# GENETIC CHANGES IN SEMANTIC CONDITIONING *

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## INTRODUCTION

The experiment here reported is essentially an extension to the problem of the genesis of certain language relationships of a technique suggested by Razran (13) and further developed by the author (15) in an earlier paper. The psychological study of semantics was long neglected by psychological discipline in favor of problems more susceptible to objective experimentation and less complicated by experiential variables. In the absence of adequate techniques, speculation took the place of observation and language study was left to the devices of the philologists, who rarely looked upon it as a problem either of social learning or individual habit formation. However, with the discovery and extension of conditioning, studies of verbal patterning and equivalence were made, first by Russian investigators in several laboratories in the U.S.S.R. and then by American psychologists. The general technique employed by these investigators was the study of generalization effects from a conditioned verbal stimulus to words semantically related to the conditioned stimulus. This is the phenomenon now identified as mediated generalization. It was found that generalization or transfer could be established from a word to such relata as the object denoted by the word and to phonetically and meaningfully related words like antonyms and synonyms. The processes conditioned to the verbal stimuli were pupillary and salivary reflexes. A summary of the work of the Soviet psychologists in this field is to be found in the paper by Keller (9).

Recently, Foley, Cofer and their collaborators have published a series of papers using memory methods for the study of mediated generalization and the interpretation of verbal behavior. After discussing the general principles of semantic conditioning and mediated generalization in relation to verbal behavior (1), these authors performed experiments involving the presentation of lists of words for memorization followed by study of the gains in retention from these lists to lists related to the original in various semantic ways. Among the relationships studied were antonyms (2), homophones, first and second order synonyms (4). In other experiments, the authors varied the language background of the Ss (6) and the professional and occu-

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pational fields in which the Ss were trained (5). In the complete experiment as described in these papers mediated generalization in adults proved to vary predictably with language generalizations previously determined by a priori reasoning (1).

Using much the same methods, Goodwin, Long and Welch (8) studied the mediated generalization of species-genus relationships among children. Training on the lower, species level transferred significantly to the higher or genus level. This is one of the few studies which approach the problem from a genetic standpoint.

Razran's series of extensive researches into relational conditioning cannot be adequately summarized here. It suffices to indicate that he has shown the transfer value of semantic relationships in adults using a conditioned salivary technique with antonymic, synonymic and homophonic stimuli (13). In other papers, he has shown the transference of single words and phonetographs such as dark-mark, again using adults as subjects (11). Theoretical considerations and the importance of generalized language habits are posited in two other articles (10, 14). It is interesting to note that in the first of these articles (10) the author states that the greatest transfer as a result of language was produced by a habit system established in early childhood. This is the earliest reference to the importance of a genetic approach to semantic conditioning.

Diven (3), Keller (9) and Wylie (16) have all studied the semantic effect in conditioning by various methods. The former found a spread of generalization from a word to other meaningful stimuli using GSR as the conditioned process. Keller also used the GSR to demonstrate mediated generalization from a picture to another similar visual representation. Transfer was not found when a verbal stimulus was substituted for the graphic representative. Wylie repeated the early experiments of Razran and Riess with results slightly at variance with those previously found. However, she used electric shock to produce the GSR and hence the procedure was not sufficiently similar to that of Razran and Riess to call for explanation of the divergencies.

The present study differs from the other experiments in two significant ways. It conditions the electro-dermal response (EDR) to a word for which a homophone, an antonym and a synonym exist, and it explores these semantic relationships as they are established in four age groups ranging from the early stages of visual language acquisition to the mature utilization of abstract verbal stimuli. The experiment therefore makes possible the development of a gradient of semantic relationships as a result of mediated generalization. These gradients are then posed as a function of the total experience of the organism in a world of increasing quantitative and qualitative changes in verbal behavior.

## METHOD

1. *Subjects.*—The plan of experimentation called for four groups of *Ss* differing only in chronological age. All of the persons used were female and drawn from New York City elementary and secondary schools and from Hunter College. In all groups but that from the College, the IQ's obtained were Stanford-Binet's. No IQ's were available for the college students, but their American Council of Education Psychological Examination percentile scores indicated ranks above the median for the nation-wide norms. Table I shows the mean ages, IQ's and ranges for

TABLE I

AGES AND IQ'S OF THE FOUR EXPERIMENTAL GROUPS

| | Group I | | Group II | | Group III | | Group IV | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Range | Mean | Range | Mean | Range | Mean | Range |
| CA | 7–9 | 7–0 to 8–9 | 10–8 | 10–0 to 11–8 | 14–0 | 13–5 to 14–10 | 18–6 | 17–2 to 20–1 |
| IQ | 112 | 92–135 | 116 | 98–129 | 120 | 101–138 | — | — |
| N | 21 | | 22 | | 25 | | 24 | |

the various groups. All age differences are obviously significant. IQ differences are not statistically reliable.

2. *Stimuli.*—The stimuli for the experiment consisted of five series of words, one of which was exposed only in the pre-conditioning test period. The other groups constituted the major bases of comparison and experimentation. All stimulus words were selected from reading material in use at the educational level from which a particular group of *Ss* was selected. In this way the relative difficulty of the various stimuli for the four age groups was equated.

The words in the series for the preconditioning period combined the 20 items to be used in subsequent sections of the study with 30 neutral words. The latter were not thereafter again presented to the *Ss*. These two groups of words, 20 crucial and 30 neutral, comprise the list hereafter referred to as the pre-test series. A separate pre-test list was evolved for each age group.

The 20 crucial words in the pre-test list were selected so as to demonstrate three types of semantic relationships: homophonic, antonymic and synonymic. Thus there were, in each list of 20 words, five actual stimuli and five homophones, antonyms and synonyms. Table II shows the stimuli in each list of crucial words for the four age groupings.

3. *Apparatus and procedure.*—In general, the apparatus and procedure used in this study were similar to those employed in the previous experiment by the author (15). A simple bucking circuit resistance box was used to measure the electro-dermal response (EDR). Basically the procedure involved three stages. In the first, preliminary determination was made of the extent of the EDR, in microamperes, to each of a series of words presented seriatim (pre-test series) and also to the sound of a moderately loud buzzer. The second stage established a conditioned response to a word from the crucial list by reinforcement with the buzzer. In the third stage, each *S* was tested to determine the amount of transfer of EDR from the conditioned stimulus to each of several words related semantically to the conditioned stimulus. At all times, the words were exposed to each *S* individually by means of lantern slides. The size of the letters in each stimulus was adjusted to the educational level of the *Ss* by appropriate backward and forward movement of the projector.

In the pre-conditioning stage each *S* was instructed to observe the word to be projected on the screen in front of her. She was told that she would be called upon to recall the word at a later date. Warning was also given that buzzers would be sounded during the session and the electrodes were explained as necessary to determine the *S*'s sweat reaction to the temperature of the closed and windowless room.

Stimuli were presented by lantern-slide projection with an exposure time of three sec. and an interstimulus interval of five sec. The order of the words was varied systematically from *S* to *S*. At five points during the session the buzzer was sounded between presentations of the verbal stimuli. After an interval of a week, the *Ss* were again tested with the neutral words

TABLE II

CRUCIAL STIMULI FOR THE EXPERIMENTAL GROUPS

| Group | Word | Homophone | Antonym | Synonym |
|---|---|---|---|---|
| I | WON | one | lost | beat |
| | WEAK | week | strong | poor |
| | CLOSE | clothes | open | shut |
| | FATHER | farther | mother | dad |
| | WHOLE | hole | part | all |
| II | SEA | see | land | ocean |
| | MAID | made | man | girl |
| | RIGHT | write | wrong | correct |
| | MALE | mail | female | man |
| | PALE | pail | dark | light |
| III | PLAIN | plane | fancy | simple |
| | BUY | by | sell | purchase |
| | BOY | buoy | girl | lad |
| | ATE | eight | starved | fed |
| | REAL | reel | false | exist |
| IV | BARE | bear | hide | expose |
| | COARSE | course | smooth | rough |
| | MINOR | miner | major | lesser |
| | FREEZE | frieze | warm | chill |
| | PEAK | peek | trough | crest |

in the pre-test series and asked to recall those previously seen. New words were added to take the place of the crucial stimuli. In this way the validity of the instructions was established. Any words to which the EDR was more than five times that obtained in the preliminary exploration were eliminated as carrying an over-load of emotional coloration.

In the conditioning stage each conditioned stimulus was inserted in a group of neutral words, and the whole list was exposed seriatim with a three-sec. exposure time and a five-sec. interstimulus interval. The order of appearance of each crucial stimulus within the list was varied randomly from trial to trial. The reinforcing buzzer sounded throughout the exposure of the conditioned stimulus and continued for another two and one-half sec. The entire procedure was repeated five times, and then the conditioned stimulus was tested without the buzzer. If the EDR at that test was not at least three times the magnitude of the response to the word prior to reinforcement, the conditioning was resumed. Testing was done every five trials. A conditioned response was held to exist when the EDR of three times the original persisted to three successive exposures of the conditioned stimulus. The amount of the first of these three EDR's was then used in tabulating the results. In all cases, the *S*s were told that they were to try to memorize the list of stimuli and to report when they had done so.

The transfer stage of the procedure then followed. As soon as the conditioned response was obtained, the *S* was shown the test words semantically related to the particular stimulus word used in that part of the experiment. The test words were presented in random order. EDR's were obtained for five successive exposures of the transfer stimuli. Extinction of the CR was then begun by repetition of the conditioned stimulus without reinforcement by the buzzer and the extent of spread of extinction to transfer stimuli noted. A week after completion of each word, the *S* was started on a new series using another conditioned stimulus word. Thus there were, for each *S*, five separate experimental sessions.

## RESULTS

The data accumulated in this part of the study are summarized in Tables III and IV. In the former are shown the comparative scorings

TABLE III

MEAN PERCENT AND RATIO OF PERCENT GAIN FOR SEMANTIC WORDS TO PERCENT GAIN FOR CONDITIONED WORDS

Entries in columns of means are based on the mean EDR of each S to five words in each stimulus category

| Stimuli | Group I | | Group II | | Group III | | Group IV | |
|---|---|---|---|---|---|---|---|---|
| | Mean % Gain | Ratio % Gain to CS | Mean % Gain | Ratio % Gain to CS | Mean % Gain | Ratio % Gain to CS | Mean % Gain | Ratio % Gain to CS |
| Word | 221.52 | — | 226.64 | — | 242.72 | — | 281.00 | — |
| Hom. | 158.57 | 71.58 | 65.18 | 28.76 | 59.92 | 24.69 | 52.16 | 18.56 |
| Ant. | 139.10 | 62.79 | 97.23 | 42.90 | 76.96 | 31.71 | 103.08 | 36.68 |
| Syn. | 129.43 | 58.43 | 59.86 | 26.41 | 109.76 | 45.22 | 148.50 | 52.85 |

TABLE IV

MEAN DIFFERENCES IN PERCENT GAIN, *t*- AND *P*-VALUES

Minus signs before mean differences indicate relative superiority of second member of pair compared

| | Stimuli Compared | | | | | |
|---|---|---|---|---|---|---|
| | Word-homo. | Word-anto. | Word-syno. | Homo.-anto. | Homo.-syno. | Anto.-syno. |
| *Group I* | | | | | | |
| Diff. between means | 62.95 | 82.42 | 92.09 | 19.47 | 29.14 | 9.67 |
| *t* | 6.96 | 12.14 | 12.99 | 2.33 | 3.39 | 1.57 |
| *P* | .01 | .01 | .01 | .02 | .01 | .20 |
| *Group II* | | | | | | |
| Diff. between means | 161.46 | 129.41 | 166.78 | −32.05 | 5.22 | 37.37 |
| *t* | 17.38 | 13.75 | 20.05 | 2.72 | .48 | 3.39 |
| *P* | .01 | .01 | .01 | .01 | .70 | .01 |
| *Group III* | | | | | | |
| Diff. between means | 182.50 | 165.76 | 132.96 | −17.04 | −49.84 | −32.80 |
| *t* | 10.75 | 11.04 | 7.19 | 1.05 | 2.56 | 2.17 |
| *P* | .01 | .01 | .01 | .30 | .01 | .02 |
| *Group IV* | | | | | | |
| Diff. between means | 228.84 | 177.92 | 132.50 | −50.92 | −96.34 | −45.42 |
| *t* | 10.61 | 5.07 | 6.25 | 1.56 | 6.04 | 1.42 |
| *P* | .01 | .01 | .01 | .20 | .01 | .20 |

of the four age groups on the conditioned stimuli and on the semantically related words. The second table shows the reliabilities of the differences between mean scores for the various age and semantic groups.

Examination of Table III reveals that there was a shift in the transfer of EDR conditioning to various semantic relationships. In the youngest group, the transfer was greatest from the original conditioned stimuli to the homophones of these words. This is indicated

by a mean percentage gain of 158.57 for the homophones as contrasted to percentage gains of 139.10 and 129.43 for antonyms and synonyms, respectively. It should be noted that each mean percentage gain is the result of tabulating the scores of all 21 *Ss* in this group on each of five original words, five homophones and similar numbers of antonyms and synonyms. Expressed somewhat differently, the mean gain of 221.52 for the original words in Group I is the mean of a series of 21 means, each of which was derived from five separate entries, each representing the increase in EDR from the original exposure to the first response in the criterion series after conditioning. So also, in the entries under homophones, etc., each mean was derived from a series of means representing five observations each. In all cases, percentage gain refers to the increase in EDR from the original pre-test list to the post-conditioning exposure of the semantically related stimuli.

The homophone, whose superiority is demonstrated in the lowest age group, does not however maintain its place in the other age groups. With an increase in C.A. to 10–8 years, the homophone drops to second place and the antonym receives the greatest amount of transferred EDR. In both younger groups, I and II, the synonym is the least transferred relationship. Group III with a mean chronological age of 14 years shows greatest transfer to the synonym with the antonym in second place. This same trend is repeated in the scores for the oldest group. In summary of this section of the study, we can state that between the ages of eight and ten transfer of EDR shifts from a homophonic to an antonymic relationship. Between the ages of ten and fourteen, a further shift displaces the antonym in favor of the synonym.

The gradient of semantic relata which was just demonstrated in terms of percent gain in conditioning of the EDR is shown again in Table III in the second column for the various age groups. Entries in these arrays show the relationship of the gains in each semantic group to the gains on the original word stimulus. In simpler form, the data here indicate the ratio of gains in homophones, antonyms and synonyms to those in the original conditioned words. Thus, for Group I, the gain in homophone EDR was 71.58 percent of that for the conditioned stimulus, that of the antonym was 62.79 percent, and that of the synonym was 58.43 percent. Again we find the order of relata the same as that above, namely, homophone, antonym, synonym. The other age groups show ratios consistent with the conclusions arrived at above. In general then, the gradient of semantic relationships for the whole group is from homophone through antonym to synonym as one progresses from eight-year olds to college students.

Table IV gives the mean differences, *t*- and *P*-values for these differences for the various age and semantic stimulus groups studied in the experiment. Wherever the differences between the means are prefaced by a minus sign, the second member of the pair is larger. The first half of the table gives the comparisons between the original words conditioned to the EDR and the semantically related transfer stimuli. Differences among the latter are shown in the remaining section of the table.

Study of the first three columns reveals that all differences favor the original stimuli over the semantic relata and are without exception significant at levels far beyond the minimum, .01, reported here. That these comparisons should be so significant statistically is not surprising, since the original word should theoretically carry more conditioned EDR than its mediated generalization transfer. The order of differences within each age group again demonstrates the same relationships reported above; i.e., a gradient of homophone, antonym, synonym for Group I; of antonym, homophone, synonym for Group II; of synonym, antonym and homophone for Groups III and IV.

The reliabilities of differences are more varied within the three arrays covering the inter-comparisons of the antonym, synonym and homophone stimuli. When the differences and their reliabilities are ranked in accordance with the gradients described above for each age category, it will be noted, that with five exceptions, all differences are significant at the .01 level. In each age group, the differences between the second and third members of the triad gradients are significant at levels of .10 to .20 (Group I), .60 to .70 (Group II), .20 to .30 (Group III) and .10 to .20 (Group IV). Although these *P*-values are lower than the rest, with two exceptions they satisfy statistical norms. In other words, the differences in end terms in each age group are of less significance than the differences between the most and next most transferred relationship. This accounts for four of the five differences of questionable significance. The remaining instance occurs in Group IV for the difference between the synonym and antonym, where the *P*-value is .10 to .20.

As a further test of the existence of the gradient and of its consistency, each word, homophone, antonym and synonym was compared within each age group. The comparison was made in terms of percent of EDR transferred from the original word to its semantic relata. The tabulation of reversals, that is, EDR change in contradiction to the gradient indicated in Tables III and IV, is shown in Table V. It should be noted that the data for this table are derived from the means of the population within each age category.

From inspection of the table, it will be seen that there were only seven instances out of a total of 80 possibilities where the gradient did

TABLE V

REVERSALS OF GRADIENT IN INDIVIDUAL WORDS

| Age Group | Items Compared | | | | | |
|---|---|---|---|---|---|---|
| | Word-homo. | Word-anto. | Word-syno. | Homo.-anto. | Homo.-syno. | Anto.-syno. |
| I | 0 | 0 | 0 | 1 | 0 | 1 |
| II | 0 | 0 | 0 | 1 | 0 | 2 |
| III | 0 | 0 | 0 | 1 | 0 | 1 |
| IV | 0 | 0 | 0 | 0 | 0 | 0 |

not hold for individual stimuli. None of the reversals occurred when the original conditioned stimulus was compared to its semantically related transfer words. Furthermore, no reversals occurred where the initial and final members of the gradient were compared. It is obvious, therefore, that the trends established in the preceding paragraphs were consistent for the isolated stimuli as well as for the group data. This is additional evidence that the words selected were approximately of the same value for the four groups of *Ss*.

In summary of this part of the experiment, then, it is possible to conclude with considerable assurance that there exists a gradient of semantic relationships for stimuli in the homophone, antonym and synonym categories, and that this gradient of transference varies with the age of the subjects. For the youngest group, transfer of EDR is greatest when words sound alike and is diminished as the meanings become more similar or better as meaningful relationships enter. For the middle age groups, oppositeness and similarity tend to assume equal value. It is not until one reaches the upper teen-age groups that likeness of meaning tends to become the dominant semantic pattern.

## DISCUSSION

Previous experimenters have established the possibility of studying semantic relationships by use of conditioning techniques, particularly those involving mediated generalization. Hull, Hilgard and Marquis, and others have pointed out that mediated generalization works along a gradient of stimulus intensity and magnitude. The studies of semantic conditioning have demonstrated another dimension of the mediated gradient, namely, the inherent meaningfulness of the stimuli. However, the authors of these experiments on verbal conditioning have for the most part neglected the specific study of the genetics of the gradients established by the experiments. Foley and his coworkers did show in one study (5) the effect of the occupation and profession of the *Ss* on the nature of the generalization patterns from neutral words to stimuli reflecting the occupational interests of the

*Ss*. They have also shown (**6**) that the previous educational experience of the *Ss* determined the gradient of generalization established to various lists of words. With these exceptions, however, the verbal stimuli have been implicitly held to have of themselves attributes which determined their place in the sequence of more or less favorably transferred responses. The present experiment has demonstrated that the relative strength of the semantic gradients does not depend on any a priori quality of the stimulus, but upon the way in which the whole organism utilizes language in its development. The change in the ranking of the homophones, antonyms and synonyms reflects the mode of the linguistic background of the various age groups. In other words, semantic conditioning does not depend solely on any attribute of the stimulus as such, but the stimuli must be interpreted as part of large situational and experiential wholes within which the organism exists and has learned to use and interpret verbal stimulation. This point of view has a close similarity to that advanced by Zener (**17**, **18**) in his study of conditioned salivary responses in dogs operating under varied motivational conditions and freed from the restraints of the traditional holders and restricted movements of the classical Pavlovian laboratory. Here, too, the dynamic interrelationships between the bell, food, organic status of the animal and the past history of the organism contributed to an understanding of the obtained variability in response after conditioning.

The present experiment suggests also that it may be possible to study the folk-etymology emphasized by Freud and more recently by the Lifwynn group under Burrow and Galt. The latter investigator has written a stimulating paper (**7**) on the etymological implications of social neurosis. He points to etymological relations which suggest psychological conflict situations such as the correspondence between words like *double*, *doubt* and *duplicity*, *integrity* and *untouchable*, *mind*, *mental* and *mendacious*, *converse* (meaning *speak*) and *converse* (meaning *opposite*). The use of mediated generalization studies at different cultural levels and under different environmental stresses may adduce more substantial evidence than etymology for the linguistic similarities apparent in the form and structure of the words.

## Summary

1. Four groups of *Ss* differing only in chronological age were conditioned to give an EDR to selected verbal stimuli.

2. Each stimulus was then followed by words representing homophonic, antonymic and synonomic relationships.

3. Transfer of EDR conditioning from the original conditioned stimuli to the semantically related words was noted.

4. For the youngest group, mean age 7–9, the homophone received most transferred EDR, the antonym and synonym following in the order stated.

5. For the age group, 10–8, the antonym stands highest, followed by the homophone and synonym.

6. For the age group, 14–0, and for the age group, 18–6, the synonym takes first place, followed by the antonym and homophone.

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Bibliography

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. Cofer, C. N., Janis, M. G., & Rowell, M. M. Mediated generalization and the interpretation of verbal behavior: III, Experimental study of antonym gradients. *J. exp. Psychol.*, 1943, 32, 266–269.
3. Diven, K. Certain determinants in the conditioning of anxiety reactions. *J. Psychol.*, 1937, 3, 291–308.
4. Foley, J. P., Jr., & Cofer, C. N. Mediated generalization and the interpretation of verbal behavior: II, Experimental study of certain homophone and synonym gradients. *J. exp. Psychol.*, 1943, 32, 168–175.
5. Foley, J. P., Jr., & MacMillan, Z. L. Mediated generalization and the interpretation of verbal behavior: V, 'Free association' as related to differences in professional training. *J. exp. Psychol.*, 1943, 33, 299–310.
6. Foley, J. P., Jr., & Mathews, M. A. Mediated generalization and the interpretation of verbal behavior: IV, Experimental study of the development of inter-linguistic synonym gradients. *J. exp. Psychol.*, 1943, 33, 188–200.
7. Galt, W. Our mother tongue. *Psychoan. Rev.*, 1943, 30, 241–262.
8. Goodwin, J., Long, L., & Welch, L. Generalization in memory. *J. exp. Pscyhol.*, 1945, 35, 71–75.
9. Keller, M. Mediated generalization: the generalization of a conditioned galvanic skin response established to a pictured object. *Amer. J. Psychol.*, 1943, 56, 438–448.
10. Razran, G. H. S. Salivating and thinking in different languages. *J. Psychol.*, 1935–1936, 1, 145–151.
11. Razran, G. H. S. Semantic, syntactic and phonetographic generalization of verbal conditioning. *Psychol. Bull.*, 1939, 36, 578.
12. Razran, G. H.S. Transportation of relational responses and generalization of the CR. *Psychol. Rev.*, 1938, 45, 532–538.
13. Razran, G. H. S. A quantitative study of meaning by a conditioned salivary technique (semantic conditioning). *Science*, 1939, 90, 89–90.
14. Razran, G. H. S. Conditioned responses. *Arch. Psychol.*, 1935, No. 191.
15. Riess, B. F. Semantic conditioning involving the GSR. *J. exp. Psychol.*, 1940, 26, 238–240.
16. Wylie, R. Generalization of semantic conditioning of the g.s.r. Unpublished M.A. thesis, Univ. Pittsburgh, 1940, p. 40.
17. Zener, K. The significance of behavior accompanying conditioned salivary secretion for theories of the conditioned response. *Amer. J. Psychol.*, 1937, 50, 384–403.
18. Zener, K., & McCurdy, H. G. Analysis of motivational factors in conditioned behavior: I, The differential effect of changes in hunger upon conditioned, unconditioned and spontaneous salivary secretion. *J. Psychol.*, 1939, 8, 321–350.