Where do Conditioned Emotional Responses Originate, and How Can We Alter the Resulting Behavior? Taking a New Look at Old Methodology

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Early researcher Charles Darwin regarded the dog as a special animal that is comparable to humans. Behavioral expert Ivan Pavlov taught us about behavior and conditioned reflexes by studying behavior patterns in response to specific stimuli. B.F. Skinner set the standard for our current understanding of learning theory and operant conditioning. Lifelong observation and research by Turid Rugaas identified specific signals with which dogs communicate and manage their environment. Such driven individuals have laid the foundation for a more knowledge-based profession, but what if we continue to ask *why*? *Why* do experiences become memories? *Why* do those memories then have the ability to impact future behavior? And, *Why* does counter-conditioning work? By studying the brain at the most fundamental level we could then gain insight into how the brain truly processes experiences; how those experiences result in conditioning, and how we can later alter that conditioning to achieve desirable behavior.

A brief history of dog behaviour and learning research

We know why dogs perform operant behavior. It is beneficial for them to learn how to perform a specific task. But, why do they display specific behavior when they are experiencing the emotions of respondent conditioning? The answers lie in combining the two distinct sciences of neuroscience and ethology. Ethology refers to the general study of animal behavior in their natural environment. Neuroscience is a vast field of study involving specific processes of the central nervous system which includes two specific sub areas of study that are of particular importance to professionals in the canine world. The first sub-area includes neurobiology which studies how the brain processes experiences, emotions and the ability to store information (make memories) for future use. In the last decade neurobiology and psychology combined to form the second sub-area of interest called neuropsychology. Neuropsychology studies how the stored information (or memories) impact future behavior, what takes place within the brain when we try to change the resulting behavior and how we can assist the brain in order to accomplish a positive change. We know that dogs are not little humans in fur coats. Therefore, in order to draw conclusions regarding our companion animals utilizing both animal and human studies, we need to first understand specifically how human and dog behavioral responses are similar and understand the processes in the brain that elicit the response.

Pavlov and his team of researchers became well known for their research and discovery of conditioned reflexes. More importantly however, Pavlov's team performed research on very different principles in comparison to other labs at the time which allowed for more observation of canine behavior in relation to humans. All of the dogs had names and interacted with the researchers both in and out of the lab and all information gathered was then applied to the study (Pavlov 1927).

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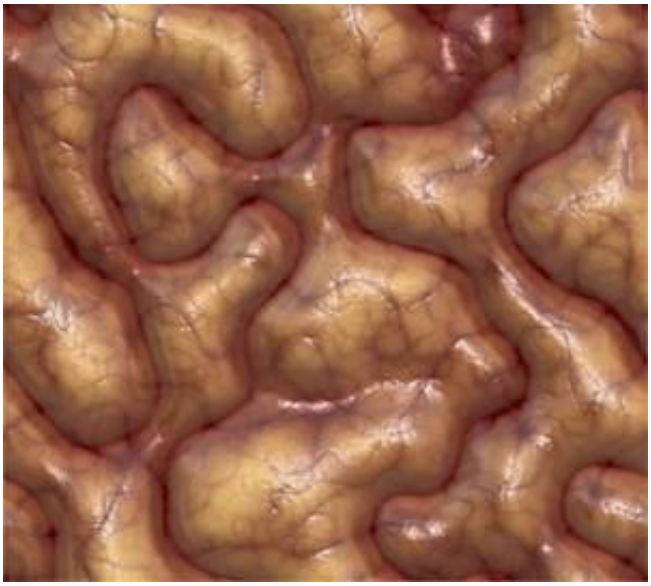
In addition, Pavlov's colleagues respected the individual personalities of the dog and therefore did not generalize specific behaviors to all dogs but only to dogs that belong to specific personality types (as defined by Hippocrates). Because of his research methodology, he was also able to observe marked individual differences between dogs in relation to previous experiences and ability to perform during the training experiments and frequently referenced similarities with human behavior (Teplov 1964). Unfortunately, much of the team's research was criticized by ethologists at the time because they felt that the dog was not being studied in its "natural" environment due to the extensive human interaction and therefore any data collected was deemed invalid (e.g. Lorenz 1954). In the last decade this topic was re-addressed studying DNA sequences and anthropology. The conclusions were made that most likely the bloodline of the wolf split into 2 sub-species 40 million years ago and the earliest evidence of a domesticated dog 14,000 years ago allowing for very different adaptation of cognition and behavior between the canine as we know it and today's wolf. This discovery lead to redefining the dog's natural environment from the "wild pack" to one with cohabitation with humans and facilitated comparison studies between canine and human behavior. Now we can reliably say, based on Pavlov's experimental approach, that dogs can be regarded as the first animal models of human personality and furthermore, that the generalized focus of his work on conditioned reflexes provided the basis for comparative studies on dogs and humans (Miklósi 2007).

Similarities in emotions and behaviour

Numerous studies performed to gain a better understanding of human behaviour and corresponding processes in the brain have utilized animal research. The dog was a popular choice for study up to the early sixties, then largely avoided in research due to the conflict over the natural environment, being viewed as an "artificial animal" because of its symbiotic lifestyle with humans (e.g. Herre and Rohrs 1990). In the last 20 years however the dog has re-emerged as one of the preferred subjects due to a number of reasons. First, dogs are very social animals. According to an article on experimental psychological research from the University of Florida, "this allows for investigations into the mechanisms that produce and maintain conspecific social behaviour, as well as the cognitive and behavioural by-products of those mechanisms" (Freuerbracher et al. 2011).



Secondly, because dogs have a close evolutionary relationship with humans, there is the potential to produce unique cognitive skills and behavioral repertoires that are closer to humans than any other species (e.g., Hare & Tomasello, 2005). A few studies from the early 60's were designed to evaluate "intelligence" of the dog in comparison to humans and resulted in incidental findings that we can now relate to respondent conditioning. For example, in 1965 Seligman performed research intended to identify neurosis in humans (Lichtenstein 1950, Solomon and Wynne 1953). In the study he subjected dogs to punishment (electric shock) and observed their behavior. What he found was that most dogs seemed to "give up and passively accept the shock" even when given the opportunity to escape and theorized that the behaviour was attributed to the dog associating the painful shock to humans and having no control of the environment (Seligman et al. 1965). This shut-down avoidance behavior is also identical to humans experiencing post traumatic stress disorder (PTSD) and has since credited Seligman with discovering what we commonly refer to as learned helplessness.

More recent evidence that dogs display behavioural similarities with humans during emotional states includes an evaluation performed by child psychologists called "Ainsworth's Strange Situation" test. This test is used to describe the pattern of attachment behaviour with children. In the test, a child and parent were placed in a room. The child's behaviour was observed when either the parent left or a stranger entered the room (Ainswoth 1967). The test was observed by Adam Miklósi and colleagues at the Eotvos Lorand University in Budapest. They found that the observed behaviours were identical to dogs when the owner left the room indicating a strong behavioural similarity between dogs and children when experiencing emotions related to attachment. Further comparison studies relating to cognitive ability of dogs and children have revealed distinct differences in learning and capability for insight (Miklósi 2007). However, reflexive behaviours relating to emotion in humans have been mirrored in the same studies performed on our canine counterparts. Recently, Emory University performed the first conscious functional magnetic resonance imaging (FMRI) study with two dogs. The dogs were desensitized to the confined space, fitted with earmuffs for protection from the loud noise and trained to lay still for 30-40 seconds at a time for the imaging process. The study focused on one specific operation of the brain; the anticipation of reward or lack thereof. Each dog was imaged as they were given a hand signal that predicted a treat and the area of the brain that then responded to the signal was captured and analysed (Berns 2012). The caudate region of the brain associated with rewards in humans showed activation in both dogs when they saw the signal for the treat but not for the no-treat signal (Pochon 2002, Daw 2006). This FMRI study has revealed significant scientific evidence for similarities between humans and dogs for basic responses. We can then examine the brain on a deeper level to gain further understanding of conditioned emotional responses (CER's).

How experiences become conditioned emotional responses

Conditioned emotional responses (CER) include changes in behaviour, the autonomic nervous system and hormonal activity elicited by a conditioned stimulus. In order for CER's to take place the brain must experience associative learning. To further understand this process we need to examine the limbic system which is also referred to as the emotional control system and is the area responsible for associative learning. The limbic system is composed of the amygdala, the hippocampus and the hypothalamus. Through both human and animal studies we know that the amygdala is responsible for emotional organization and considered the central hub of fear processing and the hippocampus plays a large role in contextual processing of memories. In other words the Amygdala is involved in implicit emotional memory and the hippocampus is involved in explicit memory about emotions (LeDoux 2007). The hypothalamus initiates the five F's: feeding, fighting, fleeing, freezing and fornication and is therefore responsible for controlling the expression of fear responses.

The hypothalamus is also the area that initiates the Hypothalamic Pituitary Adrenal (HPA) axis resulting in a surge of endocrine hormones such as adrenalin and cortisol to facilitate a quick response of the body (Post 1998, Schaoter 1996, McCarthy 1995). These areas provide the basic foundation to respondent behaviour by creating associative learning and when the conditioned stimulus occurs at a later time it retrieves the associative memory in the Amygdala which is connected to the hypothalamus and activates areas responsible for behaviour including the autonomic nervous system and HPA axis.

The Role of the neuron in conditioned emotional responses

The brain is composed of two types of cells, glial cells and neurons. Glial cells provide support and protection for neurons. It is the neurons which allow the limbic system of the brain to perceive, learn, memorize, experience emotion and carry out observable actions (behavior) through both electrical and chemical transmissions. Chemical transmissions initiate responses in other neurons by utilizing neurotransmitters such as Dopamine, Norepinephrine, Serotonin, Acetylcholine and Oxytocin. FMRI studies focus on metabolic changes observed in neurons in specific areas of the brain which have allowed scientists to understand which parts of the brain activate with a given stimuli. By taking a closer look at neurons themselves we can understand how the brain can initiate a reflexive emotional response.

Neuronal plasticity has gained increased attention in the field of neuropsychology in the last decade. Plasticity is defined as the ability of the nervous system to change in response to an experience. According to The Neuroscience of Psychotherapy, "The growth and connectivity of neurons is the basic mechanism of all learning and adaptation." When it comes to learning there is one common factor in ALL studies performed on dogs – the ability to master the task is directly related to previous experience. This is due to the ability of neurons to form connections between multiple areas of the brain to recall past experience and automatically initiate a response with the purpose to be as efficient as possible. To prove this point – it is impossible for a human to write a whole page of random numbers. Each time it has been attempted a pattern between the numbers is always revealed (Corzolino 2012). This is due to the connections between neurons. The brain becomes "hard wired" to act in a specific way for each specific experience.

Neurons can continue to grow and form new connections in two ways. First, they can expand the length of the dendrites to connect existing neurons forming new pathways. Secondly, in the last decade it has been discovered that the areas of the brain responsible for ongoing learning actually experience neurogenesis, or the development of new neurons with experiences (Eriksson et al 1998). This is particularly relevant when dealing with CER's. In the case of a traumatic or potentially life threatening experience, new neurons are formed and pathways connected to provide an immediate and efficient response and any connection between neurons that are inefficient for survival are never developed allowing for quick life saving actions. For example, humans with PTSD physically cannot speak when experiencing a stimulus that recalls the previous event due to the lack of connection to Broca's area (the area of the brain responsible for verbal expression) (Corzolino 2012, Post 1998). Since talking is not a necessary skill when escaping a life threatening experience the connection is not formed. Instead, advantageous connections are formed for ideal evaluation of the situation including those parts of the brain that perceive visual and auditory stimulus and those that have previously initiated successful escape of the threatening situation such as coordination and movement. It is important to remember that the body has adapted for centuries to be as efficient as possible. The close proximately and relationship between neurons allows for extremely quick memory storage, recall and appropriate action (Corzolino 2012, Grillon 2007, Rosenkranz 2003). The amygdala is the first to respond to an early predictor of a previously dangerous situation. The neurons of the amygdala then immediately initiates a chain reaction of impulses, utilizing connections formed with the hypothalamus, essentially "hijacks" other parts of the brain to initiate and carry out responses that have proven beneficial in previous experiences without cognitive thought processes.

Take fear for an example. If a person approaching has resulted in a traumatic experience in the past the amygdala recalls the strong emotion of the trauma, disengages the cortex and instantly engages the hypothalamus and HPA axis resulting in an efficient response behavior that has proven to be the most successful to avoid, in one way or another, the predicted conflict. This knowledge provides evidence as to why such behavior cannot be “fixed” by basic training techniques. When we observe CER’s in dogs this is also evident. Because of the lack of connections between neurons we see such behaviors as freezing and whale eye as well as other avoidance behaviors. These new scientific findings also explain why a dog that is experiencing the emotions of fear or extreme distress can only learn how to escape or avoid and also sheds light on shut down avoidance behaviors such as learned helplessness and disassociation.

Why does counterconditioning work?

Successful counterconditioning reconnects neurons and increases the plasticity of the nervous system by processing new experiences on a more conscious level. William James said, “Plasticity then, in the wide sense of the word, means the possession of a structure weak enough to yield to an influence, but strong enough not to yield all at once.” Our goal of counterconditioning on a neuronal level is to alter previous connections between neurons or networks to change a response of fear to a response of joy by facilitating involvement of processes within the frontal cortex and prefrontal cortex (Rosenkranz 2003). In other words, changes in the synchrony of the activation of multiple neural networks may also play a role in the coordination of their activity and the emergence of conscious awareness (Crick, 1994). In humans this can be accomplished more easily through speech therapy. In order to tell an emotional story, networks that participate in language (Broca’s area), emotion and memory need to become integrated in order to relay correct details and proper affect (Cozolino 2010). For obvious reasons dogs pose much more of a challenge in accomplishing such integration of neuronal networks. However it is important to remember that association areas within the cortex serve the roles of bridging, coordinating and directing the multiple neuronal circuits to which they are connected (Cozolino 2010).

According to Louis Cozolino, the actual mechanisms of integration are still unknown, but they are likely to include some combination of communication between local neuronal circuits and the interactions among functional brain systems. When we have an understanding of neuronal network integration and neuronal plasticity we gain more insight as to why counterconditioning and desensitization protocols, when implemented correctly, are so successful and how we can continue to expand our knowledge and abilities to help distressed dogs. We can therefore argue that the utilization of effective counterconditioning techniques involves the frontal cortex and prefrontal cortex to facilitate the dog consciously evaluating the situation and forming new neural connections or networks, ultimately increasing plasticity and helping change the behavioral response. Much more research is required to truly understand the concept of neuronal plasticity in relationship to conditioned emotional responses in dogs and the impact on successful counter conditioning. However this may be a start to a whole new approach on how we view our beloved companions.