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# Neurobiological foundations of aesthetics and art

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ABSTRACT

A theory of the neurobiological foundations of aesthetics and art is described. This has its roots in emotion, in which what is pleasant or unpleasant, a reward or punisher, is the result of an evolutionary process in which genes define the (pleasant or unpleasant) goals for action. To this is added the operation of the reasoning, syntactic, brain system which evolved to help solve difficult, multistep, problems, and the use of which is encouraged by pleasant feelings when elegant, simple, and hence aesthetic solutions are found that are advantageous because they are parsimonious, and follow Occam's Razor. The combination of these two systems, and the interactions between them, provide an approach to understanding aesthetics that is rooted in evolution and its effects on brain design and function.



## 1. Introduction

A theory of the neurobiological foundations of aesthetics and art is described. This has its roots in emotion, in which what is pleasant or unpleasant, a reward or punisher, is the result of an evolutionary process in which genes define the (pleasant or unpleasant) goals for action (Rolls, 2005, 2014a). It is argued that combinations of multiple such factors provide part of the basis for aesthetics. To this is added the operation of the reasoning, syntactic, brain system which evolved to help solve difficult, multistep, problems, and the use of which is encouraged by pleasant feelings when elegant, simple, and hence aesthetic solutions are found that are advantageous because they are parsimonious, and follow Occam's Razor. The combination of these two systems, and the interactions between them, provide an approach to understanding aesthetics that is rooted in evolution and its effects on brain design and function (Rolls, 2011c, 2012b, 2014a, 2016a).

I start by considering how affective value is generated in the brain as a solution to the problem of how genes can specify useful goals for actions. This is more efficient and produces more flexible behaviour than by specifying the actions themselves. Then, in Sections 5 and 6, I develop this theory further into a theory of the foundations of aesthetics and art.

## 2. Emotions as states elicited by rewards and punishers

Emotions can usefully be defined (operationally) as states elicited by rewards and punishers that have particular functions (Rolls, 1999, 2005, 2014a). The functions are defined below, and include working to obtain or avoid the rewards and punishers. A reward is anything for which an animal (which includes humans) will work. A punisher is anything that an animal will escape from or avoid. A diagram summarizing some of the emotions associated with the delivery of a particular reward or punisher or a stimulus associated with them, or with the omission of a reward or punishment, is shown in Fig. 1. It is emphasized that this shows states elicited by any one reward of punisher, and that there are many different rewards and punishers. This helps to account for many different emotions (Rolls, 1999, 2005, 2014a).

The proposal that emotions can be usefully seen as states produced by instrumental reinforcing stimuli follows earlier work by Millenson (1967), Weiskrantz (1968), Gray (1975, 1987), and Rolls (1986a, 1986b), 1986b, 1990; 1999, 2000; 2005). (Instrumental reinforcers are stimuli which, if their occurrence, termination, or omission is made contingent upon the making of a response (action), alter the probability of the future emission of that response.)

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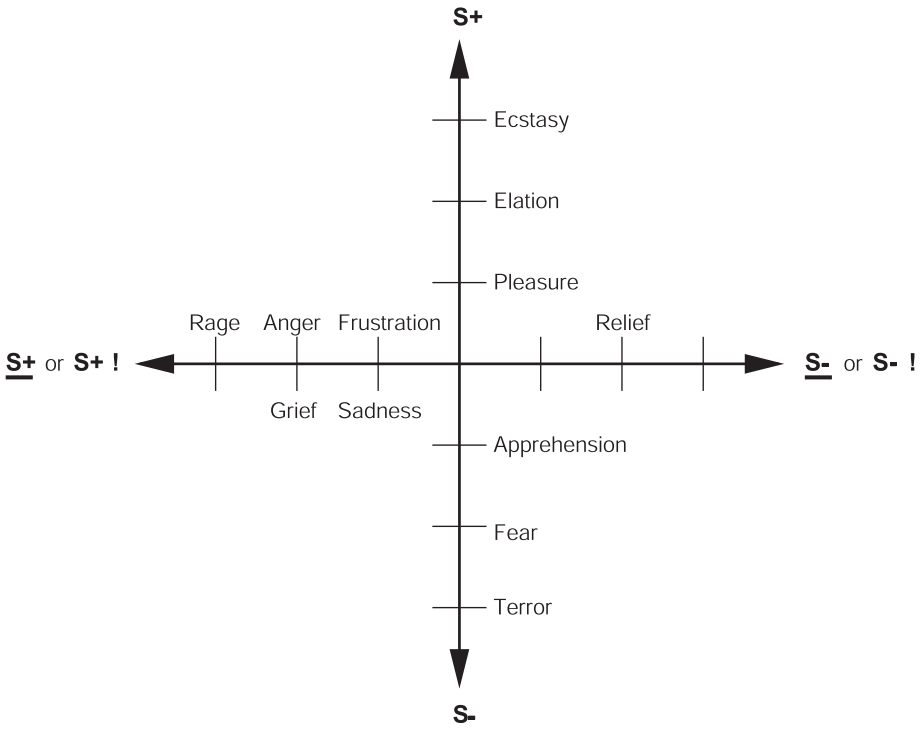


**Fig. 1.** Some of the emotions associated with different reinforcement contingencies are indicated. Intensity increases away from the centre of the diagram, on a continuous scale. The classification scheme created by the different reinforcement contingencies consists of (1) the presentation of a positive reinforcer (S+), (2) the presentation of a negative reinforcer (S-), (3) the omission of a positive reinforcer (S+) or the termination of a positive reinforcer (S+!), and (4) the omission of a negative reinforcer (S-) or the termination of a negative reinforcer (S-!).

Some stimuli are unlearned reinforcers (e.g., the taste of food if the animal is hungry, or pain); while others may become reinforcing by learning, because of their association with such primary reinforcers, thereby becoming 'secondary reinforcers'.

This foundation has been developed (see Rolls, 1986a, 1986b, 1986b, 1990, 1999, 2000, 2005, 2014a) to show how a very wide range of emotions can be accounted for, as a result of the operation of a number of factors, including the following:

1 The *reinforcement contingency* (e.g., whether reward or punishment is given, or withheld) (see Fig. 1).
2 The *intensity* of the reinforcer (see Fig. 1).
3 Any environmental stimulus might have a *number of different reinforcement associations*. (For example, a stimulus might be associated both with the presentation of a reward and of a punisher, allowing states such as conflict and guilt to arise.)
4 Emotions elicited by stimuli associated with *different primary reinforcers* will be different. A list of some primary reinforcers to illustrate some of the different affective states is provided in *Emotion and Decision-Making Explained* (Rolls, 2014a, 2014b, 2014c) and in *Neuroculture* (Rolls, 2012a, 2012b).
5 Emotions elicited by *different secondary reinforcing stimuli* will be different from each other (even if the primary reinforcer is similar).
6 The emotion elicited can depend on whether an *active or passive behavioural response* is possible. (For example, if an active behavioural response can occur to the omission of a positive reinforcer, then anger might be produced, but if only passive behaviour is possible, then sadness, depression or grief might occur.)

By combining these six factors, it is possible to account for a very wide range of emotions (for elaboration see Rolls, 2014a, 2014b, 2014c).

## 3. The functions of emotion

The most important functions can be summarized as follows (Rolls, 1990, 1999, 2005, 2014a):

1 The *elicitation of autonomic responses* (e.g., a change in heart rate) and *endocrine responses* (e.g., the release of adrenaline). These prepare the body for action.
2 *Flexibility of behavioural responses to reinforcing stimuli*. Emotional (and motivational) states allow a simple interface between sensory inputs and action systems. The essence of this idea is that goals for behaviour are specified by reward and punishment evaluation. When an environmental stimulus has been decoded as a primary reward or punishment, or (after previous stimulus-reinforcer association learning) a secondary rewarding or punishing stimulus, then it becomes a goal for action. The person can then perform any action (instrumental response) to obtain the reward, or to avoid the punisher. Thus there is flexibility of action.

The emotional state intervenes between delivery of the stimulus and its decoding as rewarding or punishing, which produces the emotional state, and the learning and performance of the action, which may only be possible with some delay. In this sense, for goal-directed action, an intervening state is required. For overlearned stimulus-response habit-based responses, no intervening state is necessary, and emotional states need not be present. This is one of the reasons why I propose that emotions are part of a brain/behaviour system in which arbitrary actions must be learned to reinforcing stimuli to obtain goals. This is an important reason why I relate emotions to the evolution of instrumental actions to rewarding and punishing stimuli, as intervening states are needed in this process (Rolls, 2014a, 2014b, 2014c). The motivation that is part of the intervening state is to obtain the reward or avoid the

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