CLARK HULL AND KENNETH SPENCE:
....... "LOST IN THE T-MAZE".....

BIOGRAPHY

As a child and young adult Hull was plagued by poor health, and he had poor eyesight all his life. A case of polio at age 24 left him disabled in one leg and forced him to wear a heavy iron brace and to always walk with a cane. Ernest Hilgard once tossed horseshoes with him behind his home and he said rather plaintively that horseshoes with his son was the first athletic event he had ever participated in. His family had little money and he had to interrupt his education several times to earn money. He studied mining engineering at the University of Wisconsin, then switched to psychology and got his Ph.D. in 1918.

He was proud of his dissertation because "it moved experimental psychology into the area of thought processes by investigating the learning of concepts" (Hilgard, 1987), and became very downcast when year after year no one paid attention to it. Other early work involved the effects of tobacco on behavior and a survey of the literature on tests and measurements. He developed methods of statistic analysis and invented a machine to calculate correlations. Intriguingly enough he investigated concept formation and even hypnosis and suggestibility. In 1927 he read Pavlov and turned to problems of conditioned reflexes and learning. His major books were Principles of Behavior (1943) and A Behavior System (1952). He was ill for a number of years while writing the latter book, and died before reading the galley proofs.

After his contact with Pavlov, Hull's position became one of an uncompromising, radically behavioristic analysis. He read Isaac Newton's Principia (1697) to find out where his early efforts at theory had faltered. Any difference between psychology and physics, held Hull, is in degree and not in kind.

His mature system of ideas left no room for consciousness, purpose, or any other mentalistic notion. When he spoke of intervening variables they closely and specifically tied to objective stimuli and responses. He viewed human behavior as automatic and reducible to the language of physics. He warned against giving subjective meanings to any behavior being observed. We mustn't anthropomorphistically think, for example, "If I were a rat, what would I do in this situation?" In 1943 he suggested that we should consider "the behaving organism as a completely self-maintaining robot, constructed of materials as unlike ourselves as may be."

I have seen no biography of Hull and am moved to speculate that the childhood of a sickly child with poor eyesight from a family with very little money could have been filled with taunts and abuse from other children, if not from parents. Such a condition could provoke someone to clamp an iron lid on the painful memories of his inner life, and could predispose him to an outlook that rules out all interest in such things. Please note that this is pure speculation, best formulated as a hypothesis. I look forward to finding some data that might support or disprove it.

OVERVIEW

For about 20 years Clark Hull held a dominant position in the history of American academic psychology. Vast numbers of experiments by experimental psychologists all across the country were carried out to confirm or challenge various details of his theoretical formulations. Then during the 1960s, almost as quickly as his ideas had come to dominate learning theory, they largely vanished from it. The conclusion became first inescapable and then widespread that the basic tack he was taking, that of trying to formulate a precise mathematical model which would identify just how much of behavior is
due to what, was an impossible task even for the Norway rat in a T-maze, which was the dominant animal and environment in this research. For a human being it was not even conceivable.

In retrospect it is incredible how much time and energy went into this endeavor and how little came out of it. I will not bother here with the details of the various mathematical models and the controversies about whether certain independent variables were related to others in an additive or multiplicative relationship. Hull perhaps added somewhat more to our knowledge of the behavior of the rat than Titchener did to our understanding of human consciousness, but not much. His basic approach turned out to be, to use a precisely appropriate metaphor in his world of rats and mazes, a blind alley.

One of Hull's starting points was in noting that conditioning theory failed to deal convincingly with motivation. He was astute enough to recognize that motivation may be viewed as either a learned aspect of behavior (as Guthrie viewed it) or as a behavioral determinant independent of learning (as Tolman viewed it). Either way, it needed to be given greater importance. Hull drew on Freud's "instincts" as motivating forces, but changed the word to "drives" in his own formulations.

Late in his life and work, in 1952, even before the futility of his modeling endeavors became evident, Hull admitted that his system probably applied only to hungry rats.

**INVESTIGATIVE STRATEGY**

Hull held that:

1. We should begin with specific testable postulates, even if based on minimal evidence. Then we derive concrete, empirically verifiable deductions from these and test them.

2. The task of a theorist is to formulate postulates so they will lead to unequivocal deductions.

3. The worth of a theory resides in how much research it generates and how consistent with its theoretical deductions the findings are.

4. He was willing to put himself on the line with his predictions. His willingness to be wrong was a remarkable virtue. He was constantly revising his theories in light of empirical results.

These first four points represent perhaps Hull's most lasting contribution to experimental psychology. No one before Tolman and Hull was as careful, sophisticated, or precise in experimental design. Their research models of compared groups were later supplanted by other models, like Skinner's single-subject designs, but the sophistication in experimental design that grew out of their work outlived their research programs and is still a characteristic feature of American academic psychology.

Also part of Hull's approach were:

5. In theorizing, a heavy emphasis on intervening variables, cast in mathematical form.

6. Kenneth Spence was intimately associated with Hull through most of Hull's career. It was Spence who urged Hull to adopt Tolman's "intervening variable" concept and approach.

We turn now to a brief characterization of some of the main features of Hull's ideas, leaving out the mathematical models which went nowhere.
DRIVE AND REINFORCEMENT

1. Drive is based on animal's need-state—hunger, thirst, sexual arousal, pain, or whatever. Drive activates behavior—any behavior.

2. Reinforcement occurs whenever drive is reduced, leading to learning of whatever response solves the animal's problem. Thus the reduction in need serves as reinforcement and produces reinforcement of the response that leads to it.

3. Basic approach: need-related motivation, drive, and S-R learning are produced by (and only by) reinforcement. The S-R connection is called "Habit:".

4. Hull held that drives are substitutable in motivating behavior. If a hungry animal has learned a given response to get food, it should be easy to transfer the same response to get water. Early studies tended to confirm this motivation transfer, but more recent experiments have failed to find such motivation transfer when proper care is taken to use sources of drive that can be independently manipulated. It now appears that what happens with difference sources of drive is very unpredictable.

AN ALTERNATIVE FORMULATION was proposed by Miller & Dollard. Using a similar habit construct, they proposed that any strong stimulus can have motivating or drive properties without being tied to the needs of the organism.

HABIT AND BEHAVIOR

1. Drive and habit act together to determine the strength of behavior. Thus the strength of behavior depends on both:

   a. animal's motivation at time of testing

   b. amount of prior learning

Neither motivation nor prior learning alone will tell us what animal do.

2. Habit is built up as result of drive reduction

3. Habit strength depends on four different classes of independent variables:

   a. Number of reinforced trials

   b. Magnitude of reward

   c. Immediacy or delay of reinforcement

   d. interval between CS onset and US.

4. Behavior can be characterized by both frequency and magnitude, and the two measures need not be correlated. We might have a very frequent response of low amplitude or a rare response of high amplitude.

EVIDENCE REGARDING DRIVE REDUCTION

http://www.sonoma.edu/users/d/daniels/hullspence.htm
1. Habit is indeed built up as result of drive reduction.

2. Experimental work has shown that there are other variables. For example, Neal Miller carried out a series of studies showing that placing food directly in the stomach is reinforcing but food in the mouth is much more reinforcing. 3. Sheffield proposed that it is not drive or need reduction that constitutes reinforcement; but simply the occurrence of a consummatory response. A rat learns a response when this response lets it eat, mate, explore, etc.

4. Ultimately, the pure drive-reduction view of reinforcement was abandoned.

**PURPOSE AND INCENTIVE**

1. Hull's first papers on learning theory in 1929 and 1930 were attempts to show that the purposiveness in behavior which Tolman had demonstrated could be explained with Pavlovian S-R associations. Hull sought to extend the S-R framework from Pavlov's original conditioning situation to the kind of situation in which behavior appears highly flexible, adaptive, and intelligent (like rats in T-mazes, we might say with tongue in cheek).

2. "Fractional anticipatory goal responses."

   This is the idea that we anticipate the reinforcing event at the end of the chain and it motivates the rat back at the beginning of the chain. We make fractional anticipatory goal responses" (rG --> r for the anticipatory response and G for the goal) that are themselves somewhat rewarding to us. For instance, someone's fantasies of sexual intercourse yet to come, and the movements and secretions associated with those fantasies, are themselves somewhat rewarding. This led to the very productive insight that it works best to work backward in teaching chains of behavior.

3. Hull recognized that variables can affect performance without materially affecting learning. Crespi (1942) ran a study in which different amounts of food did not affect learning but did affect performance. Hull concluded that a fractional ancipatory goal reaction becomes a conditioned reinforcing stimulus, with reinforcing consequences. His final explanation of Crespi's results was that animals getting more food have a more vigorous rG conditioned to the goal box.

4. Hull's explanation for the latent learning demonstrated by Tolman was that "habit strength" had built up on early trials but performance was poor because incentive motivation was low. When the rat found food, considerable incentive motivation was suddenly present.

**HABIT FAMILY HIERARCHIES**

1. This somewhat intimidating phrase refers to alternative behavior sequences that lead to the same goal. Component acts of these sequences become conditioned to the same fractional ancipatory goal reactions and in this sense constitute a "family."

2. The weaker responses in this hierarchy--farther to reinforcement, or more difficult to make, etc., are less likely behavior sequences (the law of less work), and thus lower in the habit-family hierarchy. That is, they are less likely to occur, even though they're there and available.

3. It appears to me (Victor) that this concept might be applied to complexes, with a variety of different defense mechanisms serving the repressive, discomfort-reducing function.
OSCILLATION AND_THRESHOLDS

1. Following Guthrie's lead, Hull was one of the earlier psychologists to recognize that behavior is essentially probabilistic. There is considerable variability in what a rat or person does.

2. He proposed that in order for behavior to occur, the factors that produce it must create a tendency to respond that is greater than a given threshold. He also assumed that the threshold varies randomly in time according to an oscillating function. This is surely wrong; it is not too difficult to identify factors inside the person or environment that could affect this threshold. But with his rats, Hull was essentially saying that behavior can be predicted only on the average, over a period of time, or over a group of animals.

KENNETH SPENCE

1. Kenneth Spence hypothesized that discrimination occurs through reinforcement combined with frustration or inhibition. The excitatory tendencies of the reinforced stimulus increase; those of the unreinforced one weaken through an active inhibitory process. This is perfectly consistent with Pavlov.

2. Spence identified Tolman's approach as SS, or Sign-signicate learning: "...organization into some kind of functional whole of the perceptual systems of the subject." A tendency to explain learning in terms of circumstances in the perceptual field. The S-R model, by contrast, accounted for learning by stimulus-response connections.

3. For Spence, reinforcement, rather than affecting habit strength, affected "incentive motivation." In regard to inhibition, for example, "early (chimpanzee) experiments suggested that the subject had to learn to expect or anticipate a reward upon responding to a stimulus before there would be any inhibition or frustration effect. This was a shift in a direction reminiscent of Tolman's formulations.

4. Hull defined learning (habit) broadly. He thought many different independent variables could affect it, but that there were only a few things which resulted in motivation (drive). Spence reversed this relationship. For him, motivation was broadly determined, including as it did both drive and incentive motivation, whereas habit strength was just a function of the number of stimulus-response pairings (this is a sort of contiguity position).