORDS USED IN THE EXPERIMENT

The word order (top to bottom) shown is that of the first presentation of each list throughout the experiment. Only the R-lists were changed in order at any time, as described in the text. Numbers in parentheses indicate the direct or indirect relationships between words in the R-lists and words in the P-list.

B.	E.L.	P.	Reinforcement Lists							
			H ₁ -R	H ₂ -R	S ₁ -R	S ₂ (2)-R	C-R			
eleven	edith	(1) sent	(3) pare	(3) pair	(3) fruit	(3) result	palm			
six	bernard	(2) vein	(4) sew	(4) so	(4) plant	(4) factory	set			
forty . . .	louise	(3) pear	(7) write	(7) rite	(7) just	(7) barely	reed			
three . . .	vivian	(4) sow	(2) vain	(2) vane	(2) vessel	(2) ship	very			
sixteen . .	joseph	(5) reign	(8) noes	(8) nose	(8) apprehends	(8) arrests	numb			
nine	dorothy	(6) sees	(9) meat	(9) mete	(9) join	(9) enlist	me			
twelve . .	henry	(7) right	(10) dō	(10) doe	(10) batter	(10) bruise	day			
five	calvin	(8) knows	(6) seas	(6) seize	(6) looks	(6) appearance	snap			
	julia	(9) meet	(5) rain	(5) rein	(5) rule	(5) principle	rope			
	samuel	(10) dough	(1) cent	(1) scent	(1) dispatched	(1) killed	spire			
Mean no. of letters per word			5.0	5.9	4.2	3.8	3.8	5.9	6.7	3.7
Range in no. of letters per word			3-7	5-7	3-5	2-5	2-5	4-10	4-10	2-5

2. *Procedure.*—The buffer, equation, and P-list were presented once to each of the 125 subjects. The same intra-serial order (that of Table 1) was used for every subject in the case of these lists. Five sub-groups of 25 subjects each were used for the presentation of the reinforcement lists. One group received four presentations of the H₁-R list, another group four presentations of the H₂-R list, and so on. The subjects were told that they would not be asked to remember the reinforcement lists. During the four presentations of a given reinforcement list, the order of the words was changed each time. The same order was used for each presentation for every subject in a given group. Furthermore, the position throughout the reinforcement presentations of all words having a relationship (direct or indirect) to a given word in the P-list was the same for all reinforcement lists. The serial order for the first R-list presentations is shown in Table 1 (reading from top to bottom). Thus, if the fifth word in one of these reinforcement list (*e.g.*, H₁-R) occurred as the first word on the second presentation of that reinforcement list, all other fifth words in the other reinforcement lists (including C-R) would likewise occur as the first words in the second presentations of the other reinforcement lists, and so on.

The regular procedure was as follows: The buffer list was presented, and S wrote his recall. The E.L. list was then presented at once, and the S's written recall of that list was immediately scored. As it was desirable to keep the learning ability of the five sub-groups equivalent, the determination of which reinforcement list to present was made on the basis of the E.L. score. (It will be seen from Table 2 that the five sub-groups were practically identical in respect to mean E.L. score.) Then a given R-list was presented four times, and this was followed immediately by the single presentation of the P-list; S then wrote the words which he recalled from the P-list, after which verbal reports were secured. During the presentation of all lists, S pronounced each word aloud as it appeared in the aperture of the memory drum.

The experiment was conducted in an inside, windowless room, with low noise level. The lists were typed on white paper and presented one word at a time by means of the Gerbrands memory drum (3, No. M1-4). By using a multiple exposure shield, previously described (2), it was necessary to change the paper only once—between the presentation of the E.L. list and the presentation of the first R-list. The drum was set at the one and one-half second exposure speed for the presentation of all words. The entire experiment required approximately 15-18 minutes for each individual S.

The specific *instructions* given to each subject were as follows. At the beginning of the experiment, E said: "Watch this opening (indicating it) in which a series of words will be exposed

TABLE 2

DATA CONCERNING THE EQUIVALENCE IN 'LEARNING ABILITY' OF THE 5 SUB-GROUPS WITH RESPECT TO EQUATION LIST SCORE

Reinforcement List	N	'Equation List' Performance			
		No. Correct	No. Incorrect	Range in No. Correct	Mean No. Correct
H ₁ -R	25	164	5	3-10	6.56
H ₂ -R	25	165	9	5-8	6.60
S ₁ -R	25	166	3	4-8	6.64
S ₂ (2)-R	25	165	3	4-9	6.60
C-R	25	165	6	5-9	6.60

one at a time. As each word is exposed, say it aloud and think of its meaning. When all the words have been exposed, you will be asked to put down on paper as many of the words of this series as you can remember. Are there any questions?" After the presentation of the first (buffer) list, *E* said: "Now, put down as many words of this series as you can remember; their order is not important." The instructions for the equation list were the same as for the buffer list. Before the presentation of the reinforcement lists, *E* said: "Now *this* time say each word aloud as you did before and think of its meaning, but you will *not* be called upon to remember them. If the letter *o* with a long line over it occurs in a word, this *o* is to be pronounced as a long *o*, as in *môde*." No other comments were made during the four presentations of the reinforcement lists, other than to repeat the above instructions before each presentation. Before the presentation of the P-list, *E* said: "Now *this* time say each word aloud and think of its meaning; when all the words have been exposed, you will be asked to put down as many of the words in *this* series as you can remember." After the P-list had been presented, *E* said, "Now put down as many of the words of this series as you can remember."

Following the S's recall of the P-list, he was asked the following questions in order: 1. "Do you have any comments?" 2. "Did you make use of any aids or other devices to help your recall? What devices?" 3. "Did you notice any relationships between words on any of the lists? What relationships?"

3. *Scoring*.—In the case of both the E.L. and the P-list, the score was computed in terms of number of words correctly recalled, as in the method of retained members. The order in which the words were recalled was not considered. All legible words were scored, and slight mistakes in spelling did not count as errors so long as it was clearly evident that the correct word and not some other word (especially the homophone) was intended.

4. *Subjects*.—125 Ss were used in the experiment, 56 male and 69 female. They were obtained from psychology classes but were naïve with respect to the purpose of the experiment. As previously described, the five sub-groups were equated for 'learning ability' on the basis of scores on the Equation List (*cf.* Table 2). They were also approximately equated as to age, sex ratio, number of courses in psychology, and number of years in college.

RESULTS

The major results of the experiment, in terms of the number of words correctly and incorrectly recalled by each of the five equated sub-groups, are presented in Table 3. The reliabilities of the differences between the mean or median of each of the four experimental sub-groups and that of the control sub-group are found in Table 4.⁶

⁶ Since normality of distribution could not be assumed, $\sigma_{\text{Mdn.}}$ was computed throughout by the following formula:

$$\sigma_{\text{Mdn.}} = \frac{i\sqrt{N}}{2F}.$$

TABLE 3

ANALYSIS OF PERFORMANCE OF THE 5 SUB-GROUPS IN THE RECALL OF THE PRESENTATION LIST

Reinforce- ment List	N	No. Correct	No. Incorrect	Range Correct	Mean Correct	S.D. Correct	Median Correct	Q Correct
H ₁ -R	25	173	13	4-10	6.72	1.61	6.67	1.24
H ₂ -R	25	141	30	3-8	5.64	1.49	5.42	1.28
S ₁ -R	25	147	14	3-9	5.88	1.46	5.92	1.11
S ₂ (2)-R	25	131	13	3-7	5.24	1.14	5.42	0.90
C-R	25	120	26	1-7	4.80	1.55	4.45	1.15

TABLE 4

RELIABILITIES OF DIFFERENCES IN CENTRAL TENDENCY BETWEEN EACH OF THE 4 EXPERIMENTAL SUB-GROUPS AND THE CONTROL SUB-GROUP IN THE RECALL OF THE PRESENTATION LIST

Reinforce- ment List	Analysis in Terms of Mean					Analysis in Terms of Median				
	σM	Difference from C-R Mean	σ diff.	Signifi- cance Ratio	Proba- bility Value	σ Mdn	Difference from C-R Mdn.	σ diff.	Signifi- cance Ratio	Proba- bility Value
H ₁ -R	.33	1.92	.80	2.39	99.16	.83	2.22	.87	2.55	99.46
H ₂ -R	.30	0.84	.79	1.07	85.77	.42	0.97	.49	1.98	97.61
S ₁ -R	.30	1.08	.78	1.38	91.62	.42	1.47	.49	3.00	99.87
S ₂ (2)-R	.23	0.44	.74	0.59	72.24	.42	0.97	.49	1.98	97.61
C-R	.32	—	—	—	—	.25	—	—	—	—

It will be noted that computations of central tendency, variability, and reliability are reported in terms of both mean and median measures. Although there is a general similarity in results obtained with these two measures, certain differences are readily apparent. Owing to the small number of cases (25) in each sub-group and the somewhat irregular distributions, the median is a more representative measure of central tendency. The present discussion, therefore, will be based upon an analysis in terms of the median, although a corresponding analysis in terms of the means can be found in Tables 3 and 4.

The median number of words correctly recalled by the control sub-group, *i.e.*, the sub-group receiving the unrelated reinforcement list, is 4.45; this may be used as a basis for evaluating the scores of the other, experimental sub-groups. It will be noted that the two sub-groups receiving reinforcement with homophone lists correctly recalled a median of 6.67 and 5.42 words, respectively. The former median is 2.22 words larger than that of the control, and the sigma of the difference is .87, with a significance ratio of 2.55; the probability-value of this difference is 99.46, indicating the chances in 100 that such a difference could not have arisen as a sampling error from a true difference of zero. The significance ratio in the case of the other

homophone-reinforced sub-group, whose median is 0.97 words larger than that of the control, is 1.98, corresponding to a probability-value of 97.61. The sub-group receiving reinforcement from synonyms of the presentation words shows a median of 5.92 words correctly recalled, the difference of 1.47 from the control median yielding a significance ratio of 3.00 and probability-value of 99.87. Finally, the sub-group reinforced with synonyms two transformations removed from the original presentation list is found, in terms of the median, to recall 0.97 more words than the control sub-group, with resulting significance ratio of 1.98 and probability-value of 97.61.

On the basis of the experimental method and treatment of data here described, it is apparent that the probability that such generalization effects might have arisen from chance factors is very small. Not only is the median number of words correctly recalled significantly greater in the case of the experimental sub-groups, but certain additional results in the case of the particular experimental sub-groups conform rather closely to theoretical expectation. Chief among these considerations is the fact that generalization to the first-order synonyms is stronger than to the second-order synonyms. No summary conclusion can be drawn, however, regarding the relative strength of generalization to homophones and synonyms. The median number of words correctly recalled for the first homophone list is greater than that for the one list of first-order synonyms, although the greater variability of the former makes its significance ratio smaller than that of the synonym list. Conflicting conclusions, furthermore, are obtained if the significance ratios of the differences between the medians are compared with those based upon the means. It is nevertheless clear that the median or mean number of words correctly recalled is significantly greater in the case of both homophone and synonym sub-groups, although it is obvious that the particular words employed as homophones or synonyms will undoubtedly influence the amount of generalization to a marked extent. In this connection, attention is called to the difference between generalization effects in the case of the two homophone lists. This difference appears to indicate that, contrary to Razran's interpretation (*cf.* 4), homophones do not represent simple instances of physical or non-mediated generalization, but rather represent such generalization complicated by other (including semantic) factors. It will also be noted that the presentation words used in the present study were selected so that two homophones of each word were available; if this narrow restriction had not been imposed, generalization along a single homophone gradient as well as along the synonym gradients would possibly have been even more readily demonstrable (owing to the more obvious homophone and synonym relationships).

The writers have tabulated the number of correct recalls of each presentation word for each of the five sub-groups. The relative frequency of recall of a given presentation word did not differ markedly among the sub-groups. Differences in the preexperimental reaction potentials of the words, as well as differences in serial position, make further interpretation of this question unwarranted.

An analysis of the individual incorrect recalls in each of the sub-groups in many cases reveals generalization effects theoretically similar to those previously described as producing the correct recalls. Examples of the possible operation of these generalization gradients are cited below. Of the 13 incorrect recalls in the H_1 -R sub-group (cf. Table 3), 10 were repetitions of words in the R-list, and 3 might be explained in terms of homophone and/or quasi-homophone gradients. Of the 30 incorrect recalls in the H_2 -R sub-group, 18 were repetitions of words in the R-list, and the remainder seem explicable on the basis of homophone gradients (one also involving a synonym relationship). In the S_1 -R sub-group, 4 of the 14 incorrect recalls were repetitions of words in the R-list; the remaining 10 could possibly be attributed to the operation of homophone, quasi-homophone, synonym, and other gradients such as antonym, genus-species, object-attribute, verb-object, and words in the same category (e.g., *ves sel-pier*). Only one of the 13 incorrect recalls in the $S_2(2)$ sub-group was a repetition of a word in the R-list; 8 of the remaining 12 errors could possibly be explained on the basis of other gradients, as above, and in the other 4 cases the relationship was obscure. Of the 26 incorrect recalls in the C-R sub-group, 16 were repetitions of the R-list, 7 might be accounted for in terms of the above-mentioned gradients, and 3 showed no apparent relationship.

Typical examples of incorrect recalls theoretically attributable to the operation of such generalization gradients were the following: (a) incorrect recall of *so*, a homophone of *sew* in R-list or of *sōw* in P-list (found in H_1 -R sub-group); (b) incorrect recall of *row*, a quasi-homophone of *sōw* in P-list (found in C-R sub-group); (c) incorrect recall of *beat*, a synonym of *bruise* in R-list (found in $S_2(2)$ sub-group); (d) incorrect recall of *weed*, a species of *plant* in R-list (found in S_1 -R sub-group); (e) incorrect recall of *apples*, in same class (fruit) as *pear* in R-list (found in $S_2(2)$ sub-group); (f) incorrect recall of *reap*, a word in 'rural category' with, and a possible antonym of *sōw* in P-list (found in $S_2(2)$ sub-group); (g) incorrect recall of *seeds*, a possible synonym of, or an object of, *sōw* in P-list (found in C-R sub-group); (h) incorrect recall of *dear*, a homophone of *deer* (not presented) whose synonym is *doe* in R-list (found in H_2 -R sub-group).

Finally, let us consider the evidence contained in the S_s ' reports. It will be recalled that three questions were asked of each S after the

experiment was concluded. The purpose of these questions was to discover if the *S* had noticed the relationship between the *R*-list and the *P*-list. In the case of the *H*₁-*R* and *H*₂-*R* sub-groups, the relationship was definitely observed in most cases. In the former group, 24 *Ss* reported it correctly, and one apparently saw the relationship in a few of the words. Of the *Ss* in the *H*₂-*R* sub-group, 18 reported the relationship clearly, 4 reported seeing it in some words, and 3 gave no evidence of having discerned it. On the other hand, the *Ss* in the *S*₁-*R* and *S*₂(2)-*R* sub-groups seldom described the relationship. Only 2 of the *S*₁-*R* *Ss* saw it clearly, 6 saw it in a few words, and the rest gave no evidence of having discovered it. One member of this group spontaneously made the following comment 24 hours after he had participated in the experiment: "There was an unconscious (*sic*) connection between those words, like *batter-dough*. I didn't realize it until today." None of the *Ss* in the *S*₂(2)-*R* sub-group gave any evidence of having seen the relationship. In the *C*-*R* sub-group, of course, no relation was present, and in only 2 cases did the *Ss* attempt to construct a relationship; these were based on quasi-homophonimity. It should be noted that even in the cases in which the *Ss* were unable to report recognition of the actual relationship, there was definite evidence of the generalization effects from the reinforcement lists to the presentation list.

Numerous other comments were made by the *Ss* in answer to the questions, such as speculation concerning the nature of the experiment and postulation of incorrect relationships. It seems unnecessary to list or to attempt to interpret these comments.

SUMMARY

This experiment was designed to demonstrate generalization (*a*) along more than one homophone gradient from a given stimulus word, (*b*) along a synonym gradient from the stimulus word, and (*c*) along a synonym gradient two degrees of transformation removed from the original stimulus word. Results seem to indicate generalization in all of these dimensions, and to this extent confirm the writers' previous theoretical analysis (1).

(Manuscript received September 24, 1942)

REFERENCES

1. COFER, C. N., & FOLEY, J. P., JR. Mediated generalization and the interpretation of verbal behavior: I. Prolegomena. *Psychol. Rev.*, 1942, 49, 513-540.
2. FOLEY, J. P., JR., & COFER, C. N. An inexpensive multiple-exposure extension for the simple memory drum. *J. Exp. Psychol.*, 1942, 31, 438-439.
3. GERBRANDS, R. *Scientific instruments* (mimeographed).
4. RAZRAN, G. H. S. A quantitative study of meaning by a conditioned salivary technique (semantic conditioning). *Science*, 1939, 90, 89-90.