Faculty Forum

You Cannot Conceive The Many Without The One
-Plato-

Issue No. 13 Spring 2010

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THE IMPORTANCE OF BEING WRONG:

WHAT ERRORS CAN TEACH US ABOUT PERCEPTION AND MEMORY

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In most situations in life, people value getting the right answer—in short, accuracy. However, when studying the human mind, psychologists often find errors much more interesting than accuracy. The underlying reason for this preference lies in the fundamental problem of the scientific study of the mind. In order to study a phenomenon scientifically, a researcher has to be able to observe repeatedly the phenomenon in an objective way. The requirement of objective observation has long challenged psychologists who are interested in human cognition (i.e., thought processes) because researchers cannot directly observe another person's thought, perception, or memory. We cannot see these processes happening in others, and very often we are not aware how they are happening in our own minds.

When people answer a question accurately, their accuracy shows that they used useful mental processes, but it does not give much information about what these processes are like. However, if we find a situation in which people consistently make the same type of error, this error is probably the result of the mental process. The best examples of such errors are perceptual illusions. When people look at a visual stimulus, typically a picture, and see something that is not actually there, where is that "something" coming from? It is not in the picture, so it must be in the viewer's mind. The illusion, an error of perception, is a result of the process the mind uses to perceive the picture. By examining the error, the thing "seen" that is not actually there, we can learn about the mind's process.

The importance of errors is not limited to learning about perception. Psychologists also find errors useful in studying memory processes. For example, in 1981 William Brewer and James Treyens showed that people's memory for particular objects is affected by the mental representation they have for the type of place they are in. Brewer and Treyens asked people to wait in a graduate student's office. When these people left the office, they were asked whether certain objects were present in the room they had just left. People systematically made certain errors. For example, most people remembered seeing books in the office; there were no books there. On the other hand, they didn't remember seeing a skull; the skull was there.

Psychologists interpreted this behavior in the following way. People have a mental representation, or a schema ("place schema"), which lists the objects that are typically found in graduate students' offices (desks, chairs, computers, books, etc.). When the participants in Brewer and Treyens's experiment were trying to remember what was in the specific office that they just left, they used this schema to help rebuild their memories. Because the "place schema" contained a slot for books, they remembered seeing books even though books were not present. The schema did not have a slot for skulls (psychology graduate students are not expected to have human skulls in their offices), so when rebuilding the memory, the schema could not help them find the memory for the skull.

Despite the apparent logic of this argument, one study cannot provide enough evidence to support the existence of these place schemas. However, multiple studies show the same clear pattern of errors: people mistakenly remember books in offices (but not in street scenes), fire hydrants in street scenes (but not in living rooms), etc. The probability that these errors come from mental schemas and that they are a result of people's use of such schemas is therefore very high.

<u>Using errors to study the mental representation of spatial layout</u>

Psychologists around the world have been using errors to study another aspect of human information processing: how we understand, represent, and interact with the spatial layout of the world around us. Spatial layout refers to the placement, organization, and orientation of objects and surfaces. Right now, the spatial layout I can see consists of a desk with a wall behind it. On the desk, a computer occupies most of the space in the center, with a keyboard in front, and a stack of papers and books sit off to the right, and so on. The size and orientation of the computer, the wall, and all the other objects and surfaces I can see, and their relative positions, constitute the scene's layout.

Understanding the layout of the world around us is one of our most important abilities. We need this knowledge implicitly in any activity we carry out. When we reach for an object on a desk, we need to be aware of the surface of the desk and the organization of objects on it. When we move around, we need to be aware of the orientation of the floor, the organization of the furniture in the room, and of the rooms and halls in the house, etc. (If you have ever mistaken the number of stairs in a staircase, you know how painful the experience can be). Moreover, we often need to understand remote and even made-up locations in pictures and movies (for example, to follow events set in J.R.R. Tolkien's Middle Earth). How do we organize and use our knowledge of this spatial layout? Many researchers (e.g., Rensink, 2000) have proposed that viewers use specific mental representations, spatial layout schemas, to find and integrate information from our visual environment. But what are the characteristics of these layout schemas? Are they the same or different from other schemas (such as the place schemas described above)? What type of information do these schemas include? The answer to many of these questions can be found by looking at the errors people make when trying to remember space.

When people view a reasonable number of photographs (e.g., 20) and are later asked to draw sketches of what they saw from memory, they systematically make a very strange error. People typically draw the photograph quite well in terms of the objects present and the organization of the objects, but they often draw MORE of the scene than was actually shown in the picture. For example, imagine a photograph of a doll on a chair in front of the main building in Walterboro or the Original Classroom Building in Allendale. The photograph would probably show the doll, the chair, part of the lawn, part of the building, and part of the big oak tree, etc. When a person draws this photograph from memory, the drawing would show the doll and the chair pretty accurately, but it would show more of the lawn, more of the building, and more of the tree than was actually shown in the photograph. Indeed the drawing would look like a more wide-angle photograph than the photograph that the person actually saw, as if the camera was moved back to include more of the scene.

This memory error, remembering more of the scene than was actually perceived, was discovered in 1989 by Helene Intraub and Michael Richardson, who studied college students in Delaware. They labeled this error “boundary extension” (BE). BE was found in recognition tests as well as drawing from memory. It was also found in tests in which viewers were allowed to move the photograph’s boundaries in accordance with their memory; people consistently moved the boundaries farther out than they had actually been. This happened when people viewed real three-dimensional environments as well as photographs (Intraub, 2004).

All of these tests, used in studies conducted in many places in the world—including the United States, England (e.g., Mathews, & Mackintosh, 2004), and China (Yang, Du & Liu, 1998)—reveal the same systematic memory error, BE. Using the logic described above, psychologists believe that this error is a result of a mental process used in perceiving and/or remembering scenes. Could it be a result of spatial layout schemas? If people use such schemas to perceive a photograph (or any limited view, such as what is seen through a window), the schema could include an expectation that the surfaces perceived continue beyond the boundaries of the view. This expectation becomes part of the mental representation for a photograph, and when people try to remember the photograph, they think they actually saw part of the space that they only expected to see (Intraub & Richardson, 1989).

Much of my research has been centered around BE, mainly testing to learn about the kind of information that is embodied in the spatial layout schemas people use. I discovered that scene layout information is needed in order for BE to occur; memory for objects without a scene, as in cut-out pictures (Gottesman & Intraub, 2002) or drawings of objects on a flat background, do not reveal the extension error. But what is the importance of scenes? What makes people have larger or smaller BE? Is the identity of the objects important? Does knowledge of the real world environment that was photographed influence BE? Does the location of the objects and surfaces influence it? Is BE useful in helping us act faster?

Students at USC Salkehatchie who volunteered for the experiment participation pool helped me to answer some of these questions. Students here showed that they too tend to remember more of the scene than they actually saw. They showed this tendency for both photographs and drawings. Indeed, the identity of the objects had no effect on the amount of BE obtained; the same extension was obtained for a clearly identifiable object and for a blob of roughly the same size and shape (Gottesman, 2009). I therefore concluded that the layout schemas that lead to BE are different from the place schemas described above (e.g., the place schema for offices that includes books but not fire hydrants). Layout schemas are not influenced by object identity; if you noticed a fire hydrant on a table in an office it would not fit your place schema, but you would remember more of the desk than was actually visible through the door because of your layout schema.

Would people's extension of photograph boundaries be larger or smaller if they are familiar with the environment that was photographed? If BE is related to layout alone, as suggested above, familiarity should not matter. On the other hand, if you know a place well—say, the entrance to the main building on the Salkehatchie East Campus—it is possible this knowledge would make you more accurate when trying to remember a photograph of it. To test these hypotheses, my colleague Margaret Munger and I showed students pictures of scenes at Davidson College and USC Salkehatchie East. Dr. Munger's students were familiar with the Davidson campus, although they had not seen these particular photographs before. They were not familiar with the USC Salkehatchie East Campus (neither the real environment nor the pictures). The opposite was true for the USC Salkehatchie East students. Many students at USC Salkehatchie West campus were unfamiliar with all environments. (If a Salkehatchie student was familiar with Davidson College or if a West Campus student was familiar with the East campus, we did not use their answers in our data analysis.)

On average, all students extended the photographs; they reported seeing a more wide-angle view of the environment than they had actually seen. Interestingly, for all campuses there was no difference between the occurrence of BE for the familiar and unfamiliar picture sets. In other words, students showed BE for photographs of their own campus just as much as they did for the unfamiliar campus. USC Salkehatchie West students, who were unfamiliar with all environments, demonstrated the same level of BE as the other students. After replicating these results twice, we can conclude that the layout representations that lead to BE are not affected by familiarity. They are constructed directly from the scene one sees at the moment, whether in a photograph, a drawing, or in real life, and knowing the environment ahead of time does not change the tendency to extend the scene in mental representations.

The study described above, while not finding any effects of familiarity on BE, found many differences between the subjects' treatment of different pictures. Some pictures, familiar or not, were extended more than others. What aspects of pictures make people extend their boundaries more? In a study using geometric forms and blobs, students showed that the size of the main objects and their apparent nearness to the viewer, based on depth cues such as height in the visual field and texture gradient, affected the amount of BE. People extend more when they think they see a small part of the scene and expect surfaces to continue for a good distance beyond what actually can be seen (Gottesman, 2004).

BE is a very curious and intriguing phenomenon that can tell us much about our spatial layout representation, but ultimately what are such representations good for? At the beginning of this discussion I claimed that these representations help us in working with the world around us—for example, when we reach for a pen. But could we not just look at the pen, see it, and then reach for it? Why do we need a mental representation? One explanation is that if it is dark or our view of the pen is blocked in some way, we need a mental representation to find it. But even if the pen is in plain view, having a mental spatial representation can help us to respond faster!

In multiple studies conducted at USC Salkehatchie, students were asked to judge the distance of objects in a scene using a technique developed in 1997 by Thomas Sanocki and William Epstein at the University of South Florida. Just like students participating in that study, South Carolina students responded faster if they got a preview of the scene (lasting a mere second). This preview enabled them to create a proper layout representation. We know that the representation needed in this task was a layout schema and not a place schema, because when students were simply told what pictures they would see next (e.g., "a kitchen") as opposed to seeing the layout, they did not judge distances faster than without a preview (Gottesman, 2007).

Moreover, our study found that a person does not have to preview all the relevant parts of the scene to be aided. Students were just as fast judging distances when they saw only part of the scene, a part that did not even include the locations that would be tested. However, this benefit was obtained only if the preview showed parts of the test-relevant surfaces. These surfaces could be mentally extended, and this mentally enlarged layout schema could—and apparently did—help judgment speed (Gottesman, 2010).

By studying the errors students make when trying to remember photographs, we found that people use several types of mental representation. One of these types, the spatial layout schema, is not influenced by the identity of the objects in the scene but is influenced by the location, size, and orientation of surfaces. It is not affected by strong familiarity with a specific environment (e.g., one's own university campus as opposed to an unfamiliar campus.) Indeed, a preview that lasts just a second is enough to enable a faster response. A good layout schema can lead to memory errors, but it helps us to interact with the world faster. If students at USC Salkehatchie never erred, we would not have discovered all of this. Sometimes, it is very useful to be wrong.

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