Lecture 28: Psychobiology of learning

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Neurobiology of Psychological Functions

Having discussed the structure and functions of the brain, we shall now look at specific psychological functions and comprehend the role of brain regulating such functions. We shall concentrate on four major topics of interest of psychologists—learning, memory, emotion and personality. The elaboration of each of these topics is preceded by recapitulating the detailed discussion on the same topic in the course *Basic Psychological Processes*. Further, the details are based on the findings from different allied areas like electrophysiology, neuropsychology and neuroimaging.

Learning: Recapitulation

Learning brings forth moderately enduring change in the behaviour through experience. Learning primarily involves formation of associations and relationship. The input demanding a response is called stimulus (S) and the action made to such input is called response (R). This S-R relationship has been widely talked about in psychology. A stimulus could be anything; an event, a situation, a condition, a signal or a cue. Further, responses could either be readily observable or not readily evident. The former is referred to as overt behaviour whereas the later is called covert behaviour.

The illustration below describes the process of classical conditioning.

Under normal circumstances

Conditioned stimulus (CS)	→	No response
Unconditioned stimulus (UCS)	→	Unconditioned response (UR)

During con ditioning

Conditioned stimulus (CS)	→	Unconditioned response (UR)
Unconditioned stimulus (UCS)		

After conditioning

Conditioned stimulus (CS)	→	Conditioned response (CR)

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There are two types of classical conditioning— *Classical Reward Conditioning* and *Classical Aversive Conditioning* . In classical reward conditioning, a reinforcer rewards the overt behaviour whereas in c lassical aversive conditioning, an aversive stimulus is paired with a conditioned stimulus (CS). This is how a neutral stimulus gets associated with a meaningful stimulus, thus deriving the capacity to elicit a similar response.

Instrumental conditioning, on the other hand, is a form of learning wherein the consequences of behaviour produce changes in the response, thus determining the probability of occurrence of the behaviour. Unlike classical conditioning, it is a voluntary process of formation and strengthening of S-R association. It is readily seen in human learning.The distinctiveness of instrumental conditioning is that the association between response and reinforcing stimulus depends on the consequences of the responses. Besides these two major types, we have also talked about cognitive learning. It centers on the cognitive maps we construct out of our experiences and how these maps guide our behaviour. Alongside we also discussed social learning which included notion of local enhancement, social facilitation, observational learning and imitation.

Psychobiology of Learning

Laboratory studies of S-R learning have been mostly conducted on rats, with few researchers opting for cats, dogs and even human babies. As you must be aware, there is a difference in the viewpoints of theorists proposing learning by conditioning and cognitive theorists. The former emphasize on stimulus-response (S-R) association whereas the later lay emphasis on consequence based expectations. According to Tolman (1932, 1948) animal learn from “what leads-to-what” and accordingly expect consequences of their behaviour. Findings of studies on rats suggest that hippocampus and caudate nucleus are the brain structures responsible for these two forms of learning. Hippocampus selectively mediates cognitive memory whereas caudate nucleus mediates S-R habit formation. Hippocampus is supposed to facilitate rapid subjective learning from own experiences whereas cortex facilitates integration of multiple experiences so as to generalize certain things. This is a slow process. Different stimuli are organized into an associative group by chunking. This forms the basis of conditioning. It has been proposed that hippocampus is instrumental in cortical chunking. The table given below summarizes the brain areas involved in Pavlovian conditioning.

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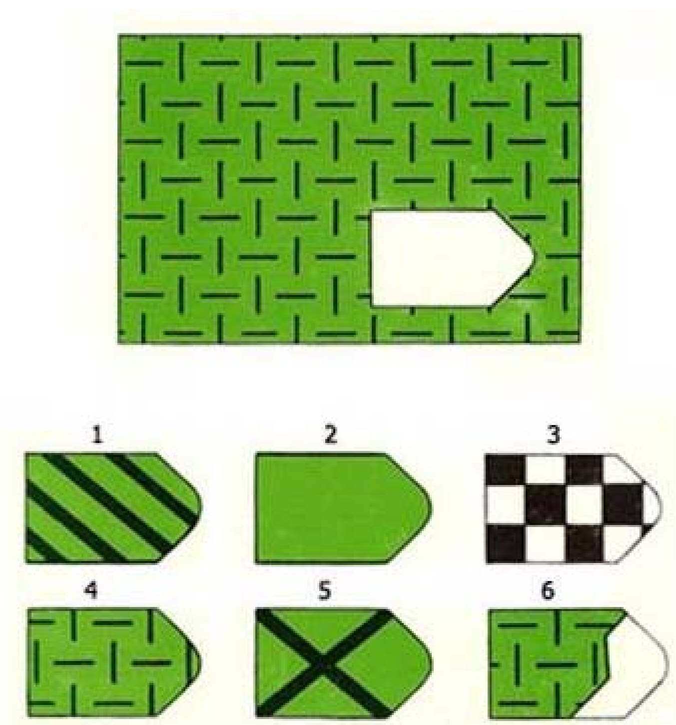
Pavlovian Conditioning	Brain Areas Involved
For conditioned stimulus (CS) to gain access to the current value of the unconditioned stimulus (US)	Basolateral amygdala (BLA)
Some forms of stimulus-response conditioning	Central nucleus of the amygdale [through brainstem arousal and response]
Mediating the impact of CS on CR	Nucleus accumbens
Detecting action-outcome contingency	Prelimbic cortex
Memorizing sensory properties of food [retrieval of specific value]	Insular cortex
Value of reinforcer controlling instrumental choice behaviour	Orbitofrontal cortex
Allowing response to emotionally significant stimuli and preventing response to inappropriate stimuli	Anterior cingulate cortex

It might be interesting for you to know that the traditional laboratory experiments on animals to empirically explore and validate S-R conditioning have been replaced by computer simulations following conditioning paradigms. Such studies have come forward with a real-time attentional model of hippocampal function (Schmajuk & Moore, 1985).

Spatial Learning

Spatial learning refers to the ability to attain a map-like depiction of the surroundings that combines features of the stimulus that are specific to certain locations. This mental map has place representations that are connected on the basis of some rules representing distance and direction among these places. Area CA3 of the hippocampus has the auto-associative binding properties. You must have come across many types of pattern completion task. The figure given below is a representative sample from a popular non-verbal test of intelligence, Raven's Progressive Matrices.



Module 5: Psychobiology

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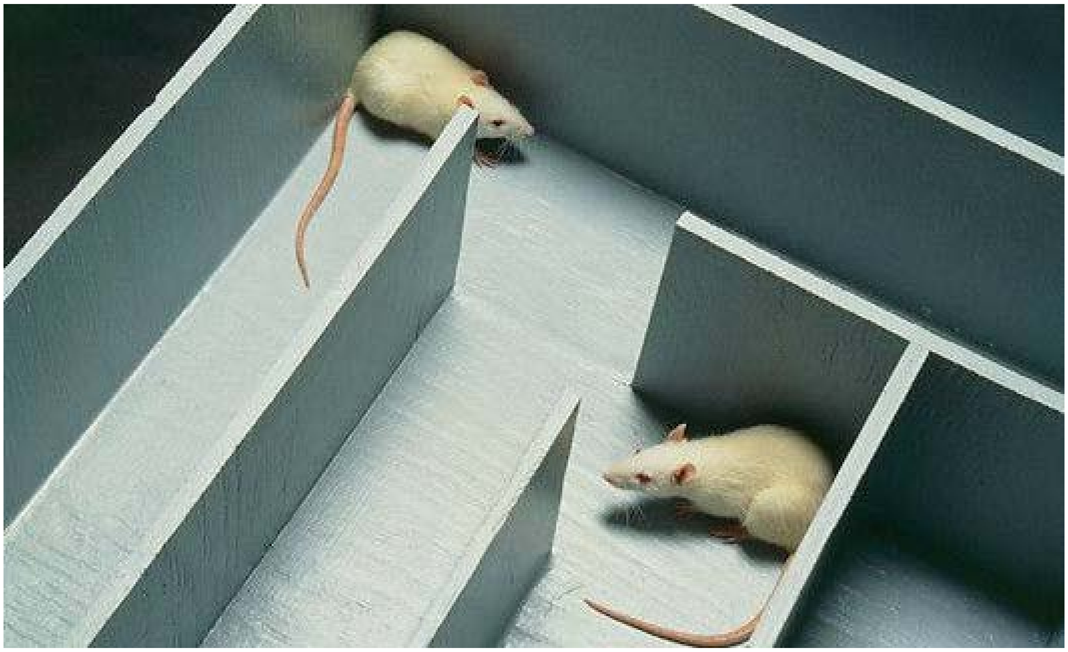
Such tasks demand the filling of the missing parts on the basis of input pattern stored in our memory. Let us take an example from the real life situation. We have multiple parking places for bicycles in the academic area. Even if you are asked later where your bicycle is you respond correctly because of input cues that trigger completion of the full encoded memory. In terms of brain representation, hippocampal system facilitates such pattern completions. There are lateral connections within the layer CA3 that enables spreading of partial activity to fill in the missing pieces.



Source: http://www.sciencephoto.com

Experiments on laboratory rats have been largely performed on different types of mazes where the rats have to go for way-finding. An example of one such experiment is given below. Outcome of these studies endorse correlation between level of acetylcholinesterase enzyme (ACHE) in the brain and the ability to solve spatial problems. Rats trained and tested on more difficult problems had higher acetylcholinesterase in the cortex compared to those trained on easier tasks. Other experience-induced changes have also been reported. Studies have reported increase in the thickness of cortex, size of neurons nuclei, size of synaptic area and branching of dendrites (up to 25%) due to experience.

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A remarkable demonstration of experience-dependent learning was seen in the experiment of Sur, Garraghty and Roe (1988). The experimenters redirected the visual inputs to the auditory cortex and vice versa and came across a path breaking finding. The neurons of the auditory cortex developed properties of the visual receptive field. However, the reverse did not happen. The visual cortex did not show properties of the auditory cortex. Although this experiment was conducted on rats, it does reflect how neural plasticity can make one learn from the experience. As far as human beings are concerned, their brain is extremely plastic in nature and learns from experiences. We have already discussed neural plasticity in the first unit.

Let us now talk specifically about human beings. It has been found that with age neurons become more myelinated along with thickening of the axons and increase in the number of synaptic boutons. The myelination of neurons by oligodendrocytes from 5-18 years influences the size of the brain (Giedd et al., 1996). The neurons of the corpus callosum show remarkable increase in myelination between 6 months to 3 years, which further continues (Paus et al., 2001; Thompson et al., 2000). Myelinated axons are supposed to facilitate learning mechanism. As life conditions might be different for different people, age is not the only determinant. Studies of human children having experienced neglect suggest delayed head growth and cognitive development. As a consequence their academic achievement in adulthood gets adversely affected. R esearch on hemispheric specialization and cognitive development suggest that the specialization of the two halves of the brain takes place at a very early stage. Atypical cognitive development could be due to damage to the cerebrum or because of the combined effect of cerebral damage and maladaptive activation pattern of the subcortical activating system.

Neuropsychological studies have confirmed that the d amage to the medial temporal lobe including the hippocampus severely affects learning. Hippocampal lesions in human beings also impair episodic memory. In terms of rate of learning, the hippocampal system learns fast whereas t he cortical system learns slowly but incrementally. On the basis of their study of context specificity of conditioning Good and Honey (1991) have shown the involvement of hippocampal-formation in incidental learning.

As human beings we learn from our experiences and the memory of such events helps us not commit the same errors that were committed earlier. Much such learning is stored in our memory. Interestingly, memories stored by the hippocampus have been found to be flexible. This means that one can infer from it in novel situations; and this makes us human.

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