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MEDIATED GENERALIZATION AND THE INTER- PRETATION OF VERBAL BEHAVIOR: I. PROLEGOMENA^{1,2}

BY CHARLES N. COFER AND JOHN P. FOLEY, JR.

The George Washington University

Since Watson's epoch-making hypothesis relating thinking to sub-vocal speech, psychologists have emphasized, to a greater or lesser degree, the important rôle which language mechanisms (verbal, manual, postural, etc.) play in complex human behavior. Although there has been much speculation regarding the nature and function of linguistic behavior, relatively few experimental data are available as the basis for systematized theory in this area. In fact, language mechanisms have often been regarded as 'uncontrolled variables' in psychological investigations.

The present paper reports an attempt (1) to extend the objective principles derived from conditioned response experimentation to certain aspects of linguistic behavior, and (2) to show how such an interpretation of language behavior throws light on other psychological phenomena in which language plays an important rôle. It should be emphasized at the outset that not only are the conditioned response principles (*e.g.*, reinforcement, generalization) here employed well established and generally accepted, but their validity as principles of linguistic behavior has been determined by

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direct experimentation, as will be noted from the survey of related experiments below, although the implications of such experiments for psychological theory do not appear to have been fully recognized.

Language is here regarded as a form of conditioned behavior—both on the part of the speaker and on the part of the person spoken to. This objective psychological approach to language behavior differs considerably from the philological and related approaches in which the major interest is in language morphology, *i.e.*, language as things—isolated words or syllables. It also differs fundamentally from the logical discipline of semiotics (*cf.* Morris, 16), which is concerned with the systematic elaboration of the meta-language in terms of which all sign situations may be classified and discussed. And it should be further emphasized that the study of language-as-conditioned behavior has no traffic with mentalistic theories which regard language as a means of ‘expressing ideas.’ For a comparison of these different approaches to language as well as for an objective psychological treatment of grammar, the reader is referred to Kantor (8).

I. EXPERIMENTAL BACKGROUND AND OPERATIONAL ANALYSIS

In the following paragraphs, we shall begin with a brief consideration of the phenomenon of generalization, followed by a discussion of the distinction between mediated and non-mediated (physical) generalization. Attention will then be directed to the problem of mediated verbal generalization,³ after which the experiments in this field will be classified and the more relevant ones briefly summarized. The present section will conclude with a theoretical analysis of mediated generalization as a specific conditioned response phenomenon.

The phenomenon of generalization or irradiation of conditioned responses refers to the empirically determined fact that if a conditioned response is established to a given stimulus

³ We recognize the possibility of linguistic mediated generalization gradients of a non-verbal nature, as in the case of sign and gesture languages. Mediated generalization in some form undoubtedly occurs in such instances, and it would be interesting to study the generalization gradients in these language systems.

(S_1), other stimuli (S_{2-n}) of the same dimension will elicit the response without reinforcement, the magnitude of the generalized response varying inversely with the distance of S_{2-n} from S_1 along the given dimension.⁴ Such stimulus equivalence or gradients of generalization have been experimentally demonstrated in the case of various stimulus dimensions, such as the pitch or loudness of tones, as determined by psychophysical experiments, and the spatial distance of tactual stimuli applied to the body surface.

Several investigators have recently shown that generalization occurs along a *semantic gradient*, although the mechanisms involved need to be clarified and extended by theoretical implication. If we omit all other experiments in which conditioned responses have been formed to verbal stimuli⁵ and consider only those directly concerned with semantic generalization, we may classify the investigations into three major categories.⁶ The first of these comprises *experiments in which a conditioned reaction has been established to a stimulus object (denotatum) and generalization obtained to its name (sign)*. Positive results of this type have been reported by Kapustnik (9), Keller (10), Kotliarevsky (11, 12), Nevsky and Levin (17), Razran (19), Smolenskaya (27), Traugott (29), and Traugott and Fadeyeva (30). Conversely, Kapustnik (9) and Shastin (25), have described *experiments in which conditioned reactions have been established to a word (sign) and generalization obtained to its object (denotatum)*. A third

⁴We are not concerned here with the phenomenon of response equivalence, or response generalization.

⁵Noteworthy among such studies have been those on the conditioned acquisition of voluntary control of previously involuntary responses, as well as those on the effect of positive and negative attitudinal factors on conditioning. Although both of these areas of investigation are relevant to the present problem of semantic generalization, no attempt will be made to consider them here. Similarly, the experiments on indirect or mediated conditioning (Shipley, N. E. Miller, Lumsdaine) are arbitrarily omitted from the present discussion, owing to the fact that the mediated generalization is not semantic in character.

⁶In his description of methods for studying conditioned reflexes in man, Ivanov-Smolensky (7) includes a discussion of verbal conditioning, but neither the original monograph nor a complete abstract was available to the writers. References to two other volumes edited by Ivanov-Smolensky, and presumably including a summary of experiments on verbal conditioning and semantic generalization performed by students in his laboratory, are cited by Razran (21, p. 90, footnotes 1 and 2).

type of experiment has been concerned with the *establishment of a conditioned reaction to one word (sign) and generalization to other semantically and phonetically related words (signs)*. Experiments by Diven (3), Keller (10), Razran (20, 21, 22), Riess (23, 24), and Wylie (32) are concerned with this problem. Since they are most relevant to the present paper, these experiments may be briefly described.

Razran (20) measured the amount of saliva secreted while he thought of 'saliva' in English, Russian, German, French, Spanish, and Polish. As controls he used the Gaelic word for saliva, with which he was unfamiliar, a pair of nonsense syllables, and a period of 'blank consciousness.' A quantitative index of his familiarity with these languages was obtained through his speeds of reading and of association in each. The results indicated that the largest amount of saliva⁷ was secreted for the Russian word, the language of his childhood and adolescence, in spite of the fact that he is now more fluent in English. The German, French, Spanish, Gaelic, and Polish words yielded decreasing amounts of saliva in this order, which was the order of his familiarity with the languages, except for a reversal between Gaelic and Polish. Thus the degree of generalization appeared to vary as a function of his knowledge of or frequency of use of the specific languages, although the results, obtained on a single subject, are tentative.

A quantitative study of semantic conditioning in three adult human subjects is elsewhere reported by Razran (21). An attempt was made to separate the semantic or meaning-content factor from the phonetic or visual-auditory form of the word by the use of synonyms and homophones. Four stimulus words (*style, urn, freeze, surf*) were flashed on a screen while the subjects were eating, the amount of salivation to each of the stimulus words and subsequently to each of the homophones (*stile, earn, frieze, serf*) and synonyms (*fashion, vase, chill, wave*) being tested.⁸ The mean generalization was

⁷ Measured by means of Razran's 'cotton technique,' which consists in ascertaining the increment in weight of an absorbent dental cotton roll inserted under the subject's tongue for a period of one minute.

⁸ *Ibid.*

59 per cent to the synonyms and 37 per cent to the homophones, thus indicating that the verbal conditioning was largely semantic.

Riess (23) has repeated Razran's experiment, using the same stimulus and test words but employing the galvanic skin reaction (GSR) to a loud buzzer as a substitute for the salivary technique. The number of subjects varied from 4 to 9 in the case of the four stimulus words. Riess also found generalization to be greater to the synonyms than to the homophones, the mean percentage gain from conditioning being 94.5 for the homophones and 141.0 for the synonyms. In a recent unpublished study Riess (24) has included antonyms and has studied generalization at different age levels. Results appear to indicate that in young children generalization is greater to the homophones than to the synonyms, with the antonyms intermediate between the two, thus suggesting the relatively greater importance of phonetic as compared with semantic factors in the behavior of young children. With adults, however, the relationship is reversed, the order of increasing amount of generalization being: homophones, antonyms, synonyms.

Wylie (32) repeated the experiment performed by Razran and Riess, conditioning the GSR (elicited by shock) to certain words and testing generalization not only to homophones and synonyms of these words but also to other words (controls) bearing no relationship to the conditioned words. She found evidence of greater generalization to the homophones and to the synonyms than to the control words, but her results indicated greater generalization to the homophones than to the synonyms. This variation from the findings of Razran and Riess may, perhaps, result from the fact that her subjects said they expected shock on the words that sounded like the conditioned words but not on the synonyms of those words. Had her subjects been misled as to the nature of the experiment, this result might not have occurred. Wylie further studied semantic generalization by using nonsense syllables. Her subjects learned several pairs of syllables by the paired associates method, and the first members of two of these

pairs were then conditioned. Generalization was found to be much greater to the syllables associated with the conditioned syllables than to those syllables associated with non-conditioned syllables.

Another experiment by Razran (22) followed the same general method as that described three paragraphs above. For single-word conditioning, semantic factors were again found to be the most important determiners of the amount of salivary generalization in the adult subject, although 'phonetographic' relationships (sound-spelling, *e.g.*, *dark*, *mark*) were also very significant, especially at the beginning of the conditioning and after long continued pairings. Syntactic generalization was also studied by conditioning a salivary reaction to a 3-word sentence (consisting of subject, copula, and predicate) and then testing for generalization to other 3-word sentences in which one or more of the three words was reversed—giving rise to 7 verbal variations and to 4 contradictory and 3 concordant statements (*e.g.*, *Poverty is degrading: Wealth is degrading, Poverty is not degrading, Poverty is not uplifting, Wealth is uplifting*, etc.). Results indicated that the amount of generalization obtained depended upon the following factors (in decreasing order of strength of generalization): general agreement of statement, agreement of copula, predicate, subject; but reversals of copulas interfered more with transfer than general reversals of statements. Razran also reported that conditioned single words lost some of their generalization-strengths when combined in sentences, and that subjects' opinions regarding the truth of the statement influenced the conditioning as well as the generalization value of the sentence.

In a study designed to investigate the conditioning of anxiety reactions (GSR) to words, Diven (3) found generalization spreading 'by meaningful relation' to other words in the series. For example, from the reinforced word *barn*, generalization occurred to other words in a 'rural' category.

In a somewhat different experiment, still in its preliminary stages, Keller (10) has found that when the GSR is conditioned to the picture of an object, there is generalization

to the name of the object. She has also shown that a conditioned response established to one picture of an object (e.g., a hat) will be generalized to the picture of another object in the same category (e.g., another hat). In part, this last result might be attributed to physical similarity of the pictures of the objects, but there may also be a factor of conceptual identity in the different pictures which is in part responsible for the generalization.

Let us now turn to a consideration of mediated as compared with non-mediated generalization. It will be noted that *the dimension along which generalization occurs in the experiments described above is not a dimension characteristic of the physical attributes of the stimuli.* The classical formulation of generalization principles presupposes naive organisms (cf. Hull, 5), whereas *mediated (e.g., semantic) generalization depends upon previously conditioned (usually language) behavior.* Razran (19, pp. 70-71) implies this distinction in his 'polymodal concept' of human conditioning, according to which the mean amount of conditioning is held to be a function of (1) a *physiological factor* dependent upon the 'biological potency' of the stimulus and its correlated 'physiological reaction-change' and (2) a *psychological factor* resulting from the associational history and patterning of the stimulus. A similar distinction has been made by Hull (6) in a discussion of the problem of stimulus equivalence in behavior theory.⁹ Hull suggests that the three mechanisms mediating stimulus equivalence are: (1) the *partial physical identity* of the stimulus compounds, (2) *primary or physiological generalization* (irradiation), and (3) *secondary or indirect generalization* through the arousal of a reaction previously conditioned to the same stimulus continuum. Hilgard and Marquis (4, p. 201, italics ours) summarize the problem of generalization and the definition of stimulus similarity as follows:

There are a number of types of equivalence between stimuli (and the responses which they evoke) which cause the stimuli to be reacted to as similar, so that conditioned responses formed to one

⁹ Many of these distinctions bear a resemblance to Kantor's interbehavioristic 'stimulus function.'

of the stimuli will be generalized to the other. Among these may be mentioned: *partial identity* (whereby stimulus A-B is similar to A-C); *sensory similarity* (so that two colors are more alike than a color and a tone); *formal similarity* (for example, two patterns of ascending pitch); *affective similarity* (equivalence mediated by emotionally flavored processes, as in the "dark brown taste" or "blue Monday"); and *mediated similarity* (as in the equivalence of words of different sounds, but of common meanings). Of these relationships, only the first (partial identity) may be conceived of as physical similarity. The second (sensory similarity) may be mediated by relatively primitive physiological processes, as represented in the classical experiments on generalization within a sensory modality. The others all depend upon relatively complex processes, many of which require previous learning in order that the stimuli involved may be responded to as similar.

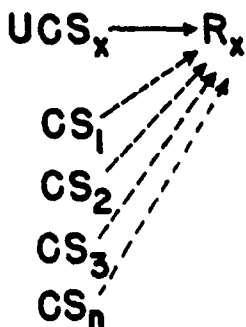
It is with this final type of 'mediated' generalization that we are here concerned. It is clear that semantic generalization would not take place in the case of a subject who did not know the meaning of the words or who saw no conceptual identity or similarity in the pictures of the hats in Keller's experiment. The mediated or semantic generalization in such experiments thus presupposes and depends upon the pre-experimental formation of conditioned responses or associations, *i.e.*, *the gradient of generalization is a gradient along a dimension of conditioned stimulus functions*. The stimuli need be similar only in so far as they have been previously conditioned to the same (or similar) response.

A simplified schema of such mediated or semantic generalization is suggested in Fig. 1. At some pre-experimental time, the subject has become conditioned, either by direct reinforcement or by higher order conditioning, to make R_x to $CS_1, CS_2, CS_3 \dots CS_n$. The subject is next experimentally conditioned by reinforcing CS_1 with UCS_y , setting up a conditioned response, R_y . Generalization is now found to $CS_2 \dots CS_n$, the magnitude of the generalized response presumably depending upon the relative strengths of the pre-experimental conditioning of $CS_1 \dots CS_n$ to R_x .

It should be emphasized that the schema in Fig. 1 is an operational account of what descriptively occurs in mediated generalization. Hypotheses regarding further, non-observ-

(1)

PRE-EXPERIMENTAL CR's



(2)

EXPERIMENTAL CR's FOR TESTING
MEDIATED GENERALIZATION

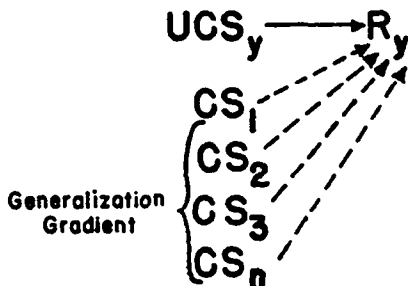


FIG. 1. Simplified descriptive schema for the development of mediated generalization.

able mechanisms could be introduced with reference to the manner in which generalization may be said to occur along the previously-conditioned stimulus-response continuum. Thus one might assume, following the theoretical analysis of Guthrie, Hull, and others, that upon the pre-experimental conditioning of $CS_1 \dots CS_n$ to R_x , each of these stimuli is also conditioned to an implicit, fractional, kinesthetic r_x , which invariably occurs with each pre-experimental reinforcement of R_x . In the later, experimental situation, CS_1 is conditioned to R_y . But during each reinforcement of this conditioning, CS_1 evokes r_x , the proprioceptive stimulation (s_x) from which also becomes conditioned to R_y . Now, when $CS_2 \dots CS_n$ is presented alone for testing mediated generalization, it will evoke r_x , whose s_x will in turn elicit R_y .¹⁰

¹⁰ Evidence concerning the rôle of such mediating responses is found in a series of different experiments by Miller (13, 14), designed to test the influence of past experience upon the transfer of subsequent training. Although both rodent and human subjects were used in different experiments, our present interest is in the verbal behavior of the latter. One such experiment made use of numbers and letters as different material categories pre-experimentally acquired and inter-associated by the subjects. A conditioned GSR differentiating between a specific number and a specific letter was set up, and differential generalization was found to other numbers and letters which had not been subject to direct reinforcement (*cf.* 13, p. 70). In further series of experiments, "controlled patterns of association were established through the learning of nonsense syllables. Possible effects of original similarities between pairs of syllables were eliminated by the systematic use of the same syllables in different patterns of association for different subjects. Differential conditioned galvanic reactions were established to a pair of stimuli by shock and non-shock combinations, after which the previous associates of the shock and non-shock pair were presented without shock. Photographic records of the responses showed contrasting reactions to the syllables associated to the shock and non-shock elements of the primary conditioning pair" (13, 'Digest,' inserted in front of 'Table of Contents').

"Additional experiments on human subjects demonstrated that (a) galvanic reactions may be conditioned to the stimuli involved in the subject's own verbal responses; (b) conditioned reactions of this type are subject to experimental extinction; (c) under certain circumstances, the functional activity of the verbal response previously associated with both members of a pair of stimuli may be essential to the subsequent transfer of conditioning from one of these stimuli to the other; and (d) under certain circumstances this crucial rôle of the mediating verbal response may be demonstrated—with dynamically opposite effects—for the transfer of either the positive or the negative aspects of a differential conditioned galvanic response" (13, p. 70). Miller thus concludes that the evidence (from both human and rodent subjects) in his series of experiments "demonstrates the influence of previous associations upon the generalization of subsequent conditioning and indicates that mediating responses can play an important rôle in this transfer" (13, 'Digest').

Miller and Dollard (15, p. 77) report an unpublished dissertation by Birge (1) in which behavioral generalization in children was found to be mediated by verbal responses. Birge found that "if young children are taught to call two very different

Thus, from a purely molar or descriptive point of view, $S_2 \dots S_n$ will lead directly to R_v . A diagrammatic representation and more detailed discussion of these inferred mechanisms are presented by Hull (6, pp. 27-28).

II. FORMAL ILLUSTRATION, METHODS OF EXPERIMENTAL DEMONSTRATION, AND IMPLICATIONS FOR BEHAVIOR THEORY

In this section an attempt will be made to extend the previous analysis and to illustrate its application to various psychological situations. More specifically, the section will begin with the discussion of a formal system of notation for designating mediated (*i.e.*, synonym) and non-mediated (*i.e.*, homophone) generalization gradients, after which the discussed synonym and homophone relationships will be illustrated by application to an hypothetical subject. A number of other gradients (other than synonym and homophone) along which mediated generalization might be expected to occur will next be suggested. A minimum number of formal concepts essential to the present theory will then be presented, followed by a discussion of methods for experimental check or demonstration of the expected relationships in the case of a given subject. The paper will conclude with the suggested application of the theory to various fields of psychological investigation.

The implications of semantic generalization for behavior theory, especially when combined with non-semantic or physical (*e.g.*, phonetic) generalization, appear not to have been adequately recognized. The relationships explicated in Fig. 1 may be regarded as a generalized statement of the nature of mediated stimulus equivalence. We are here interested in one form of mediated generalization, *viz.*, that involved in verbal language behavior; we are also con-

stimulus objects by the same name, other responses (such as reaching for the objects) are more likely to generalize from one to the other than when the two objects have been given different names." Birge likewise noted that "such generalization is much more likely to occur when the children say the name aloud, so that it is certain that the cue-producing response is actually present, than when they do not say the name aloud" (15, p. 77). Miller and Dollard (15, pp. 74-78) also discuss the rôle of the mechanism of mediated generalization in various forms of adult social behavior.

cerned with non-mediated generalization insofar as it plays a part in these problems.

In Fig. 2 we have suggested certain formal relationships

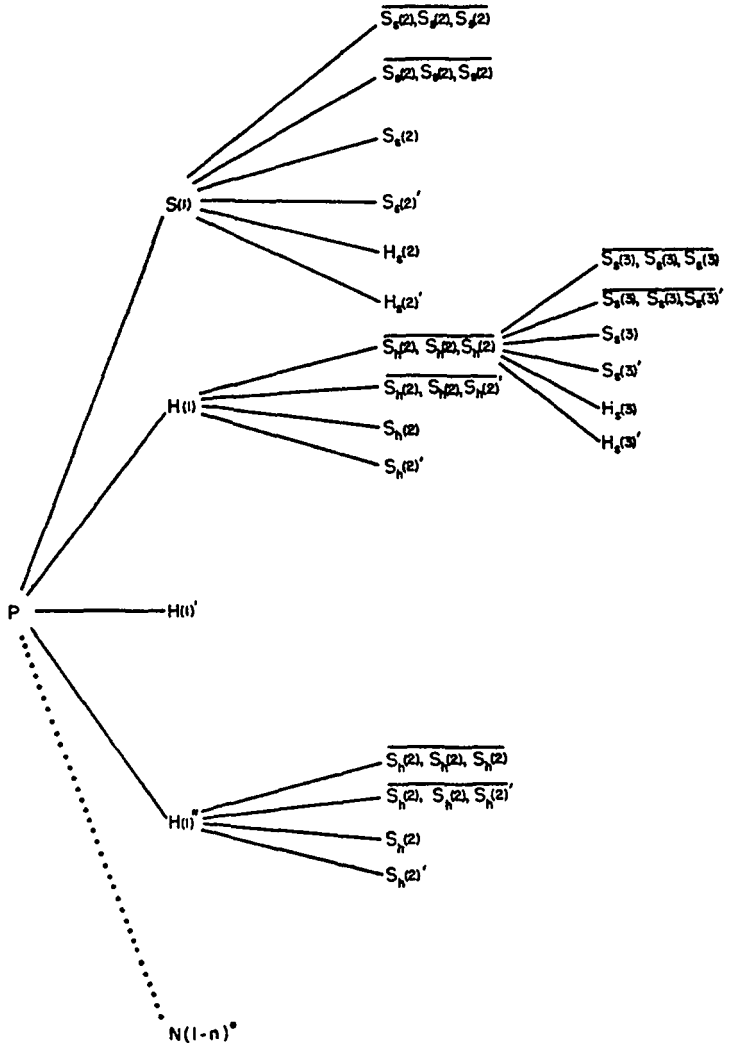


FIG. 2. Formal illustration of certain phonetic and semantic (mediated) generalization gradients in hypothetical subject.

* For experimental purposes it is necessary to have a neutral (control) word, N , at every stage in the diagram; a set of such neutral words bearing the relationship of synonymy or homophony to each other could also be utilized as additional controls.

which might be expected to obtain in the case of an organism whose language behavior is highly developed. Mediated generalization is here depicted in terms of synonymy of words and non-mediated generalization in terms of homophony of words. The following set of definitions will explain the system of notation used in this figure:

P refers to the original, reinforced stimulus (presentation) word.

S refers to a synonym of *P*.

H refers to a homophone of *P*.

N refers to a neutral word.

Numbers in parentheses designate the number of semantic or phonetic transformations removed from *P*.

*S*₁ refers to a synonym of the preceding synonym.

*S*₂ refers to a synonym of the preceding homophone.

*H*₁ refers to a homophone of the preceding synonym.

(No notation is required for a homophone of a preceding homophone. Cf. below.)

A prime ('), or primes ('' or '''), is used to differentiate various words or various sets of words which are synonyms or homophones of the preceding word but not synonyms or homophones of each other.

A long bar (—) is used to cover a set of words (synonyms) which are also synonyms of each other. It is extremely unlikely that there will be a set of homophones which are synonyms of each other.

It is evident that if two or more words are homophones of a preceding word they will be homophones of each other. It is extremely unlikely that there will be a set of synonyms which are homophones of each other.

It will be noted that Fig. 2 is a formal representation of some of the possible relationships arising from certain phonetic and semantic (mediated) generalization gradients. A given word, *P*, is presented and reinforced. According to the data of Diven (3), Razran (21, 22), Riess (23, 24), and Wylie (32), synonomous words, when presented, will likewise elicit a response, though less in degree. Now *P* may have only one synonym or it may also have several synonyms; in the latter case these several synonyms may not bear to *P* the same degree of semantic relationship, *i.e.*, one word (synonym) may be more completely interchangeable with *P* than the others although all must bear some degree of interchangeability

with *P*. (In this connection it should be noted that language authorities seldom assert that two words have precisely the same meaning. It seems likely, therefore, that the foregoing statement is sound.¹¹) Therefore, we may have a series of words, varying in semantic similarity to *P*, which would be likely to elicit different degrees of response as a function of the degree of their similarity to *P*.¹²

Furthermore, *P* may have more than one meaning; e.g., the word *vain* has both the meaning of *conceited* and of *fruitless*. Hence, it is possible to conceive the reinforcement of *P* as causing generalization effects along more than one semantic series.

Another possibility for generalization from the reinforced word (*P*) is provided by the homophone relationship.¹³ For example, if *vain* is the reinforced word, the effects of this reinforcement may spread to *vein* and to *vane*. We cannot be certain that these words would elicit different amounts of response to form a definite gradient, but such factors as relative familiarity of the homophones (cf. Razran, 20) and degree of similarity in spelling might cause a definite gradient to appear.¹⁴ At any rate, we are probably justified in assuming that generalization would occur to homophones, whatever the type of curve.

Deriving from the foregoing generalization gradients are several other possibilities:

¹¹ It is necessary to remember that the relation of synonymy in the language behavior of persons is dependent upon previous associations (conditioning). Hence, we cannot expect generalization gradients to picture the dictionary semantic relationships but should expect them to vary with the particular individual in the light of his language history. Cf., e.g., Mosier, C. I., A psychometric study of meaning. *Psychol. Bull.*, 1939, 36, 607-608, and *J. soc. Psychol.*, 1941, 13, 123-140.

¹² *Ibid.*

¹³ There are many possibilities here. In the text we are chiefly concerned with words, conventionally designated as homonyms or homophones, which are alike in sound but not in spelling and meaning. Homographs could also be considered, both when the words have the same sound and spelling but different meanings (e.g., *fair*, *beautiful* and *fair*, *market*) and when the words are spelled alike but differ in both sound and meaning (e.g., *bow*, *knot* and *bow*, *forward part of a vessel*). Likewise, we have said nothing concerning the place of the antonym in this picture. Generalization along each of these (and other) continua could readily be investigated.

¹⁴ It should also be noted that partial identity in sound or spelling might be adequate for some generalization to appear. For example, if *lamp* be the reinforced word, generalization might appear to such words as *tramp*, *cramp*, *camp*, etc. Cf. Razran (22).

1. From each of the synonyms of the original word there will be possible homophone gradients. Also, in the event that any of these synonyms has more than one distinct meaning, there will be in addition gradients formed by the synonyms arising from the different meaning, as well as homophone gradients arising from each of the members of the new synonym series.

2. Each of the homophones arising from the synonyms described above in 1 also may have synonyms, causing additional synonym gradients to appear; these synonyms may have homophones, more than one meaning, etc. The number of possible gradients is thus extended to a very large number.

3. Each of the members of the series of words homophonous with respect to *P* may have synonyms,—several sets of synonyms in the cases of words having more than one meaning. Each of these synonyms may have homophones, and so on.

With these statements and comments as an introduction, we may now examine Fig. 3, which illustrates the application of the relationships discussed in Fig. 2 to a concrete but hypothetical example. In discussing this diagram, certain important considerations must be kept in mind. The semantic and phonetic gradients portrayed are *limited* to synonym and homophone relationships, and for purposes of clarity, only *certain* of these relationships have been suggested. Moreover, the relationships or dimensions shown are purely *formal*, whereas those involved in the case of actual subjects would be distinctly idiosyncratic—varying as the result of the individual subject's particular linguistic biography. Fig. 3 thus pictures certain formal relationships, or generalization gradients, which, it is assumed, may be *simultaneously* activated (strengthened) upon the reinforcement of *P*. In the following descriptive text, the italicized words are the words found in Fig. 3, and the symbols indicate where they would appear in Fig. 2.¹⁵

¹⁵ To a certain extent the relationships suggested in Fig. 3 have also been suggested by Woodworth (31, pp. 36-37), although less systematically, in his discussion of 'mediate' or 'indirect recall.' Cf. a later section of this paper.

The presentation word *vane* (P) is taken as the original, reinforced stimulus from which generalization would be expected to occur along the synonym gradient leading to *weathercock* ($S_{(1)}$) and along homophone gradients leading to *vain* ($H_{(1)}$) and to *vein* ($H_{(1)'}).$ The word *four* ($N_{(1)}$) is inserted as a neutral or control word. From *vain*, three different synonym gradients are shown, the first leading to *fruitless* ($S_h(2)$), another to *conceited, egotistical, proud* or *pompous* ($S_h(2), S_h(2), S_h(2), S_h(2)$), and a third to *trifling* or *foolish* ($S_h(2), S_h(2)')$. *Pompous* bears a quasi-homophonic relationship to *pampas* ($H_s(3)$), from which alternate synonym and homophone gradients lead consecutively to *steppes* ($S_h(4)$), *steps* ($H_s(5)$), *stairs* ($S_h(6)$), *stares* ($H_s(7)$), and *looks* ($S_h(8)$). Two synonym gradients are depicted from *fruitless*. The one to *sterile* or *barren* ($S_s(3), S_s(3)$), leads from *barren* to its synonym, *dull* or *stupid* ($S_s(4), S_s(4)$), and to its homophone, *baron* ($H_s(4)$), whose synonym is *nobleman* or *lord* ($S_h(5), S_h(5)$). The other synonym gradient from *fruitless* leads to *useless, unprofitable, worthless* or *idle* ($S_s(3), S_s(3), S_s(3), S_s(3)')$, the homophone gradients from *idle* leading to *idol* ($H_s(4)$) and to *idyll* ($H_s(4)')$; whereas the synonym gradient from *idol* leads to *god* ($S_h(5)$). It is of some theoretical significance to note, as shown by the broken line in Fig. 3, that *god* is a synonym of *lord* ($H_s(5)$), whose associative strength is derived through *baron* ($H_s(4)$) and *barren* ($S_s(3)$) (cf. above); thus a circularity is achieved in the suggested semantic and phonetic gradients, and the words *god* and *lord* would be expected to show intensified magnitudes owing to algebraic summation of their reaction potentials (cf. below).

From *vein* ($H_{(1)'}),$ another homophone of the original presentation word *vane* (P), three different synonym gradients are represented in Fig. 3. One leads to *bed, fissure* or *lode* ($S_h(2), S_h(2), S_h(2)''$), with *lode* furnishing the homophone, *load* ($H_s(3)$) and the synonyms, *path, road* or *way* ($S_s(3), S_s(3), S_s(3)$), the last named leading to its homophone, *weigh* ($H_s(4)$) and thence to the latter's synonym, *measure* ($S_h(5)$). A second gradient from *vein* leads to *vessel* or *tube* ($S_h(2), S_h(2)')$, the latter having the two additional synonym

gradients terminating in *pipe* ($S_s(3)$) and *tunnel* ($S_s(3)'$), respectively. The third synonym gradient represented from *vein* leads to *streak, touch, tinge* or *strain* ($\overline{S_h(2)}, S_h(2), S_h(2), S_h(2)$), from the last word of which the following eight synonym gradients (all $S_s(3)$) are derived: *verse* or *poem*; *melody, tune* or *air*—leading to the last's homophone *heir* ($H_s(4)$); *manner, tone, tenor* or *style*—leading to the last's synonym, *fashion* ($S_s(4)$), and homophone *stile* ($H_s(4)$), with its own synonym, *gate* ($S_h(5)$) and its homophone, *gait* ($H_s(6)$) and the latter's synonym, *walk* ($S_h(7)$); *race, stock, descent* or *family*; *sort* or *kind*; *strive* or *endeavor*; *stretch* or *pull*; and *percolate* or *filter*—leading to the latter's homophone, *philter* ($H_s(4)$), and its own synonym, *potion* ($S_h(5)$). Attention is also called to the fact that *poem* ($S_s(3)$) is a possible synonym of *idyll* ($H_s(4)'$), as indicated by the broken line in Fig. 3, which fact illustrates another case of circular or double reinforcement along different semantic and phonetic generalization gradients. Similarly, *stile* ($H_s(4)$) is a synonym of *steps* ($H_s(5)$), and *way* ($S_s(3)$) is a synonym of *walk* ($S_h(7)$). These examples of circular generalization gradients differ from the *god-lord* relationship discussed in the preceding paragraph in that in the present instances the reaction potentials of the two words (*poem* and *idyll*; *stile* and *steps*; *way* and *walk*) are of different theoretical magnitudes, since they differ in the number of semantic and phonetic transformations removed from the original, reinforced presentation word, *vane*.

As was previously pointed out, the above gradients suggested in Figs. 2 and 3 have been limited to *certain of the formal synonym and homophone relationships* assumed to obtain in the case of the original, experimentally reinforced presentation word. In the actual experimental situation, many additional gradients will obviously operate concurrently. The following list of such formal gradients,¹⁶ or formal dimensions along which generalization may be expected to occur, may serve to indicate this semantic and

¹⁶ This list follows, with modification, the classification of responses in the free association experiment, as suggested by Jung and adapted by Wells, F. L., A preliminary note on the categories of association reactions, *PSYCHOL. REV.*, 1911, 18, 229-233.

phonetic multiplicity: egocentric (*success—I must*); egocentric predicate (*lonesome—never*); evaluation (*rose—beautiful*); matter-of-fact predicate or substance-attribute (*spinach—green*); attribute-substance (*green—spinach*); subject-relation, including agent-action (*dog—bite*) and action-agent (*bite—dog*); object-relation, including verb-object (*shoot—deer*) and object-verb (*deer—shoot*); causality, including cause-effect (*joke—laughter*) and effect-cause (*laughter—joke*); coordination (*cow—horse*); subordination or genus-species (*fruit—apple*); supraordination or species-genus (*table—furniture*); contrast, opposites, or antonym (*black—white*); coexistence or contiguity (*Sunday—church*); identity or synonym (*blossom—flower*); diminutives (*man—boy*), and their converse (*boy—man*); phrase completing (*forward—march*); word completing or compounding (*black—board*); assonance, partial identity, or rhyme (*pack—tack*); syntactic change (*deep—depth*); homonym, including homophone (*vane—vain*) and homograph *a* (*fair, beautiful—fair, market*) as well as homograph *b* (*bow, weapon—bow, forward part of vessel*). In addition, generalization may be expected to occur along dimensions relating to other formal aspects of the words,¹⁷ such as number of syllables, presence of prefix or suffix, presence and particular location of particular letters (*e.g.*, initial letter, as in the case of alliteration), as well as words associated with national, political, economic, 'racial,' social, occupational, fraternal, recreational, or purely 'personal' matters. In the case of the actual subject, of course, the existing mediated verbal generalization gradients will be idiosyncratic—the result of the individual's particular past conditioning. The above, formal

¹⁷ Skinner (26, p. 96) refers to certain of these mediated generalization gradients, although from a different point of view and in a less systematic manner. He writes: "Perseveration is a figurative way of saying that when a member of a group is elicited, all members of the group are temporarily strengthened relative to their normal latent strengths. Thus, if I say *hire*, all my responses which resemble that response are temporarily strengthened—particularly the response *hire* itself, which is likely to be elicited again sooner than its resting strength would dictate, and *higher*, which leads me to pun. Also strengthened are all words beginning with *h* (hence alliteration) and all ending in *ire* (hence rhyme). As to perseveration of theme, my response *hire* strengthens all responses associated with its referent, and I am likely to 'go on' to speak of labor, wages, and so on."

gradients are thus hypothetical abstractions illustrative of some of the possible logical and philological relationships.

The foregoing discussion has been designed to suggest some of the possible interpretations of verbal behavior in the light of a systematic application of the concept of generalization to at least a part of this field. It is, of course, necessary to check, experimentally, the relationships postulated above; we shall deal with this matter in a later section of this paper. It first seems necessary, however, to outline a minimum number of formal concepts which might somewhat simplify the application of the previous analysis to areas of behavior in which language plays a part. At this stage in the development of our analysis, we have not thought it essential to set down a number of definitions and rigorously worded postulates, although we recognize both the desirability and the necessity for doing so ultimately. Therefore, we are here introducing only the most vital concepts which we regard as important to the further explication of the present theoretical and experimental analysis.

1. *Reaction potential*.—When an organism is introduced into a given stimulating situation, there may, originally, be no especial response apparent. Subsequent to the reinforcement of some S-R sequence, however, the organism, in the presence of this situation, will respond in a predictable way. Thus we may say that the organism has a *reaction potential*.¹⁸

2. *Strength of reaction potential*.—If two reactions are possible in a given situation and one is made instead of the other, the former may be said to have possessed a greater strength of reaction potential than the latter. Within the framework of the present schema, the reaction made by the organism at any given time will depend upon the relative strengths of the existing reaction potentials, the strongest reaction potential evoking its response if its strength is above the reaction threshold. If two reaction potentials of equal or approximately equal strength are present, there will be

¹⁸ This term is similar in many respects to such terms as response tendency, reaction tendency, response potential, behavior tendency, behavior potential, excitatory potential, etc., used by other writers.

no response (inhibition, blocking) until spontaneous recovery or some other process causes one reaction potential to become stronger than the other.¹⁹

The strength of a given reaction potential at any moment may be assumed to depend upon the number of experimental reinforcements of *P*, the number of semantic and phonetic transformations it (the given word) is removed from *P*,²⁰ and the number of pre-experimental reinforcements of the given word (*cf.* Fig. 2). It is also possible that to the reaction potential of a given word would be added the pre-experimental reaction potential of *P* and that of each of the words preceding it along the continuum from *P*. Whether this is the case is a question for empirical determination.

Further, if a given reaction potential be derived from reaction potentials present as a result of the simultaneous activation of two or more gradients arising directly or indirectly from the reinforcement of *P*, as in the case of the god-lord, idyll-poem, gate-steps, and way-walk examples cited above, the strength of the reaction potential of this response will be intensified, since the positive reaction potentials from the different gradients may summate.²¹

3. *Reaction threshold*.—It may be assumed that for a response to occur, the strength of its reaction potential must reach a certain magnitude (and that positive potentials must exceed negative ones by this amount). This magnitude may be designated as the *reaction threshold* and for purposes of convenience may be regarded as equal for all verbal responses.

¹⁹ For completeness, it would be necessary to assume a liminal difference between the strengths of two reaction potentials before one could evoke its reaction in the presence of the other.

²⁰ We may assume, for the sake of simplicity, a constant decrement in the generalization of reaction potential from *P* for each of the transformations a given word is removed from *P*. We recognize that this assumption may be too simple and that the amount of generalization of reaction potential may be a function, for example, of the pre-experimental reaction potential of the given word. Similarly, we have assumed that all reaction potentials at a given number of transformations from *P* will be incremented by a constant amount upon the reinforcement of *P*. This, also, may be too simple an assumption.

²¹ We recognize that inhibitory gradients arising from the negative reinforcement (punishment) of *P* are possible. It may be assumed that the negative reaction potentials of members of such series will sum algebraically with such positive reaction potentials as may exist.

The application of the principle of generalization to language behavior is based upon the experimental evidence and logical inferences summarized above. The evidence thus far available has been secured by studying the subject's reactions without any especial effort to control or to secure information about his previous language history. In other words, the investigations have proceeded without a systematic attempt to discover the relative strengths of different reaction potentials at the moment of experimentation. In some ways this is an unsatisfactory situation. For this reason, as well as to indicate the manner in which we might go about determining whether Fig. 2 (or its special case, Fig. 3) is an adequate representation of the way in which generalization operates in the case of language behavior, we wish now to mention briefly four possible procedures for giving the experimenter some degree of knowledge concerning or control over the relative strengths of the verbal reaction potentials in the subject with whom he expects to work.

(1) The first method involves the pre-experimental reinforcement of certain verbal reactions, such that when the experimental session itself begins, the experimenter will have reason to expect that certain reaction potentials will be stronger than others.

(2) The second method involves the pre-experimental determination of the present strength of reaction potentials either statistically through Kent-Rosanoff frequencies, for example, or by actual measurements of word association tendencies in the subjects in question.²²

(3) The third method, similar in some respects to the second, involves securing information concerning the subject's language biography, as was the case in Razran's experiment (20) cited above, in which the experimenter was able to assess the relative familiarity of the subject with different languages.

²² The verbal summator, described by Skinner (26), could likewise be employed for this purpose. This method consists in the repeated presentation of skeletal speech samples which, through summation and 'imitation,' elicit the strongest latent speech responses of the subject.

(4) The fourth method involves setting up an artificial situation in which symbols (*e.g.*, nonsense syllables) having small (minimal) amounts of reaction potential could be used and differentially strengthened in a manner similar to that employed in Wylie's experiment (32, *vide supra*).

By employing such methods as these along with an involuntary response, such as the GSR, one should be able to determine fairly accurately whether the picture given in our theoretical diagrams resembles that present in an actual subject, or whether there are certain major inadequacies in our analysis.

On the basis of the foregoing analysis, it seems possible to integrate certain diverse phenomena ordinarily regarded in psychological writings as more or less unrelated. We have chosen a few such examples for brief comment. Although these examples have been selected from various traditional 'fields,' it is to be noted that the distinctions between these fields are somewhat arbitrary (and from our standpoint unsatisfactory).

1. *Perception*.—Perception is usually defined as the response to the 'meaningful character' of a stimulus in terms of past experience or in terms of the 'structural properties' of the field. From the point of view of the present writers, a perceptual response is a conditioned response; the response may have originated through direct or higher order conditioning or may have resulted from generalization. Undoubtedly much of this generalization arises from physical similarity of stimuli, although it may likewise occur frequently through semantic and related gradients (*cf.* above). Thus, for example, in certain experiments on the perception of tachistoscopically presented forms, the subjects' reports evidence modification of the original figure in the direction of a familiar (often verbalized) object. Perhaps many instances of the '*déjà vue*' phenomenon as well as other cases of recognition may also be accounted for through the processes of mediated generalization, although the factor of partial physical identity of the situations must also be recognized as important.

2. *'Set' or Einstellung*.—When a given performance is modified by events which precede it in time, this modification is often attributed to the 'set' of the subject, and the set is said to have resulted from the prior events. Many instances of 'set' are alleged to involve muscular adjustments, but other instances, particularly those involving verbal processes, are left unexplained (unless naming may be said to constitute an explanation!).²³

It seems possible that the mechanism of mediated generalization may be operative in some of these cases. The writers are currently attempting to test this possibility by determining the number of words from a given list which can be reported by subjects after a single exposure; sometimes the test list is preceded by experience with synonyms of its members, whereas the control condition involves pre-test experience with unrelated words. A 'set' is thus built up in the one case, or, as we have phrased it, the activation of semantic gradients through the presentation of the synonyms should result in a superior performance on the related list. A practical example of this sort is found in the memory span test, in which the results might be influenced by the pre-test verbal behavior of both subject and examiner. Thus, the memory span for disconnected words might be greatly modified if some of their synonyms chanced to be employed before the actual administration of the test or if different words in the series fell on the same or mutually reinforcing gradients.

3. *Learning*.—Many problems in the psychology of learning may likewise be clarified by this analysis, at least in the case of problems in which meaningful words—discrete or connected—are employed. One of us (2) has previously suggested that gradients of the sort described above may operate to cause at least some of the errors made in prose learning.²⁴

²³ The importance of 'set,' attitudinal factors, and the like has been demonstrated in a number of conditioning experiments; such factors undoubtedly operate through instructions, 'sophistication,' and implicit self-administered stimulation, both before and during the course of many other kinds of experiments.

²⁴ Cf. also Thorndike's (28) analysis of the possible rôle of phonetic and semantic factors in producing errors during the learning of English equivalents of French words.

4. *Memory (Indirect recall)*.—One example will perhaps suffice to illustrate the application of the present theory of mediated verbal generalization to memory behavior. In his discussion of memory, Woodworth (31, pp. 36-37) has described a process which he has called indirect or mediated recall. Thus in recalling the second of two paired associates, the subject may report the use of intermediary steps such as meaningful relation. For instance, in the case of the pair, *above-conceal*, the word *ceiling* may intervene, being similar in meaning to *above* and similar in sound to *conceal*. These relationships would seem explicable in terms of semantic gradients in the first step and in terms of quasi-phonetic gradients in the second. Other memory phenomena, such as perseveration, might also be clarified by this type of analysis.

5. *Intelligence*.—While a detailed analysis has not been attempted, it seems possible that the gradients here described may be important in differentiating various degrees of 'intelligence,' as measured by the usual verbal intelligence tests. Thus, the level of performance on such tests may well be influenced by the number and type of semantic transformations which a subject, by virtue of his previous learning, is able to accomplish.

6. *Reasoning*.—Success in reasoning situations is often regarded as a function of the number of modes of attack with which a subject may approach the problem, or as related to the variety of approaches he exhibits in discovering a solution. It may perhaps be suggested that in the verbal sphere, at least, the number and type of semantic transformations which the subject is able to accomplish is an important determinant of the reasoning process.

7. *Free association*.—Free association, whether in laboratory or everyday life situation, offers an obvious illustration of mediated verbal generalization. Beginning with a stimulus word or other stimulus material, the course of the responses may be regarded as determined by the language relationships peculiar to a given subject (according to the dimensions above indicated) and by the different strengths of the existing reaction potentials. Other language relationships not strictly

determined by phonetic and formal or institutionalized semantic factors (*i.e.*, those associations peculiar to any one individual's reaction history) likewise play a part.²⁵ A similar statement may be made with respect to reverie and other imaginative behavior. Non-verbal stimulation, such as pictures, scenes, and the like, may well initiate a series of vocal (or sub-vocal) reactions in these instances.

8. *Emotional behavior.*—A suggestion may also be made as to the possible importance of the mechanisms here described in the case of emotional behavior. If a traumatic experience (to take a relatively simple example) be accompanied by a chance event, *e.g.*, the lighting of a cigarette, a whole series of words may subsequently cause anxiety or fear (neurotic) behavior. Thus, generalization could occur from *match* to such words as *wedding*, *marriage*, *wedlock*, *nuptial*; from *light*, generalization might take place to *lamp*, and, through assonance or partial identity, to *tramp* and finally to *hobo*. In the last instance the individual would probably be unable to report the reasons for his fear of hoboes ('unconscious anxiety,' *sic*) and a lengthy investigation at best might be necessary to get at the basis for the fear.²⁶ From this point of view, the free association technique may be regarded as a diagnostic method for studying the patient's particular semantic gradients in order to determine the biographical events leading to his aberrant conditioning. It is interesting to note that other so-called psychoanalytic mechanisms and techniques might perhaps be treated in a similar manner.

²⁵ In this connection it is important to note that even if one assumes a fixed number of semantic and phonetic dimensions and a purely formal language history, the individual may give consecutive verbal responses which bear no relationship to each other along any of these dimensions. Such consecutive apparently unrelated responses frequently occur in continuous free association experiments. From our discussion of the theoretical basis of semantic and phonetic generalization, it will be apparent that such superficially unrelated responses (*e.g.* *load* and *baron* in Fig. 3) might lawfully occur provided their reaction potentials were of sufficient strength at consecutive intervals of time.

²⁶ A fascinating field for investigation is here suggested in connections with Mowrer's discussion of the motivational value of anxiety in learning. This problem, however, is beyond the scope of the present paper. Cf. Mowrer, O. H. A stimulus-response analysis of anxiety and its rôle as a reinforcing agent. *PSYCHOL. REV.* 1939, 46, 553-565.

We could multiply indefinitely these instances of the type of psychological inquiry to which the application of the theory here advanced would seem to promise fruitfulness. And it should be noted that most of these questions are capable of direct experimental test, at least in principle. Indeed, many relevant data are already available in the literature, and need only be summarized in the light of the present systematization in order to bring considerable clarity and unity into otherwise disparate and unsystematized areas of investigation.

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