

DORSAL COLUMN

Book Review

Hot cognition explained

Emotion and Decision-Making Explained is the bold claim of Edmund Rolls in the title of his new volume, which updates the earlier work *Emotion Explained* (2005), with the motivation partly to recognize the recent explosive interest in, and overlap between, these two areas of enquiry, as well as to assimilate the new directions stimulated by advances in neuroeconomics and related approaches. The book is a comprehensive survey of the tremendous advances made in 'affective neuroscience' over the past 50 years or so, in the context of the many significant contributions and exciting discoveries of Rolls himself and of his collaborators, covering basic anatomical principles, neurophysiology, behaviour and modelling. The volume thus serves to track Rolls' own intellectual development and research career from early studies in single unit behavioural electrophysiology conducted in macaques, to pioneering experiments on the central substrates of taste and pleasure in humans using functional brain resonance imaging, to the most recent forays into theoretical neuroscience, including computational modelling. In that sense it is perhaps more akin to a scientific odyssey or autobiography than a textbook, although one would struggle to find another single volume that covered so much of relevance in the field with writing so clear and tutorial, doubtless honed by several generations of teaching undergraduates at Oxford University.

The pedagogical value of the book is enhanced by its clever organization, by 80 pages or so of explanatory appendices and glossary which lighten the burden for the main text, by ample illustrations, and a rich collection of sumptuous colour plates. The book is handsomely produced, apparently being typeset by the author himself, with few obvious errors. I will certainly use it myself in undergraduate and graduate level courses.

The main theoretical framework adopted is that of conventional animal learning theory, blended with the computational approaches of modern reinforcement learning and applied to systems level neuroscience and Darwinian evolutionary theory. Thus, genes are assumed to code for valuable biological goals such as food, and selection pressure is therefore applied in favour of acquiring flexible patterns of behaviour that can capitalize on environmental cues predicting the availability of such goals. On the other hand, the complexities of considering sexual behaviour simply in terms of reward value systems are entertainingly covered

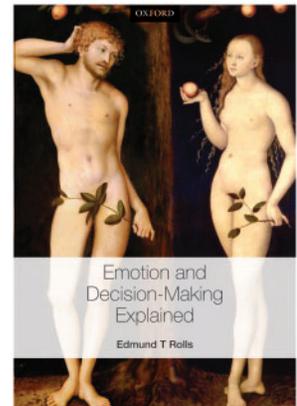
EMOTION AND DECISION-MAKING EXPLAINED

By Edmund T. Rolls 2013.

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in a chapter on sexual motivation with a pronounced sociobiological bent. The diversity of emotions such as guilt and anger is explained as variations in response to basic contingencies of reinforcement, much like the writings of O. Mowrer, amongst others, although there is apparently little coverage of 'counterfactual' emotions such as regret.

Brain mechanisms of emotion are developed from the processing of sensory input, such as taste, smell, touch and vision, and include references to some of the author's most celebrated empirical work in terms of single unit recording of defined secondary pathways in structures such as the orbitofrontal cortex, later related convincingly to functional MRI studies of hedonic responses in humans. The orbitofrontal cortex is essentially identified as the 'head ganglion' of a human reinforcement system where emotional value is invested in inputs, whether to primary rewards or punishers or to symbolic stimuli of other modalities associated with such goals, i.e. conditioned or secondary reinforcers. The book describes one of the most important discoveries to have come from the Rolls' laboratory, the neural instantiation of the phenomenon of 'sensory specific satiety', that phenomenon whereby the attractiveness of a particular food declines as a function of its familiarity, thereby explaining our propensity for deserts on a relatively full stomach. This 'gating' of value of sensory stimuli as a function of motivational state is a central theme of the book and figures particularly in a chapter devoted to hunger and appetite. The acquisition of learned behaviour and its flexibility, e.g. in terms of reversal learning, is another likely function of

orbitofrontal cortex, despite some recent controversy, and the detection of altered contingencies by neurons in the orbitofrontal cortex and its connections with the amygdala, is another familiar finding which has generated considerable research in the last decade, some of which is reviewed here.

The amygdala, cingulate cortex, medial prefrontal cortex, insula and basal ganglia are similarly covered selectively, but authoritatively, in separate sections or chapters. Special coverage in the basal ganglia chapter is afforded of Wolfram Schultz's seminal discovery in macaque monkeys of 'error-predicting' dopamine neurons in the ventral midbrain during the learning of rewarded tasks. Rolls is quick to remind us on p. 282 in emboldened text that:

'... dopamine neurons could not convey information about a primary reward obtained if the trial is successful. They are thus unlike, and could not perform the functions of the outcome value neurons of the orbitofrontal cortex.'

He also points out that they are unlike negative prediction error signals of the orbitofrontal cortex, which increase their firing rate when an expected reward is not obtained. In fact, Rolls is critical of the 'reward prediction error signal' hypothesis and comes down in favour of a view not a million miles from that of others, including myself, that striatal dopamine activity reflects behavioural preparation (or 'activation'), although he also allows for the possibility that the tonic and phasic modes of activity of the system may accommodate a range of complementary functions.

Aside from the coverage of dopamine, the coverage of neurochemical correlates of emotion and motivation is rather disappointingly perfunctory, perhaps understandably so in a book of some 700 pages. The other monoamines, noradrenaline and serotonin are mentioned in specific contexts; noradrenaline only in relation to emotional memory (reference to a paper by Borsini and Rolls, 1984) though surprisingly not in relation to more recent work on reconsolidation of memory relevant to post-traumatic stress disorder; and serotonin (5-HT) is mentioned mainly in terms of its contribution to the pharmacology of human depression, despite its paradoxical contributions to both anxiety and depression and its likely role in aversion as well as reward. These topics are covered in more detail in the text cited of Iversen *et al.* (2008). Similarly, the neuroendocrinology and neurochemistry of stress does not get covered in any great detail, despite its obvious relevance. Nonetheless, Rolls deserves praise for making many clinical links in this monumental review, and there is

a thoughtful section, for example, on human brain imaging investigations of mood and depression, as well as references at appropriate junctures to anorexia, bulimia, and anxiety disorders. Thus, although I would certainly recommend the present volume to a clinical psychiatric and neurological readership, it would be more for its emphasis on brain systems and networks underlying emotion than for their neurochemical modulation.

The last half of the book is concerned with decision-making mechanisms through instructive coverage of topics such as decisions under risk and ambiguity, Prospect theory, confidence, 'noise', and perceptual decision-making, in a synthesis that engages basic neural network theory, modelling, evolutionary theory and neuroimaging. I was impressed by the representation of 'dynamical neuropsychiatry', in terms of the imaginative, though speculative, modelling of OCD in attractor networks modulated by cortical glutamate. Terminal sections include readable accounts of classical and behavioural economics, which are brought around, full circle, to neural representations, for example of sensory satiety, in the orbitofrontal cortex, as well as 'a theory of consciousness'. In this final chapter, Rolls fairly admits in advance that 'what is written cannot be regarded as being as firmly scientific as the other chapters in the book' (p. 484). Nevertheless, he makes a stimulating attempt to at least address the mysteries of qualia, aesthetics, ethics and free will, in the context of attempting to explain the origin of emotional feelings and their subjective expression via language. Emotion is thus not quite explained, but the issues remain wide open for future investigation.

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