美作女子大学・美作女子大学短期大学部紀要
1996, Vol. 41, 22～37

論　文

Components in "same"-"different" judgments as an interface between perception and higher cognition (1)

知覚とより高次の認知をつなぐインターフェイスとしての同異判断(1)

Masahiko Saito

The study of "same"-"different" judgment is very important area in cognitive psychology. The judgment task itself is simple; subjects must decide whether two stimulus patterns are identical or not. Two stimuli are presented either simultaneously or sequentially. Researchers have extensively measured the judgment reaction times in order to investigate perceptual and cognitive phenomena: for example, in various matching and attention tasks (e.g., Posner, 1978), in visual and memory searches (e.g., Sternberg, 1969; Atkinson, Holmgren, & Juola, 1969), and in more cognitive tasks (e.g., Shepard & Metzler, 1971). Therefore, the theories of "same"-"different" judgment mechanism should assume essential roles in these research areas.

One important theoretical problem is the "fast-same" phenomenon. When the judgment mechanism uses one-to-one feature matching, "same" responses should be slower than "different" responses. This prediction rests on the following reasoning: In "same" trials, subjects must determine whether *every* feature is the same one by one, whereas in "different" trials, they can respond when they discover one differing aspect. However, in some cases, "same" responses are reported to be faster than "different" ones (e.g., Bamber, 1969; 1972; Cleaves, 1977; Corballis, Lieberman, & Bindra, 1968; Cunningham, Cooper, & Reaves, 1982; Decker, 1974; Hock, 1973; Keuss, 1977; Krueger, 1973; Nickerson, 1973; 1978; Silverman, 1973; Silverman, & Goldberg, 1975; Snodgrass, 1972; Taylor, 1976; Tversky, 1969). Since "same"responses are paradoxically fast, many researchers term this experimental finding the "fast-same" phenomenon (for review, see Nickerson, 1978; Farell, 1985).

A number of theories explaining the "fast-same" phenomenon have been proposed, but no current paper has demonstrated the definitive superiority of any one theory, probably because these theories are based on different types of information-processing principles. The noisy-operator theory proposed by Krueger (1978) assumes a sequential sampling mechanism which cancels out the disturbing effect of internal noise and performs pattern matching. This matching mechanism produces the "fast-same" phenomenon.

This research was supported by Grant-in-Aid for Encouragement of Young Scientists (121-8002-61710102 in 1986 and 121-8003-62710098 in 1987) from The Ministry of Education, Science and Culture of Japan.

The author gratefully acknowledges the advises by Naoya Mori and by Daynise Irene Holloway.

This noisy matching processor has its own property that induces the phenomenon. On the one hand, Proctor (1981) proposed a theory of basically different type; his matching processor does not have its own property of inducing the phenomenon. According to his theory, it is the combination of three principles (priming, response competition, and levels of processing) that produces the phenomenon.

If different theories stated varying assumptions about an identical process, experiments should discriminate between them more easily. That is, experimental procedures could be focused on distinctive characteristics among the theories. However, in practice, it is not the case. There always remains possibility that even if a theory cannot predict an experimental result, the result does not refute the theory. This is because, some factor quite beyond the theory's scope might produce the discrepancy between the theory and the data, and the theory might still be tenable providing that factor is unessential to the matching mechanism. Even if another theory predicts the result, we cannot confidently choose either theory until we determine whether the factor is essential (or unessential) to the matching mechanism.

It seems that we need some global framework which clarifies the psychological significance of each assumption. Many theorists have not discussed two important questions: First, what are "sameness" and "difference?" Second, what type of stimulus features (or attributes) are compared by the "same"-"different" judgment mechanism? Before constructing theory, we should discuss these questions in order to decide what type of information-processing principle we should adopt.

After discussing the above two questions, the present paper will propose a new theory. The purposes of proposing the new theory are as follows: (1) to explain matching phenomena; (2) to provide links between them and our knowledge regarding perception and cognition; and (3) to demonstrate a processing principle: The principle states that in pattern matching judgments, reaction times and error rates do not depend on quantitative judgment-criteria settings but on decision rules across several description viewpoints and on differing rules across resolution levels of analysis. The present research aims at demonstrating this principle.

Framework of the Present Theory and the Theoretical Bases of its Individual Assumptions.

1. What are "Sameness" and "Difference?"

The hardware of human perceptual information processing has a stimulus-feature-detection system or primal-sketch mechanism which produces the early representation of visual image (see Marr, 1982). However, these are not ones which signal sameness of patterns. The term of "sameness" in the present context means the information which directly affords some advantage to either behavior or thinking. The "same"-"different" judgment is not used to determine the same parts of primal sketches (nor of feature distributions) but to achieve a categorization of objects.

"Sameness" should relate to individual purpose which regulates either behavior or thinking. In one situation, we may say "the same" for a couple of letters such as 'Aa;' in another situation, grade school children must say "different" for a couple of digits such as '22,' because the left digit means 'twenty.' Even *physical* identity does not denote absolute "sameness," since the individual digits are at different locations, and their positions relate basic information for both perception and cognition.

Furthermore, even when two objects are different in size from each other, we may say, "they are the same." In fact, difference in size could be critical to survival; for example, size is significant for fighting, making instruments, or so forth. The point is that "sameness" judgment is a different ability from identifying an object. In the present theoretical context, "sameness" judgment is a component of many intellectual abilities such as language, mathematical thinking, science, or philosophy. In this meaning, the judgment mechanism acts as an interface between perception and higher intelligence. Therefore it is difficult to construct an all-purpose pattern matcher.

Some theories (e.g., Posner, 1978; Proctor, 1981) assume two types of processing: one based on a visual code and another based on a name code; but such a processing-code classification is not always clear-cut. For example, are a hat and a picture of it the same or not? Both of them use the same term 'hat.' However, similarity between shapes can be continuously changed. Which system (the physical and name matchers) performs the matching task using intermediate levels of the similarity continuum? Are a particular melody played on a piano and that on a guitar the same or not? We can recognize that they are the same melody but sound is different. Of course, irrelevant features might be neglected by some prior processing (or selective attention). However, can an all-purpose selection mechanism exist? We need further discussion about recognition systems.

2. Descriptions of Visual Stimuli.

Hubel and Wiesel (1962) stated a physiological theory which assumes a hierarchical "feature"-detection organization, i.e., simple cell, complex cell, and so forth. In a psychological study, however, Pomerantz (1978) demonstrated that under some conditions, the most basic stimulus feature detected by the perceptual system are not line slant (detected by the simple cell). Also, in physiological study, some researchers doubt this hierarchical "feature"-detection organization (e.g., Maffei, 1985; Tolhurst & Dean, 1985). Hence, whether the most basic stimulus attributes for vision are very simple "features" is open to question. These controversies bring the assumption which states the "same"-"different" judgment mechanism is based on very-simple-feature comparisons into questions.

In addition, larger "same" reaction time is obtained when two familiar objects (or letter strings) are presented upside down (e.g., Egeth & Blecker, 1971; Hock, 1973; Hock & Marcus, 1976; Well, Pollastek, & Schindler, 1977; though Ambler & Proctor, 1976, did not find this effect under a certain condition). This orientation effect suggests that theories are problematic which assume only simple-visual-feature comparisons. In fact, even when stimuli are presented upside down, such analysis ought to be identically useful, since both stimuli are displayed at the same orientation. Accordingly, we should consider another unit of information used by the "same"-"different" judgment mechanism.

Proctor and Healy (1985) found several facts that suggested some information pooling (e.g., "difference count": Krueger, 1978; "goodness of match": Ratcliff, 1981) in a pattern matching task. At the same time, however, one aspect of the results suggested that the interpretation was oversimplistic. That is, the averaged data agreed with the pooling hypothesis, but partial analysis of a serial position effect contradicted the hypothesis. (For the complex details and reasoning, see Proctor & Healy, 1985.) These results suggest that information is weighted by serial positions and then pooled. However, another interpretation should also be considered. It suggests that the matching system compares descriptions which consist of information units having structure (not information pooling), and these descriptions represent the relationship between wholistic structure and parts.

This explanation is formed on the following empirical bases: When we try a geometric proof, a change of visual organization sometimes leads us to true reasoning (e.g., Kanizsa, 1979, Chap. 13). In short, we find the "same" figures (*congruent*) or the same shapes (*similar*). This phenomenon implies that a change of *internal description* style (or representation style) can occur: various types of internal descriptions can be utilized to represent one stimulus pattern.

In addition, using a human-face matching task, Czigler (1985) found that "same" reaction time for isolated eyes was more than that for eyes in identical faces. On the other hand, the reverse relation was found for hair. The role of the whole (face) in the analysis of the parts (eyes or hair) was different according to the *eye* and *hair* conditions. Obviously, the role of wholistic-structure information is not fixed. If the information processing involves weighted pooling, it needs some prior processing, since weighting which involves eye-hair difference entails prior recognition of the eyes or hair. However, it is curious that the processing system integrates the information with the wholistic structure (face). If one can recognize the eyes (or hair) before matching, he/she should be able to judge by the recognized information, since the subjects were only asked to judge eyes (or hair) "sameness."

The present theory accordingly assumes that pattern matching mechanism compares various types of *internal descriptions* with stimuli. The theory assumes neither feature matching nor the uni-dimensional pooling of information. Necessarily it rejects all types of template matching hypothesis, since this needs some uni-dimensional pooling. In the present theory, a system utilizes several descriptions simultaneously (multiple-viewpoint description hypothesis; see below); the descriptions represent both overall structure and roles of parts in a pattern. It is hence natural to assume that important parts (within whole structure) are stressed in the descriptions. This property resolves the whole-part problems presented by Proctor and Healy (1985) and by Czigler (1985). That is, the eyes (hair) "sameness" judgment reaction time depends on whether the processing system describes particular parts of stimulus as a main factor determining a facial impression or not. Under this hypothesis, pattern matching is the check of correspondence between descriptions. The matching system employs a kind of information pooling, but this is not uni-dimensional.

It is assumed that the description process uses propositions (e.g., Anderson, 1983; Kintsch, 1974), and that the propositions represent the roles of parts within an overall stimulus structure. The present theory, however, does not assume that some discrete symbols compose the descriptions. Their communication or processing medium (microstructure) may be a distributed system (e.g., Knapp & Anderson, 1984; Kohonen, 1977; Hinton & Anderson, 1981; Rumelhart, McClelland, & the PDP research group, 1986).

3. Multiple-Resolution Hypothesis

Here, we would like to discuss another problem which relates the levels of detail at which the stimulus analysis mechanism operates. Even the most strict drawing can not ideally describe the same shapes with quantum-level accuracy. Observers having infinite ability then would not find any absolutely identical things. On the other hand, observers having low ability can detect some "sameness." For example, an observer who only responds light energy above a threshold can classify visual stimuli into two sets: light and dark. It is very possible that a low-level-resolution analyzer catches some global attributes of visual stimuli, as Palmer (1975) pointed out, and finds a type of global sameness.

Palmer (1977; 1980) classified perceptual representations into three types which differ in resolution level [1] (the level of detail): entire perceptual field, whole configuration, and elements of the configuration. The present theory extends this to a four-level assumption. When explaining multiletter matching, Palmer's third level seems to be divided into two levels. That it, one level represents the strings of four randomly-selected letters as a group (see Krueger, 1978; Silverman, 1973), and another represents individual letters within the strings one-by-one. The theory, then, assumes that a descriptor which analyses and describes stimuli have four parallel subprocesses; each of them produces descriptions which are based on analysis at a resolution level.

Furthermore, the grouping of stimulus letters is assumed to be automatic. This assumption corresponds with the Gestalt law. For example, in a visual search experiment, Pomerantz, Sager, and Stoever(1977) found that a pair of near-positioned parentheses was found faster than single one. That is, the recognition system automatically identified each of near parentheses as an integrated pattern. Consequently, under the component part condition (single parenthesis), the response was slower than that under the configural condition (two parentheses).

Of course, a sharp resolution device can be tuned to any low resolution level, but such a single-sharp-device hypothesis seems questionable. An information-processing system having only one sharp resolution device must select an adequate resolution level (a level of detail) in an individual situation. It would, however, be rather difficult to make such a decision. Even if top-down control based on one hypothesis-confirmation procedure regulates the tuning according to contextual information, such a system could miss some important information, because unexpected but useful information frequently comes from surroundings.

A sequential system might solve this problem: the sharp resolution device is primary, while a secondary one detects global information from results of the primary analysis. But such a hypothesis is quentionable, because several facts suggest that such a sequential theory is inadequate: i.e., "immediate encoding into category" (Ingling, 1972), "Forest-before-tree" phenomenon (e.g., Navon, 1977), "Local and global effect in configurations of ambiguous triangles" (Palmer, 1980), "Global and local levels interaction" (Hoffman, 1980), "Outside-in" strategy (Earhard & Walker, 1985), and a faster "cognitive" comparison than a "physical"-dimension matching (Garner, Podgorny, and Frasca, 1982).

4. Multiple-viewpoint description Hypothesis.

The name of each letter must be recognized from its various letter fonts and hand-written variations. The variety of fonts and hand-written styles is very wide (see figures in Hofstadter, 1985, p.244, 270, and 271). Even when using both the meta font of each letter and its variations, we can not produce all possible variants of the letter (see Hofstadter, 1985, Chap. 13).

Hofstadter(1985) presented many examples of letter style variations, and his Figure 12-4 (p. 244) is particularly important. He found that Chinese and Japanese people can recognize that all the characters in the figure are identical letters, even though the characters have few common geometrical parts. Hofstadter, then, pointed out that we must consider conceptual "roles" rather than geometrical parts (p.279).

Although naming is considered a very difficult problem, the naming performance is performed rapidly. It is important that we recognize a letter printed with an unexpected font. In the present theory, a key hypothesis related to this problem is nesting parallelism: (1) Four subprocesses simultaneously describe an input pattern independently of each other; individual subprocesses use global or elemental terms, according to their resolution level (a level of detail). (2) Each individual subprocess produces not one description only but several descriptions simultaneously. These stimulus descriptions are based on different viewpoints.

Descriptions signal the roles of individual parts within a stimulus pattern. (This "role" might be different from Hofstadter's "role," since this has a geometrical nuance.) When the stimulus is 'A,' for example, one description produced by a subprocess could be "two rods stand supporting each others with a short horizontal stick between them," Others may be as follows: "a triangle whose base is open with a short stick attached at a middle height," or "a triangle having two short legs." These are possible descriptions but not the only necessary ones for stimulus 'A.' We need further research in order to determine exact description styles. However, now, we only need the concept of multiple-viewpoint descriptions in order to explain the "same"-"different" judgments.

These descriptions are produced by different "describing" procedures based on different points of view. Before seeing a stimulus, however, the perceptual system can not know which of the procedures is the most efficient (or adequante) to describe the stimulus in a particular situation. The present theory hence assumes that each subprocess simultaneously uses several procedures. That is, each individual subprocess produces several descriptions simultaneously, as mentioned above. A categorizer then selects a description (see below) and thus decides an overt response.

Using the nested parallelism of multiple descriptions, our present theory explains the very rapid recognition performance. The descriptor sends out several different descriptions even if some of them are not practical in every situation, and the categorizer selects an adequate one for an individual purpose. That is, no control mechanism is assumed in the describing process. If, before seeing a stimulus, the system must select one "describing" procedure, the description system includes a rather complex control and decision mechanism and its performance can not be rapid.

Employing this hypothesis, the present theory explains different phenomena without assuming the different settings of judgment criteria on a similarity scale. In most cases, the criteria are assumed to be constant. In pattern matching or recognition experiments, I doubt the assumption that criteria can be freely adjusted at specific points, because it implies another implicit assumption. The implicit assumption states that subjects can use very efficient intuitive statistics to determine the criteria which are adequate in an individual situation (or experimental task). Of course, an ability of intuitive statistics can not be denied, but the statistics does not agree with the normative model. Even for the technicians of mathematical statistics, the intuitive judgments of probability deviate widely from the normative theory (see Tversky & Kahneman, 1971).

It should be noted that in signal detection experiments, it had been demonstrated that subjects can alter their response criterion (e.g., Tanner & Swets, 1954). However, the subjects in these experiments were not asked to adjust multiple criteria. They only tried to decrease either the miss or false alarm rate when they are asked to do so. On the other hand, in "same"-"different" jufgment, subjects are instructed to respond as accurately and rapidly as possible.

If different criteria settings explain different phenomena, this explanation implies that subjects adjust differently in individual experiments. That is, they ought to adjust each of several criteria (e.g., three criteria: Ratcliff, 1985) at the spcific point which warrants some likelihood ratio. Note that if they use groundless criterion values, their responses could be neither rapid nor accurate. Accordingly, such a multiple-criteria theory must assume that the matching mechanism can simultaneously identify two probability distributions (one for "same" and one for "different"). The distributions depend on the individual stimulus set employed in each experiment. The mechanism hence can not identify distributions until it performs a number of trials.

Note that the tail areas of the distributions are most important, since subjects must adjust their criteria somewhere within the tails. If not, their responses will be erroneous. Because the distributions are not uniform, samples from the tails are relatively few. The subjects' estimation of the tails hence is unreliable even after a large number of trials. If employed stimulus sets consist of multiletter strings or figures whose attributes have some interdependency, the statistical work becomes harder. During early trials, then, one subjects' estimation of the tails and criteria used will not necessarily agree with each other subject's estimation. The agreement will, however, appear in later trials, since all of them will have accumulated enough statistical data to determine the distributions.

If the typically-found "fast-same" phenomenon really depends on such multiple-criteria setting, the across-subject mean of reaction time will typically show the phenomenon during later trials, rather than during early trials. As it is, the reaction times in Proctor and Rao (1983, Experiments 1 and 3) showed greater "same"-"different" disparity in the experimental session 1 than in the session 2. It should be noted that the "same"-"different" disparities of errors were identical in both sessions. This result brings the multiple-critera theories into question. The present theory, then, employs another principle. (cf. Ratcliff, 1985; Proctor, 1986; and see Krueger, 1985, in which Krueger states a criterion inertia model.)

5. Naming and Abstract Categorization.

In the present theory, the categorizer receives all the descriptions from the descriptor. The categorizer selects descriptions which are consonant with a knowledge base and a specific purpose. It thus achieves some categorization of stimuli.

That is, it produces abstract descriptions. If this system is like a current computer, such a categorization procedure would be very complex; but it would not be so for some parallel distributed processing (PDP) (e.g., Harmony theory by Smolensky, 1986). The descriptions produced by the categorizer designate conceptual "roles" (these "roles" are identical to Hofstadter's "role;" see Hofstadter, 1985, p.279).

The point is that we must consider how to recognize the huge number of variants of letter fonts, hand-written letters, and lettering arts, for example. The nested multiple-description system shows high flexibility when it recognizes letters.

This categorizer is assumued to have greater controllability than the descriptor. The following experiment suggests this assumption. In a tachistoscopic identification experiment, Corcoran and Rouse (1970) found that the response accuracy was lower when both typed- and hand-written words were presented within an exprimental block than when they unmixed. On the other hand, the mixing of different letter cases (or different "hand") did not affect accuracy when the typed- and hand-written ones were not mixed. This phenomenon hence can not be attributed to the different number of stimuli but to the number of an abstract categories. Obviously such abstract information, 'typed' or 'hand written,' helps the categorizer performance.

Nested Multiple-description Theory.

The nested multiple-description theory assumes two processes, a descriptor and a categorizer (see Figure 1). The descriptor utilizes four subprocesses which have different resolution levels (Level 1 to Level 4). The categorizer classifies the descriptions produced by the descriptor into cognitive categories.

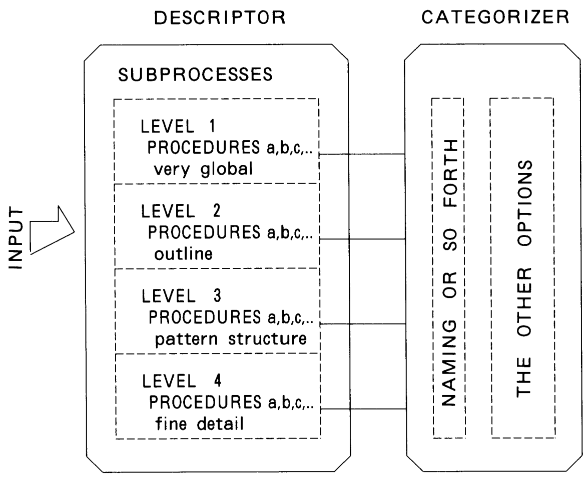

Figure 1. System architecture of Nested Multiple-description theory.

1. Descriptor

Subprocesses. Basic assumptions about the descriptor subprocesses are summarized in Table 1: (1) Level 1 describes the categorical size of stimulus and global linearity (or curvilinearity). This subprocess also controls a size scaling mechanism. (2) Descriptions produced by Level 2 represent the outline of stimulus (i.e., 'boxness,''circleness,''triangleness,' and so forth) as well as other global features (un-filled figure, filled figure, and so forth). (3) Level 3 delineates stimulus structure, but this can specify neither slight skew nor tiny ornaments of letters or objects. (4) Level 4 describes enough fine details to specify a clear visual image.

When many letters are presented together in the same visual field, two subprocesses, Level 1 and Level 2 can not discriminate proximal letters, because their resolution levels of anlysis are low. Consequently, they integrate the letters as a whole. On the one hand, Level 3 describes

Table 1
Stimulus properties described by each subprocess.

level	described stimulus property
1	categorical size global linearity or curvilinearity
2	outer shape (boxness, circleness...) and some other global features (un-filled circle, filled ciecle...)
3	internal structure (four-letter grouping)
4	fine description (letter-by-letter processing)

four letters as a group, and Level 4 describes items in a one-by-one manner. However, the value of the grouping limit in Level 3 increases with high familiarity (e.g., spelling pattern: Spoehr & Smith, 1975), as mentioned below.

Multiple-viewpoint description. Each individual subprocess simultaneously produces several descriptions for each stimulus pattern. These descriptions are based on various viewpoints; and a different set of symbolic units is used for producing each different description. All descriptions produced by one subprocess have the same resolution level of detail, according to the level of the subprocess. In short, the descriptor performs nested parallel processing. An individual subprocess produces several descriptions, while at the same time, concurrent subprocesses also proceed with their own processing.

Depending on capacity limitation, an individual subprocess can not simultaneously use all innate or learned "describing" procedures. Whereas perceptual learning increases the number of the "describing" procedures, previously learning procedures are not always needed in every day life. Several provide options, and as mentioned below, a perceptual set makes them active.

Processing speed of individual subprocess.

Describing a pattern structure necessitates a larger amount of information than describing such details as categorical size. Besides, informatin processing in brain should be accompained by internal noise (Krueger,1978). Consequently, descriptions produced by a higher-(sharper-) resolution subprocess stabilize later than those involving a lower-level one of resolution.

Automatism. Since ordinary recognition is very fast, it is assumed that descriptions produced by the descriptor are neither the results of top-down processing nor of hypothesis-confirmation procedure. Attending to stimuli makes the descriptor active. Even when observers know, for example, that all stimuli used are identical letters, no subprocess halts when the observers are attending to stimuli. Priming manipulations, such as the prepresentation of relevant stimulus, automatically modify each "describing" procedure, and each procedure temporarily includes a different technique of stressing important parts (e.g, Saito,1980).

On the one hand, mental set can alter active "describing" procedures. Although this is a cognitive performance, other descriptor performances are fairly automatic.

Capacity allocation. This particular theory assumes that each subprocess has its own resource capacity and that the capacity is constant when an arousal level does not vary. Then, the resource value allocation for each "describing" procedure action decreases with the number of the procedures activated in an individual subprocess. This number will thus affect overt reaction time. (Short-term learning modifies the number, see below.) This assumption is similar to Kahneman's (1973) attention theory. However, contrary to his general theory, software does not control the values. Within each subprocess, the allocation is automatic and despends on the number of the procedures involved (also see Norman & Bobrow, 1975).

2. Categorizer

The categorizer receives all descriptions produced by the descriptor and selects those which match both a given knowledge base and a specific purpose. Using them, it produces descriptions which designate abstract categories. The categorizer thus controls an overt response.

This categorizer is more *cognitive* than the descriptor. Higher control can easily add categorization procedures employed within a particular situation (e.g., the odd-ness of number, the types of facial expressions, or so forth).

The Derived Characteristics of the Present Theory and Predictions.

In the present theory, "same"-"differnt" judgment results from the search for correspondence between descriptions. Each subprocess of the descriptor produces two sets of descriptions, one set for each of two simuli. When "same"-"different" judgment is needed, it searches across the two sets. Each individual subprocess then cries "same !" when it finds a correspondence between descriptions. All descriptions produced by a given subprocess are the result of identical-resolution analyses, and any-viewpoint match is acceptable as that-level "sameness" (though different viewpoint descriptions help identification by the categorizer). For example, "sameness" of Level 2 involves outline and openness match while that of Level 3 entails structure match, and so forth. The criterion value of judgment is assumed to be constant in most predictions.

Level 3 identifies the roles main lines in each letter have. Identifying letters or "same-" "different" judgment for letter pairs is based on this-level descriptions, since such a judgment does not need Level-4 descriptions. Level-4 descriptions result from sharp-resolution analyses and express not only the main structure of the letter but tiny ornaments or slight skew as important attributes. This property is termed overquality. On the other hand, discrimination between similar but different fonts needs the Level-4 descriptions. The categorizer hence selects a level of "sameness," according to a specific purpose.

1. Effects of Experimental Manipulations on the Descriptions.

Table 2 shows the experimental variables which affect the quality of descriptions produced by the subprocesses. Although usually these experimental variables are not completely independent of each other, each factor affects the descriptions in its own manner. For example, complex stimuli tend to be similar to each other, but complexity must not be confused with similarity. Even when using simple stimuli, we can construct both similar and dissimilar pairs.

According to the assumptions about internal descriptions, types of difficulty in matching tasks are classified into three categories as follows: (1) Dissimilarity between stimuli will affect discriminability between their descriptions. (2) Four factors, complexity, familiarity, good configuration, and length of letter string influence the compactness of descriptions. High compactness refers to concise and compact descriptions (see Table 2). Great complexity makes compactness low while both high familiarity and good configuration make compactness high

Table 2
Experimental variables which affect descriptions.

experimental variables	effect on descriptions
dissimilarity +	discriminability +
familiarity +	compactness +
good configuration +	compactness +
complexity +	compactness +
length of letter string+	compactness − (except Level 4)
stimulus quality −	credibility −

+ denotes increase, and − decrease.

(e.g., spelling patterns, see Spoehr & Smith, 1975). When stimuli have the latter, descriptions consist of more efficient units. Long letter string results low compactness, though descriptions at Level 4 is the exception, because this level subprocess describes stimuli in a letter-by-letter manner. (3) Low stimulus quality will decrease the credibility of the descriptions.

Percetual priming. Under the simultaneous-presentation condition, inter-item bilateral symmetry (see Fox, 1975; Richards, 1978) may affect comparison efficiency. The symmetry is formed by two identical stimuli. This enhances the "same"-"different" disparity, since this symmetry is specific to "same" stimulus pairs. However, this is not the primary cause of the phenomenon, because the disparity was found in various other stimulus displays. For example, in Richards' (1978) experiment, where stimulus display contained no inter-item symmetry, the disparity existed. Although a statistical test was not conducted, the difference was large. In addition, some studies found the disparity, using an above-and-below presentation method (e.g., Krueger, 1984; Reagan, 1981).

Under the sequential stimulus-pair presetation condition. the "fast-same" disparity is greater than that under the simultaneous one. Proctor (1981) attributed this difference to a priming effect; the processing of first-presented letter(s) eases the processing of second-presented one(s). In the present theory, the processing of first-presented letter(s) modifies the technique of stressing important parts in individual "describing" precedures. "Primed" procedures are used for second-presented letter(s), and stressing thus eases individual comparisons of the descriptions.

Mental set. Mental set affects reorganization of ambiguous or fragmented figure perception (see Steinfeld, 1967). This process is rather slow: We need much time to see a fragmented figure as a meaningful figure. The theory under consideration predicts this as follows: The descriptor does not have "describing" procedures which can describe such an artificially-fragmented figure as a whole. Whereas they can describe the fragments as sets of lumps, the resultant descriptions are not compact. At first sight, the descriptions denote many irregular fragments. When the instruction is given which says "this is a meaningful picture," the categorizer constructs several hypotheses (new "describing" procedures) and makes the descriptor use these new procedures. When receiving new descriptions, the categorizer checks whether the new descriptions can be classified into some meaningful set or not.

In such a situation, the descriptor must employ new "describing" procedures. According to capacity limitation, some standard procedures hence need to become temporarily optional. However, if the descriptor activates only fragmented-figure-oriented procedures, subjects can not recognize anything other than fragmented figures. In fact, we can recognize experimenter's face, even when trying to see the fragmented figures. Accordingly each hypothesis must be tested separately. Thus one identification takes a long time. When subjects have a prior mental set (for example, "this is a watch"), hypothesis testing is easier. Then recognition latency will thus be significantly shorter. Reorganization in geometrical problem solving is performed in the same manner.

Amateurs cannot recognize the locus of a peptic ulcer on X-ray film because their description system does not have an adequate "describing" procedure. Also, their categorizer can not construct a hypothesis which designetes how to describe the ulcer.

(A mathematical model of the present theory will be proposed in the next paper, and applications of the theory to other cognitive paradigms will be in the third paper.)

Footnote

1. There are some cases of multiple descriptions (representations). In a computer system for pattern recgnition, a program is capable of multi-level perceptoin: seven levels such as schemas, objects, volumes, and so forth (for review, see McArthur, 1982). In a geologic interpertation problem solver, a multiple representations of geological knowledge is used (Simmons, 1983). Each type representation in this program is specialized for a different reasoning task: qualitative and quantitative simulations. However, these were not constructed to explain psychological phenomena, and they are rather different from the present nested multiple-description hypothesis. As mentioned below, four levels of detail and seven different viewpoints are assumed, based on data from psychological experiments. These are not correspond to qualitative-quantitative classification nor the level differences such as schemas, objects, volumes, and so forth.

Abstract

The nature of "same"-"different" judgment is discussed, and then a theory of "same"-"different" judgment mechanism is proposed, theory which addresses a wide range of problems: ordinary matching tasks, size invariant matching, perceptual priming, mental set, disjunctive judgment task, and so forth. Multiple-description (multiple-viewpoint description system), search for correspondence between descriptions, multiple resolution levels of analysis, priming, and a categorization system are assumed. The self-terminating correspondence-search hypothesis explains the "fast-same" phenomenon.

References

Ambler, B.A., & Proctor, J. (1976). The familiarity effect for single-letter pairs. *Journal of Experimental Psychology: Human Perception and Performance.* **2**, 222-234.

Anderson, J.R. (1983) *The architecture of cognition.* Cambridge: Harvard University Press.

Atkinson, R.C., Holmgren, J.R., & Juola, J.F. (1969). Processing time as influenced by the number of elements in a visual display. *Perception & Psychophysics*, **6**, 321-236.

Bamber, D. (1969). Reaction time and error rates for "Same"-"different" judgments of multi-dimensional stimuli. *Perception & Psychophysics*, **6**, 169-174.

Bamber, D. (1972). Reaction times and error rates for judging nominal identity of letter strings. *Perception & Psychophysics*, **12**, 321-326.

Cleaves, E. T. (1977). Comparison of reaction time patterns in a sequential visual recognition task with simple geometric forms. *Perception & Psychophysics*, **22**, 191-200.

Corballis, M., Lieberman, W., & Bindra, D. (1968). Discriminability and central intermittency in Same-Different judgment. *Quarterly Journal of Experimental Psychology*, **20**, 51-61.

Corcoran, D.W.J., & Rose, R.O. (1970). An aspect of perceptual organization involved in reading typed and handwritten words. *Quarterly Journal of Experrimental Psychology*, **22**, 526-530.

Cunningham, J.P., Cooper, L.A., & Reaves, C.C. (1982). Visual comarison processes; Identity and similarity decisions. *Perception & Psychophysics*, **32**, 50-60.

Czigler, I. (1985). Matching of facial features: Continuous processing, improper filtering, and wholistic comparison. *Perception & Psychophysics*, **37**, 257-265.

Decker, L.R. (1974). The effect of method of presentation, set, and stimulus dimensions on "same"-"different" reaction times. *Perception & Psychophysics*, **16**, 271-275.

Earhard, B., & Walker, H. (1985). An "outside-in" processing strategy in the perception of form. *Perception & Psychophysics*, **38**, 249-260.

Egeth, H., & Blecker, D. (1971). Differential effects of familiarity on judgments of sameness and differenece. *Perception & Psychophysics*, **9**, 321-326.

Farell, B. (1985). "Same"-"different" judgments: A review of current controversies in perceptual comparisons. *Psychological Bulletin*, **98**, 419-456.

Fox, J. (1975). The use of structural diagnostics in recognition, *Journal of Experimental Psychology; Humman Perception and Performance*, **104**, 57-67.

Garner, W.R., Podgorny, P., & Frasca, E. M. (1982). Physical and cognitive dimensions in stimulus comparison. *Perception & Psychophysics*, **31**, 507-522.

Hinton, G.E., & Anderson, J.A. (1981). *Parallel models of associative memory*. Hillsdale, New Jersey: Lawrence Erlbaum.

Hock, H.S. (1973). The effect of stimulus structure and familiarity on same-different comparison. *Perception & Psychophysics*, **14**, 413-420.

Hock, H.S., & Marcus, N. (1976). The effect of familiarity on the processing of fragmented figures. *Perception & Psychophysics*, **20**, 375-379.

Hoffman, J.E. (1980). Interaction between global and lacal levels of a form. *Journal of Experimental Psychology: Human Perception and Performance*, **6**, 222-234.

Hofstadter, D.R. (1985). *Metamagical themas: Questing for the essence of mind and pattern.* New York: Basic Books.

Hubel, D.H., & Wiesel, T.N. (1962). Receptive fields, binocular interaction and functional architecture in the cat's visual cortex. *Journal of Physiology*, **160**, 160-154.

Ingling, N.W. (1972). Categorization: A mechanism for rapid information processing. *Journal of Experimental Psychology*, **94**, 239-243.

Kahneman, D. (1973). *Attention and effort.* Englewood Cliffs, New Jersey: Prentice-Hall.

Kanizsa, G. (1979). *Organization in vision: Essays on Gestalt perception.* New York: Praeger Publishers.

Keuss, P.J.G. (1977). Processing of geometrical dimensions in a binary classification task: Evidence for a dual process model. *Perception & Psychophysics*, **21**, 371-376.

Kintsch, W. (1974). *The representation of meaning in memory*. Hillsdale, New Jersey: Lawrence Erlbaum.

Knapp, A.G., & Anderson, J.A. (1984). Theory of categorization based on distributed memory storage. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 10, 616-637.

Kohonen, T. (1977). *Associative memory*. Berlin, Heidelberg: Springer Verlag.

Krueger, L.E. (1973). Effect of irrelevant surrounding material on speed of same-different judgment of two adjacent letters. *Journal of Experimental Psychology*, **98**, 252-259.

Krueger, L.E. (1978). A theory of perceptual matching. *Psychological Reveiw*, **85**, 278-304.

Krueger, L.E. (1984). Self termination in Same-different judgments: Multiletter comparison with simultaneous and sequential presentation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **10**, 271-284.

Krueger, L.E. (1985). Effect of intermixed foveal and parafoveal presentation on *same-different* judgments: Evidence for a criterion inertia model. *Perception & Psychophysics*, **37**, 266-271.

McArther, D.J. (1982). Computer vision and perceptual psychology. *Psychological Bulletin*, **92**, 283-309.

Maffei, L. (1985). Complex cells control simple cells. In D. Rose & V.G. Dobson (Eds), *Models of the visual cortex* (pp.334-340). London: John Wiley & Sons.

Marr, D. (1982). *Vision: A computational investigation into the human representation and procesising of visual information*. San Francisco: W.H. Freeman and Company.

Navon, D. (1977). Forest bofore trees: The precedence of global featuers in visual perception. *Cognitive Psychology*. **9**, 353-384.

Nickerson, R.S. (1973). Frequency, recency, and repetition effects on same and different response times. *Journal of Experimental Psychology*, **101**, 330-336.

Nickerson, R.S. (1978). On the time it takes to tell things apart. In J. Requin (Ed). *Attetion and Pefoemance VII* (pp. 77-88). Hillsdale, New Jersey: Erlbaum.

Norman, D.A., & Bobrow, D.G. (1975). On data-limited and resource-limited precesses. *Cognitive Psychology*, **7**, 44-64.

Palmer, S.E. (1975). Visual perception and world knowledge: Notes on a model of sensory-cognitive interaction. In D.A. Norman & D.E. Rumelhart (Eds), *Explorations in cognition* (pp. 279-307). San Francisco: W.H. Freeman and Company.

Palmer, S.E. (1977). Hierarchical structure in perceptual representation. *Cognitive Psychology*, **9**, 441-474.

Palmar, S.E. (1980). What makes triangles point: Local and Global effects in configurations of ambiguous triangles. *Cognitive Psychology*, 12, 285-305.

Pomerantz, J.R. (1978). Are complex visual features derived from simple ones? In E.L.J. Leeuwenberg & H.F.J.M. Buffart (Eds), *Formal theories of visual perception* (pp. 217-229). New York: John Wiley & Sons.

Pomerantz, J.P., Sager, L.C., & Stoever, R.J. (1977). Perception of wholes and their component parts: Some configural superiority effects. *Journal of Experimental Psychology: Human Perception and Performance*, **3**, 422-435.

Posner, M.I. (1978). *Chronometric explorations of mind*. Hillsdale, New Jersey: Lawrence Erlbaum.

Proctor, R.W. (1981). A unified theory for matching task phenomena. *Psychological Review*, **88**, 291-326.

Proctor, R.W. (1986). Response bias, criteria settings, and the fast-same phenomenon: A reply to Ratcliff. *Psychological Review*, **93**, 473-477.

Proctor, R.W., & Healy, A.F. (1985). Order-relevant and order-irrelevant decision rules in multiletter matching. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **11**, 519-537.

Proctor, R.W., & Rao, K.V. (1983). Null effects of exposure duration and heterogeneity of difference on the *same-different* disparity in letter matching. *Perception & Psychophysics*, **33**, 163-171.

Ratcliff, R. (1981). A theory of order relations in perceptual matching. *Psychological Review*, **88**, 552-572.

Ratcliff, R. (1985) .Theoretical interpretation of the speed and accuracy of positive and negative responses. *Psychological Review*, **92**, 212-215.

Reagan, J.E. (1981). Effect of familiarity on multielement matching. Journal of Experimental Psychology: Human Perception and Performance, **7**, 1273-1282.

Richards, J.T. (1978). Interitem structure and the facilitation of simultaneous comparison. *Journal of experimental Psychology: Human Perception and Performance*, **4**, 72-87.

Rumelhart, D.E., McClelland, J.L., & the PDP group. (1986) *Parallel distributed processing: Explorations in the microstructure of cognition, Vol. 1: Foundation.* Cambridge: The MIT Press.

Saito, M. (1980). Perceptual set and selective information processing. *The Japanese Journal of Psychology*, **51**, 1-8.

Shepard, R.N., & Metzler, J. (1971). Mental rotation of three dimensional objects. *Science*, 171, 701-703.

Silverman, W.P. (1973). The perception of identity in simultaneously presented complex visual displays. *Memory & Cognition*, **1**, 459-466.

Silverman, W.P., & Goldberg, S.L. (1975). Further confirmation of same vs. different processing differences. *Perception & Psychophysics*, **17**, 189-193.

Simmons, R.G. (1983). Representing and reasoning about change in geologic interpretation (Technical rept.) MIT Artificial Intelligence Lab. Report No. : AI-TR-749.Master's thesis.

Smolensky, P. (1986). Information processing in dynamical systems:Foundations of harmony theory. In D.E. Rumelhart, J.L. McClelland, & the PDP research group (Eds), *Parallel distributed processing: Explorations in the microstructure of cognition, Vol. 1 : Foundation* (pp. 194-281). Cambridge: The MIT Press.

Snodgrass, J.G. (1972). Matching patterns vs matching digits: The effect of memory dependence and complexity on "same"-"different" reaction times. *Perception & Psychophysics*, **11**, 341-349.

Spoehr, K.T., & Smith, E.E. (1975). The role of orthographic and phonotactic rules in perceiving patterns. *Journal of Experimental Psychology: Human Perception & Performance*, **104**, 21-34.

Steinfeld, G.J. (1967). Concepts of set and availability and their relation to the reorganization of ambiguous pictorial stimuli. *Psychological Review*, **74**, 505-522.

Sternberg, S. (1969). The discovery of processing stages: Extensions of Donder's method. In W. G. Koster (Ed), *Attention and Performance I* (pp. 276-315). Amsterdam: North Holland.

Tanner, W.P.JR., & Swets, J.A. (1954). A decision making theory of visual detection. *Psychological Review*, **61**, 401-409.

Taylor, D.A. (1976). Holistic and analytic precesses in the comparison of letters. *Perception & Psychophysics*, **20**, 187-190.

Tolhurst, D.J. & Dean, A.F. (1985). Are simple cells and complex cells distinctly different? In D. Rose & V.G. Dobson (Eds), *Models of the visual cortex* (pp. 320-325). London: John Wiley & Sons.

Tversky, B. (1969). Pictorial and verbal encoding in a short-term memory task. *Perception & Psychophysics*, **6**, 225-233.

Tversky, a., & Kahneman, d. (1971). Belief in the law of small numbers. *Psychological Bulletin,* **76,** 105-110.

Well, A.D., Pollastek, A., & Schindler, R.M. (1975). Facilitation of both "same" and "different" judgments of letter strings by familiarity of letter sequence. *Perception & Psychophysics*, **17**, 511-520.

(1995年12月１日　受理)