

Cognitive Psychology Laboratory

Edward L. DeLosh & Paul S. Merritt

Colorado State University

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PATTERN RECOGNITION

One of the most basic and natural of our human skills is the ability to recognize and identify incoming stimuli, a process known as pattern recognition. Pattern recognition involves the comparison of external, environmental stimuli to stored information about past experiences. It is through this comparison process that we come to recognize a stimulus as familiar, identify the stimulus, and thereby give meaning to that stimulus. Thus, the process of pattern recognition is central to our ability to understand and interpret incoming information.

Despite its central importance in giving meaning to our environment, the ability to recognize patterns is something that we often take for granted. This is because pattern recognition comes to us so easily. We are able to recognize a virtually unlimited number of items readily and with seemingly little or no cognitive effort. In fact, the process usually occurs so quickly and automatically that we are not even cognizant that any type of processing has taken place. But do not let the ease of pattern recognition fool you—this is a truly exceptional feat.

Consider our ability to recognize handwriting. Unless handwriting is especially illegible, we have little trouble reading it. Yet there is tremendous variability in handwriting. Sometimes words are printed, sometimes they are written in cursive, sometimes there is a mixture of printing and cursive. Plus upper- and lower-case letters look quite different, and both cases can take on a number of distinct forms (e.g., see Figure 3-1). Moreover, there are extreme differences in individual styles of handwriting; people vary extensively with regard to the angle, flow, weight, and thickness of their writing. Nonetheless, we read these very different forms and styles with considerable ease.

As a testament to just how remarkable this is, realize that the most powerful computers today, using the most sophisticated software available, still fair quite poorly at deciphering handwriting. In fact, they make frequent errors when attempting to recognize the handwriting of just *one* person, even with training and experience with that person's writing!

So what is it that underlies this amazing ability? What is the process that leads to recognition and identification? How is it that visually distinct patterns are perceived as one and the same? And how is it that something so complex comes to us so easily?

Cognitive psychologists have long been intrigued by such questions and have proposed several possible explanations, some based on templates, others based on features, and still other based on relations among features. Here we will consider two of the most popular views: template-matching theory and feature-detection theory.

Template-Matching Theory

According to **template-matching theory**, an incoming stimulus is compared to specific patterns (or templates) that have been stored in memory in an attempt to find a good match. When a good match is found, the stimulus is identified based on that match. For example, assume a visual pattern is presented and it consists of two oblique lines that meet at the top and a horizontal line that connects the oblique lines in the middle. According to the theory, this pattern is compared to a wide variety of templates stored in memory. A good match would occur when the pattern is compared to the template for the capital letter A. At that point, the stimulus would be recognized and identified as an A.

The template-matching view is simple and intuitive, and we know that such a system is capable of accurately recognizing patterns. After all, banking firms use template-matching devices in order to identify the digits at the bottom of checks. But note that in order for this recognition device to be successful, very distinct digits must be used (this is why the numbers on checks look so peculiar). The question, then, is whether we as humans recognize and identify stimuli in the same fashion, given the tremendous pattern variability that we face in our daily lives.

As it turns out, template-matching theory has great difficulty with pattern variability. All of the patterns shown in Figure 3-1 are readily recognizable as the letter A. However, the only way a template-matching model is assured of performing accurately across such variations is if there are many templates in place to accommodate the variety of patterns. Why? Assume that the pattern at the top of Figure 3-1 is the template for A. You can see that some of the other patterns in the figure do not match this template very well. To overcome problems of this sort, template-matching theory requires many different templates of the pattern A (and all other patterns).

Figure 3-1. Some variations in form and style for the letter A.



Similarly, numerous templates are necessary to handle variations in size and orientation (so that an A rotated 30 degrees would still be recognized as an A, for instance). When you multiply the huge number of unique patterns that we can identify times the many possible variations of those patterns—variations in form, style, size, and orientation—you can see that a virtually unlimited number of templates would be required for accurate recognition. Many theorists believe that such a large number of stored templates is unreasonable.

Even more damaging to template-matching theory is the fact that it does not allow for different interpretations of the same stimulus. Yet we know that the interpretation of a stimulus varies depending on the situation, a person's perspective, their mood, etc. A famous example is the drawing that can be interpreted as either a vase or two people facing one another. Similarly, template-matching theory can not account for **context effects** in which the same stimulus is interpreted differently depending on its surroundings. In Figure 3-2, the middle patterns in the two words are identical, yet one is interpreted as an H and the other as an A.

Feature-Detection Theory

Due to the shortcomings described above, an alternative explanation of pattern recognition was developed. This explanation, known as **feature-detection theory**, was designed to accommodate pattern variability by focusing on common elements across different instances of an object. The theory proposes that we break a stimulus down into its component features and then use these features to infer the identity of the stimulus.

The idea is that each type of pattern is stored as a set of features and an associated label. A presented stimulus is compared to this stored information and is identified according to the best match. Specifically, the number of common features between the stimulus and each stored item is determined. Then the stimulus is assigned the label corresponding to the set of features that produces the greatest feature overlap. For instance, the pattern “E” might be stored as the set of features {vertical line, three horizontal lines} and would be associated with the sound “eee,” our label for this pattern in the English language. If a stimulus with the same features is presented, it would most likely be labeled “eee” due to a perfect match of features.

Some experimental evidence supports this view. A logical prediction of feature-detection theory is that patterns with similar features (e.g., *E* and *F*) should be mistaken for one another more often than patterns with dissimilar features (e.g., *E* and *W*). That is, the rate of **perceptual confusions** should reflect the number of features that stimuli have in common. This has been observed in a number of experiments (e.g., Geyer & DeWald, 1973; Garner, 1979; Townsend, 1971). Similarly, when deciding if pairs of letters are the same or different, it takes longer if the letters share many features than if they share few features (Gibson, Schapiro, & Yonas, 1968).

For the current project, you will participate in a classic letter detection experiment that examines a prediction very similar to the one discussed above, and as such, further tests feature-detection theory. Follow the directions given on the preceding page to complete the experiment, using the answer sheet given below.

Figure 3-2. Demonstration of the effect of context on pattern recognition.



TAE CAT

DESIGN AND LOGIC OF EXPERIMENT

The experiment you just completed is a modified version of Neisser's classic work using the visual search task (Neisser, 1964, 1967). In Neisser's original experiments, blocks of letters were presented and participants had to find a specified target letter within this block as quickly as possible. Response time was the measure of interest. In our variation of this task, you had to find a designated target letter and list the letter immediately after it while under time pressure. Accuracy is our measure of interest. Neisser's experiments and our experiment both included two experimental conditions. In one condition, the target letter shared several features with the surrounding background letters (feature-similar background). For example, if the target letter was O, the background consisted of other rounded letters such as Q, D, and G. In a second condition, the target letter shared few features with the set of background letters (feature-dissimilar background). In this case, the background letters for a target of O were angular letters such as V, X, and Y.

The logic behind the experiment is as follows: if pattern recognition occurs through feature detection, it should be more difficult to detect the target letter among items with similar features than among items with dissimilar features. That is, the feature-similar background should produce more perceptual confusions than the feature-dissimilar background. In Neisser's experiments, this would be indicated by slower search time for similar backgrounds relative to dissimilar backgrounds. In our experiment, this would be revealed by reduced accuracy for similar than for dissimilar backgrounds.

The manipulation discussed above is the central focus of the experiment, but there are a couple of additional design features worth noting. As you would expect, search time depends on the location of the target letter within the array: the further the target is placed down and to the right, the greater the reaction time. In order to prevent this factor from skewing the results, target location was matched across the two experimental conditions. That is, if a target letter occurred in the ninth row, third column for one of the dissimilar-background trials, then a target letter would also occur in the ninth row, third column for one of the similar-background trials. On average, then, target location was equivalent for the similar- and dissimilar-background conditions.

In addition, two different target letters were used: the rounded letter Q and the angular letter Z. For the target Q, the dissimilar background consisted of E, I, M, V, W, and X; the similar background consisted of C, D, G, O, R, and U. For the target Z, the dissimilar background consisted of C, D, G, O, R, and U; the similar background consisted of E, I, M, V, W, and X. The reason for including two different target letters was to ensure that the results were not specific to a particular letter.

Finally, the order of presentation for similar versus dissimilar trials was randomized. This is much preferred over blocking the two types of trials together. If trials were blocked so that the first twenty represented one condition and the second twenty another condition, then any observed differences between backgrounds could be due to those backgrounds *or* to the order of presentation. Consider one reasonable possibility: if dissimilar trials were presented last, an advantage for those trials could be due to lower feature overlap, but this finding could also be due to improvement with practice. In fact, some research shows that practice does have a significant effect on visual search time (Neisser, 1964). So when designing or evaluating an experiment, even seemingly unimportant features like presentation order should be considered.

CLASSIC FINDINGS

In Neisser's (1964) original experiment, he found that the background manipulation did reliably influence the speed of search. Specifically, the experiment showed that the letter Z was detected much faster when displayed in the context of rounded letters than when displayed in the context of angular letters. In fact, search time was about twice as fast for the dissimilar-background condition than for the similar-background condition. Based on this finding, Neisser suggested that searching a visual array is based primarily on the detection of distinctive features.