A Darwinian Theory of Emotion Specifying what is Innate, and what is Learned: Emotion, Consciousness, and Dual Routes to Action

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A theory of emotion, of its functions and evolutionary adaptive value, and of its brain mechanisms analyzed at the neuronal and neuronal network level is described. Emotions can be defined as states elicited by rewarding and punishing stimuli, and brain mechanisms that evaluate and learn about which stimuli are rewarding and punishing are therefore closely involved in emotion (Rolls, 1999, 2000). The operation of the orbitofrontal cortex illustrates this (Rolls, 1996, 1999; Rolls and Treves, 1998).

The orbitofrontal cortex contains the secondary taste cortex, in which the reward value of taste is represented. It also contains the secondary and tertiary olfactory cortical areas, in which information about the identity and also about the reward value of odours is represented. The orbitofrontal cortex also receives information about the sight of objects from the temporal lobe cortical visual areas, and is involved in learning and in reversing stimulus-reinforcement associations. The stimulus might be a visual or olfactory stimulus, and the primary (unlearned) reinforcer a taste or touch. Indeed, investigations using fMRI in humans show that the orbitofrontal cortex is involved in the representation of the pleasantness of touch. Damage to the orbitofrontal cortex impairs the learning and reversal of stimulus-reinforcement associations, and thus the correction of behavioural responses when these are no longer appropriate because previous reinforcement contingencies change. The information that reaches the orbitofrontal cortex for these functions includes information about faces, and damage to the orbitofrontal cortex can impair face expression identification. This evidence thus shows that the orbitofrontal cortex is involved in decoding some primary reinforcers such as taste and touch; in learning and reversing associations of visual and other stimuli to these primary reinforcers; and plays an executive function in controlling and correcting reward-related and punishment-related behaviour, and thus in emotion. Because emotions in primates are generally to complex stimuli such as the faces or voices of particular individuals, or to particular objects or social situations, cortical decoding to the object level is usually required. This is performed in areas such as the inferior temporal visual cortex, where the reinforcement value of stimuli is not represented, but which provide major afferents to structures such as the orbitofrontal cortex and amygdala, where the reinforcement value is learned by stimulus-reinforcement association learning (see Rolls, 1999).

One way in which cognition is related to emotion is that whenever cognitive processing leads to identification that a stimulus, event, or idea is reinforcing, emotion will result. A second way is that cognitive processing may be affected by backprojections to higher cortical areas from parts of the brain involved in emotion (see Rolls, 1999; Rolls and Treves, 1998). The issue of emotional feelings is part of the very large problem of consciousness (see Rolls, 1997, 1999).

Emotion-related decisions may be made implicitly, using routes from for example the orbitofrontal cortex and amygdala to the basal ganglia. This system is able to influence behavior based on direct decoding of whether a stimulus is associated by previous learning with reinforcement. A second brain system enables immediate reinforcers to be deferred, and instead using Aif-then@ statements to be made to obtain longer-term reinforcers. This system requires syntactic manipulation of symbols, and the reinforcers are chosen on quite a different basis, so that the two systems do not
necessarily agree (see Rolls, 1999, 2000). However, once the possible reinforcers have been selected by either the immediate or deferred (implicit or explicit) system, sending the computed decision to the body and then acting on the feedback would do no more than introduce noise into the decision system (see Rolls, 1999).

References