Chapter 23

Neurobiological foundations of art and aesthetics

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23.1 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, 2013a). 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 multi-step 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 2011a, 2012).

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 behavior than by specifying the actions themselves. Then, in sections 23.5 and 23.6, I develop this theory further into a theory of the foundations of aesthetics and art.

23.2 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, 2013a). 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 Figure 23.1. It is emphasized that this shows states elicited by any one reward or punisher, and that there are many different rewards and punishers. This helps to account for many different emotions (Rolls 1999, 2005, 2013a).

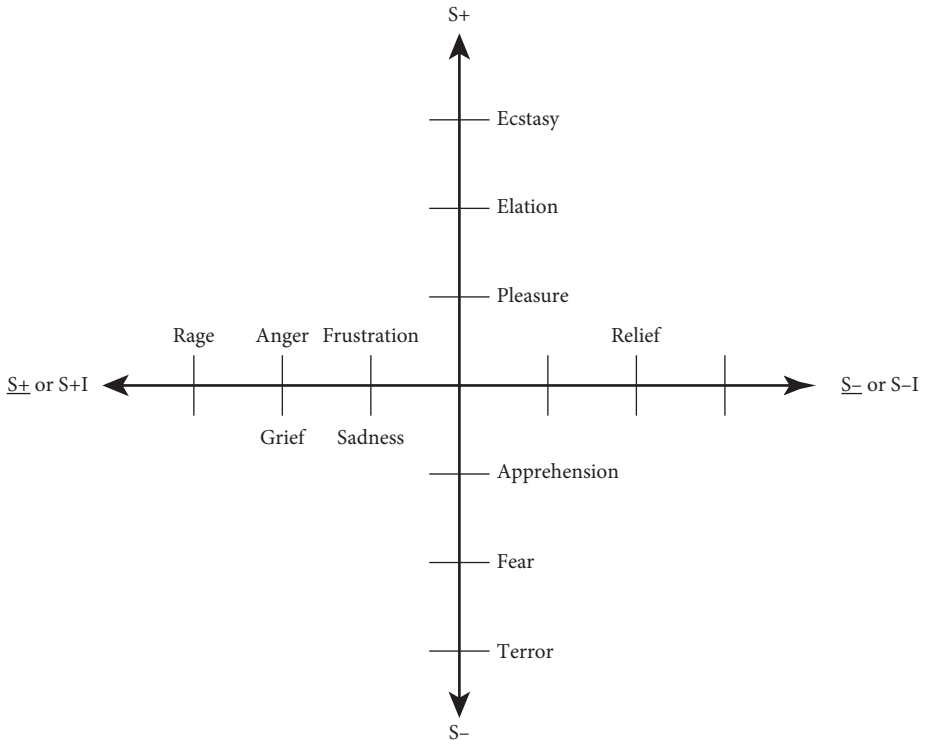

Figure 23.1 Some of the emotions associated with different reinforcement contingencies are indicated. Intensity increases away from the center of the diagram, on a continuous scale. The classification scheme created by the different reinforcement contingencies consists of (1) the presentation of a positive 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-!).

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

This foundation has been developed (see Rolls 1986a,1986b, 1990, 1999, 2000, 2005, 2013a) 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 Figure 23.1).

(2) The *intensity* of the reinforcer (see Figure 23.1).

(3) Any environmental stimulus might have a *number of different reinforcement associations* (e.g. 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 2013a) and in *Neuroculture* (Rolls 2012).

(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 behavioral response* is possible. (For example, if an active behavioral response can occur to the omission of a positive reinforcer, then anger might be produced, but if only passive behavior 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 2013a).

23.3 The functions of emotion

The most important functions can be summarized as follows (Rolls 1990, 1999, 2005, 2013a):

(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 behavioral 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 behavior 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 over-learned 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/behavior system in which arbitrary actions must be learned to reinforcing stimuli in order 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 2013a). The motivation that is part of the intervening state is to obtain the reward or avoid the punisher, and animals must be built to obtain certain rewards and avoid certain punishers. Further, and very importantly for this shows why emotions have evolved, primary or unlearned rewards and punishers are specified by genes which effectively specify the goals for action. This is the solution which natural selection has found for how genes can influence behavior to promote their fitness (as measured by reproductive success), and for how the brain could interface with sensory systems to action systems, and it is an important part of Rolls' theory of emotion (1990, 1999, 2005, 2013a).

Selecting between available rewards with their associated costs, and avoiding punishers with their associated costs, is a process that can take place both implicitly (unconsciously) and explicitly using a language system to enable long-term plans to be made (Rolls 2005, 2008). These many different brain systems, some involving implicit evaluation of rewards, and others explicit, verbal conscious evaluation of rewards and planned long-term goals, must all enter into the selector of behavior (see Figure 23.2). This selector is poorly understood, but it might include a process of competition between all the competing calls

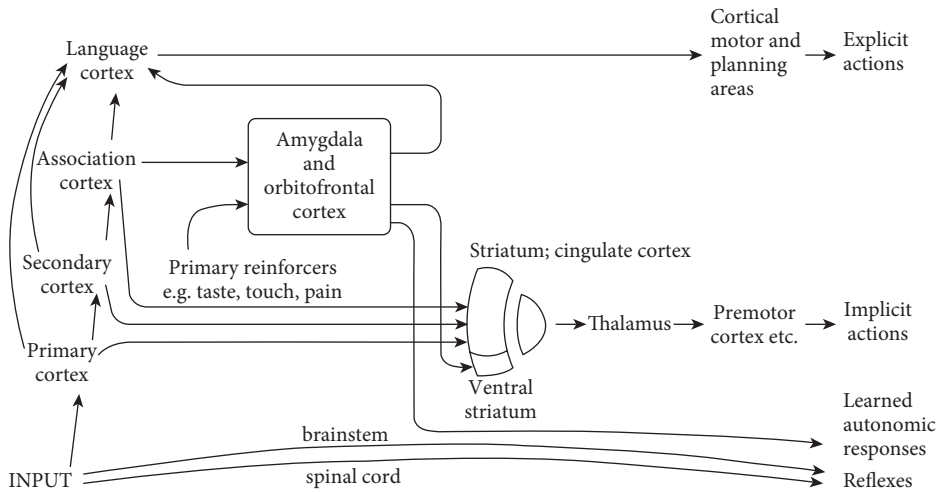

Figure 23.2 Dual routes to the initiation of action in response to rewarding and punishing stimuli. The inputs from different sensory systems to brain structures such as the orbitofrontal cortex and amygdala allow these brain structures to evaluate the reward- or punishment-related value of incoming stimuli, or of remembered stimuli. The different sensory inputs enable evaluations within the orbitofrontal cortex and amygdala based mainly on the primary (unlearned) reinforcement value for taste, touch, and olfactory stimuli, and on the secondary (learned) reinforcement value for visual and auditory stimuli. In the case of vision, the "association cortex" which outputs representations of objects to the amygdala and orbitofrontal cortex is the inferior temporal visual cortex. One route for the outputs from these evaluative brain structures is via projections directly to structures such as the basal ganglia (including the striatum and ventral striatum) to enable implicit, direct behavioral responses based on the reward- or punishment-related evaluation of the stimuli to be made. The second route is via the language systems of the brain, which allow explicit decisions involving multi-step syntactic planning to be implemented.

on output, and might involve the anterior cingulate cortex and basal ganglia in the brain (Rolls 2005, 2008, 2013a) (see Figure 23.2).

23.4 Dual routes to action: gene-defined goals, and syntactic reasoning

The first route is via the brain systems that have been present in non-human primates such as monkeys, and to some extent in other mammals, for millions of years, and have built in the brain a system for defining these goals. Achieving these goals feels pleasant or unpleasant. The goals may be primary reinforcers, or stimuli associated with them by learning.

The second route in humans and also perhaps closely related animals involves a computation with many "if . . . then" statements to implement a plan to obtain a reward. In this case, the reward may actually be *deferred* as part of the plan, which might involve working first to obtain one reward, and only then to work for a second more highly valued reward, if this was thought to be overall an optimal strategy in terms of resource usage (e.g. time). In this case, syntax is required, because the many symbols (e.g. names of people) that are part of the plan must be correctly linked or bound. Such linking might be of the form: "if A does this, then B is likely to do this, and this will cause C to do this. . . ." The requirement of syntax for this type of planning implies that an output to language systems in the brain is required for this type of planning (see Figure 23.2). Thus the explicit language system in humans may allow working for deferred rewards by enabling use of a one-off, individual, plan appropriate for each situation.

The question then arises of how decisions are made in animals such as humans that have both the implicit, direct, reward-based instrumental action, and the explicit, rational, planning systems (see Figure 23.2) (Rolls 2008, 2013a). One particular situation in which the first, implicit, system may be especially important is when the interests of the genes are being maintained. In contrast, when the implicit system continually makes errors, it would then be beneficial for the organism to switch from automatic, direct action based on obtaining what the orbitofrontal cortex system decodes as being the most positively reinforcing choice currently available, to the explicit conscious control system that can evaluate with its long-term planning algorithms what action should be performed next.

The second route to action allows, by reasoning, decisions to be taken that might not be in the interests of the genes, might be longer-term decisions, and might be in the interests of the individual. Thus we may speak of the choice as sometimes being between the "Selfish Genes" (Dawkins 1989) and the "Selfish Phenes" (Rolls 2011b, 2012, 2013b).

23.5 A theory of the neurobiological foundations of aesthetics and art

23.5.1 Introduction to and outline of the theory

Now that we have a fundamental, Darwinian approach to the value of people, objects, relationships, etc., I propose that this provides a fundamental neurobiological approach to understanding aesthetics and art. I propose that while the gene-specified rewards and

punishers define many things that have aesthetic value, the value that we place on items is enhanced by the reasoning, rational system which enables what produces aesthetic value to become highly intellectualized, as in music.

I emphasize at the outset that this does not at all reduce aesthetics to a common denominator. Genetic variation is essential to evolution by natural selection, and this is one reason why we should expect different people to assign aesthetic value differently. But rational thought, which will lead in different directions in different people, partly because of noise caused by random neuronal firing times in the brain (Rolls and Deco 2010; Rolls 2013a), and because of what they have learned from the environment, and because different brain areas will be emphasized in different people, will also be different between individuals, so that the rational system will also contribute to differences between individuals in what is considered aesthetic.

Indeed, although the theory presented here on the origin of aesthetics is a reductive explanation in that it treats the underlying bases and causes, it should not be seen to "reduce" aesthetics. Far from it. When we understand the underlying origins and bases of aesthetics, we see that the processes involved are elegant and beautiful, as part of a Darwinian theory. But the approach also provides important pointers about how to enhance aesthetics. For example, by understanding that verbal-level cognitive factors that can be produced by reasoning have a top-down modulatory influence on the first cortical area where value (reward) is made explicit in the representation, the orbitofrontal cortex (de Araujo et al. 2005; Grabenhorst et al. 2008; McCabe et al. 2008; Rolls 2013a, 2013c), we can see ways in which we can enhance our aesthetic feelings. (For example, if love be the thing, then it can be heightened by explicitly choosing the musical treatment of it in Wagner's *Tristan and Isolde*.)

I should also emphasize that aesthetic value judgments will usually be influenced by a number of different value factors, so that while accounting for an aesthetic judgment by just one of the value factors I describe is and will often seem too simple, it does seem that aesthetic value judgments can be understood by combinations of some of the factors I describe.

I emphasize that rewards contribute to what makes stimuli or brain processing positively aesthetic, beautiful; and that the punishers contribute to what makes stimuli or processing in the brain aesthetically negative, lacking beauty, ugly, or distasteful. Both rewards and punishers are needed for the theory of aesthetics.

The overall theory of the origin of aesthetics I propose is that natural selection, whether operating by "survival or adaptation selection," or by sexual selection, operates by specifying goals for action, and these goals are aesthetically and subjectively attractive or beautiful (Rolls 2005, 2013a), or the opposite, and provide what I argue here is the origin of many judgments of what is aesthetic.

23.5.2 "Survival" or "adaptation" selection (natural selection in a narrow sense)

"Natural selection" encompasses in its broad sense both "survival or adaptation selection," and sexual selection. Both are processes now understood to be driven by the selection of

genes, and it is gene competition and replication into the next generation that is the driving force of biological evolution (Dawkins 1986, 1989). The distinction can be made that with "survival or adaptation selection," the genes being selected for make the individual stronger, healthier, and more likely to survive and reproduce, whereas sexual selection operates by sexual choice, selecting for genes that may or may not have survival value to the individual but enable that individual to be selected as a mate or to compete for a mate in intra-sexual selection and thus pass on the genes selected by intra-sexual or inter-sexual selection to the offspring. More generally, we might have other types of selection as further types of natural selection, including selection for good parental care, and kin selection.

Many of the reward and punishment systems described by Rolls (2013a) deal with reward and punishment decoding that has evolved to enable genes to influence behavior in directions in a high-dimensional space of rewards and punishments that are adaptive for survival and health of the individual, and thus promote reproductive success or fitness of the genes that build such adaptive functionality. We can include kin-related altruistic behaviors because the behavior is adaptive in promoting the survival of kin, and thus promoting the likelihood that the kin (who contain one's genes, and are likely to share the genes for kin altruism) survive and reproduce. We can also include reciprocal altruism as an example of "survival or adaptation" selection. Tribalism can be treated similarly, for it probably has its origins in altruism. Resources and wealth are also understood at least in part as being selected by "survival" natural selection, in that resources and wealth may enable the individual to survive better. As we will see next, resources and wealth can also be attractive as a result of sexual selection.

23.5.3 Sexual selection

Darwin (1871) also recognized that evolution can occur by sexual selection, when what is being selected for is attractive to potential mates (*inter-sexual selection*, for example the peacock's "tail," and a slim, young-looking physique in females as a signal of fertility), or helps in competing with others of the same sex (*intra-sexual selection*, e.g. the deer's large antlers, and a strong male physique).

Overall, Darwinian natural or survival selection increases health, strength, and potentially resources, and survival of the individual, and thus ability to mate and reproduce, and to look handsome or beautiful. Inter-sexual sexual selection does not make the individual healthier, but does make the individual more attractive as a mate, as in female choice, an example of intersexual selection. Intrasexual sexual selection does not necessarily help survival of the individual, but does help in competition for a mate, for example in intimidation of one male by another (Darwin 1871; Kappeler and van Schaik 2004). The differences between "survival" and sexual selection are elaborated elsewhere (Rolls 2011a, 2012, 2013a).

23.5.4 Beauty in men and women

Given this background in the processes that drive evolution to make certain stimuli and types of brain processing rewarding or punishing, in this section I examine how they

contribute to what factors make men and women aesthetically beautiful, and that influence their depiction in art.

23.5.4.1 Female preferences: factors that make men attractive

Factors that across a range of species influence female selection of male mates include the following.

23.5.4.1.1 **Athleticism** This is the ability to compete well in mate selection (including being healthy and strong), as this will be useful for her genes when present in her male offspring. Consistently, women show a strong preference for tall, strong, athletic men (Buss and Schmitt 1993).

23.5.4.1.2 **Resources, power, and wealth** In species with shared parental investment (which include many birds and humans), having power and wealth may be attractive to the female, because they are indicators of resources that may be provided for her young. Consistently, women place a greater premium on income or financial prospects than men (Buss 1989, 2008).

23.5.4.1.3 **Status** Status correlates with the control of resources (e.g. alpha-male chimpanzees take precedence in feeding), and therefore acts as a good cue for women. Women should therefore find men of high status attractive (e.g. rock stars, politicians, and tribal rulers), and these men should be able to attract the most attractive partners. Consistent with this, cross-culturally, women regard high social status as more valuable than do men, and attractive women often marry men of high status (Buss 1989, 2008). Status may be attractive because of direct effects (e.g. as an indicator of resources for children), or because of indirect effects (because high status implies good genes for offspring).

23.5.4.1.4 **Age** Status and higher income are generally only achieved with age, and therefore women should generally find older men attractive. Cross-culturally, women prefer older men (3.42 years older on average, and marriage records from 27 countries show that the average age difference was 2.99 years) (Buss 1989).

23.5.4.1.5 **Ambition and industriousness** These may be good predictors of future occupational status and income and are attractive to women (Buss 1989).

23.5.4.1.6 **Testosterone-dependent features** These may also be attractive. These features include a strong (longer and broader) jaw, a broad chin, strong cheekbones, defined eyebrow ridges, a forward central face, and a lengthened lower face (secondary sexual characteristics that are a result of pubertal hormone levels).

23.5.4.1.7 **Symmetry** This may be attractive (in both males and females), in that it may reflect good development *in utero*, a non-harmful birth, adequate nutrition, and lack of disease and parasitic infections (Thornhill and Gangestad 1999).

AQ1 23.5.4.1.8 **Dependability and faithfulness** These may be attractive, particularly where there is paternal investment in bringing up the young, as these characteristics may indicate stability of resources (Buss et al. 1989).

23.5.4.1.9 **Risk-taking by men** This may be attractive to women, perhaps because it is a form of competitive advertising: surviving the risk may be an honest indicator of high-quality genes (Barrett et al. 2002).

23.5.4.1.10 **Other** Characteristics that may not be adaptive in terms of the survival of the male, but that may be attractive because of inter-sexual sexual selection, are common in birds, perhaps less common in most mammals, though present in some primates (Kappeler and van Schaik 2004), and may be present in humans (see section 23.5.3).

23.5.4.1.11 **Odor** The preference by women for the odor of symmetrical men is correlated with the probability of fertility of women as influenced by their cycle (Gangestad and Simpson 2000). Another way in which odor can influence preference is by pheromones that are related to major histocompatibility complex (MHC) genes, which may provide a molecular mechanism for producing genetic diversity by influencing those who are considered attractive as mates (Rolls 2011a, 2012, 2013a).

23.5.4.2 Male preferences: what makes women attractive and beautiful to men

Males are not always indiscriminate. When a male chooses to invest (e.g. to produce offspring), there are preferences for the partner with whom he will make the investment. Accurate evaluation of female quality (reproductive value) is therefore important, and males look out for cues to this, and find these cues attractive, beautiful, and rewarding. The factors that influence attractiveness include the following (Barrett et al. 2002; Rolls 2011a, 2012, 2013a).

23.5.4.2.1 **Youth** As fertility and reproductive value in females is linked to age (reproductive value is higher when younger, and actual fertility in humans peaks in the 20s), males (unlike females) place a special premium on youth. It is not youth per se that men find attractive, but indicators of youth; for example, neotenous traits such as blonde hair and wide eyes. An example of this preference is that male college students preferred an age difference on average of 2.5 years younger (Buss 1989). Another indicator of youth might be a small body frame, and it is interesting that this might contribute to the small body frame of some women in this example of sexual dimorphism.

23.5.4.2.2 **Beautiful features** Features that are most commonly described as the most attractive tend to be those that are oestrogen-dependent; for example, full lips and cheeks, and short lower facial features (oestrogen caps the growth of certain facial bones).

Why do women apparently compete for men by paying attention to their own beauty and fashion? Perhaps the answer that males who are willing to make major investments of time and resources in raising the children of a partner are a somewhat limiting resource (as other factors may make it advantageous genetically for men not to invest all their resources in one partner), and because women are competing to obtain and maintain this scarce resource. Faithful men may be a limited resource because there are alternative strategies that may have a low cost, whereas women are essentially committed to a considerable investment in their offspring.

Given that men are a scare resource, and that women make such a major investment in their offspring that they must be sure of a man's commitment to invest before they commit in any way, we have a scientific basis for understanding why women are reserved and more cautious and shy in their interactions with men, which has been noticed to be prevalent in visual art, in which men look at women, but less vice versa (Berger 1972).

23.5.4.2.3 **Body fat** The face is not the only cue to a woman's reproductive capacity, her attractiveness, and beauty. Although the ideal body weight varies significantly with culture (in cultures with scarcity, obesity is attractive and relates to status, a trend evident in beautiful painting throughout its history), the ideal distribution of body fat seems to be a universal standard, as measured by the waist-to-hip ratio (which cancels out effects of actual body weight). Consistently, across cultures, men preferred an average ratio of 0.7 (small waist/bigger hips) when rating female figures (line drawings and photographic images) for attractiveness (Singh and Luis 1995). At a simpler level, a low waist-to-hip ratio is an indication that a woman is not already pregnant, and is thus a contributor to attractiveness and beauty.

23.5.4.2.4 **Fidelity** The desire for fidelity in females is most obviously related to concealed ovulation—see the following and *Emotion and Decision-Making Explained* (Rolls 2013a)—and therefore the degree of paternity uncertainty that males may suffer.

23.5.4.2.5 **Attractiveness and the time of ovulation** Although ovulation in some primates and in humans is concealed, it would be at a premium for men to pick up cues to ovulation and find women highly desirable (and beautiful) at this time. Possible cues include an increased body temperature reflected in the warm glow of vascularized skin (Vandenberghe and Frost 1986), and pheromonal cues. Another possibly unconscious influence might be on the use of cosmetics and the types of clothes worn, which may be different close to the time of ovulation.

In humans, male investment in caring for the offspring means that male choice has a strong effect on intra-sexual selection in women. Female cosmetic use and designer clothing could be seen as weapons in this competition, and perhaps are reflected in extreme female self-grooming behavior such as cosmetic surgery, or pathological disorders such as anorexia, bulimia, and body dysmorphic disorder. By bombarding people with images of beautiful women, the media may heighten intra-sexual selection even further, pushing women's competitive mating mechanisms to a major scale.

23.5.5 Pair-bonding, love, and a beautiful partner

Attachment to a particular partner by pair bonding in a monogamous relationship, which in humans becomes manifest in love between pair-bonded parents, and which occurs in humans in relation to the advantage to the man of investing in his offspring, may have special mechanisms to facilitate it. One is oxytocin, a hormone released from the posterior pituitary, whose other actions include the milk let-down response, which is released during mating and which promotes attachment, making a partner attractive (Lee et al. 2009).

Are similar mechanisms at work in humans to promote pair bonding and love (and what is found to be aesthetically attractive, and to influence depictions in art)? There is as yet no definitive evidence for this, but in humans, oxytocin is released by intercourse, and especially at the time of orgasm, in both women and men (Meston and Frohlich 2000; Kruger et al. 2003).

23.5.6 Parental attachment: beautiful children

Many mammal females make strong attachments to their own offspring and this is also facilitated in many species by oxytocin. In humans, oxytocin is released during natural childbirth, and rapid placing of the baby to breast feed and release more oxytocin (Uvnas-Moberg 1998) might further facilitate maternal attachment to her baby. Prolactin, the female hormone that promotes milk production, may also influence maternal attachment and how beautiful a mother thinks her child is. It is certainly a major factor in humans that bonding can change quite suddenly at the time that a child is born, with women having a strong tendency to shift their interests markedly towards the baby as soon as it is born (probably in part due to hormonal influences), and this can result in relatively less attachment behavior to the husband.

The tendency to find babies beautiful is not of course restricted to parents of their own children. Part of the reason for this is that in the societies in which our genes evolved with relatively small groups, babies encountered might often be genetically related, and the tendency to find babies beautiful is probably a way to increase the success of selfish genes. One may still make these aesthetic judgments of babies in distant countries with no close genetic relationship, but this does not of course mean that such judgments do not have their evolutionary origin in kin-related advantageous behavior.

23.5.7 Synthesis on beauty in humans

We see that many factors are involved in making humans attractive, and beautiful. All may contribute to different extents, and differently in different individuals, and moreover we may not be conscious of some of the origins of our aesthetic judgments but may confabulate reasons for what we judge to be aesthetic.

When there is a biological foundation for art, for example when it is figurative, and especially when it is about human figures, there may be a basis for consensus about what is good art—art that stimulates our rational system and at the same time speaks to what we find beautiful due to our evolutionary history. However, if art becomes totally abstract, we lack the biological foundation for judging whether it is aesthetically beautiful, and judgments may be much more arbitrary and driven by short-term fashion. Some abstraction away from very realistic and figurative in art can of course have advantages because it allows the viewer to create in his or her own experience of a work of art by adding his or her own interpretation of it.

There is an important point here about the separation between art and the world. Objects of art can idealize beauty, and enhance it. An example is the emphasis on thin bodies, long limbs, and athletic poses found in some Art Deco sculpture, for example in the works

of Lorenzl. Here what is beautiful can be made super-normal, one might say in the literal sense super-natural. Another example is in the emotion in the music of Wagner's *Tristan and Isolde*. We see that art can emphasize and thus idealize some of the properties of the real world, and lose other details that do not enhance or distract from it. This abstraction of what we find beautiful due to evolution can be seen in some semi-figurative/semi-abstract art, as in some of the line drawings of humans by Matisse and Picasso. It is also found in the sculptures of human forms of Brancusi. What I argue is that if art becomes too abstract then it loses the aesthetic value that can be contributed by tapping into these evolutionary origins. Interesting cases are found in the sculptures of Barbara Hepworth and Henry Moore. In the case of Barbara Hepworth, I find it interesting that she often retains sufficient figurative allusions in her sculpture to tap into evolutionary origins, in that some of her sculptures do seem to have some relation to male and female forms and relations. Much of the sculpture of Henry Moore is clearly figurative, and where it becomes apparently very abstract it may lose what is gained by tapping into evolutionary origins, but may gain by association and interpretation in relation to his more figurative work. Where art becomes very abstract, as in some of the work of Mark Rothko, perhaps those especially interested are those who have expertise themselves in what is being achieved technically, such as the painting of colors by Rothko.

23.5.8 Sexual selection of mental ability, survival or adaptation selection of mental ability, and the origin of aesthetics

Miller (2000, 2001) has developed the hypothesis that courtship provides an opportunity for sexual selection to select non-sexual mental characteristics such as kindness, humor, the ability to tell stories, creativity, art, and even language. He postulates that these are "courtship tools, evolved to attract and entertain sexual partners."

Miller (2000, 2001) also suggests that art, language, and creativity can be explained by sexual selection, and that they are difficult to account for by survival selection. He suggests that art develops from courtship ornamentation, and uses bowerbirds as an evolutionary example. Male bowerbirds ornament their often enormous and structurally elaborate nests or bowers with mosses, ferns, shells, berries, and bark to attract female bowerbirds. The nests are used just to attract females, and after insemination the females go off and build their own cup-shaped nests, lay their eggs, and raise their offspring by themselves with no male support. In this sense, the bowers are useless ornamentations that do not have survival value. Darwin (1871) himself viewed human ornamentation and clothing as outcomes of sexual selection. Sexual selection for artistic ability does not mean of course that the art itself needs to be about sex. This example helps to show that sexual selection can lead to changes in what is valued and found attractive in areas that might be precursors to art in humans. In Miller's (2001) view, the fine arts are just the most recent and pretentious manifestations of a universal human instinct for visual self-ornamentation, which in turn is a manifestation of sexual selection's universal tendency to ornament individuals with visual advertisements of their fitness. Thus, the human capacity for visual artistry is viewed as a "fitness indicator," evolved like the peacock's tail and the bowerbird's bower

for a courtship function. So although inherently useless, the bower or work of art is seen as attractive because it is difficult to produce, and might only be made by a brain that is very competent in general, and thus the bower or work of art may act as a fitness indicator.

A useful point (Miller 2001) is that although artworks are now commodified and distributed widely so that we may not necessarily know the artist producing the ornament, when we seek the evolutionary origins of art we should remember that any artwork our prehistoric ancestors would have been able to see would have probably been made by a living individual with whom they could have interacted socially or sexually. The artist was never far from his or her work, or else the work could not have functioned as the artist's extended phenotype.

Miller (2000) further suggests that language and creativity may be related to systems that can explore random new ideas and they also may be courtship devices in males to attract females. My view, elaborated here and elsewhere (Rolls 2008; Rolls and Deco 2010; Rolls 2012, 2013a), is that language and creativity have functions that have survival value and thus are not just sexually selected.

Indeed, a criticism of the approach of Miller (2000) is that many of these characteristics (e.g. language, creative solutions, originality, problem solving) may have survival value, and are not purely or primarily sexually selected. For example, syntax and language have many uses in problem solving, planning ahead, and correcting multi-step plans that are likely to be very important to enable immediate rewards to be deferred, and longer-term goals to be achieved (Pinker and Bloom 1992; Rolls 2008, 2012, 2013a). In relation to aesthetics, I argue that when syntax is used successfully to solve a difficult problem we feel aesthetic pleasure, and I argue that the generation of pleasure generated by the survival value of good ideas contributes to the appeal of those ideas, and that sexual selection of the ideas as mental ornaments is not the only process at work in aesthetics.

Moreover, the notion (Miller 2000, 2001) that art has to do with useless ornaments (useless in the sense that sexual selection is for characteristics that may not have "survival" value, but may be attractive because they are "indicators of fitness") does not have much to say about the utilitarian arts such as simplicity of design in architecture. Perhaps the structure of a piece of music can appeal and be pleasing because it taps into our syntactic system that finds that elegant and simple solutions to problem solving produce pleasure. Further, interest in social relations and knowledge about them is adaptive as it may help to understand who is doing what to whom, and more generally help to understand what can happen to people. A great deal of literary fiction addresses these issues and is not primarily ornamental and without inherent value. Thus, although Miller (2000, 2001) may well be right that there are aspects of art that may be primarily ornamental and useless and these are simply indicators of general mental fitness, though attractive to members of the opposite sex in courtship, I suggest that much art has its roots in goals that have been specified as pleasurable or unpleasurable because of their adaptive or survival value, whether as primary reinforcers, other stimuli associated by learning with these, or rewards of a more cognitive origin that accrue when difficult cognitive, syntactic problems are solved (Rolls 2011a, 2012, 2013a).

Miller might predict that men should be specialized to have artistic creativity, to provide an ornament that women might find attractive because it is a fitness indicator. Evidence on this is difficult to evaluate, because there have been fewer opportunities available for women in the past, as argued for so beautifully by Virginia Woolf in *A Room of One's Own* (1928), and I come to no conclusions, but have the following thoughts. Whereas Virginia Woolf argues about circumstances, one can consider in addition the possibility that women's and men's brains have been subject to different selective pressure in evolution, and that this might contribute to differences in the ways in which they are creative. In terms of artists, composers of music, poets, writers of drama and non-fiction, there appears to be on average a preponderance of men relative to women. This is on average, and there are individual women who given the distribution around the average are undoubtedly highly creative in these areas, and have made enormous contributions. If this is the case (and it might take a long time into the future to know, given the imbalance of opportunity in the past), does this mean that sexual selection is the underlying process? I suggest that this would not necessarily be the case. Such a "sexual dimorphism" could occur by natural (adaptation) selection, not by sexual selection, in that women might have specialized for an environmental niche to emphasize child rearing, cultivation including food gathering and preparation, fashioning of clothing, and creating peaceful order among siblings and parents. On the other hand, men might have specialized for an environmental niche to emphasize spatial problem solving, useful for producing and using tools, building shelters, creating structures, etc., and navigational problem-solving useful for hunting, all of which would be good for survival. Interestingly, the same (narrow) natural selection pressure might have provided a survival advantage for men to have a stronger physique which is likely to be advantageous when manufacturing items useful for survival such as shelters. Thus interestingly, one of the predictions of sexual selection, sexual dimorphism, including human mental problem-solving as well as physique, could in this case have its origin at least partly in adaptation and survival.

There is however a possible exception to the generalization that at least in the past men have been more likely to be creative in "art" than women, and this is the area of literary fiction, where there are many women with high reputations as novelists (e.g. Jane Austen, George Eliot, Virginia Woolf). If women take more to this area of creative art, might this be because of the adaptive value of gossip to women, so knowing about who is doing what to whom, and having an interest and expertise in this, could be adaptive, perhaps helping a woman, and her children, to survive better (Dunbar 1996)? If this were the case, there might even be a prediction that women might be relatively better, on average, in areas of fiction, such as novels, where this interest and expertise in mind-reading and gossip, might be especially engaged. More generally, the evolutionary survival value approach might argue that women have adapted to relational, social, caring, problem solving, and the novel, particularly the novel of manners, is ideally suited to displaying this specialization. Indeed, the specialization for a caring role is consonant with Carol Gilligan's argument in *In a Different Voice* (1982) that women's sense of morality concerns itself with the activity of "care . . . responsibility, and relationships."

The overall point I make is that natural selection, sometimes operating by "survival or adaptation selection," and sometimes by sexual selection (and sometimes both), operates by specifying goals for action, and these goals are aesthetically and subjectively attractive or beautiful (Rolls 2012, 2013a), or the opposite, and provide what I argue here is the origin of many judgments of what is aesthetic. Many examples of these rewards and punishers, many of which operate for "survival or adaptation selection," and many of which contribute to aesthetic experience and judgments, are described elsewhere (Rolls 2011a, 2012, 2013a).

23.5.9 Fashion and memes

We have seen that sexual selection can provide runaway selective pressure for what is not something that is produced by "survival or adaptation" selection. In a sense, a fashion or useless ornament (which may indicate fitness) can be selected for genetically.

However, fashion is a strong characteristic of many human aesthetic judgments, and we may ask if there are further reasons for this that are not to do with genetic variation (which necessarily takes place over generations), but that instead operate over timescales of months to years. Such fashions (in, for example, clothing) may occur because they fit adaptations of the human mind, themselves the result of adaptive pressure in evolutionary history. For example, the human mind will be attracted towards new ideas (of clear adaptive value, for it is only by exploring new ideas that advantage may be gained partly as a result of finding a match with one's own genetically influenced capacities) (Rolls 2013a). In this way, there may be runaway changes that do not necessarily make the individual better adapted to the environment. Of course, many factors, again frequently of evolutionary origin, influence fashion, including its cost (of which the brand is an indicator) which helps to make it attractive as it indicates wealth, plentiful resources, and status, and the elegance and simplicity of the idea, which as argued below, the human mind finds attractive because simplicity often is a good indicator of a correct and useful solution to a problem. It is argued that memes (Blackmore 1999), ideas that follow some of the rules of fashion, fit these properties of the human mind.

23.5.10 The elegance and beauty of ideas, and solving problems in the reasoning system

Solving difficult problems feels good, and we often speak about elegant (and beautiful) solutions. What is the origin of the pleasure we obtain from elegant ideas, what makes them aesthetically pleasing? It is suggested that solving problems should feel good to us, to make us keep trying, because being able to solve difficult problems that require syntactic operations may have survival value (Rolls 2013a). But what is it that makes simple ideas and solutions (those with fewest premises, fewest steps to the solution, and fewest exceptions for a given level of complexity of a problem) particularly aesthetically pleasing, so much so that physicists may use this as a guide to their thinking? It is suggested that the human brain has become adapted to find simple solutions aesthetically pleasing because they are more likely to be correct (Rolls 2012, 2013a), and this is exactly the thrust of parsimony and Occam's Razor—the principle or heuristic that entities and hypotheses should not

be multiplied needlessly; the simplest of two competing and otherwise equally effective theories is to be preferred. The principle states that the explanation of any phenomenon should make as few assumptions as possible, eliminating those that make no difference in the observable predictions of the explanation or theory.

This finds expression in art: in, for example, the structure of a piece of music, in the solution of how to incorporate perspective into painting (which developed over hundreds of years and was helped by the camera obscura), and in the interest by Vitruvius and Leonardo in the proportions of the human body (tapping into our gene-based appreciation of that) to provide rules for proportions in architecture. Of course, focus on intellectual aspects of art can lead to art that we may find fascinating and revealing, if not conventionally physically beautiful, as in some of the work of Francis Bacon's. Factors such as cultural heritage and familiarity with the rules of a system can also make a style of architecture more appealing than something very unfamiliar. Some of the history of ecclesiastical architecture in England from the eleventh to the fifteenth century (from Norman through Early English and Decorated to Perpendicular styles) can also be seen as solutions to difficult architectural problems, of how to increase the light and feeling of space in a building, and how to create an impression of grand and daring height.

23.5.11 Cognition and aesthetics

Not only can operation of our reasoning, syntactic, explicit, system lead to pleasure and aesthetic value, as just described, but also this cognitive system can modulate activity in the emotional, implicit, gene-identified goal system. This cognitive modulation, working from the level of word descriptions, can have modulatory effects right down into the first cortical area, the orbitofrontal cortex, where affective value, including aesthetic value such as the beauty found in a face, is first made explicit in the representation (O'Doherty et al. 2003; de Araujo et al. 2005; Grabenhorst et al. 2008; McCabe et al. 2008; Rolls and Grabenhorst 2008; Grabenhorst and Rolls 2011; Rolls 2012, 2013a). Indeed, cognition and attention can be used to enhance the emotional aspect of aesthetic experience, as described in section 23.5.1.

The human mind may create objects such as sculpture and painting in ways that depend to different extents on the explicit reasoning system and the more implicit emotional system. I know at least one sculptor who intentionally reduces cognitive processing by turning off attention to cognitive processing when creating works of art, and then follows this with an explicit, conscious, reasoning stage in which selections and further changes may be made, with the whole creation involving very many such cycles.

Because cognition can by top-down cortico-cortical back projections influence representations at lower levels, it is possible that training, including cognitive guidance, can help to make more separate the representations of the representations of stimuli and their reward value at early levels of cortical processing (Rolls and Treves 1998; Rolls and Deco 2002; Rolls 2008). This top-down effect may add to the bottom-up effects of self-organization in competitive networks that also through repeated training help representations of stimuli to be separated from and made more different to each other (Rolls and Treves 1998; Rolls

and Deco 2002; Rolls 2008). These effects may be important in many aesthetic judgments that are affected by training, including the appreciation of fine art, architecture, and wine.

23.5.12 Wealth, power, resources, and reputation

As already described, wealth, power, resources, and status are attractive qualities, aesthetically attractive, because resources are likely to be beneficial to the survival of genes. Reputation is similar, in that guarding one's reputation can be important in reproductive success: trust is important in a mate, or in reciprocal altruism, and hormones such as oxytocin may contribute to trust (Lee et al. 2009). This provides some insight into the history of Western art, in which individual and family portraits frequently have as one of their aims the display of wealth, power, and resources. The clothes and background depicted in these paintings often show how wealthy and powerful their owners are. Commissioned portraits thus frequently emphasize beauty, status, wealth, and resources. Interestingly, because self-portraits are rarely commissioned they are less likely to emphasize these characteristics (Cumming 2009); they can reflect subjective knowledge of the person portrayed. An additional property that can add aesthetic value to a portrait is that an image of someone held dear is associated with the owner and the attraction of photographic images is an example of this. Religion and states of spiritual ecstasy often aimed at achieving everlasting happiness should also be recognized as drivers of art.

23.5.13 The beauty of scenery and places

Many topological features of landscapes may be aesthetically attractive because they tap into brain systems that evolved to provide signals of safety, food, etc. Open space may be attractive because potential predators can be seen; cover may be attractive as a place to hide (Appleton 1975); a verdant landscape may be attractive because it indicates abundant food; flowers may be attractive as predictors of fruit later in the season. The color blue is preferred by monkeys, and this may be because blue sky, seen from the canopy, is an indicator of a safe place away from predators on the ground (Humphrey 1971). A clear red/orange sunset may be attractive as a predictor of good weather, and of safety overnight without bad weather. These factors do not operate alone to produce beauty, but may contribute to aesthetic beauty which I argue is influenced by many of the factors described in this theory of the origin of aesthetics.

23.5.14 The beauty of music

Vocalization is used for emotional communication between humans, with an origin evident in other primates (Rolls et al. 2006). Examples include warning calls, war-like encouragement to action, and a soothing lullaby or song to an infant. It is suggested that this emotional communication channel is tapped into by music, and indeed consonant versus dissonant sounds differentially activate the orbitofrontal cortex (Blood et al. 1999; Blood and Zatorre 2001) involved in emotion (Rolls 2013a). Of course, the reasoning system then provides its own input to the development, pleasure, and aesthetic value of music in ways described in sections 23.5.10 and 23.5.11.

What underlies the greater pleasure and aesthetic value that many people accord to consonant as opposed to dissonant music? I suggest that consonance is generally pleasant because it is associated with natural sounds, including vocal ones, with a single source that is naturally harmonic. A good example is a calm female voice. Dissonance may often occur when there are multiple unrelated sources, such as those that might be produced by a catastrophe such as an earthquake, or boulders grinding against each other (or strings on a violin that are not tuned to be harmonics of each other). Further, a human voice when angry, shouting, etc. (and therefore by evolutionary adaptation affectively unpleasant) might have non-linearities, in, for example, vocal cords due to over-exertion, and these may be harmonically much less pure than when the voice is calm and softer.

23.5.15 Beauty, pleasure, and pain

If a mildly unpleasant stimulus is added to a pleasant stimulus, sometimes the overall pleasantness of the stimulus, its attractive value, and perhaps its beauty, can be enhanced. A striking example is the sweet, floral scent of jasmine, which as it occurs naturally in *Jasminum grandiflorum* contains typically 2–3 per cent of indole, a pure chemical which on its own at the same concentration is usually rated as unpleasant. The mixture can, at least in some people (and this may depend on their olfactory sensitivity to the different components), increase the pleasantness of the jasmine compared to the same odor without the indole. Why might this occur? One investigation has shown that parts of the brain such as the medial orbitofrontal cortex that represent the pleasantness of odors (Anderson et al. 2003; Rolls et al. 2003; Grabenhorst and Rolls 2009) can respond even more strongly to jasmine when it contains the unpleasant component indole, compared to when it only contains individually pleasant components (Grabenhorst et al. 2007). Thus one brain mechanism that may underlie the enhancement effect is a principle that brain areas that represent the pleasantness of stimuli can do so in a way that is at least partly independent of unpleasant components, thereby emphasizing the pleasant component of a hedonically complex mixture.

A second factor that may contribute to the enhanced pleasantness of the mixture of jasmine and indole is that the indole may produce a contrast effect in the brain areas that represent the pleasant components of the mixture. An indication of this was found in increased activations in the medial orbitofrontal cortex (which represents the pleasantness of many stimuli) when the jasmine–indole mixture was being applied, compared to just the jasmine alone (Grabenhorst et al. 2007). To the extent that the representation of pleasantness may drive hedonic experience separately from unpleasantness representations (Grabenhorst et al. 2007), and this might be facilitated by paying attention selectively to the pleasantness of a stimulus versus its unpleasantness (Rolls et al. 2008), then a factor might be the increased activation of pleasantness representations if there is a component to the stimulus that is unpleasant, and can enhance the pleasantness representation by a contrast effect. Another example of enhancement of pleasant by unpleasant stimuli occurs when an odor become more pleasant if it is preceded by an unpleasant (compared to a

pleasant) odor, an effect represented in the human orbitofrontal cortex (Grabenhorst and Rolls 2009).

A third factor is that the interaction between the pleasant (jasmine) and unpleasant (indole) components makes the complex hedonic mixture (jasmine + indole) capture attention (which in turn may enhance and prolong the activation of the brain by the complex hedonic mixture), and evidence for the capture of attentional mechanisms in the brain by the pleasant–unpleasant mixture has been found (Grabenhorst et al. 2011).

These principles may of course operate in most areas where pleasant and unpleasant stimuli combine. Examples might include the pleasure we get from demanding terrain (high cliffs, high mountains, high seas), from spicy food that activates capsaicin (hot somatosensory) as well as gustatory and olfactory receptors (Rolls 2007), from tragedy in literature, although empathy makes a large contribution here, and from difficult feats, such as those performed by Odysseus (Rolls and Deco 2010).

Let us consider the paradox of tragedy. For Aristotle, tragedy purged one of anxieties (Herwitz 2008). Somehow the depiction of tragedy in drama, which raises unpleasant emotions such as sadness at the tragedy, can also as drama afford pleasure. Hume's explanation was that the beauty of the language and the eloquence of the artist's depictive talents are the source of pleasure (Hume 1757; Yanal 1991). Is there more to say about this? Schadenfreude, gloating, pleasure at the distress of an envied person, is associated with activation of brain areas that respond to pleasant stimuli (Shamay-Tsoory et al. 2007; Takahashi et al. 2009), and I suggest is related to the evolutionary origin of competition between individuals, and winning the competition. It is probably not an important factor in the appreciation of tragedy in drama. What may be more important is first that we (and this is especially strong in women) always want to know what is happening to whom, and gossip has evolutionary value (Dunbar 1996) in that this can provide information about how others are likely to treat one, and more generally, about the things that can happen to people in life, and from which lessons can potentially be derived. Second, the ability to empathize with another's emotions, and indeed to be good at empathy and find it rewarding, may also be important in communities in order to facilitate kin or reciprocal altruism (Ridley 1996). Third, the ability to consider a theory of other people's minds is adaptive in facilitating prediction of their behavior (Frith and Singer 2008), and fascination with this subject should again in an evolutionary context be rewarding and be associated with pleasure. It is suggested that these three factors are at least important contributors to the pleasure that people find in tragedy in drama. The same factors, I suggest, are also important contributors to the popularity of novels. In the cases of both drama and novels, we know that they are fiction, or at least that the events described are not happening to the spectator or reader, and this helps to make them particularly rewarding ways to learn about social relations and life events because there is no risk to the spectator or reader.

Knowing that the work of art (music, literature, painting, sculpture) is a fiction may also account for why the "aesthetic" emotions are not as long-lasting, and are not as motivating, as the goals in real life.

23.5.16 Absolute value in aesthetics and art

The approach described here proposes that what we find aesthetic has its roots and origins in two main processes, gene-specified goals, rewards, and punishers, and the value that is felt when our reasoning system produces, and understands, elegant and simple solutions to problems (Rolls 2012). What implications does this have for absolute aesthetic value? The implication is that while there is no absolute aesthetic value that is independent of these processes, we will nevertheless find considerable agreement between individuals, especially when the aesthetic value being judged has its roots in the two main processes described. However, as illustrated here, there will be variation for good evolutionary reasons between what different individuals find of value, and there will be variation in individuals' thought processes caused by their cultural heritage, and by noise in the brain which is an important component to creativity (Rolls and Deco 2010; Rolls 2012). For these reasons, and because aesthetic value is multifactorial (i.e. is influenced by multiple conscious and unconscious processes), we must expect variation in aesthetic value across people, time, and place, with no absolute aesthetic value.

23.6 Is what is attractive also beautiful and aesthetic?

I wish to counter a possible objection to the theory of the origin of aesthetics described here. This is that some of the goals specified by our genes, such as the reward value and pleasantness of a high-energy high-fat diet, might seem rather unsavory, and not quite aesthetic. The point I make is that it is not just the gene-specified rewards and punishers that cause stimuli to have aesthetic value. My proposal is that the reasoning (rational) system also contributes to aesthetic value and in a number of ways. It makes rather longer-term goals attractive. It introduces the further goal that innovation is attractive, as this is likely to help solve difficult problems and move the person into a new part of state space where the person may have an advantage. It introduces the use of syntactic relational structure to provide another way of computation. Problem solving using this reasoning system is encouraged by simple elegant solutions which are rewarding and which have aesthetic value, as described above. These factors would help the sophisticated structure in a Bach partita and fugue to contribute to what we judge as aesthetically pleasing, because such music taps not only into our emotional systems but also into the systems that provide intellectual pleasure because difficult and complex structural problems are posed, and solutions to these difficult structural problems are provided which provide aesthetic pleasure.

In this sense, aesthetic value may have its roots partly in gene-specified rewards (and punishers), but also in the pleasure that the rational system can provide when it is posed, and finds, elegant and simple solutions (which by parsimony are likely to be correct) to complex problems. For this reason, emotions may not be perfectly aligned with aesthetic value. Although both have their origin in gene-specified rewards, emotions may be produced by any one of a large number of reinforcers, whereas aesthetic value usually includes contributions of the reasoning (rational) system, as just described.

Art as a whole is a larger issue than aesthetics and beauty. The content of "Art" might, I suggest, be seen as the result of multiple separate trajectories through a state space in which each trajectory is guided by the origins of aesthetics (products of adaptations for survival and of sexual selection for useless sometimes handicapping ornament, and rational thought to develop structure in which an elegant and simple solution is pleasing), and depends on each previous trajectory, the history of art in each culture. Each trajectory is not itself deterministic because it is influenced by noise (Rolls and Deco 2010; Rolls 2012) (as is Darwinian evolution). Thus, future trajectories cannot be predicted. In each trajectory, though, a number of factors dominate, including newness (which is biologically attractive as argued earlier), a quality of wildness (as in Beethoven's late string quartets), as well as what we rationally find aesthetic (as described earlier), and what survival and sexual selection have also provided in us as some of the origins of aesthetics.

23.7 Comparison with other theories of aesthetics

Much research I have performed shows that there is a perceptual representation of objects formed in cortical areas that is kept separate from the representation of the affective value of objects, which happens further on in processing, in brain regions such as the orbitofrontal cortex (and in an area to which it projects, the anterior cingulate cortex) and the amygdala (see Figure 23.2) (Rolls 2008 2, 2013a). AQ2

There are good functional and adaptive reasons for separate representations of objects and of their affective value. We can still see and recognize objects (including tastes, smell, the sight of objects, etc.) even when they are not rewarding to us; for example, if they are foods and we are not hungry. We are not blind to objects when they are not rewarding or punishing. Moreover, it is adaptive to be able to learn about where we have seen objects, people, etc., even if they are not currently rewarding, so that we can find them later when they are needed. Thus there is strong neuroscientific evidence, and sound biological arguments, for separate representations of perceptual objects and of their affective value. Baumgarten (1750) expressed this thought in his *Aesthetica* when he suggested that sensation, the use of the five senses, is separate from sensibility, which is something more, a "kind of intuition/cognition/formulation of the thing which judges it beautiful," and in doing so gave rise to the term aesthetics (Herwitz 2008). Before this, abstract questions such as "what is beauty," "what is art," had not been discussed generically in philosophy (although Aristotle had discussed the social role of drama as purging us of ever present anxiety, and Plato had dismissed poetry as obfuscating by sending the mind reeling into hypnotic trances instead of focusing on rational deductions and argument) (Herwitz 2008).

David Hume (1777) takes a broad view of taste (which engages beauty), and argues for five standards of ("delicacy of") taste that might be shown by experts: "Strong sense, united to delicate sentiment, improved by practice, perfected by comparison, and cleared of all prejudice, can alone entitle critics to this valuable character; and the joint verdict of such, wherever they are to be found, is the true standard of taste and beauty." Hume's difficulty is that he believes taste is objective, because delicacy is the probing instrument for truth; but

instead, taste is a circular and constructivist enterprise (Herwitz 2008). My approach has in contrast a clear foundation for aesthetics in brain function and its evolutionary design, with clear views about how it includes rational thought which provides its own pleasures, and about how art can idealize beyond the normal world by building on these foundations and origins.

Immanuel Kant (1724–1804) distinguishes between liking something and finding it beautiful. According to Kant, when I find a painting beautiful this is not conditioned by any causal relation between its properties and my pleasures. For Kant, a judgment of beauty carries the weight of "ought," that others should judge it beautiful too, so his theory has moral implications. His judgment of beauty is a "disinterested" judgment, one that is not peculiar to him. He wants the beauty to be in the person, but not causally dependent on the properties of the object in the world such as the pleasure it produces (Kant 1790). He thus appears to be committed to an objective and universal view of art, with exactly how this view is arrived at not at all clear. The biological and neuroscientific view that I propose indicates that, in contrast, art is not universal or objective, but instead can be judged to be good art if it taps into many of the human rational and gene-based reward systems (see further section 23.6), with therefore individual differences expected, as described in section 23.5.16.

Darwin (1871) recognized that evolution can occur by sexual selection, when what is being selected for has no inherent adaptive or survival value, but is attractive to potential mates (inter-sexual selection), or helps in competing with others of the same sex (intra-sexual selection). His view was that natural beauty arose through competition to attract a sexual partner. His process of sexual selection through mate choice—the struggle to reproduce, not to survive—drove the evolution of visual ornamentation and artistry, from flowers through bird plumage to human self-adornment. Many have developed or ascribed to this idea (including Thorstein Veblen (1899), Ernst Gombrich (1977), Amotz Zahavi (1978), and Denis Dutton (2009)), and Miller (2000, 2001) has proposed a sexual selection theory of art. The implication of Miller's theory is that art has to do with what are frequently useless ornaments (useless in the sense that sexual selection is for characteristics that do not have "survival" value, but are usually just attractive because they are handicaps and are indicators of fitness). I agree that useless, handicapping ornamentation produced by sexual selection does play a role in aesthetics. However, the sexual selection theory does not therefore have much to say about the utilitarian arts such as simple design in architecture. Perhaps the structure of a piece of music can appeal, and be pleasing, because it taps into our syntactic system that finds that adaptive, survival value-related, elegant and simple solutions to problem-solving produce pleasure. As I argued above, interest in social relations and knowledge about them is adaptive and this has survival value as it may help to understand who is doing what to whom, and more generally to understand what can happen to people, and much fictional literature addresses these issues, and is not purely ornamental and without inherent value. Thus although Miller may well be right that there are aspects of art that may be primarily ornamental and useless, though attractive to members of the opposite sex in courtship, I suggest that a great deal of art has its roots in

goals that have been specified as pleasurable or unpleasurable because of their "survival or adaptive" value, whether as primary reinforcers, other stimuli associated by learning with these, or rewards of a more cognitive origin that accrue when difficult cognitive, syntactic, problems are solved. I also emphasize that some of the characteristics emphasized by sexual selection may have some inherent survival value (sections 23.5.3.1 and 23.5.3.2).

My theory (the Rolls' theory) of the foundations of aesthetics and art thus specifies the roles of Darwinian "survival or adaptive" selection and sexual selection in aesthetics (Rolls 2011a, 2012). It is thus thoroughly Darwinian. A key idea is that many of the things that provide pleasure, or its opposite, do so because they are, or are related to, the gene-specified goals for action. Motivational states arise when trying to obtain these goals, and emotional or affective states when these goals are obtained, or are not obtained. These states are associated with affect and value, and with subjective pleasantness or unpleasantness, because it is an efficient way in which genes can influence their own (reproductive) success ("fitness"), and much more efficient and effective as a Darwinian process than prescribing that the animal should make particular responses to particular stimuli (Rolls 2013a). The theory is that aesthetic value has its roots partly in these gene-specified rewards that have survival or adaptive value, but also in the pleasure that the rational system can provide when it is posed, and finds, elegant and simple solutions (which by parsimony are likely to be correct and hence adaptive) to complex problems, and to some extent in sexual selection. What makes good art can be influenced by many factors, as described here, so it is complex and multifaceted, and these factors must include whether the effect of the art is for good or for ill. It also follows that attempts in aesthetics to produce a systematic account based on consistent explicit beliefs will not succeed because many factors that are not necessarily consistent with each other are involved in aesthetic values, and because some of these factors operate at least partly unconsciously and non-propositionally/non-syntactically; that is, using computational systems in the brain that do not involve reasoning (Rolls 2012, 2013a).

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