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Reading 15: MAPS IN YOUR MIND

Tolman, E. C. (1948). Cognitive maps in rats and men. *Psychological Review, 55,* 189–208.

Many of the studies in this book are included because the theoretical propositions underlying them and their findings contradicted the prevailing view and conventional wisdom of their time. Bouchard's revelations concerning genetic influences on personality (Reading 3), Hobson and McCarley's conceptualization of dreams (Reading 7), Watson's study of Little Albert (Reading 10), and Harlow's theory of infant attachment (Reading 17), among other research studies, all challenged the status quo of psychological thinking and thereby opened up new and often revolutionary interpretations of human behavior. Edward C. Tolman's theories and studies of learning and cognition made just such a contribution. During the years when psychology was consumed with strict stimulus-response learning theories that dismissed unobservable, internal mental activity as "unknowable," Tolman, at the University of California at Berkeley, was doing experiments demonstrating that complex internal cognitive activity could be studied in rats, not only in people, and that these mental processes could be studied without the necessity of observing them directly. Due to the significance of his work, Tolman is considered to be the founder of a school of thought within the field of learning psychology that is called *cognitive-behaviorism.*

To experience some of what Tolman proposed, imagine for a moment that you want to make your way from your present location to the nearest post office or video store. You probably already have an image in your mind of where these are located. Now think about the route you would take to get there. You know you have to take certain streets, make specific turns at the right intersections, and eventually enter the building. This picture in your mind of your present location relative to the post office or video store and the route you would follow to travel between them is called a *mental representation.* Tolman called these representations *cognitive maps.* Tolman maintained that not only do humans use cognitive maps, but other animals, including rats, think about their world in similar ways. Why does anyone care how a rat thinks? Well, if you were a learning theorist in the 1930s and 1940s, the main research method being used was rats in mazes; people were very interested in how they *learned.*

THEORETICAL PROPOSITIONS

In the first half of the 20th century, learning theorists were on the front lines of psychology. In addition to trying to explain the mechanisms involved in learning, they were invested in demonstrating the "respectability" of psychology as a true science. Because psychology had been emerging as a science, from its roots in philosophy, for only a few decades, many researchers felt that the best way to prove psychology's scientific potential was to emulate the so-called *hard* sciences, such as physics and chemistry. This notion led the learning theorists to propose that the only proper subjects for study were, as in physics and chemistry, observable, measurable events. In that light, a stimulus applied to an organism could be measured, and the organism's behavior in response to that stimulus could be measured. But they contended that what went on *inside* the organism between these two events was not observable or measurable, so it could not be studied and, moreover, it was not considered important. According to this view, when a rat learned to run through a maze faster and faster and with fewer and fewer errors, the learning process consisted of a succession of stimuli to which a succession of correct responses led to the reward of food at the end of the maze. This focused, stimulus-response, connectionist view of all behavior formed the core of behaviorism and dominated the first 50 years or so of behavioral psychology's history.

Led by Tolman during the 1930s and 1940s, a small band of "renegades" appeared who maintained that much more was going on inside the learning organism than mere responses to stimuli. In fact, Tolman proposed two main modifications to the prevailing view. One was that the true nature and complexity of learning could not be fully understood without an examination of the internal mental processes that accompany the observable stimuli and responses. As Tolman stated in the famous 1948 article that is the subject of this discussion:

> We believe that in the course of learning something like a field map of the environment gets established in the rat's brain. We agree with the other [stimulus-response] school that the rat running a maze is exposed to stimuli and is finally led as a result of these stimuli to the responses which actually occur. We feel, however, that the intervening brain processes are more complicated, more patterned, and often . . . more autonomous than do the stimulus-response psychologists. (p. 192)

The second proposal made by Tolman was that even though internal cognitive processes could not be directly observed, they could be objectively and scientifically inferred from observable behavior.

METHOD AND RESULTS

Tolman presented numerous studies in his 1948 article to support his views, all of which involved maze learning by rats. Two of the studies that clearly and concisely demonstrated his theoretical position are included here.

The first was called the *latent learning* experiment. For this study, rats were divided into three groups. Group C (the control group) was exposed to

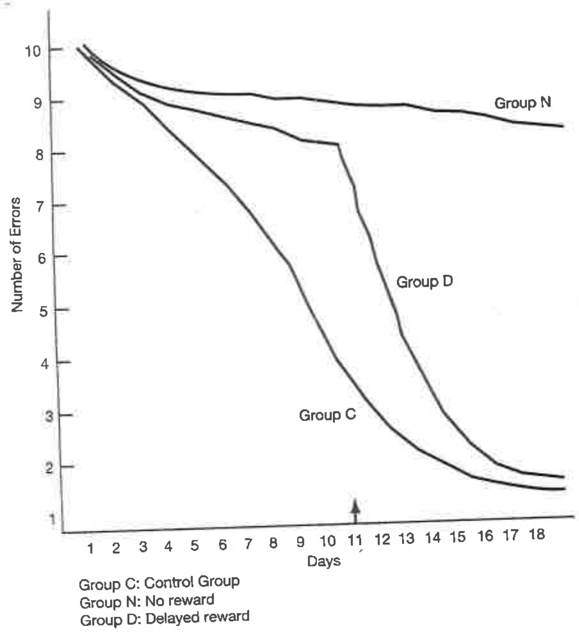

FIGURE 15-1 Latent learning experiment error rates in maze learning. (Adapted from p. 195.)

a complex maze using the standard procedure of one run through the maze each day with a food reward at the end of the maze. Group N (no reward) was exposed to the maze for the same amount of time each day but found no food and received no reward for any behavior in the maze. Group D (delayed reward) was treated exactly like group N for the first 10 days of the study, but then on day 11 found food at the end of the maze and continued to find it each day thereafter.

Figure 15-1 summarizes the results for the three groups based on the average number of errors (running down blind alleys) made by each group of rats. As you can easily see in the graph, the rats in Groups N and D did not learn much of anything about the maze when they were not receiving any reward for running through the maze. The control rats learned the maze to near perfection in about 2 weeks. However, when the rats in Group D discovered a reason to run the maze (food!), they learned it to near perfection in only about 3 days (day 11 to day 13). The only possible explanation for these findings was that during those 10 days when the rats were wandering around in the maze, they were learning much more about the maze than they were showing. As Tolman explained, "Once . . . they knew they were to get food, they demonstrated that during the preceding nonreward trials, they had learned where many of the blinds were. They had been building up a 'map' and could utilize [it] as soon as they were motivated to do so" (p. 195).

The second study to be discussed here is called the "spatial orientation" experiment. Stimulus-response (S-R) theorists had maintained that a rat only "knows" where the food reward is by running the maze (and experiencing all the S-R connections) to get to it. This is very much like saying that you only

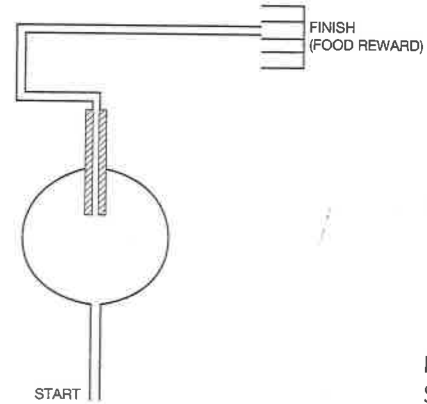

FIGURE 15-2 Spatial orientation experiment: Simple maze. (Adapted from p. 202.)

know where your bedroom is by walking out of the kitchen, across the living room, down the hall, past the bathroom, and into your room. In reality, you have a mental representation of where your bedroom is in the house without having to "run the maze." Tolman's spatial orientation technique was designed to show that rats trained in a maze actually know the location in space of the food reward relative to their starting position even if the elements of the maze are radically changed, or even removed.

First, rats learned to run the simple maze shown in Figure 15-2. They would enter the maze at the start, then run across a round table and into the path leading, in a somewhat circuitous route, to a food reward at the end. This was a relatively simple maze and no problem for the rats that learned it to near perfection in 12 trials.

Then the maze was changed to a sunburst pattern, similar to that shown in Figure 15-3. Now when the trained rats tried to run their usual route, they found it blocked and had to return to the round table. There they had a

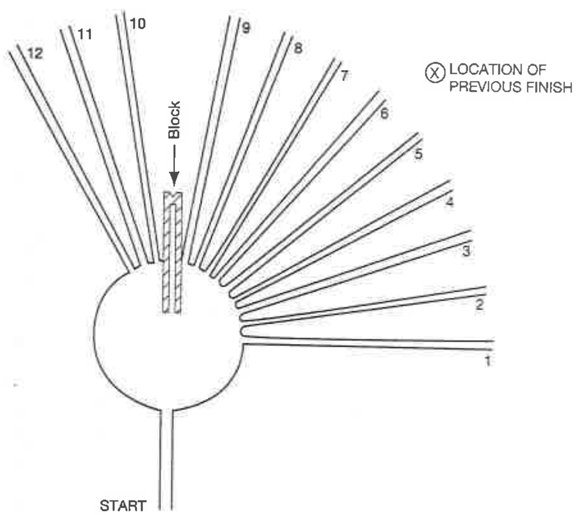

FIGURE 15-3 Spatial orientation experiment: Sunburst maze. (Adapted from p. 203)

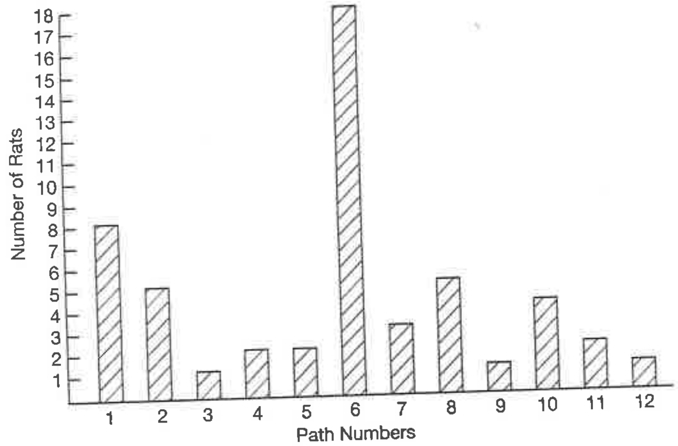

FIGURE 15-4 Spatial orientation experiment: Number of rats choosing each path. (Adapted from p. 204)

choice of 12 possible alternate paths to try to get to where the food had been in the previous maze. Figure 15-4 shows the number of rats choosing each of the 12 possible paths.

As you can see, Path 6, which ran to about 4 inches from where the food reward box had been placed in the previous maze, was chosen by significantly more rats than any other possible route. S-R theory might have predicted that the rats would choose the path most closely in the direction of the first turn in the original maze (Path 11), but this was not the case. "The rats had, it would seem, acquired not merely a strip-map to the effect that the original specifically trained-on path led to food, but rather a wider, comprehensive map to the effect that food was located in such and such a direction in the room" (p. 204). Here, Tolman was expanding his theory beyond the notion that rats, and potentially other organisms including humans, produce cognitive maps of the route from point A to point Z. He was demonstrating that the maps that are produced are not mere *strip maps* represented as A to B to C and so on, to Z, but are much broader, comprehensive or conceptual maps that give organisms a cognitive "lay of the land."

DISCUSSION

Tolman's concluding remarks in his 1948 article focused on this distinction between narrow strip maps and broader comprehensive maps. In applying his findings to humans, Tolman theorized that comprehensive maps of our social environment are advantageous to humans, although narrow, striplike maps can lead to negative human conditions, such as mental illness or prejudice and discrimination. His reasoning was based on findings related to the studies

described previously indicating that when rats were overmotivated (e.g., too hungry) or overfrustrated (e.g., too many blind alleys), they tended to develop very narrow maps and were less likely to acquire the comprehensive cognitive mapping skills of the rats described in his studies. Acknowledging that he was not a clinical or social psychologist, Tolman offered this as a possible explanation for some of society's social problems. In Tolman's words:

> Over and over again men are blinded by too violent motivations and too intense frustrations into blind . . . haters of outsiders. And the expression of their hates ranges all the way from discrimination against minorities to world conflagrations.
>
> What in the name of Heaven or Psychology can we do about it? My only answer is to preach again the virtue of reason—of, that is, broad cognitive maps. . . . We dare not let ourselves or others become so over-emotional, so hungry, so ill-clad, so over-motivated that only narrow strip-maps will be developed. All of us . . . must be made calm enough and well-fed enough to be able to develop truly comprehensive maps. . . . We must, in short, subject our children and ourselves (as the kindly experimenter would his rats) to the optimal conditions of moderate motivation and an absence of unnecessary frustrations, whenever we put them and ourselves before that great God-given maze which is our human world. (p. 208)

SUBSEQUENT RESEARCH AND RECENT APPLICATIONS

Over the decades since Tolman's early studies, a great deal of research has supported his theories of cognitive learning. Perhaps the most notable outgrowth of Tolman's ideas and reasoning is the fact that one of the most active and influential subfields of the behavioral sciences today is *cognitive psychology*. This branch of psychology is in the business of studying internal, unobservable cognitive processes. Since the time only a few decades ago when the entire concept of "mind" was rejected as subject matter for scientific investigation, psychology has made a nearly complete reversal. Now it is generally accepted that the way a stimulus is processed mentally through perceiving, attending, thinking, expecting, remembering, and analyzing is at least as important in determining a behavioral response as the stimulus itself, if not more so.

Tolman's theory of cognitive mapping has influenced another area of psychology known as *environmental psychology*. This field is concerned with the relationship between human behavior and the environment in which it occurs. A key area of research in environmental psychology is concerned with how you experience and think about your life's various surroundings, such as your city, your neighborhood, your school campus, or the building in which you work. The study of your conceptualizations of these places is called *environmental cognition*, and your precise mental representations of them have been given Tolman's term, *cognitive maps*. Using Tolman's basic concepts, environmental psychologists have been influential not only in our understanding of how people understand their environments but also in how environments should be designed or adapted to create the optimal *fit* with our cognitive mapping processes.

One of the environmental psychologists who led in applying Tolman's ideas to humans was Lynch (1960). Lynch proposed five categories of environmental features that we make use of in forming our cognitive maps. *Paths* are perceived arteries that carry traffic, whether it be in cars, on foot, on bicycles, or in boats. *Edges* are boundaries we use in our cognitive mapping to divide one area from another, but they do not function as paths, such as a canyon, a wall, or the shore of a lake. *Nodes* are focal points, such as city parks, traffic circles, or a fountain, where paths or edges meet. *Districts* take up large spaces on our mental representations and are defined by some common characteristic, such as the theater district or restaurant row. *Landmarks* are structures that are used as points of reference within a map and are usually visible from a distance, such as a clock tower, a church steeple, or a tall or especially unusual building.

This early article by Tolman articulating his theory of cognitive mapping has been cited throughout the 50 years since its publication consistently and frequently in a wide array of diverse studies. For example, a recent study applied Tolman's model of cognitive maps to understanding how birds rely on the location of the sun to find landmarks and create cognitive maps for their remarkable migratory treks over hundreds or even thousands of miles each year (Bingman & Able, 2002). On a different track, a study from the field of tourism cited Tolman's ideas in an examination of how travelers in wilderness areas (*nature-based tourists*) develop their knowledge of the terrain they are exploring (Young, 1999). The author found that several factors influenced the quality of the participants' mental maps, including mode of transportation, whether they had visited the region before, number of days spent in the area, where they were from, their age, and their gender.

Today, much of our "traveling" does not require going anywhere at all, at least in a physical sense. We can now find our way to anywhere in the world on the Internet. Tolman's conceptualization of cognitive maps has even influenced research on the psychology of the World Wide Web. Imagine for a moment what you do when you are on the Internet: you explore; you jump from place to place; you surf; you navigate, you google. You don't really go anywhere geographically, yet you often feel as if you have been on a journey. And chances are, most of you could probably go there again using approximately the same route, right? If so, you have formed a mental map of a small part of the Web. A study in a journal devoted to research on human–computer relationships examined Internet search behavior and the strategies people use to navigate the Web (Hodkinson et al., 2000). The researchers were able to translate Web search behavior into graphic form, identify individual search strategies, and suggest possible methods for improving Internet search effectiveness.

Tolman's research was incorporated into a study that may have shed some light on that age-old gender stereotype: "Men never ask for directions." Research by Bell and Saucier (2004) explored the connection between people's gender and sex hormone levels with their ability to navigate along a specified route. Imagine for a moment that you are moving along a path from point A to point B. Along the way, you will pick up some mental images of your surroundings, such as notable landmarks in the distance and specific points of interest along your route, and you will probably have a general sense of the direction from which you began your journey. If asked to point to some of these mental representations, you would likely indicate the correct direction for some, but not for others. In other words, you would have developed a cognitive map of your route, but it would seldom be perfect. Bell and Saucier asked participants to do just this and found that greater levels of testosterone, the primary male sex hormone, was significantly related to increased accuracy in these pointing tasks, indicating a clearer understanding of the cognitive maps the participants formed during their environmental experiences. So, does this mean that men ask for directions less than women do because men already know where they are? No. As intriguing as these findings are, a great deal more research will be needed to answer *that* one!

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Hodkinson, C., Kiel, G., & McColl-Kennedy, J. (2000). Consumer Web search behavior: Diagrammatic illustration of wayfinding on the Web. *International Journal of Human-Computer Studies, 52*(5), 805–830.

Lynch, K. (1960). *The image of the city.* Cambridge, MA: MIT Press.

Young, M. (1999). Cognitive maps of nature-based tourists. *Annals of Tourism Research, 26*(4), 817–839.

Reading 16: THANKS FOR THE MEMORIES!

Loftus, E. F. (1975). Leading questions and the eyewitness report. *Cognitive Psychology, 7*, 560–572.

PERRY MASON: Hamilton, I believe that my client is telling the truth when she says she was nowhere near the scene of the crime.

HAMILTON BURGER: Perry, why don't we let the jury decide?

PERRY MASON: Because, Hamilton, I don't believe there is going to be a trial. You haven't got a case. All you have is circumstantial evidence.

HAMILTON BURGER: Well, Perry, I suppose this is as good a time as any to tell you. We have someone who saw the whole thing, Perry. We have an *eyewitness!*

And, as the mysterious music rises in a crescendo, we know that this is going to be another difficult case for the most victorious TV lawyer of all time, Perry Mason. Even though we are reasonably certain Mason will prevail in the end, the presence of a single eyewitness to the crime has seemingly changed a weak