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Review Article

ASSOCIATIVE LEARNING THEORIES AND NEUROBIOLOGICAL BASIS: A REVIEW OF PRINCIPLES AND RECENT RESEARCHES

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A B S T R A C T

The Review paper aims at exploring the theories of associative learning, their neurobiological basis and explanation of deviance (Psychopathology) on the basis of these theories in the light of recent research. The paper mentions relation of classical theories to recent research. There are sections discussing theories of associative learning, how "wrong"/ deviant responses/ behavior are learned i.e. how there are chances of development of psychopathology by learning. The research studies discussed, involve implementation of classical and new theories of conditioning into describing phenomena of overall learning, the underlying biology of learning along with conceptualization of development of psychopathology from a neurobiological perspective.

INTRODUCTION

Learning has been defined as a relatively permanent change in behavior brought in an individual as a result of experiences. There are two types of learning which are non-associative learning comprising of habituation or sensitization to a single stimulus and a more complex associative learning that involves forming an association between situation/stimuli and responses. Associative learning involves learning by processes such as Conditioning (Classical, Operant), observation (Observational Learning) and Imprinting. Over a long period of time, multiple research has contributed to the field of associative learning including works form a number of famous contributors such as Pavlov, Skinner, Hebb, Rescorla, Bloom etc. there are many aspects and implications to associative learning which are discussed further in the review. Bloom (1956, 1964) proposed his hierarchical model of domains of learning (goals) which are cognitive, affective and psychomotor, each comprising of their own subdivisions. These domains are not mutually exclusive but however, their actions of concerns are distinctive. The paper attempts to explore the role of associative learning in the context of these three domains. Associative learning and its impacts are studied under the light of classical and recent researches.

METHOD

A systematic search was conducted using the keywords "Association learning", "conditioning", "neurobiology of learning", "conditioning and psychopathology" etc. The empirical studies chosen were from the last decade, and theoretical concepts have been explained by detailing the findings obtained prior to the last decade. The articles were obtained from online databases such as Springer, Jstor, PubMed, EBSCO, ProQuest and Google Scholar. In this review, the need to understand academic stress has been highlighted by bringing into focus the biological and psychosocial aspects of association learning. Research were compiled in coherent structure to explain major themes of the review and draw a comprehensible sense of what is going on.

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DISCUSSION

Major theories

Classical Conditioning by Pavlov talks of an association formed between Conditioned Stimuli (CS) and the response when CS is paired with and Unconditioned/neutral stimuli (UCS). The neurobiological basis of this process is being studied. Later Rescorla and Wagner (1972, 1988) added to the concept talking about the element of "surprise" that the organism experienced when the CS and the UCS are paired. This "surprise" had a major role to play in the process of learning and depended upon the strength of cues present at the time (of trial). It was not only the pairing but other intrinsic factors that also had a major role to play. They also introduced an equation that expressed association in terms of a single number, where when the number was positive the association was positive and when the number was negative the association was negative. Hamme and Wasserman (1994) later introduced the concept of "backward blocking" in cue competition of stimuli and stated that it indicated retrospective revaluation during the conditioning process. This elaborate

and continuing set of research plays a major role in the behavioristic explanation of learning process and forms the basic knowledge of how associative learning occurs.

Operant Conditioning by Skinner (1938) talks about the role of punishment and reinforcements in forming an association between stimuli and response, leading to a phenomenon commonly known as the shaping of behavior. This also inculcates principles of free trials (like the gestalt theories, trial, and error) of responses; the responses which are rewarded by reinforcement and followed by positive feedback/results are repeated more often and are strengthened, those which result in negative, undesirable outcomes are avoided and weakened. Such is the shaping of behavior. The different schedules of reinforcements (Fester & Skinner, 1957) also have differential impact upon the associative learning such that the behavior rewarded variably and unpredictably make the behavior consistent and strengthen it, and behavior those that have large time lag between the response and reinforcement, or those that are not followed by desirable conditions weaken and "extinct". The principles of operant conditioning are widely implemented in human and animal training (and education).

Observational Learning occurs when one watches others, imitates them or just observes them. One learns by copying the behavior and experiencing them or even by looking at others' behavior, evaluating their consequences and choosing to/not to behave in a similar way. Such forms the basis of social learning. Observational learning marks that learning is not only behavioral but also cognitive process and occurs in social contexts. (Unlike the previous ones) according to this theory the learner is not a passive learner but actively evaluates behavior, conditions, and consequences as well as performs on multiple levels (cognitive, behavioral and affective) to learn. Major concepts of observational learning were put forward by Albert Bandura (1961, 1971) who said that learning requires for stages which are 1.Attending to the context, surrounding to know what is happening around (attention), 2. Remembering what had/has happened, such that associations are formed (Memory, Retention), 3.Repeating the behavior; the observer is physically and intellectually capable of performing the behavior (Initiation, Motor response), 4. The learner is driven to behave or not to behave in a certain way, based on consequences or results (Motivation). According to this concept, changes in the behavior of an individual are the result of associations, formed by experiences and are not merely innate. Observational learning brings adjustment in terms of adaptation to new situations or information by Assimilation (incorporation of new information) or Alteration (modification of existing knowledge). Observational learning is different from mere imitation as imitation occurs by observation of con-specifics whereas observational learning involves detailed analysis observant and the environment along with the context (higher and more descriptive cognitive process compared imitation) (Heyes, 1993). In a study, it was found that monkeys learned behavior more accurately when they saw a tutor monkey do mistakes (Riopelle, 1960). Thus observational learning also includes the concept of "Modeling" of behavior.

Imprinting is the phase sensitive learning that occurs at a particular age or period of life and is related to the process of maturation. The learning may, however, occur, independent of consequences of learning.

These theories have many implications in explanation of human behavior and also in the management of those which are found to be deviant (Psychological disorders). These theories have a multidisciplinary implementation, from training animals to education and treatment of psychopathology.

Neurobiology of associative learning

The basic biology of associative learning is "neurons that fire together wire together". Such is the core of the Hebbian Theory, that say that associations between two or more neurons are increased when they fire together and thus also inspires the concepts of neural plasticity. There are multiple types of research in the domain of associative learning that aim to explore role and changes in different parts of the brain.

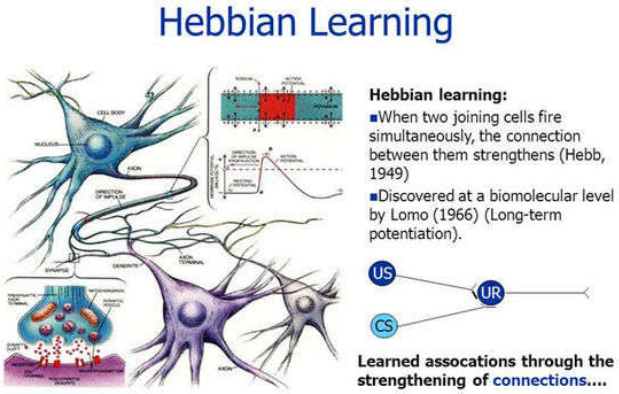

Figure 1 Neurobiology of Association learning ("Brain function is growing far faster than simple natural selection would dictate" Rogers, 2017)

In one study Roesch, Esber, Li, and Daw (2012) found that there was neural activity in rats' basolateral amygdala in responses to reward and that there was an immediate heightened activity with the presentation of reward. The firing was directly proportional to the reward intensity. Contrary changes were also observed when the expectations for rewards were violated. This verified the biological concepts in Rescorla-Wagner model of conditioning.

In a study using fMRI and region-of-interest based normalization method, Prevost, McCabe, Jessup, Bossaerts, and O'Doherty (2011) found that two different regions of the amygdala lighted up during two different association learning that is, reward and avoidance learning. The basolateral amygdala responded more to reward learning whereas the centromedial complex, more to avoidance learning. Computation based model is implemented to analyze the fine neural connections in the amygdala.

Human lesion studies and fMRI research reveal that Cerebellum has a major role in associative learning and that there is differential compartmentalization of cerebellar structure for different kinds of associative learning. It is observed that medial zone is concerned with fear conditioning, intermediate zone for eye blinking conditioning. The lateral regions add on to fear conditioning. It can be understood that cerebellum may largely be responsible for prediction of consequential events, sensory stimuli. (Timmanna, Dreppera, Fringsa, Maschkea, Richtera, Gerwiga & Kolbb, 2010).

Behrens, Hunt, Woolrich, and Rushworth (2008) studied social learning assuming that it shared the same neural pathways as reward-based learning systems. The neural pathways were

found to be similar however the processing was found in parallel. Two neighboring divisions of anterior cingulate cortex were found to be central to the process, and when making a decision the information from the parallel pathways combine within the ventromedial prefrontal cortex. Such highlighted that social learning can be understood as the same means of associative learning in humans, specifically considering the neural basis.

A study was done by Boll, Gamer, Gluth, Finsterbusch, and Buchel (2012) to understand the role of amygdala under attention based theories of associative learning such as Pearce-Hall model. Using a paradigm that combined separate assessment of associability at cue presentation and prediction errors in learning, with the help of fMRI, two different regions of the amygdala were identified to function differently. There were signal changes in the corticomedial amygdala and the midbrain irrespective of a shock given or avoided, i.e. less response in avoidant learning and corticomedial amygdala reflected surprises. It was thus concluded that there are significant changes brought about in the brain circuits by associative learning.

Neurotransmitters too play a major in associative learning. In a study Evans, Shergill and Averbeck (2010) found that oxytocin had a significant effect on learning. In this, the participant learned which face (visual stimuli) was rewarded more, and it was seen that the participants who were injected with oxytocin, showed less aversion to angry face stimuli. The study hence the study rendered information on how learned choice behavior is affected by both financial (reward) and social information which is different from experimental and control conditions.

Much other research substantiates the ever-growing knowledge about the biology and neuroscience of learning, and diverse concepts and findings, interact and coexist to explain the neural aspects of phenomena known as associative learning.

(Associative) learning the wrong things

It has been known for some time now that learning is one of the ways that psychopathology develops. It is also seen in some research that some psychopathological conditions are developed by Classical Conditioning and maintained by Operant Conditioning. The case of "little Albert" is one of the most common examples of how conditioning may lead to the development of potential psychopathology. It is important to understand the dynamics of learning and its theories that try to explain, address and treat psychological deviance in the context, in light of some recent research.

According to Maren, Phan and Liberzon (2013) studies in Classical conditioning on rodents and humans indicate that context-based behavior is largely dependent upon learning and memory which incorporate neural circuits in and between the amygdala, hippocampus, and medial prefrontal cortex. It has been that many psychopathological conditions such as Post-traumatic stress disorder, Substance abuse disorder, and schizophrenia are related to dysfunction in these circuits.

A research by Bruchey, Jones, and Monfils (2010) suggests how social (observed) experiences gets conditioned and associative learning occurs by both observational learning and conditioning. They suggested that after fear conditioning memory retrieval are followed by the fear expression. They exposed a rat to a cage where it observed a rat taking a shock after a beep sound. The other rat was getting conditioned but it was seen that the observer cage mate also learned the fear responses by observation. This may be one way which "fear" schemes are learned. These findings hence contribute to the explanation of phobias.

Mineka and Oehlberg (2008) compiled a review of papers highlighting contemporary models anxiety disorders in the context of learning and individual differences in association learning of fear/anxiety. They discussed on different aspects of learning of fear and anxiety and highlighted major themes. They found that many associative learning theories were capable of explaining generalization of fear behavior. It incorporates contextual learning, conditioning-generalization of fear, affective anxiety, observational learning of fear, and dynamics by which they are sustained by operant conditioning. Acheson, Forsyth, and Moses (2012) talk of interoceptive fear condition as the core of panic disorders. In the research, they found fear conditioning in paired condition and resistance to extinction (fear responses) to unconditioned stimulus. They also suggested that resistance and generalization may be due to inability to differentiate between CS and UCS due to a strong association between them. Here electrodermal reading and self-report indexes were taken as measures. The findings corroborated with recent theories of association learning explanations of panic.

In a study Endrass, Kloft, Kaufmann, and Kathmann (2010) found that there was enhanced avoidance learning was found in patients with Obsessive Compulsive Disorder that reflects exaggerated anticipation and tendency to avoid the aversive condition. Further analysis revealed the role of dopaminergic pathways and signaling in rewarding the negative behaviors in OCD. Such may show how OCD is developed by Classical Conditioning and sustained by some sort of Operant Conditioning.

Multiple approaches to theories of learning explain causes and development of deviant behavior, however, more research is needed to for understanding the changing dynamics of psychopathology.

CONCLUSION

There are many implications of theories of associative learning in fields of education, psychotherapy, and training. Its simplicity and applicability make it easy to be implemented diversely. Associative theories inspire Psychotherapy models such Behavior Therapy, managing learning disability, Training (Conditioning) for differently abled persons, education paradigms. The testing of Association learning paradigms, reveal interesting facts about brain and behavior, constraints of capacity, and provide modular approaches to manage issues of mind and behavior. There is a need for more research in applications of these learning theories in their pure form, experimentation in newer context when the world is dynamic, and small things get associated to large things affecting our lives at large.

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