Effects of Stimulus Similarity on Perceptual and Conceptual Comparisons[1]

Donald Robbins and L. E. Bourne, Jr.

University of Colorado

Institute of Cognitive Science

University of Colorado

May, 1981

Technical Report No. 102

ABSTRACT

Subjects were to judge as rapidly as possible whether pairs of geometric designs were the same or different on a given relevant dimension (size, shape or color. Response times varied depending on the number of values on non-relevant dimensions shared by the comparison stimuli (stimulus similarity). "Same" responses were facilitated by stimulus similarity, regardless of whether the stimuli were perceptually available for comparison or available (identified by verbal labels) only for conceptual or memorial comparison. "Different" responses were slowed by similarity in the perceptual task. An experimental manipulation which permits the subject to identify the comparison stimuli prior to a memorial comparison did not change the basic similarity function. The data are generally more consistent with an activation rather than a search/retrieval theory of short term memory. A linear model with two similarity dependent parameters for response competition and semantic distance effects gives a close quantitative account of the data.

Effects of Stimulus Similarity on Perceptual and Conceptual Comparisons[1]

Donald Robbins and L. E. Bourne, Jr.

The purpose of these experiments is to examine the effects of stimulus similarity on the speed and accuracy of stimulus comparison. The task for subjects is to decide whether two stimuli are the same or different on a designated dimension, such as color. The similarity of the two stimuli is varied by manipulating the number of other dimensions on which they are identical or different. We are particularly concerned with the difference that stimulus similarity might make in judging sameness or difference when the stimuli are perceptually available for comparison or available for comparison only in memory. This difference has important implications for models of memory and for decisions about which processes in memory are similarity-dependent.

The question we deal with is not new. There have in fact been many studies of similarity effects in stimulus comparisons. In the case of perceptual comparisons, the common finding is that mismatches on irrelevant dimensions (dissimilarity between stimuli) inhibit or slow down "same" responses. That is, if two stimuli are identical on the dimension of comparison, the correct response will be inhibited by increasing the number of differences on irrelevant dimensions. This effect has been shown over a variety of conditions and types of stimuli and is not, at this time, an issue of dispute (Egeth, 1966; Hawkins & Shigley, 1972). The effect of stimulus similarity on "different" responses, however, is inconsistent, sometimes increasing reaction time (Williams, 1974; Connor, 1972), but often having no effect (Well & Green, 1972; Krueger, 1973) in the empirical studies that are presently available.

The usual explanation for similarity effects in the perceptual comparison findings entails the operation of two underlying processes, response competition and attention distraction. Response competition operates such that differences on irrelevant dimensions bias the subject to say "different." Thus, increasing the number of differences on irrelevant dimensions slows down "same" responses and speeds up "different" responses. The distraction process operates such that the more differences on irrelevant dimensions, the more likely is the subject's attention to be attracted to those dimensions. Thus, the more mismatches, the slower reaction time should be regardless of whether the correct response is "same" or "different." Therefore, "same" responses should be inhibited by the response competition and distraction process, both of which increase in potency with the number of mismatches on irrelevant dimensions. Response competition and distraction have antagonistic effects on "different" responses. If response competition effects are stronger than distraction effects, "different" responses should be enhanced by increasing the number of mismatched irrelevant dimensions. Just the opposite effect should obtain if distraction effects are stronger than response competition. Obviously, if the two effects are equal, the number of irrelevant dimensions will have no observable effect.

The literature on memorial or conceptual comparisons is not quite as systematic as, nor is it easy to compare to, the literature on perceptual comparisons. In tasks where the subject is required to judge whether two stimuli belong to the same category, similarity has been shown to enhance "same" responses and degrade "different" responses (Caramazza, Hersh & Torgerson, 1976), much in the manner of perceptual comparisons. These studies are based typically on the rated similarity of members of natural categories rather than manipulations of features of the stimuli. Studies of the symbolic distance effect are also pertinent. In these experiments, subjects are taught labels for a set of stimuli which vary along some single dimension, e.g., size. The labels are then presented in pairs and the subject must make a judgment about which of the two referents has a more extreme value on the underlying dimension, essentially a "difference" response. Typically it has been found that speed of response is directly related to distance between stimuli (i.e., dissimilarity) on the underlying continuum (Moyer & Bayer, 1976). Thus, similarity tends to inhibit the "different" judgment here as in other memorial and some perceptual tasks.

While there is a considerable literature on similarity effects in perceptual and conceptual judgments, there are no studies, to our knowledge, which examine perceptual and conceptual comparisons within the same paradigm and using the same corpus of stimulus materials. That, then, is one goal of the present research.

In all conditions of the present experiment, comparisons are to be made between two geometrical designs which can differ on as many as three dimensions, size, color, and form. In the case of perceptual comparisons, the two designs to be compared are presented physically for the subject to examine. In the case of the corresponding conceptual task, well-learned verbal labels for the two comparison stimuli are presented. It stands to reason, of course, that conceptual comparisons will take longer to make, given the same level of accuracy. For one thing, conceptual tasks may require the search and retrieval (and/or activation) of memory representations of the two stimuli associated with the presented labels. But, in addition to search/retrieval time, it may also take longer to make a comparison in memory than it does to make a comparison between physically presented objects. Thus, there may be two components operating in the conceptual tasks, above and beyond those operating in the perceptual version: (a) search/retrieval (or activation) of memory representations and (b) comparison of activated representations.

On the basis of available data, we expect reaction times in the conceptual task to depend on stimulus similarity, though the focus of this dependency is not clear. There appear to be two primary possibilities. If we assume a multistore model of memory (e.g., Atkinson & Shiffrin, 1968), similarity of stimuli to be compared is likely to exert its influence on search/retrieval time in long term memory. That is, two stimuli at disparate locations in long term memory are likely to take longer to search out, match and retrieve than two adjacent stimuli. If we assume an activation model memory (e.g., Shiffrin & Schneider, 1977) the effect of similarity is more likely to manifest itself in the comparison operation. That is, two stimuli at disparate (activated) locations might take more time to compare than adjacent stimuli, a semantic distance effect. Thus, while both models expect both slow and similarity-dependent response times in the conceptual task, the locus of the effect differs.

Consider "same" responses in the conceptual comparison task. The more dimensions of difference between two comparison stimuli, the slower the subject will be to identify them as same on the designated dimension. Response competition, distraction and memorial processes (search/retrieval, activation or comparison) operate in concert to slow down response time. Expectations with regard to "different" responses are not quite so clear because of the possible offsetting effects of competition and distraction. With similarity-dependent memory processes added, however, we should observe a difference in similarity function between perceptual and conceptual tasks in the direction of positive effects of similarity even for "different" responses in the conceptual task.

Present experiments develop a methodology to examine these issues. The methodology derives from a simple stage-wise model of perceptual (RT_p) and conceptual (RT_c) comparison times which includes, in addition to a constant base reaction time (B), contributions from previously identified response competition (c) and distraction (d) processes, both of which are similarity dependent. The most general statement of this model incorporates both similarity independent (M) and similarity-dependent (m) parameters for the conceptual task. The data, of course, will speak to the necessity of both terms.

(1) $RT_p = B + (c + d) f(s)$

(2) $RT_c = B + M + (c + d + m) f(S)$, where $f(S)$ is some (presumably) linear function of similarity (S); c, d and m are coefficients of response competition, distraction and memory processes (undefined), and B and M are constants for base response time and memory (undefined) respectively.

Experiment 1 examines the following set of expectations. In the case of perceptual comparisons, "same" judgments will be facilitated by increasing similarity while "different" judgments will exhibit less of an effect, being inhibited by similarity if response competition is stronger than distraction and facilitated if distraction is stronger than response competition. Conceptual comparisons will be slower because of the addition of the assumed memory processes. Under these conditions, both "same" and "different" responses are likely to be enhanced by increasing similarity due to the greater adjacency of representation of similar items than dissimilar items in memory. In Experiment 2, we attempt to determine the dependency of the memorial comparison process on similarity exclusive of search/retrieval by a procedure which allows the subject to retrieve representations in advance of the comparison process. The results should tell us whether comparison per se, exclusive of retrieval, depends at all on the similarity of the two stimuli to be compared.

Experiment 1

Method

Subjects. The subjects were 60 undergraduate introductory psychology students who participated in partial fulfillment of a course requirement. Subjects served in single sessions, lasting 1.5 hr.

Design. The design included four within subjects variables: Type of Task (Conceptual, Perceptual comparisons), Relevant Dimension (Size, Color, Shape), Response (Same, Different) and Similarity (Zero, One, Two). The Similarity variable was calibrated in terms of the number of dimensions, other than the relevant dimension on which the two comparison stimuli were identical.

Trials were organized into six blocks with 2 min. rests between blocks. The six blocks each consisted of 69 trials of either the Conceptual or the Perceptual task, and with Size, Color, or Shape selected as the Relevant Dimension. The first five trials of each block were practice trials. Of the remaining 64 trials, 32 were "same" response trials and 32 were "different" trials. Of each set of 32, 8 trials had Similarity 0, that is, the stimuli were different on both irrelevant dimensions, 16 trials had Similarity 1 (8 trials with each irrelevant dimension different), and 8 trials involved Similarity 2.

Stimuli and equipment. There were two types of stimulus slides employed in this study, Geometric and Syllabic. The geometric stimuli consisted of slides of geometric figures which varied along three dimensions, size, color, and shape, with each dimension taking one of two values, resulting in eight different figures. The values of color were yellow and black, of shape, triangle and square, and of size, large (9 mm along the base) and small (3 mm along the base). The syllabic stimuli were taken from Noble's (1961) list of 2100 CVC combinations. They consisted of 8 CVCs which had both low meaningfulness and low associative values ($m' < 1.75$, $a' < 1.85$).

The apparatus consisted of two Kodak Carousel slide projectors, with external Lafayette shutters, positioned side by side. The slide images were projected in pairs on a rear projection screen 102 cm from the projector and 120 cm from the subjects with the slide image areas coterminus. The subjects responded on a two button box with one button labeled "Same" and the other "Different." The labels were switched between subjects so that half the subjects used their preferred hand for the "same" responses and half used their nonpreferred hand.

Procedure. Subjects first heard a set of instructions informing them of the nature of the task they were to perform. They were then given a set of 8 cards each of which contained one of the 8 geometrical stimuli on one side, and a corresponding nonsense syllable label on the other side. The subjects studied the syllable-design correspondences on these cards freely for 15 min and were then tested, with feedback, over each of the pairs. This testing was performed by presenting the geometric stimuli and requiring the subject to give the corresponding syllables and vice versa. Subjects were required to give the 8 correspondences between syllables and geometric stimuli correctly, in both directions, three consecutive times before they were allowed to continue with the experiment.

Prior to each block of trials, one stimulus dimension was designated as relevant. Then on each trial of the Perceptual task, subjects were presented with a pair of geometric stimuli. The subjects' task was to decide whether the two figures were the same on the relevant dimension, ignoring any differences on the other dimensions. In the Conceptual task, subjects were presented with a pair of nonsense syllables on each trial. In this task they were required to decode the syllables into the appropriate geometric figures according to the correspondences they had previously memorized, and then to decide whether the figures were the same on the designated relevant dimension. The same dimension was relevant for all trials within a block, but the relevant dimension changed between blocks. Subjects were instructed to keep their index fingers over the two buttons on the response box at all times so as to respond as quickly and as accurately as possible.

Results

Response accuracy, measured in proportion-correct responses, was relatively constant over conditions in this experiment. Differences obtained largely, although not exclusively in speed of response. Therefore, the primary data to be reported in this section are reaction times. Unless otherwise indicated, all ps $< .05$.

There is a variety of significant effects, but the source of variance of greatest interest in the RT data is the Task (conceptual vs. perceptual) x Response ("same" vs. "different") x Similarity interaction which was highly reliable, $F(2,118)=161.08$, $MS_e = .10$. This interaction is portrayed in Table 1.

Insert Table 1 about here

"Same" reaction times decreased as similarity increased, the effect being numerically larger in the case of conceptual comparisons. In contrast, "different" reaction times diverged in the conceptual and perceptual tasks with increases in similarity, becoming faster in the conceptual task and slower in the perceptual task.

The other significant results are either qualified by or are independent of this interaction. The conceptual task produced significantly slower reaction times than the perceptual task, $F(1,59)=589.20$, $MS_e = 2.92$, the overall difference being approximately 1.8 seconds. There is a corresponding difference in error rates (2.7% perceptual vs. 7.9% conceptual). Relevant dimensions differed only in reaction time, with responses to color being fastest and to shape slowest, $F(2, 118)=11.15$, $MS_e = 0.73$. The interactions of Task by Similarity and Response by Similarity were significant but of no consequence in view of the higher order interaction of these three variables.

There is one curious and inexplicable interaction, Relevant dimension x Response x Similarity, $\underline{F}(4,236)=9.29$, $p<.01$, $MS_e = .06$. "Different" reaction times increased with similarity when shape was the relevant dimension, whereas they decreased with similarity for the other two relevant dimensions. "Same" reaction times decreased with increasing similarity in all cases, but the effect was slightly greater for shape than for the other two dimensions. Dimensional peculiarities are not unknown in geometric stimuli, and it is to this factor that we attribute the result. This observation does not appear to compromise any of the major effects.

Discussion

The results obtained in the perceptual task are essentially those reported earlier in the literature. "Same" reactions become faster while "different" reactions become slightly slower with increases in similarity. The results can be accounted for in terms of distraction and competition processes, if we assume that the response competition is stronger overall in its control of response time than distraction.

There is a huge scalar of difference between reaction times in the perceptual and the conceptual task. In addition, it is observed that both "same" and "different" response time decrease with similarity in conceptual comparisons. If we assume the same two processes, response competition and distraction, are operative in basically the same way and magnitude in the conceptual task, how then does one account for the different functions observed in the conceptual and the perceptual task? First of all, there is either a search/retrieval or an activation component involved in the conceptual task which is not present in the perceptual task. This component may be essentially automatic but nonetheless is time-consuming, thus producing the scalar difference in response times for the two comparison tasks.

There must be one or more other processes operating in conceptual comparisons which are similarity-dependent, for the functions for "different" reaction times are not parallel in the conceptual and perceptual tasks. One likely candidate is the act of making comparisons in memory. The argument is that comparisons of items from adjacent representational points (similar items) are easier and therefore faster than pairs of items which reside at distant locations, the typical semantic distance phenomenon. The outcome is that similarity speeds up both "same" and "different" judgments in a conceptual task, leading to similar functions for the two types of responses and to a difference in function between perceptual and conceptual tasks for "different" responses. The magnitude of this effect is sufficient to override what would otherwise be an increase in response times with similarity for "different" responses in the conceptual task.

But this argument is based largely on conjecture. Because there are at least two factors, activation (retrieval/search) and comparison, which might operate in the conceptual task above and beyond those operating in the perceptual task, we really cannot be sure which of the two (or both) is similarity dependent. What we need is a method to eliminate either the activation (retrieval/search) process or the comparison process. Experiment 2 addresses this issue.

Experiment 2

As previously discussed, a major difference between a multistore model of memory and an activation model lies in the expected location of the similarity effect in memory. A multistore model suggests that the locus of any similarity effect lies in search and retrieval while an activation theory supplies an effect in the comparison operation. To establish the independence of activation (retrieval/search) and memorial comparison processes and to determine which is similarity-dependent, we need a method for eliminating one process while still requiring the other. If such a procedure can be found and if conceptual task response times continue to depend, as they did in Experiment 1, on the similarity between comparison stimuli, then, at the very least, we would have established that the remaining process is similarity dependent.

The procedure we propose for this purpose involves a simple rearrangement of events in the conceptual task used in Experiment 1. This rearrangement, which we refer to as Reverse Prime (RP), presents the subject with the two items for comparison in advance of naming the dimension on which they are to be compared. Thus, in the conceptual task, subjects in Condition RP would first see two labels for geometrical design to be compared. After ample time is allowed for activating the representation corresponding to those labels, the dimension for comparison is identified and response time is measured from the onset of that signal. We argue that this response time is independent of time for activation (retrieval/search) and reflects primarily the additional operation of memory comparison above and beyond processes operative in the perceptual comparison task. The purpose of Experiment 2 is then to compare performance in both conceptual and perceptual comparison tasks under the condition used in Experiment 1, henceforth called Normal or Condition N, with performance on the same tasks under Condition RP.

Method

Subjects. The subjects were 36 introductory psychology students who participated for three consecutive days, for 1.5 hr. on the first day and for 45 min. on the second and third days, in partial fulfillment of a course requirement.

Design. The design included six within subjects variables: Days, Task (Conceptual, Perceptual), Prime Condition (Normal, Reverse Prime), Relevant Dimension (Size, Color, Shape), Response (Same, Different), and Similarity (0, 1, 2).

On each of three days, there were 72 different types of trials corresponding to the combinations of these variables (2 X 2 X 3 X 2 X 3). Each type of trial occurred four times on each day, resulting in 12 observations per subject per cell when collapsed over Days. The factor of Days was used simply as a replication and to examine possible practice effects. There were four main trial type configurations of interest created by the interaction of Task with Prime Condition: Perceptual-Normal, Perceptual-Reverse Prime, Conceptual-Normal and Conceptual-Reverse Prime. Trials were run in blocks for each of these four trial type configurations, but were randomized within each block with respect to the variables of Relevant Dimension, Response and Similarity.

Stimuli and apparatus. The stimuli were identical to those of Experiment 1, except that eight new CVC combinations were used. The CVCs used were again chosen for low meaningfulness (scaled meaningfulness, $m' < 1.45$) and low associative value (rated associations, $a' < 1.60$).

Except for the addition of a third projector to show the priming slide (naming the relevant dimension) the apparatus operated in the same way as Experiment 1. The centers of the slide images projected on the rear viewing screen formed an equilateral triangle with the edges of the slide image areas coterminus. On Normal trials, the shutter for the upper projector opened to present the prime (size, color or shape) slide. After a 1.5 second delay, the shutters on the two lower projectors opened revealing the pair of stimulus items. In Reverse Prime mode, the order of presentation was reversed, stimuli first and prime 1.5 seconds later. The opening of the final shutter(s) caused a timer to be activated. The prime interval of 1.5 sec was determined on the basis of pilot data to be adequate to allow for decoding of the syllable stimuli to their geometric referents.

Procedure. On the first day, each subject was familiarized with the stimulus materials and tested on the correspondences as in Experiment 1. Subjects were then instructed as to the nature of the task and presented practice trials as in Experiment 1. After these trials, subjects were informed about the difference between Normal and Reverse Prime trials. On Normal trials, they were to note the contents of the first slide, and, when the stimulus slides appeared 1.5 sec later, to make a similarity judgment based on the previously named dimension. On Reverse Prime trials, subjects were instructed to use the interstimulus interval to prepare themselves to make a judgment as soon as the relevant dimension slide was shown. In the conceptual task, subjects were instructed to use the 1.5 sec interval to "decode" the labels. Following these additional instructions, subjects were each given 20 more practice trials with feedback. Half of these trials used geometric stimuli, and half nonsense syllables. Of each of these trial types, half were Normal and half were Reverse prime. The order of trials was random.

In the experiment-proper, subjects were presented with 78 trials of each of the four types, presented in blocks with a 3 min. pause between blocks. The ordering of the blocks was counterbalanced across days and across subjects such that the same sequence of blocks was never presented to a subject on more than one day, and each type of block was represented equally often in each serial position.

On the second and third days of the experiment, subjects were first given 10 min. to restudy the geometric figures, nonsense syllables, and their correspondences. Following this, they were again tested on the material in a manner identical to the first day.

Results and discussion

As in Experiment 1, major effects are evidenced primarily in the speed rather than the accuracy measure. Primary interest lies in two interactions, Task X Response X Similarity, the interaction of significance in Experiment 1, and Task X

Response X Similarity X Prime condition. If practice and prime condition have no interactive effects, we would expect the first interaction to parallel the outcome of Experiment 1. Significance of the second interaction will tell us something about the role of activation vs. comparison processes in the memorial task. From Experiment 1, we know that the similarity functions for "different" responses are not the same in conceptual and perceptual tasks under condition N. The critical consideration in the present data is the similarity function that obtains for "different" responses in Condition RP. If providing the subject with labels for the two stimuli to be compared allows the subject not only to activate the corresponding nodes in memory but also to bring them forward for side-by-side comparison in working memory, then we would expect roughly the same similarity function for "different" responses under the conceptual task as under the perceptual task, even though it may take considerably more time in the conceptual case. Thus, if Condition RP facilitates the comparison process by permitting anticipatory retrieval of nodes to be compared, we should get a reliable four-way interaction of Task X Response X Similarity X Prime condition. If, on the other hand, condition RP facilitates node activation only (and not the comparison process), then there will not be an interaction. Facilitation of the activation process in Condition RP should make conceptual responses faster (and possibly more accurate). It should not change the nature of the similarity function for "different" (or "same") responses, however, because the distance between activated nodes is, by assumption, based on similarity.

The data, broken down according to the four major variables, are presented in Table 1. The three-way interaction of Task X Response X Similarity, was highly significant, $F(2,70)=94.04$, $\underline{Ms}_e = .25$ in reaction times, but the four-way interaction was not. As can be seen from Table 1, the major influence of Condition

RP was to decrease reaction times across the board in the conceptual task. Perceptual comparison times showed little effect.

The reaction times obtained in this experiment are, in general, slightly faster than those reported in Experiment 1. This can be understood in terms of a significant main effect of practice (Days), $F(2,70) = 177.37$, $MS_e = 2.02$, reflecting the fact that reaction time decreases by an average of approximately 700 msec over the three days. But this practice effect interacts with none of the other major variables of the experiment. It should also be noted that the dimension used as the basis of comparison produced a reliable difference in reaction time, $F(2,70) = 41.57$, $MS_e = .77$, and errors. Overall, subjects were quicker to respond when the task was to judge stimuli on the basis of size or color than when a shape judgment was required. Relevant dimension interacted with similarity, response, and type of task, though these effects do nothing to compromise the basic major conclusion about the influence of prime condition on conceptual and perceptual comparisons.

General Discussion

Results of these two experiments portray a clear picture of the differences between perceptual and conceptual comparisons of formally identical stimuli and of the effects of stimulus similarity on the relevant subprocesses. Consider first perceptual comparisons. Using an existing large data base, we argued that stimulus similarity, calibrated in terms of the number of overlapping features on independent stimulus dimensions, would affect performance through two mechanisms. A distraction process should slow both "same" and "different" responses. Response competition, in contrast, should have a differential effect on "same" and "different" responses. As similarity increases, "same" responses should be speeded while "different" responses should be slowed down. These arguments lead to a simple linear model portrayed in Equations 1 and 2.

The outcomes of both experiments are consistent with this model if one assumes that the response competition process is stronger than the distraction process. In fact, the data suggest that distraction, if it operated at all in these data, operated minimally. A simpler model which ignores the distraction parameter altogether is just as consistent, quantitatively, with the outcome of both experiments as is the more complex two-parameter model. Thus, for purposes of these data, we argue:

(3) $RT_p = B + c \cdot f(s)$

Data from conceptual problems are consistent with the simple model developed for perceptual comparisons as far as it goes. They require, however, minimally, one additional parameter. As we have noted, there are at least two ways in which memory might enter to effect reaction times when the comparisons are indirect. First, it will take time for the presented stimuli (labels) either to retrieve or to activate the objects (representations) for memorial comparison. Second, comparisons might be slower for stimuli in memory than for stimuli in the visual field. Search and retrieval, activation and memorial comparison processes, under certain models, could be similarity dependent. One contribution of the present set of data is to elucidate the focus of the similarity effect.

Consider the following argument. Memorial comparisons occur in short term memory. That is to say, for a comparison of this sort to take place, the subject must be aware of the two stimuli. If one adopts a theory of memory which assumes separate long term and short term stores, then similarity (if it is effective at all) is likely to affect retrieval from long term to short term memory. Retrieval to short term memory will be more rapid if the two stimuli in question have adjacent addresses in long term memory than if they are more distantly placed. The comparison of stimuli, represented "side-by-side" in short term memory is less likely to be affected by similarity except for ways already considered in perceptual comparisons.

If, on the other hand, one adopts an activation theory, a different expectation seems natural. Suppose short term memory, rather than having a unique location, is considered to be the activated portion of long term memory. There is no retrieval then of representations from long term into short term store. Rather, it is a matter of "lighting up" the nodes corresponding to the two to-be-compared stimuli. In this case, we suggest that activation (the counterpart of search/retrieval in the alternative model) will not be similarity dependent but is rather an automatic and parallel function of the presentation of the two retrieval cues. What is similarity dependent for reasons of semantic distance, is the comparison process itself for it should be easier to compare adjacent activated nodes than more distant nodes.

The data of Experiment 2 speak to the distinction between these two possibilities. Condition RP was designed to eliminate retrieval or activation processes from response times. In this case nodes corresponding to the two comparison stimuli are activated in advance of knowing the basis (dimension) of comparison. Response time is measured from the point of cuing the basis of comparison to the completion of the comparison process itself. The effect of similarity was virtually identical under Conditions N and RP, although obviously response times were significantly lower overall for Condition RP. This implies that it is the comparison process per se, rather than retrieval or activation which is similarity dependent. It further implies that an activation as opposed to a retrieval model of short term memory is more appropriate for the data reported.

Again, it is possible to write a relatively simple linear model for response times in the conceptual task. What is required, above and beyond the model for perceptual comparisons, is two additional components one of which is and the other which is not similarity-dependent. Thus: (4) $RT_C = B + M\ (c + m)\ f(S)$.

To test the accuracy of this model, a subset of the data obtained in Experiments 1 and 2 was used to provide parameter values for the model. The model, incorporating those values, was then used to "predict" the remainder of the data set. The values used in the model are shown in Table 2.

Insert Table 2

These values were obtained from the experimental data for the "Different" response condition, with Similarity values 0 and 1. A comparison of the obtained and predicted data for Experiments 1 and 2 is given in Table 1. The correlations between obtained and predicted data for the perceptual and conceptual conditions respectively were $r = .995$ and $r = .955$ for Experiment 1 and $r = .908$ and $r = .999$ for Experiment 2.

As can be seen from Table 2 there is a great deal of consistency across experiments for the values of c, the response bias effect, and m, the effect of similarity on memory. Indeed the simple linear model, which incorporates only two similarity dependent parameters, response competition and memorial comparison, appears to account in detail for the results of these two experiments.

Footnote

1. This research was conducted within the Institute of Cognitive Science. The work was supported by Research Grant BNS 76-81416 from the National Science Foundation.

REFERENCES

Arkinson, R. C. & Shiffrin, R. M. Human memory: A proposed system and its control processes. In K. W. Spence and J. T. Spence (Eds.) _The psychology of learning and motivation: Advances in research and theory_. Vol. 2, New York: Academic Press, 1968.

Caramazza, A., Hersh, H., & Torgerson, W. Subjective structures and operations in semantic memory. _Journal of Verbal Learning and Verbal Memory_, 1976, _15_, 103-117.

Connor, J. M. Effects of increased processing load on parallel processing of visual displays. _Perception and Psychophysics_, 1972, _12_, 121-128.

Egeth, H. E. Parallel versus serial processes in multidimensional stimulus discrimination. _Perception and Psychophysics_, 1966, _1_, 245-251.

Hawkins, H. L., & Shigley, R. H. Irrelevant information and processing mode in speeded discrimination. _Journal of Experimental Psychology_, 1972, _96_, 389-395.

Kreuger, L. E. Effect of irrelevant surrounding material on speed of same-different judgment of two adjacent letters. _Journal of Experimental Psychology_, 1973, _98_, 252-259.

Moyer, R. S., & Bayer, R. H. Mental comparisons and the symbolic distance effect. _Cognitive Psychology_, 1976, _8_, 228-246.

Shiffrin, R. M. & Schneider, W. Controlled and automatic human information processings II. Perceptual Learning, automatic attending, and a general theory. _Psychological Review_, 1977, _84_, 127-190.

Well, A. D., & Green, J. Effects of color differences in a letter matching task. _Psychonomic Science_, 1972, _29_, 109-110.

Williams, C. The effect of an irrelevant dimension on "same-different" judgments of multi-dimensional stimuli. _Quarterly Journal of Experimental Psychology_, 1974, _26_, 26-31.

TABLE 1

Obtained Data and Model Generated Values

		Different			Same	
	Similarity	0	1	2	0	1
EXPERIMENT 1						
Perceptual	Obtained	908	933	929	913	908
	Model	908*	933*	958	908	883
Conceptual	Obtained	2951	2909	2818	2945	2846
	Model	2951*	2909*	2867	2950	2858
EXPERIMENT 2						
Perceptual	Obtained	839	865	902	890	860
	Model	839*	865*	891	839	813
Conceptual	Obtained	2477	2415	2368	2454	2378
	Model	2477*	2415*	2353	2477	2363

*Values used to estimate parameters

TABLE 2

Model Parameters Estimates, Milliseconds

EXPERIMENT 1	EXPERIMENT 2
B = 908	B = 839
M = 2042	M = 1638
c = 25	c = 26
m = 67	m = 88