Finke, R. A. & Freyd, J. J. (1994) Imagery. In R. Sternberg (Ed) Encyclopedia of Intelligence (pp. 561-63). New York: Macmillan Publishing Company.

IMAGERY Imagery refers to the mental depiction or re-creation of people, objects, and events that are not actually present. By closing one's eyes and generating the appropriate image, for example, one can imagine the face and voice of a best friend, how appliances are arranged in a kitchen, or the manner in which an elephant runs. The experience of imagining something is similar in many respects to that of actually perceiving something, and, in some cases, the image can be exceptionally clear and vivid.

Imagery can also be used to envision things that are merely hypothetical. For example, a person can imagine a creature consisting of the head of a chicken and the body of a lion, and even explore how that creature might behave—although nothing of the sort actually exists. Imagery can thus be used not only to retrieve past experiences, as when recalling how one's room looked when one was a child, but also to explore new possibilities.

There are many practical uses of imagery in everyday life. One can imagine the best route for getting to work or school, novel ways of using tools, or creative things to do on a vacation. Imagery can even be helpful in such common activities as cooking a meal. For example, one might imagine the likely texture, taste, and appearance of a favorite chocolate cake if the recipe were modified to include three additional egg whites.

Clearly, imagery is of considerable value in a variety of activities. But how, exactly, does imagery contribute to what we think of as intelligence? What aspects of intelligence are influenced by imagery? To address these questions, we consider some of the most important functions of imagery, which have been explored in recent experimental studies.

FUNCTIONS OF IMAGERY

Mental Image Scanning. When one is asked about the physical characteristics of something, such as its size or features, it often helps to retrieve an image and to imagine scanning it. For example, suppose someone asked you whether Abraham Lincoln had bushy eyebrows. Although few people would have ever learned this as an explicit fact about Lincoln, most could answer the question by imagining that they were looking at a picture of Lincoln and inspecting his eyebrows.

Retrieving and scanning an image facilitates what is called *crystallized intelligence*—the ability to recall useful information when needed. How quickly this can be done depends on several factors. Studies have found that the time it takes to imagine scanning from one feature of an image to another increases in proportion to the distance scanned, as if one were actually scanning a real picture or object (Kosslyn, Ball, & Reiser, 1978). In an image, as in a real object, it takes longer to find a small feature than to find a large feature (Kosslyn, 1975). For example, it is easier to tell what an elephant's eyes look like if you imagine that the elephant is standing next to you, as opposed to standing on a distant hill. These and other studies on mental image scanning are reviewed in Kosslyn (1980).

Mental Rotation. Imagery can also be used to mentally rotate objects or patterns. This serves three functions. First, it can help one to identify pictures or objects that appear at unfamiliar orientations, as when a photograph is turned around. Second, it enables one to mentally align objects that are at different orientations, to see how their shapes or other features might correspond. Third, it can help one to become properly oriented within one's environment. For example, if you were lost, and remembered looking at a map that was oriented the wrong way, you could imagine turning the map around in order to use it. These imagery skills bear on what is called *fluid intelligence*—the ability to see relationships and solutions to problems that were not previously learned.

In general, mental rotations are performed at a constant rate, with larger angles of rotation requiring more time to complete (Shepard & Metzler, 1971). With practice, most people can become proficient at using mental rotation, irrespective of the complexity of the imagined pattern or form (Cooper & Podgorny, 1976). In addition to mental rotation, other types of mental transformations have been explored, including imagined changes in the size and shape of objects. Studies on imagined rotations and transformations are reviewed in Shepard and Cooper (1982).

Mental Extrapolation. Another important function of imagery is to anticipate continuations of motions. For example, if a moving object passes momentarily out of view, one can imagine where and when the object will reappear by imagining how its motion would continue. These *mental extrapolations* are especially useful in complex activities, such as driving a car or performing in an athletic event, where one needs to anticipate and remember the consequences of one's actions. They bear on an aspect of intelligence known as *motor skills*.

Recent studies have explored the mental extrapolation of movement and its effect on one's memory. When a stimulus display implies a simple rotation of a pattern, an observer's memory for the orientation of the pattern is shifted forward, in the direction of the implied rotation. This phenomenon, called *representational momentum* (Freyd & Finke, 1984), occurs with both auditory and visual stimuli. As with physical momentum, representational momentum is proportional to the implied velocity of the motion. These memory shifts can also occur with static stimuli, such as photographs. Freyd (1987) has suggested that the images we form have an inherent dynamic quality, which we can use to anticipate future events.

Creative Mental Synthesis. One of the most creative uses of imagery is to imagine putting old things together in new ways, to see what might result. Often, the discoveries are quite surprising and unexpected. For example, suppose you had a basketball, a yardstick, a flat sheet of plywood, and some glue. What kinds of interesting things could you make by combining these objects? The ability to imagine new combinations of things is called *mental synthesis*, and it plays an important role in *creative intelligence*.

Studies on mental synthesis have shown that most people are able to make creative discoveries by using imagery. When instructed to imagine combining letters, numbers, and other simple patterns, people can often come up with strikingly creative patterns and symbols (Finke & Slayton, 1988). When imagining combinations of three-dimensional object parts, people can often discover new inventions that could potentially be developed and marketed (Finke, 1990). These images can also be interpreted in more abstract ways, representing, for example, novel concepts in scientific fields. Studies on mental synthesis and their creative implications are reviewed in Finke (1990).

Problem Solving. A further way in which imagery contributes to intelligence is through the use of images to solve various types of problems. In trying to solve a mystery, for instance, it helps to visualize how all the clues could be put together. This is an example of what is called *convergent thinking*, the ability to see the underlying structure that connects many things.

Another type of problem-solving skill that imagery can facilitate is that of finding unusual uses for common objects. For example, one might imagine using a brick as a paperweight, a foot warmer, or an emergency hammer. This ability to think of unusual or unconventional possibilities is called *divergent thinking*.

Imagery can also be useful in helping one to construct *mental models* of physical or conceptual systems (Johnson-Laird, 1983). Suppose, for example, one were trying to understand how a car engine worked. One could construct an image representing a possible

model for how the different parts of the engine might function and then evaluate the model. Mental models can help one understand difficult concepts, such as the theory of relativity, by incorporating visual or spatial analogies that are easier to comprehend. Reviews of the various functions of imagery in problem solving can be found in Finke, Ward, and Smith (1992).

CONCLUSIONS

What is it about imagery that makes it so different from other forms of mental representation and allows it to make these distinctive contributions to intelligence? First, most theories of imagery assume that images draw on perceptual knowledge and relations that are not normally available when one is merely retrieving facts about something (Finke, 1979). Second, images represent this information in a coherent, accessible manner that allows new and often complex relations to be recognized quickly and efficiently (Kosslyn, 1980). Third, images exhibit a flexibility that is often absent in other forms of mental representation (Finke, 1989). There is even evidence that certain parts of the brain are specifically designed to generate images and to discover the intricate relationships and possibilities they depict (Kosslyn, 1987).

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