

## A Study of Denotative Similarity with Restricted Word Associations<sup>1</sup>

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Data for this study were collected in two parts. In the first, 70 Ss responded to a list of stimuli in seven tasks of restricted association. The second part of the study employed stimuli consisting of 11 of these original stimuli plus their primary responses in each of the seven tasks. These were given to 50 new Ss under the same seven task instructions. The seven tasks were Superordinates, Coordinates, Similar, Contrasts, Functions, Qualities, and Parts. The main analysis of data was the derivation of matrices of response overlap for the seven semantic relationships corresponding to the restricted-association tasks.

Primary interest centered on similarity relationships. High overlap along the diagonal of the response-overlap matrix characterized the Similar. Overlap in five of these diagonal cells was found to discriminate Similar from the other relationships. A measure of the degree of Restricted-Association Similarity (RAS) was derived, based on this discriminating overlap.

This paper describes an exploratory attempt at a methodology for the study of word similarity. Similarity, which has achieved important status as an independent variable in verbal learning, has been previously measured by rating scales (Haagen, 1949), connotative distances based on the semantic differential (Osgood, Succi, and Tannenbaum, 1958), and various indexes of association and associative overlap (Marshall and Cofer, 1963). Several such measures of similarity have been studied by Wimer (1963) who factorially analyzed some of their interrelationships.

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The present approach combines a measure of restricted-association overlap, similar to previous measures of free-association overlap, with a conception of meaning which relies on formal and physical semantic relationships in a manner previously suggested by Riegel and Riegel (1963). The basic assumption of the approach is that the similarity of a pair of words can be estimated by the degree to which they share the same semantic relationships with the same words—or, operationally, the degree to which they share a distribution of restricted-association responses. Tasks of restricted association are assumed to correspond to various semantic relationships between words. Seven of the 16 tasks used by Riegel (1965a) were chosen for this purpose: Superordinate, Coordinate, Similar, Contrast, Part, Function, and Quality. Each task describes the relationship of the response to the stimulus. The degree to which a pair of words has overlapping re-

sponses under each of these tasks of restricted association is considered an index of their denotative similarity. Thus two words which are perfectly similar are assumed to have the same Superordinates, the same Coordinates, Parts, etc.—i.e., 100% overlap or completely identical response distributions under the seven tasks. The degree of similarity can therefore be estimated by the deviation of their response distributions from perfect overlap.

While the use of this overlap method as a measure of similarity was the main purpose of the study, there was a secondary interest in observing whether words bearing relationships other than similarity, e.g., superordination, would produce a unique pattern of response overlap.

## METHOD

### *Restricted-Association Tasks*

Seven tasks of restricted associations were presented with the following instructions to Ss:

*Superordinates:* Find a class name for the stimulus. For instance class names for the word *FORK* are *SILVERWARE* or *UTENSIL*. Class names for the word *LIMOUSINE* are *CAR* or *VEHICLE*.

*Coordinates:* Find another member of the class to which the stimulus belongs. For instance, *SPOON* or *KNIFE* belong to the same class as the word *FORK*. *TRAIN* or *BIKE* belong to the same class as *CAR*.

*Parts or Attributes:* Find a word that denotes an essential part or attribute of the stimulus. For instance, essential parts of a *FORK* are the *HANDLE* or the *METAL*. Essential attributes of *WISDOM* are *EXPERIENCE* or *MATURITY*.

*Similar:* Find a word that means essentially the same as the stimulus. For instance *RAKE* or *BRANCH* may be regarded as similar to *FORK*. *AUTO* or *AUTOMOBILE* may be regarded as similar to *CAR*.

*Contrasts:* Find a word that means essentially the opposite of the stimulus. For instance, *KNIFE* or *SPOON* may be regarded as contrasts to *FORK*. *FOOLISHNESS* or *STUPIDITY* may be regarded as contrasts to *WISDOM*.

*Functions:* Find a word that denotes a usage of the stimulus. For instance, a *FORK* is used to *EAT* or *TAKE-UP*. *CAR* is used to *TRAVEL* or *DRIVE*.

*Qualities:* Find a word that denotes a quality of the stimulus. For instance, a *FORK* is *POINTED* or *HEAVY*. A *CAR* is *FAST* and *SHINY*.

### *Subjects and Procedure*

*Part 1.* Seventy Ss enrolled in an introductory psychology course at The University of Michigan served in the first part of the study. Each S was given an instruction sheet and seven stimulus sheets, one for each task described above. Each sheet contained the same 50 stimuli, all of which were nouns. The order in which Ss received the seven tasks was randomized. The Ss were instructed to respond to one task at a time, without referring to their responses on previous pages. They gave one response to each stimulus on each page. The responses thus collected were then used in Part 2 of the study.

*Part 2.* Fifty Ss enrolled in introductory psychology courses at Michigan served in the second part of the study. The stimuli were chosen from the first part of the study in the following manner: Eleven of the original 50 stimuli, plus the primary responses to these 11 stimuli under each of the seven tasks, were selected and are listed in Table 1. After the eliminations of duplicated responses, the total number of stimuli for the second part of the study was 54. The administration of the tasks followed the same procedure as described for Part 1.

## RESULTS AND DISCUSSION

Part of the aim of the study was to derive matrices of response overlap, based on 11 stimuli for each of the seven word relations. Each of the seven relationships was expected to produce a unique overlap matrix. In particular, for *Similar*s, a matrix of response overlap with the seven tasks

TABLE 1  
ELEVEN ORIGINAL STIMULI AND PERCENT ASSOCIATIVE FREQUENCY OF PRIMARY RESPONSES UNDER EACH TASK

Stim	Tasks of restricted association							Qua
	Sup	Coo	Par	Sim	Con	Fun	Qua	
table	furniture	90 chair	63 leg	83 desk	46 chair	56 eat	41 flat	35
chair	furniture	89 table	34 leg	53 stool	37 table	54 sit	86 hard	16
bed	furniture	81 couch	29 mattress	66 couch	33 chair	39 sleep	80 soft	63
man	human	37 woman	76 head	33 boy	19 woman	81 work	39 strong	21
woman	human	44 man	70 head	20 girl	27 man	86 love	19 soft	17
hand	body	25 foot	59 finger	91 paw	26 foot	79 grasp	19 soft	12
head	body	47 arm	17 brain	24 top	26 foot	59 think	69 round	34
sheep	animal	87 cow	26 wool	66 lamb	31 cow	21 wool	26 woolly	31
lion	animal	77 tiger	69 mane	31 tiger	44 mouse	29 roar	25 strong	20
baby	human	34 child	37 hand	7 infant	36 adult	51 cry	33 small	16
foot	body	36 hand	56 toe	83 hand	24 hand	67 walk	60 flat	10

occupying corresponding rows and columns, was expected to show a pattern of high overlap along its diagonal—reflecting the assumption that similar words should have the same Superordinates, Parts, etc.

*An Example of Response Overlap for Two Similar*s

Clarification of the method of analysis can be served by a consideration of the primary similars, *TABLE* and *DESK*. Under the Superordinate task there was one response shared by these two stimuli—*FURNITURE*, which was given to *TABLE* by 49 Ss and to *DESK* by 47 Ss. The smaller of these numbers, in this case 47, was entered into the overlap matrix as a percentage, in this case 94%. Table 2 gives the complete

primary Similar). Cell (Sim, Co) reflects the opposite situation: 16% of Coordinates to *TABLE* were Similar to *DESK*; plus, 22% of Ss gave *TABLE* as Similar to *DESK*. The above technique was applied to all stimuli across the Similar row and Similar column. For the cell (Sim, Sim) two figures of mutual evocation are obtained, e.g., *TABLE* was given as Similar to *DESK* by 22% of Ss, while *DESK* was given as Similar to *TABLE* by 48% of Ss. In these cases, the smaller of the two numbers was added, consistent with the technique of minimum overlap. The necessity for this procedure becomes apparent when the alternative of not adding mutual evocations is considered: If, in an extreme case, two words were so similar as to evoke only each other under the Similar instructions, their common overlap would necessarily be zero for both the Similar row and column.

TABLE 2

OVERLAP MATRIX FOR TABLE-DESK IN PERCENT

S R \	Sup	Coo	Par	Sim	Con	Fun	Qua
Sup	94	6	0	8	0	0	0
Coo	10	38	0	60	46	0	0
Par	0	0	54	0	0	2	12
Sim	6	38	4	64	12	0	4
Con	0	30	0	18	58	0	0
Fun	2	2	6	6	0	34	4
Qua	2	2	16	2	0	4	42

minimum overlap matrix thus derived for *TABLE* and *DESK*. As predicted for Similar, the highest overlap occurred on the diagonal. Among the cells off the diagonal, only those involving Coordinates show high overlap.

In the determination of the overlaps, a procedure employed by Deese (1962) for free associates was used, modified by the assumption that under the Similar instructions each stimulus evoked itself as its primary response. Thus, the number of times that one of the paired stimuli evoked the other, under any task instruction, was added to the overlap figures in the Similar column (or row) for that stimulus. Accordingly, the 60% overlap in cell (Coo, Sim) for *TABLE-DESK* has two components: 12% of the Similar given to *TABLE* were given as Coordinates to *DESK*; in addition, *DESK* itself was given as a Similar to *TABLE* 48% of the time (to be expected, of course, since *TABLE* and *DESK* are

*Mean Overlap Matrix for Similar*s

For each relationship, a matrix of mean response overlap was constructed from the overlap matrices of each of the 11 word pairs representing a given relationship, as determined by the primary responses from Part 1. Although mean matrices for all seven relationships were involved in the subsequent analyses, only the matrix for Similar is given here (Table 3).

Matrices were expected to produce discriminable differences in overlap patterns among the various tasks. A nonmathematical cut-off technique was used to make such discriminations. Table 4 represents the "critical" cells—cells which were found

TABLE 3

MEAN OVERLAP MATRIX FOR SIMILARS IN PERCENT

S R \	Sup	Coo	Par	Sim	Con	Fun	Qua
Sup	69	10	1	21	3	2	1
Coo	9	21	2	54	13	1	1
Par	2	3	30	3	1	7	9
Sim	12	45	2	58	16	1	1
Con	2	13	0	23	33	0	0
Fun	1	2	7	3	0	35	7
Qua	1	1	7	2	0	3	26

TABLE 4  
 CELLS IN WHICH HIGH OVERLAP DISTINGUISHES ONE OR MORE RELATIONSHIP FROM THE OTHERS

R/S	Sup	Coo	Par	Sim	Con	Fun	Qua
Sup	Sim Con Coo						
Coo		Sim Coo <sup>a</sup>		Sim Con Coo			
Par			Sim Coo <sup>a</sup>				
Sim	Sup	Sim Con Coo	Par	Sim Coo <sup>a</sup>	Con Coo <sup>a</sup>	Fun	Qua
Con				Con Coo <sup>a</sup>	Sim Coo <sup>a</sup>		
Fun						Sim	
Qua							Sim

<sup>a</sup> Coordinates in these cells are not distinguished when the word pairs of highest associative frequency are used exclusively.

to distinguish either one, two, or three tasks from the remainder. Table 4 was derived by testing all cells for all tasks for deviation from the average of the seven matrices. Arithmetic deviations of greater than 10% were used to define critical cells.

In general, the greatest overlaps occurred in the cells which represent the intersection between the Similar and the task of the given relationship. For example, the greatest overlap for the Superordinates was in cell (Sim, Sup), and this cell was also the critical one for the Superordinates. For Parts the critical cell was (Sim, Par), for Functions (Sim, Fun), and for Qualities (Sim, Qua). Because the cut-off criterion was fairly high, these four relationships had only one critical cell each.

According to Table 4, eleven cells are involved in the discrimination of Coordinates, Similar, and Contrasts, with only two making unique discriminations, (Fun, Fun) and (Qua, Qua). Cells (Sup, Sup), (Coo, Sim), and (Sim, Coo) distinguish only a subset of relationships—a cluster, consisting of Coordinates, Similar, and

Contrasts. In cells (Coo, Coo), (Par, Par), (Sim, Sim) and (Con, Con) this subset is further reduced to include only Similar and Coordinates. Complementary to these are cells (Sim, Con) and (Con, Sim) which group together Coordinates and Contrasts. Finally, cells (Fun, Fun) and (Qua, Qua) isolate Similar to the exclusion of all others. Because of their lack of independence, no cell could distinguish between Contrasts and Coordinates.

#### *Overlap Matrices for Highly Associated Word Pairs*

The method of analysis has imposed some constraint upon the data, which has to be considered in the interpretation of the results. In particular, two factors bear upon the interpretation of the data: (a) the overlap matrices are *averages* based on 11 word pairs which vary in strength of the relationship; (b) each relationship is composed of a stimulus and its primary response obtained from *different* Ss. These two factors combine to imply that more pronounced overlap matrices may characterize a more ideal case and hence another analysis was done to check this possibility, as well as to test the importance of the *degree* of association.

For each of the seven tasks, the 11 word pairs were ranked according to the frequency of the primary responses given by Ss in the second part of the experiment. An example from the Similar relationship will illustrate the procedure. Following are the 11 original stimuli and their primary Similar, with the number of Ss (out of 50) who gave the response in the second part of the study: *BABY-INFANT*, 31; *BED-COUCH*, 31; *TABLE-DESK*, 26; *SHEEP-LAMB*, 24; *CHAIR-STOOL*, 23; *LION-TIGER*, 22; *HAND-PAW*, 17; *MAN-BOY*, 13; *WOMAN-GIRL*, 13; *HEAD-TOP*, 13; *FOOT-HAND*, 7. Thus for the Similar, the overlap for the highest four pairs is the mean for *BABY*, *BED*, *TABLE*, and *SHEEP*, while the overlap for the lowest pairs is the mean for *MAN*, *WOMAN*, *HEAD*, and *FOOT*.

The effect of this division was not systematic for all tasks; the overlap in some cells increases, while it decreases in others. For the Similar, however, every cell on the diagonal increased in magnitude when only the four strongest Similar were considered. This clearly supports the expectation that as word pairs approach ideal similarity, overlaps along the diagonal increase, approaching but never reaching an upper limit of 100%.

#### *Relations among Coordinates, Contrasts, and Similar*

The list of 54 stimuli (see Table 1) reveals a great amount of overlap involving the Coordinates. Empirically there is a lack of independence, particularly between Coordinates and Contrasts, which shared six primary responses, and between Coordinates and Similar which shared two responses. Indeed, one response, *FOOT*, served as the primary Coordinate, Contrast, and Similar to *HAND*.

This clearly makes an interpretation of the Coordinate task rather difficult. This lack of independence, however, is not merely an empirical misfortune, but a reflection of logical interrelationships. Apparently, Similar and Contrasts are proper subsets of the Coordinates for which common membership in the class of Superordinates is a necessary requirement. This assumption is supported by the overlap

data, particularly for the four word pairs with highest associative frequency. The Superordinate overlap is 81% for Similar and 79% for Contrasts. Thus, in giving a Similar or a Contrast, Ss will necessarily respond with a word which is also a Coordinate; in giving a Coordinate, he is likely to respond with a Similar or Contrast.

Empirically, Coordinates, Similar, and Contrasts are characterized by high overlaps along the diagonal cells. However, Similar are clearly separated from Coordinates and Contrasts in certain cells, particularly when the four most highly associated pairs are considered. Thus, all three tasks are characterized by high Superordinate overlap, but Similar show markedly more overlap in the Similar, Contrast, Part, Function, and Quality cells.

#### *A Measure of Similarity*

As mentioned previously, the overlap matrix for a pair of completely similar words is assumed to have 100% overlap along the diagonal, except in the (Coo, Coo) cell. However, since it was found that Superordinate overlap did not distinguish Similar from Contrasts, only five cells remain significant for similarity: (Par, Par), (Sim, Sim), (Con, Con), (Fun, Fun), and (Qua, Qua). For any pair of words the deviation from 100% of their response overlap in these five cells can, therefore, be considered as a measure of their similarity. The same measure can also be expressed simply in terms of the mean overlap for two words in these five cells. Since the latter is comparable to previous indexes of associative overlap (Marshall and Cofer, 1963), it was employed here on a sample of 16 word pairs, including the 11 primary Similar. The resulting measures of Restricted-Association Similarity (RAS), ranged from .600 for *BABY-INFANT* to .016 for *FOOT-FLAT*. Other

word pairs relatively high on the RAS measure were *TABLE-DESK* (.500), *LION-TIGER* (.496), *CHAIR-STOOL* (.492), *SHEEP-LAMB* (.484), and *BED-COUCH* (.408). Some of the pairs in the intermediate range were *WOMAN-GIRL* (.292), *HAND-PAW* (.260), *HEAD-BRAIN* (.224), *MAN-BOY* (.204). Lowest in RAS were *HEAD-TOP* (.068), *BABY-ADULT* (.054), and *BED-SLEEP* (.040). Although *HEAD* and *TOP* were primary similars, their RAS was quite low and was exceeded by two of the five Nonsimilar pairs.

Since the relationship between measures of associative overlap and other measures of word similarity would seem to have some relevance for verbal learning (Wimer, 1963), as well as for associative aspects of meaning similarity, a measure of free-associative overlap was taken on 12 of these 16 word pairs to provide a comparison with the results of the restricted association measure. (For four of the word pairs no free-associative data could be found which had been collected on the same population for both words). The measure of free association overlap employed is that of Bousfield, Whitmarsh, and Berkowitz (1960), the index of Mutual Relatedness (MR), and is comparable to other measures developed by Cofer (1957) and Deese (1962). MR is simply the number of responses in common to two words, plus their mutual evocations, divided by the total number of responses to the two words. The response frequencies for this index were obtained from the free-associative norms of Riegel (1965b).

The comparison of the two measures indicated that RAS and MR are less than independent, but by no means identical in what they measure. The range on MR was from .445 for *BED-SLEEP* to .010 for *FOOT-FLAT*. In general, word pairs high on RAS were also high on MR, with some

significant exceptions, the most striking of which is *BED-SLEEP*, which ranked fifteenth in RAS but 1st in MR. Likewise *FOOT-HAND* is higher in MR than RAS, while the reverse is true for some other pairs, including most noticeably *HEAD-BRAIN*, *MAN-BOY*, *WOMAN-GIRL* and *COUCH-BED*. The *tau* rank-order correlation coefficient for the 12 pairs having both measures is .24 ( $p < .14$ ). Since MR and other measures of free associative overlap have been shown to have predictive value in various verbal learning tasks (Marshall and Cofer, 1963), and since other measures of similarity seem to have less predictive value (Wimer, 1963), it may be of interest to check the predictive value of RAS. Presumably, RAS would be a weaker index of associative interference, since it apparently depends on restricted responses, some of which would not be at high strength, except under restricted conditions.

It would be of more immediate interest, perhaps, to investigate the agreement between this kind of similarity measure and scaled similarity based on Ss' ratings of similarity, as an intuitive validation of the measure. In this regard, it may be significant to note that, as measured by RAS, the most similar word pair is *BABY-INFANT*, the only pair of words in the sample approaching real similarity in the usual sense. That is, these words alone (*MAN-BOY*, *WOMAN-GIRL*, and *HEAD-TOP* are possible exceptions) are likely to be interchanged in denoting the same physical object, a fact which gives some intuitive support to the method. Finally, another line of interest in this method lies in the possibility of describing word similarity in terms of dimensions of semantic relationships. Such a procedure would involve an analysis of the response overlaps for the various tasks along lines described by Riegel and Riegel (1963).

## REFERENCES

- BOUSFIELD, W. A., WHITMARSH, G. A., AND BERKOWITZ, H. Partial response identities in associative clustering. *J. gen. Psychol.*, 1960, 63, 233-238.
- COFER, C. N. Associative commonality and rated similarity of certain words from Haagen's list. *Psychol. Rep.*, 1957, 3, 603-606.
- DEESE, J. On the structure of associative meaning. *Psychol. Rev.*, 1962, 59, 421-430.
- HAAGEN, C. H. Synonymity, vividness, familiarity and association value ratings of 400 pairs of common adjectives. *J. Psychol.*, 1949, 27, 453-463.
- MARSHALL, G. R., AND COFER, C. N. Associative indices as measures of word relatedness: a summary and comparison of ten methods. *J. verb. Learn. verb. Behav.*, 1963, 1, 408-421.
- OSGOOD, C. E., SUCI, G. J., AND TANNENBAUM, P. H. *The measurement of meaning*. Urbana, Ill., Univ. Illinois Press, 1957.
- RIEGEL, K. F. The Michigan restricted association norms. *Rep. No. 3*, NIMH Grant MH 07619, Univ. Michigan, 1965a.
- RIEGEL, K. F. Free associative responses to the 200 stimuli of the Michigan Restricted Association Norms. *Rep. No. 8*, NIMH Grant MH 07619.
- RIEGEL, K. F., AND RIEGEL, RUTH M. An investigation into denotative aspects of word-meaning. *Lang. Speech*, 1963, 6, 5-21.
- WIMER, C. An analysis of semantic stimulus factors in paired-associate learning. *J. verb. Learn. verb. Behav.*, 1963, 1, 397-407.

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