

# **Neuroculture**

## On the implications of brain science

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## Preface

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Understanding how our brains work, and how evolution has shaped them, has interesting implications for understanding many aspects of human behaviour. To help understand ourselves this book describes the implications of our modern understanding of brain function for many different areas. They include emotion; social behaviour; rationality vs emotion; the philosophy of the relation between the mind and the brain, and of consciousness; aesthetics; ethics, economics; psychiatry; religion; and politics.

It is argued that a new type of understanding of these issues can emerge from the developments in understanding the brain and behaviour that are emerging from modern neuroscience, and how our brains have been shaped by evolution. This new understanding may have important implications for understanding the forces at work in areas such as emotional and social behaviour, economics, aesthetics, ethics, and politics.

The author brings a unique perspective to these issues, which can be grouped together as **neuroculture**, because of his approach to understanding the brain and biological mechanisms of emotion (*Emotion Explained*, 2005, Oxford University Press) which he now argues has implications for our understanding of aesthetics, sociality, ethics, and economics; and because of his approach to how the brain works at the mechanistic, i.e. neurobiological and computational, level (*Memory, Attention, and Decision-Making: A Unifying Computational Neuroscience Approach*, 2008, Oxford University Press; *The Noisy Brain: Stochastic Dynamics as a Principle of Brain Function*, 2010 with G.Deco, Oxford University Press) which is important for understanding human choices, decision-making, economics, psychiatry, normal aging, and relations between mental and physical events.

By combining rigorous neuroscientific approaches both to the evolutionary adaptive value of emotion and how this has shaped our brains, and to brain computation (i.e. how the brain works), the author brings a rational, fundamental, and new approach to these issues in the new area of **Neuroculture**. Each area covered is prefaced by the term ‘neuro’, to emphasize that it is the implications of our understanding of brain function that is being investigated in each chapter. The areas covered include Neuroaffect (Chapter 3); Neurosociality (Chapter 4); Neuroreason (Chapter 5); Neurophilosophy (Chapter 6); Neuroaesthetics (Chapter 7); Neuroeconomics (Chapter 8); Neuroethics (Chapter

9); Neuropsychiatry (Chapter 10); Neuroreligion (Chapter 11); and Neuropolitics (Chapter 12). Chapter 2, Neuroscience, introduces how we understand how the brain works, how it computes, at the level of the operations of brain cells, and of networks of brain cells, focusing on areas that help to provide a foundation for understanding these fascinating questions of emotion, rationality, decision-making, and memories that shape our lives, feelings, and behaviour. Some of these areas are developing rapidly, for example neuroethics, but the author seeks to bring an original approach to these areas, by building on his expertise in the brain mechanisms and evolutionary bases of emotion, and in computational neuroscience, to develop an understanding of why our brains operate as they do, and what the implications are.

The approach taken in this book is based on an understanding of the actual mechanisms by which the brain functions, as well as the evolutionary pressures that have led to the design of our brains. The approach thus goes beyond evolutionary psychology (or sociobiology), which considers behavioural adaptations shaped by evolutionary pressure, but has not taken the brain mechanisms involved into account in a direct way. Understanding the brain mechanisms involved helps us to understand reward processes and thereby to address aesthetics, emotion, decision-making, ethics, free will, and economics. Understanding the brain mechanisms involved in detecting causality helps one to address religion. Understanding the brain processing at the mechanistic level also provides a way to address how alterations in brain systems may lead to psychiatric and behavioural dysfunctions, which may then, in the light of our understanding of how they are implemented in the brain, become more easily treatable. The approach based on what the brain computes, and how it computes, is thus important in the approach taken in this book to a wide range of issues. The approach is fresh, for it seeks to understand many of the ways in which we behave by understanding some of the difficult computational problems faced by the brain, and the types of solution that the brain has found to these computational problems.

The overall aims of the book are developed further, and the plan of the book is described, in Chapter 1, Section 1.1.

The material in this text is the copyright of Edmund T. Rolls. Part of the material described in the book reflects work performed in collaboration with many colleagues, whose tremendous contributions are warmly appreciated. The contributions of many will be evident from the references cited in the text. I dedicate this book to them; to many scientific colleagues including Colin Blakemore, Marian Dawkins, and Larry Weiskrantz whose integrity and support have been outstanding; and to colleagues in other areas who have inspired me, including the sculptor, artist, and musician Penny Wheatley, and the philosopher David Rosenthal. Much of the work described would not have been possible without financial support from a number of sources, particularly

the Medical Research Council of the UK, the Human Frontier Science Program, the Wellcome Trust, and the James S. McDonnell Foundation. The book was typeset by the author using LaTeX and WinEdt.

The cover shows part of the picture *The Birth of Venus* painted by Sandro Botticelli in c. 1486. The metaphor is that Botticelli was thinking about the origins of love, and beauty. I, in this book, am considering the scientific foundations of love, beauty, aesthetics, ethics, and many related aspects of our being in terms of how different evolutionary forces have shaped our brains, our emotions, and our rationality.

Updates to some of the publications cited in this book are available at <http://www.oxcns.org>.

I dedicate this work to the overlapping group: my family, friends, and colleagues – *in salutem praesentium, in memoriam absentium*.

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## 7 Neuroaesthetics

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### 7.1 Introduction

What are the foundations of what we appreciate in art? Is art—visual art, literature, music—related to fundamental adaptive capacities that help survival and thus reproduction, or is art a useless ornament, like a peacock’s ‘tail’, shaped by sexual selection?

A theory of the origins of aesthetics 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 2005a) (see Chapter 3). 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 (see Section 7.11). The combination of these two systems, and the interactions between them, provides an approach to understanding aesthetics (Rolls 2011h) that is rooted in evolution and its effects on brain design and function.

I have considered in Chapter 3 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. The approach provides part of a theory of how value is placed on some stimuli. Value will be placed according to whether the stimuli activate our reward or punishment systems, themselves tuned during evolution to produce goals that will increase the fitness of our genes. (‘Fitness’ refers to the reproductive success of genes.) Moreover, we have seen that these gene-defined goals may include a wide range of reinforcers, including many involved in social behaviour, and define some of the things that make people and objects attractive. We have seen that humans by reasoning can define a wider range of goals, or at least can place different values on goals as a result of reasoning, and use reasoning as a second route to action (Chapter 5). We have also seen that cognition can influence the representation of affective value in the orbitofrontal cortex. The analysis of the evolutionary basis of reward value provides a fundamental and Darwinian way to understand emotion (Rolls 2005a).

## 7.2 Outline of a neurobiological approach to aesthetics

I now explore whether the same approach can provide a neurobiological basis for understanding aesthetics. Now that we have a fundamental, Darwinian, approach to the value of people, objects, relationships etc., I propose that this provides a fundamental approach to understanding aesthetics and aesthetic value, that is, what we value aesthetically. 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. However, even here I argue that there are certain adaptive principles that influence the operation of our rational system that provide a systematic way to understand aesthetics and aesthetic value.

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) (Section 2.12), 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. Differences in rational thought will thus 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 at all 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, Rolls, Velazco, Margot and Cayeux 2005, McCabe, Rolls, Bilderbeck and McGlone 2008, Grabenhorst, Rolls and Bilderbeck 2008a), 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 *Tristan and Isolde*.)

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

I also emphasize that this is a theory of the origin of aesthetics. I provide generic examples, but of course cannot cover all factors that influence value. An indication of the range of factors that can provide a basis for aesthetic judgements is shown in Table 3.1, but this is by no means complete. These examples are gene-defined goals for action, and we are built to want to obtain these goals (the basis for motivation), to treat them operationally as rewards or punishers, and to have pleasant or unpleasant affective feelings when they are delivered (the basis of emotion) (Rolls 2005a). It is argued here that these factors contribute to aesthetic judgements, that any one stimulus will often have multiple such attributes, and that these factors are afforded by operations of the reasoning system.

I emphasize that rewards of which examples are provided in Table 3.1 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 2005a), or the opposite, and provide what I argue here is the origin of many judgements 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, are shown in Table 3.1.

In contrast to my theory, Miller (2000, 2001) emphasizes the role of sexual selection. Understanding the mechanisms that drive evolution to make certain stimuli rewarding or punishing can help us to understand the origin of aesthetics, and I therefore summarize the characteristics of these two evolutionary processes in Sections 7.3 and 7.4.

I note first that the term ‘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, Dawkins 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 the individual to be selected as a mate (by intersexual selection), or to compete for a mate in intra-sexual selection, and thus pass on the genes selected by inter-sexual selection or intra-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.

### 7.3 ‘Survival’ or ‘adaptation’ selection (natural selection in a narrow sense)

Darwin (1871) distinguished natural selection from sexual selection, and this distinction has been consolidated and developed (Fisher 1930, Hamilton 1964, Zahavi 1975, Dawkins 1986, Grafen 1990a, Grafen 1990b, Dawkins 1995, Hamilton 1996, Miller 2000). Natural selection can be used in a narrow sense to refer to selection processes that lead to the development of characteristics that have a function of providing adaptive or survival value to an individual so that the individual can reproduce, and pass on its genes. In its narrow sense, natural selection can be thought of as ‘survival or adaptation selection’.

An example might be a gene or genes that specify that the sensory properties of food should be rewarding (and should taste pleasant) when we are in a physiological need state for food. Many of the reward and punishment systems described here and by Rolls (2005a) deal with this type of reward and punishment decoding that has evolved to enable genes to influence behaviour in directions in a high-dimensional space of rewards and punishments that are adaptive for the 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 behaviours because the behaviour 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 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. (I note that natural selection in a broad sense includes ‘survival or adaptation’ selection, sexual selection, selection for good parental care, etc.)

### 7.4 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), 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).

The most cited example of mate selection (inter-sexual selection) is the peacock’s large ‘tail’, which does not have survival value for the peacock (and

indeed it is somewhat of a *handicap* to have a very long tail), but, because it is attractive to the peahen, becomes prevalent in the population. Indeed, part of the reason for the long tail being attractive may be that it is an honest signal of phenotypic fitness (a 'revealing signal' that is a 'fitness indicator'), in that having a very long tail is a handicap to survival (Zahavi 1975), though the signalling system that reveals this only operates correctly if certain conditions apply (Grafen 1990a, Grafen 1990b, Maynard Smith and Harper 2003). The fact that the long tail is actually a handicap for the peacock, and so is a signal of general physical fitness in the male, may be one way in which sexual selection can occur stably (Zahavi 1975, Grafen 1990a, Grafen 1990b).

Another account is that the inherited genes for a long tail may be expressed in the female's sons, and they will accordingly be attractive to females in the next generation (Fisher's 'sexy son' account) (Fisher 1930). Although the female offspring of the mating will not express the male father's attractive long-tail genes, these genes are likely to be expressed in her sons. The female has to evolve to find the characteristic being selected for in males attractive for this situation to lead to selection of the characteristic being selected for by the choosiness of females. Indeed, the fact that the female who chose a long-tailed male has children following her mating with genes for liking long-tailed males, and for generating long tails, is part of what leads to the sexual selection.

The peacock tail example is categorized as sexual selection because the long tail is not adaptive to the individual with the long tail, though of course it is useful to the male's genes to have a long tail if females are choosing it because it indicates general physical fitness. However, sexual selection can also occur when a revealing or index signal or fitness indicator is not associated with a handicap, but is hard to fake, so that it is necessarily an honest fitness indicator (Maynard Smith and Harper 2003). An example occurs in birds that may show bare skin as part of their courtship, providing a sign that they are parasite resistant (Hamilton and Zuk 1982). Revealing bare skin in women can be beautiful and may have its origins partly in this, as well as in perhaps displaying secondary sexual characteristics (such as breasts) that may be attractive to men (with an origin as indicators of sexual maturity and of maternal readiness). (Note that this account is very different to that of Sigmund Freud.)

The mechanisms of mate choice evolution include the following (Andersson and Simmons 2006):

(i) Direct phenotypic effects. Female preference for a male ornament can evolve as a result of direct phenotypic benefits if the ornament reflects the ability of the male to provide material advantages, such as high-quality territory, nutrition, parental care, or protection.

(ii) Sensory bias. Female preference favouring a male ornament can initially evolve under natural selection for other reasons, for instance in the context of

foraging or predator avoidance. Males evolving traits that exploit this bias then become favoured by mate choice (Ryan 1998).

(iii) Fisherian sexy sons. If there are genetic components to variance in female preference and male trait, a female choosing a male with a large trait bears daughters and sons that can both carry alleles for a large trait, and for the preference for it. This genetic coupling might lead to self-reinforcing coevolution between trait and preference (Fisher 1930, Mead and Arnold 2004). (Sexual election may be identified when females choose sexy mates so that the female's sons will be sexy and attractive. Survival selection may be identified if the choice helps the female's daughters as well as sons.)

(iv) Fitness indicator mechanisms ('good genes' or 'handicap mechanisms') suggest that attractive male traits reflect broad genetic quality (Zahavi 1975, Grafen 1990a, Grafen 1990b). Female preference for such traits can provide genetic benefits to those of her offspring that inherit favourable alleles from their father.

(v) Genetic compatibility mechanisms. As well as additive genetic benefits reflected by indicator traits, there might be non-additive benefits from choosing a mate with alleles that complement the genome of the chooser. Examples have been found for instance in major histocompatibility complex genes, which may be associated with odour preferences for potential mates (Dulac and Torello 2003). These genes are involved in the process by which a cell infected with an antigen (from a virus or bacterium) displays short peptide sequences of it at the cell surface, and the T lymphocytes of the immune system then recognize the fragment, and build an antibody to it. This MHC gene system must maintain great diversity to help detect uncommon antigens, with an advantage arising from mating with an individual with different MHC genes. At least some of the MHC genes are very closely associated with gene-specified pheromone receptors, with individual pheromone receptor cells often expressing one or a few MHC genes in a complex with specific V2R-specified olfactory receptors (Dulac and Torello 2003). Thus, a mate may be found attractive (and beautiful) based on odour, and a mechanism such as this may operate in humans (see Rolls (2005a)).

The evolution of mate choice is based either on direct selection of a preference that gives a fitness advantage (mechanisms i–ii) (i.e. there is a survival or adaptation advantage); or on indirect selection of a preference as it becomes genetically correlated with directly selected traits (mechanisms iii, iv) (i.e. the trait has no advantage, and might be thought of as a useless ornament) (Andersson 1994, Mead and Arnold 2004). In addition, rather than favouring any particular display trait, mate choice might evolve because it conveys non-additive genetic benefits (mechanism v). These mechanisms are mutually compatible and can occur together, rendering the evolution of mating prefer-

ences a multiple-causation problem, and calling for estimation of the relative roles of individual mechanisms (Andersson 1994).

Some characteristics of sexual selection that help to separate it from survival selection are as follows:

First, the sexually selected characteristic is usually sexually dimorphic, with the male typically showing the characteristic. (For example the peacock but not the peahen has the long tail.) This occurs because it is the female who is being choosy, and is selecting males. The female is the choosy one because she has a considerable investment in her offspring, whom she may need to nurture until birth, and then rear until independent, and for this reason has a much more limited reproductive potential than the male, who could in principle father large numbers of offspring to optimize his genetic potential. This is an example of a sexual dimorphism selected by inter-sexual selection. An example of a sexual dimorphism selected by intra-sexual selection is the deer's antlers. Sexual dimorphism usually reflects sexual selection, but may not, with an example being that the female may be cryptic (hidden against the background, camouflaged) when incubating eggs, in order to be a good parent.

Second, sexually selected characteristics such as ornamentation helpful in identification are typically species-specific, whereas naturally selected characteristics may, because they have survival value for individuals, be found in many species within a genus, and even across genera.

Third, and accordingly, the competition is within a species for sexual selection, whereas competition may be across as well as within species for natural (survival) selection.

Fourth, sexual selection operates most efficiently in polygynous species, that is species where some (attractive) males must mate with two or more females, and unattractive males must be more likely to be childless. Polygyny does seem to have been present to at least some extent in our ancestors, as shown for example by body size differences, with males larger than females. This situation is selected because males compete harder with each other in polygynous species compared to monogamous, where there is less competition. In humans, the male is 10% taller, 20% heavier, 50% stronger in the upper body muscles, and 100% stronger in the hand grip strength than the average female (Miller 2000).

Fifth, the sexually selected characteristics are often apparent after but not before puberty. In humans, one possible example is the deep male voice.

Sixth, there may be marked differences between individuals, as it is these differences that are being used for mate choice. Sexual selection thus promotes genetic diversity. In contrast, when natural or survival selection is operating efficiently, there may be little variation between individuals.

Seventh, the fitness indicator may be costly or difficult to produce, as in this way it can reflect real fitness, and be kept honest (mechanism iv above).

However, sexual selection is not as pure as was once thought: females are less choosy, and more promiscuous, than was once thought (Birkhead 2000).

Overall, Darwinian natural or survival selection increases health, strength, and potentially resources, and survival of the individual, and thus the 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 inter-sexual selection. *Intra-sexual 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 behaviours and characteristics involved in sperm competition (Section 4.7), which itself may influence what is judged to be attractive and beautiful, are produced by intra-sexual sexual selection (Rolls 2005a, Andersson and Simmons 2006).

It turns out that many of the best examples of inter-sexual sexual selection are in birds (for example the peacock's tail, and the male lyre bird's tail). In mammals, including primates, the selection is often by size, strength, physical prowess, and aggressiveness, which provide for direct physical (and other types of) competition, and are examples of intra-sexual selection (in males) (Kappeler and van Schaik 2004).

It has been suggested that sexual selection is important for further types of characteristic in humans. For example, it has been suggested that human mental abilities that may be important in courtship such as kindness, humour, and telling stories, are the type of characteristic that may be sexually selected in humans (Miller 2000). Before assessing this (in Section 7.9), and illuminating thus some of what may be sexually selected rewards and punishers that therefore contribute to human affective states and aesthetics, we should note a twist in how sexual selection may operate in humans.

In humans, because babies are born relatively immature and may take years of demanding care before they can look after themselves, there is some advantage to male genes of providing at least some parental care for the children. That is, the father may invest in his offspring. In this situation, where there is a male investment, the male may optimize the chance of his genes faring well by being choosy about his wife. The implication is that in humans, sexual selection may be of female characteristics (by males), as well as of male characteristics (by females). This may mean that the differences between the sexes may not be as large as can often be the case with inter-sexual sexual selection, where the female is the main chooser.

One example of how sexual selection may affect female characteristics is in the selection for large breasts. These may be selected to be larger in humans than is really necessary for milk production, by the incorporation of additional

fat. This characteristic may be attractive to males (and hence produce affective responses in males) because it is a symbol relating to fertility and child rearing potential, and not because large breasts have any particular adaptive value. It has even been suggested that the large breast size makes them useful to males as a sign of reproductive potential, for their pertness is maximal when a (young) woman's fertility and reproductive potential is at its highest. Although large breasts may be less pert with age, and it might thus be thought to be an advantage for women not to have large breasts, it may be possible that this is offset by the advantageous signal of a pert but large breast when fertility and reproductive potential is at its maximal when young, as this may attract high status males (even though there may be disadvantages later) (Miller 2000). Thus it is possible that inter-sexual selection contributes to the large breast size of some women. The fact that the variation is quite large is consistent with this being a sexually selected, not survival-selected, characteristic. Thus sexual selection of characteristics may occur in women as well as in men, and may contribute to aesthetic judgements.

## 7.5 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 review how they contribute to what factors make men and women aesthetically beautiful. Many of these factors have been described in Chapter 4, and so they are reviewed briefly here in terms of how these factors contribute to aesthetic judgements.

Many of these factors may operate unconsciously, and we may confabulate a rational verbal account about why we judge that something is beautiful. We may not realize that the following factors can influence our aesthetic judgements.

### **Female preferences: factors that make men attractive and beautiful to women**

Factors that across a range of species influence female selection of male mates include the following (Section 4.4.1).

#### **Athleticism**

#### **Resources**

#### **Power and wealth**

#### **Status**

**Age** Status and higher income are generally only achieved with age, and therefore women generally find older men attractive.

**Ambition and industriousness** These may be good predictors of future occupational status and income, and are attractive. Valued characteristics

include those that show a male will work to improve their lot in terms of resources or in terms of rising up in social status.

**Testosterone-dependent features** 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). High testosterone levels are immuno-suppressing, so these features may be indicators of immuno-competence (and thus honest indicators of fitness). The attractiveness of these masculinized features increases with increased risk of conception across the menstrual cycle (Penton-Voak et al. 1999). The implication is that the neural mechanism controlling perception of attractiveness must be sensitive to oestrogen/progesterone levels in women. Another feature thought to depend on prenatal testosterone levels is the 2nd/4th digit ratio. A low ratio reflects a testosterone-rich uterine environment. It has been found that low ratios correlate with female ratings of male dominance and masculinity, although the relationship to attractiveness ratings is less clear (Swaddle and Reiersen 2002).

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

**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. 1990).

**Risk-taking** Risk-taking by men 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).

**Features selected by inter-sexual sexual selection** 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, include the peacock's tail.

**Odour** The preference by women for the odour of symmetrical men is correlated with the probability of fertility of women as influenced by their cycle (Gangstad and Simpson 2000). Another way in which odour 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, as described in Section 4.4.1.

It is important to note that physical factors such as high symmetry and that are indicators of genetic fitness may be especially attractive when women choose short-term partners, and that factors such as resources and faithfulness

may be especially important when women choose long-term partners, in what may be termed a conditional mating strategy (Buss 2008, Buss 2006). This conditionality means that the particular factors that influence preferences and what may be found to be aesthetic alter dynamically, and preferences will often depend on the prevailing circumstances, including the current opportunities and costs.

### **Male preferences: what makes women attractive and beautiful to men**

When a male chooses to invest (for example 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 a male will need to look out for cues to this, and find these cues attractive, beautiful, and rewarding. The factors that influence attractiveness include the following (Section 4.4.2) (Barrett et al. 2002).

**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 twenties), males (unlike females) place a special premium on indicators of youth, for example neotenous traits such as blonde hair and wide eyes. 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.

**Beautiful features** Features that are most commonly described as the most attractive tend to be those that are oestrogen-dependent, e.g. full lips and cheeks, and short lower facial features.

Women appear to spend more time on fashion and enhancing beauty than men. Why should this be, when in most mammals it is males who may be gaudy to help in their competition for females, given that females make the larger investment in offspring? In humans, there is of course value to investment by males in their offspring, so women may benefit by attracting a male who will invest time and resources in bringing up children together. But nevertheless, women do seem to invest more in bearing and then raising children, so why is the imbalance so marked, with women apparently competing by paying attention to their own beauty and fashion? Perhaps the answer is 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, being beautiful and fashionable is important to women. 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. These factors lead to greater variability in men's strategies, and thus contribute to making men who invest in their offspring a more limited resource than women who invest in their offspring.

Given that men are a scarce resource, and that women have 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).

**Body fat** Although the body weight found most attractive 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). Thornhill and Grammer (1999) also found high correlations between rating of attractiveness of nude females by men of different ethnicity. At a simpler level, a low waist to hip ratio is an indication that a woman is not already pregnant, and thus a contributor to attractiveness and beauty.

**Fidelity** The desire for fidelity in females is most obviously related to her concealed ovulation (see next paragraph and *Emotion Explained* (Rolls 2005a)), and therefore the degree of paternity uncertainty that males may suffer. Males therefore place a premium on a woman's sexual history. Virginity was a requisite for marriage both historically (before the arrival of contraceptives) and cross-culturally (in non-Westernised societies where virginity is still highly valued) (Buss 1989). Nowadays, female monogamy in previous relationships is a sought-after characteristic in future long-term partners (Buss and Schmitt 1993). (Presumably with simple genetic methods now available for identifying the father of a child, the rational thought system (Rolls 2005a) might just rely on those to establish paternity, yet the implicit emotional system may still place high value on personality characteristics indicating fidelity, as during evolution, fidelity was valued as an indicator of paternity probability.) The modern rational emphasis might be especially placed on valuing fidelity because this may indicate less risk of sexually transmitted disease, and perhaps the emotional value and attractiveness of fidelity will be a help in this respect.

**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 other cues to ovulation, and find women highly desirable (and beautiful) at these times. Possible cues include an increased body temperature reflected in the warm glow of vascularized skin (vandenBerghe and Frost 1986), and pheromonal cues. Indeed, male raters judged the odours of T-shirts worn during the follicular phase as more pleasant and sexy than odours from T-shirts worn during the luteal phase (Singh and Bronstad 2001). Women generally do not know when they are ovulating (and in this sense ovulation may be double blind), but there is a possibility that ovulation could unconsciously affect female behaviour. In fact, Event-Related Potentials (ERPs) were found to be greater to sexual stimuli in ovulating women, and these could reflect increased affective processing of the stimuli (Krug et al. 2000). This in turn might affect the outward behaviour of the female, helping her to attract a mate at this time. 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 most species, females invest heavily in the offspring in terms of providing the eggs and providing the care (from gestation until weaning, and far beyond weaning in the case of humans). Females are therefore a 'limited resource' for males allowing the females to be the choosier sex during mate choice. 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 behaviour such as cosmetic surgery, or pathological disorders such as anorexia, bulimia, and body dysmorphic disorder. The modern media, by bombarding people with images of beautiful women, may heighten intra-sexual selection even further, pushing women's competitive mating mechanisms to a major scale.

## 7.6 Pair-bonding, love, and beauty

We have seen in Section 4.5 some of the factors that promote pair-bonding and love, including oxytocin. These processes influence what we judge as beautiful, and aesthetic. An implication is that there may be hormonal, and other biological, mechanisms that have an effect of cementing attraction and love of a particular person after the process has been started. This may have an effect on (partly) blinding a person to a partner's imperfections, and may thus contribute to each individual's judgements about the beauty of a partner, an aesthetic judgement.

Given this Darwinian approach rooted in selfish (Dawkins 1989) genes, should we describe the aesthetic state of love as selfish? I suggest that the answer is that although individual acts can be truly altruistic (and non-adaptive), even the altruism implied by love must have its origins in selfish genes, which shape human behaviour to in this case produce a state that promotes the production of and survival of offspring. Overall, for a characteristic (such as falling in love, or reciprocal altruism, or kin altruism) that is influenced by genes to remain in a breeding population, the characteristic must be good for the (selfish) gene or it would be selected out.

Even love guided by rational thought must not overall detract too much over generations from the wish to produce offspring, or it would tend (other things being equal) to be selected out of the gene population.

## 7.7 Parental attachment: beautiful children

Many mammal females make strong attachments to their own offspring, and this is also facilitated in many species by oxytocin, as described in Section 4.6. In humans oxytocin release during natural childbirth, and rapid placing of the baby to breast feed and release more oxytocin (Uvnas-Moberg 1998), might 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 should be understood by all parents 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 under hormonal influences), and this can result in relatively less attachment behaviour to the husband/partner.

Lack of parental care in step-fathers is evident in many species, and can be as extreme as the infanticide by a male lion of the cubs of another father, so that his new female may come into heat more quickly to have babies by him (Bertram 1975). Infanticide also occurs in non-human primates (Kappeler and van Schaik 2004). In humans, the statistics indicate that step-fathers are much more likely to harm or kill children in the family than are real fathers (Daly and Wilson 1988).

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 judgements of babies in distant countries with no close genetic relationship, but this does not of course mean that such judgements do not have their evolutionary origin in kin-related advantageous behaviour.



**Fig. 7.1** Two Forms (January) 1967. Barbara Hepworth. (See colour plates Appendix B.)

## 7.8 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 judgements, 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 judgements may be much more arbitrary, and driven by short-term fashion. Some abstraction away from the very realistic and figurative in art can of course have advantages for it allows the viewer to create in their own experience of a work of art by adding their own interpretation.

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 Josef 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 *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.

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 Henri Matisse and Pablo Picasso. It is also found in the sculptures of human forms of Constantin Brancusi.

What I argue is that if art goes 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 now see that she often retains sufficient figurative contribution to her sculpture to tap into evolutionary origins, and I show Fig. 7.1 as an example of a work that after all seems to have some relation to a male and female. Much of the sculpture of Henry Moore is clearly figurative, and where his sculpture 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 colours by Rothko.

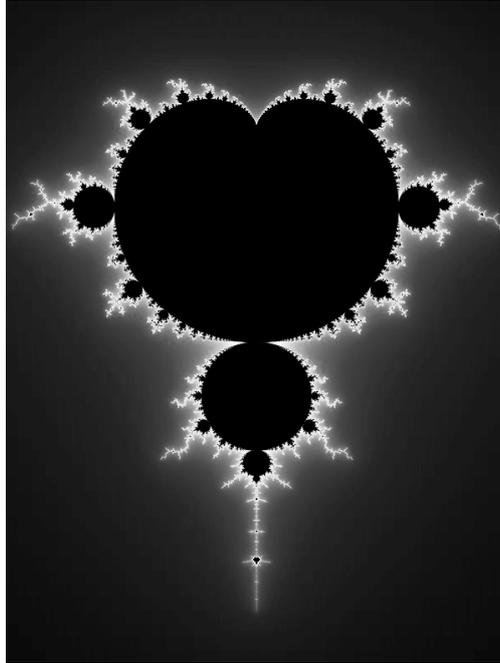
I thus argue that figurative or semi-figurative may tend to provide wide appeal, and to continue to do this, as it often taps into the biological underpinnings of art and beauty. With fully abstract art, it may be much less certain that it will have wide and long-lasting appeal. Interesting light on this was shown by monkeys' preferences for fractal images. An example of a fractal image is shown in Fig. 7.2. The monkeys tended to prefer more complex fractal images, but each monkey's preference rankings were very different (Takebayashi and Funahashi 2009). The preference ranking was reflected in the responses of orbitofrontal cortex neurons, with some having firing rates that represented the preference ranking on a continuous scale (Shintaro Funahashi, Kyoto University, personal communication 2011). The implication is that there may be a biological propensity to have different preferences for different types of abstract image, but that there may not be consistency of preference between individuals. In contrast, face beauty (also reflected in the activations in the human orbitofrontal cortex (O'Doherty et al. 2003b)), with its biological underpinnings is much more universally agreed (Thornhill and Gangstad 1999, Jefferson 2004). Even when there are biological underpinnings, we may also expect individual differences in what is found attractive and aesthetic, for individual differences

in the sensitivity to different types of reward are an important source of variation that drives evolution (Chapter 3).

Consistent with this analysis, it has been shown that human medial orbito-frontal cortex activations reflect the rated beauty of paintings and music (Ishizu and Zeki 2011). Each participant viewed 60 paintings and listened to 60 musical excerpts. The visual stimuli included paintings of portraits, landscapes, and still lifes, most of them from Western art but three from Oriental art. The auditory stimuli included classical and modern excerpts of mainly Western music with two Japanese excerpts. The activations in the medial orbitofrontal cortex reflected the beauty of the paintings and the music, which were categorized as beautiful, indifferent, or ugly by each participant. Each individual's ratings were used in the analysis, and, because they were figurative stimuli, there was some agreement between participants. As this was a brain imaging study, it could not show that different neurons were activated by the paintings and the musical stimuli, but this is likely, given our knowledge of the principles of the neuronal representations of different rewards in the orbitofrontal cortex (Rolls 2005a, Rolls and Grabenhorst 2008, Rolls 2008b, Grabenhorst and Rolls 2011). This latter is an important point in Rolls' theory of emotion (Rolls 2005a), for each type of reward must be represented independently of other types of reward, so that the appropriate action can be made to obtain each particular reward (Chapter 3).

## **7.9 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, humour, the ability to tell stories, creativity, art, and even language. He postulates that these are "courtship tools, evolved to attract and entertain sexual partners". One mechanism of sexual selection views organisms as advertisers of their phenotypic fitness, and Miller sees these characteristics as such signals. From this perspective, hunting is seen as a costly and inefficient exercise (in comparison with food gathering) undertaken by men to obtain small gifts of meat for women, but at the same time to show how competitive and fit the successful hunter is in relation to other men. Conspicuous waste, and conspicuous consumption, are often signs in nature that sexual selection is at work, with high costs for behaviours that seem maladaptive in terms of survival and natural selection in the narrow sense. The mental characteristics described above are not only costly in terms of time, but may rely on many genes operating efficiently for these characteristics to be expressed well, and so, Miller suggests, may be 'fitness indicators'. Consistent with sexual selection,



**Fig. 7.2** Fractal image. A fractal is a rough or fragmented geometric shape that can be split into parts, each of which is (at least approximately) a reduced-size copy of the whole, a property called self-similarity. This example is of the Mandelbrot set. Fractal images can be produced by mathematical algorithms. (See colour plates Appendix B.)

there is also great individual variability in these characteristics, providing a basis for choice.

One mental characteristic that Miller suggests could have evolved in this way is kindness, which is very highly valued by both sexes (Buss 2008), and is usually judged as aesthetically pleasing. In human evolution, being kind to the mother's children may have been seen as an attractive characteristic in men during courtship, especially when relationships may not have lasted for many years, and the children might not be those of the courting male. Kindness may also be used as an indicator of future cooperation. In a sense kindness thus may indicate potential useful benefits, consistent with the fact that across cultures human females tend to prefer males who have high social status, good income, ambition, intelligence, and energy (Buss 2008). Kindness may also be related to kin altruism (Hamilton 1964) or to reciprocal altruism (Trivers 1971), both of which are genetically adaptive strategies (Section 4.2).

Although the simple interpretation of all these mental characteristics is that they indicate a good provider and potential material and genetic benefits (and thus would be subject to natural or survival selection), Miller (2000) argues

that at least kindness is being used in addition as a fitness indicator and is being sexually selected.

Morality can be related in part to kin and reciprocal altruism, which influence survival, and make many of the behaviours described as moral also attractive, because of their evolutionary adaptive value (Ridley 1996, Rolls 2005a) (see Chapter 9). In addition, moral behaviour may bring reproductive benefits and be attractive through the social status that it inspires or by direct mate choice for moralistic displays during courtship (Miller 2000). The suggestion made by Miller (2000) is that the status of moral behaviour helps to attract mates, because it may reflect fitness as the moral behaviour may have costs. In turn, the same effects may influence aesthetic judgements.

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 ornamentation, 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 art-works are now commodified and spread wide so that we may not know the artist producing the ornament, when we seek the evolutionary origins of art, we should remember that any art-work our prehistoric ancestors would have been able to see, would have probably been made by a living individual with whom they could have inter-

acted 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) also suggests that language evolved as a courtship device in males to attract females. Miller (2000) further suggests that creativity may be related to systems that can explore random new ideas, and also is a courtship device in males to attract females. My view, elaborated here (Chapter 5) and elsewhere (Rolls 2005a, Rolls 2008c, Rolls and Deco 2010, Rolls 2010d, Rolls 2011b), 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 for both sexes, and are not purely or primarily sexually selected. For example, syntax and language have many uses in problem solving, planning ahead, and correcting multiple-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 2005a, Rolls 2008c). 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, Miller 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 reasoning system that finds that elegant and simple solutions to problem-solving produce pleasure. As I argue, 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 to understand what can happen to people, and much fictional literature 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 are just 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 reasoning, problems are solved (see Table 3.1).

Another problem with Miller's approach is that traits that become sexually selected often have survival value in the first place, so it is often not possi-

ble to fully dissociate sexual selection from survival or adaptation selection (Andersson 1994, Andersson and Simmons 2006).

Another potential problem with Miller's approach is that some of the processes involved in sexual selection favour fast runaway evolution, because sexual preferences are genetically correlated with the ornaments they favour. Why does mental capacity not develop more rapidly, and with larger sex differences, in humans, if Miller (2000) is right? Why is there not a faster runaway? Miller suggests a number of possible reasons.

1. There is a high genetic correlation between human males and females, with 22/23 chromosomes the same.

2. The female's brain must evolve to be able to appreciate the male's mental adornment – and might even be one step ahead to judge effectively. Further, similar or partly overlapping brain mechanisms may be used to produce (in males) and perceive (in females). In addition, male self-monitoring (and female practice) may help appraisal. Males may even internalize female's appreciation systems, to predict their responses.

3. There is mutual choice in humans: males choose females because human males do make a parental investment; and females compete for males. Indeed, the selection of a long-term partner is mutual, and this tends to reduce sex differences. Consistent with this, Buss (1989, 2008) has shown that, in contrast to the situation with long-term selection of a partner, human sex differences are more evident in short-term mating. It is likely in fact that sexual selection works mainly through long-term relationships, because of concealed ovulation in women. This means that only in a relatively long-term relationship is it likely that a man will become the father of a woman's child, because only if he mates with her regularly is there a reasonable probability that he will hit her fertile time.

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* (Woolf 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 sexual selection would not necessarily be the major, and certainly not the only, driving factor. 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 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 ‘survival and adaptation selection’ (Section 7.3).

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 more excellent, on average, in areas of fiction, such as novels, where this interest and expertise in mind-reading and gossip, might be especially engaged. (The fact that autism, which is associated with problems with mind reading, is several times more prevalent in men than in women (Baron-Cohen 2008) does fit with this general approach about adaptations suitable for different environmental niches.) More generally, the evolutionary survival value approach might argue that women have adapted to relational, social, caring, problem-solving, and that 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, see above), operates by specifying goals for action, and these

goals are aesthetically and subjectively attractive or beautiful (Rolls 2005a), or the opposite, and provide what I argue here is the origin of many judgements 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 judgements, are shown in Table 3.1.

## 7.10 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, fashions are strong characteristics of many human aesthetic judgements, 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 operate over time-scales 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 2005a). In this way, there may be runaway changes that do not necessarily make the individual better adapted to the environment, in a way that some consider could be analogous to Fisherian selection (Section 7.4). Of course, many factors, again frequently of evolutionary origin, influence fashion, including its cost (of which the label is an indicator) which helps to make it attractive as it indicates wealth, 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.

The mechanism of transmission and function of memes are though very different from those of genes. Memes may fit the mind, and be passed from individual to individual, often as useless ornaments. Genetic evolution on the other hand provides an elegant and efficient way to search a landscape where there may be many separate hills of different heights where the height of the hills represents the optimality of a solution (Ackley 1987, Rolls and Stringer 2000). Recombination of genes during sexual reproduction allows new combinations of genes to be brought together to perform local optimization or hillclimbing. Mutation, perhaps 100 times more rare in nature, allows an occasional jump to a new part of the space where there might be a higher hill that can be climbed by the local hillclimbing performed by sexual reproduction. Thus genetic evolution

is very different from the transmission of memes. This, of course, is why we have and like sex.

### **7.11 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?

I suggest that solving problems should feel good to us, to make us keep trying, as being able to solve difficult problems that require syntactic operations may have survival value (Rolls 2005a). 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 2005a), and this is exactly the thrust of parsimony and Occam's Razor. (Occam's Razor is 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. The principle is also captured by the term parsimony.)

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 took hundreds of years and was helped by the camera obscura); and in the interest by Vitruvius and Leonardo da Vinci 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.

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) can also be seen as solutions to difficult architectural problems, of how to increase the light and feeling of space in a building, and its impression of grand and daring height.

## 7.12 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, 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 in a face, is first made explicit in the representation (O'Doherty et al. 2003b, De Araujo et al. 2005, McCabe et al. 2008, Rolls 2010a, Grabenhorst et al. 2008a, Rolls and Grabenhorst 2008, Grabenhorst and Rolls 2011). Indeed, cognition and attention can similarly be used to enhance the emotional aspect of aesthetic experience, as described in Section 7.2.

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 backprojections influence representations at lower levels, it is possible that training, including cognitive guidance, can help to make more separate the representations of stimuli and their reward value at early levels of cortical processing (Rolls and Treves 1998, Rolls and Deco 2002, Rolls 2008c). 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 2008c). These effects may be important in many aesthetic judgements that are affected by training, including the appreciation of fine art, architecture, and wine.

## 7.13 Wealth, power, resources, and reputation

As described above, 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 portrayal of wealth, power, and resources. The clothes and background are consistent

with a contribution of these underlying origins. 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), and of course can also reflect subjective knowledge of the person portrayed.

An additional property that can add value judged as aesthetic to a portrait is that an image of someone dear is associated with that person, and what that person means to the viewer, and the attraction of photographic images illustrates this. Religion and its accompanying states aiming often at everlasting happiness must also be recognized as drivers of art.

### **7.14 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. (Orians and Heerwagen 1992). 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. Many of the properties of the savanna in which we evolved fit this (Orians and Heerwagen 1992) (the ‘savanna hypothesis’ of why we find certain types of countryside beautiful), and an English parkland may reflect many of these characteristics. The colour 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 as origins contribute to aesthetic beauty which I argue is multifactorial, influenced by many of the factors described in this theory of the origins of aesthetics (Rolls 2011h).

### **7.15 The beauty of music**

Vocalization is used for emotional communication between humans, with an origin evident in other primates (Rolls et al. 2006a). Examples include warning calls, warlike 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 vs dissonant sounds differentially activate the orbitofrontal cortex (Blood, Zatorre, Bermudez and Evans 1999, Blood and Zatorre 2001), which is involved in emotion (Rolls 2005a). Of course, the

reasoning system then provides its own input to the development, pleasure, and aesthetic value of music, in ways described in Sections 7.11 and 7.12.

What may underlie the greater pleasure and aesthetic value that many people accord to consonant vs dissonant music? I suggest that consonance is generally pleasant because it is associated with natural including vocal sounds with a single source that naturally has harmonics. 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 the vocal cords due to over-exertion, and these may be harmonically much less pure than when the voice is calm and softer.

## 7.16 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% 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 odour 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 (Rolls, Kringelbach and De Araujo 2003c) can respond even more strongly to jasmine when it contains the unpleasant component indole, compared to when it only contains individually pleasant components (Grabenhorst, Rolls, Margot, da Silva and Velazco 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 this 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 pleasantness representation may drive hedonic experience separately from unpleasantness representations

(Grabenhorst et al. 2007), then a factor might be the increased activation of pleasantness representations if there is a component to the stimulus that is unpleasant due to a contrast effect heightening the pleasantness. This contrast effect might be facilitated by paying attention selectively to the pleasantness of a stimulus vs its unpleasantness (Rolls, Grabenhorst, Margot, da Silva and Velazco 2008b, Grabenhorst, Rolls and Parris 2008b, Ge, Feng, Grabenhorst and Rolls 2011). Another example of pleasantness enhancement of pleasant by unpleasant stimuli occurs when an odour become more pleasant if it is preceded by an unpleasant (compared to a pleasant) odour, a ‘relative pleasantness’ 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, Rolls and Margot 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 2007d); from tragedy in literature, though empathy makes a large contribution here; from difficult feats, such as those performed by Odysseus illustrated on the front cover of Rolls and Deco (2010), etc.

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). What more can we 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, Tibi-Elhanany and Aharon-Peretz 2007, Takahashi, Kato, Matsuura, Mobbs, Suhara and Okubo 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 you, and more generally, about the things that can happen to people in life, and from which we can potentially learn.

Second, the ability to empathize with another’s emotions, and indeed to be

good at this and find it rewarding, may also be important in communities, in order to facilitate kin or reciprocal altruism (Ridley 1996).

Third, the ability to have a theory of other people's minds is adaptive in facilitating prediction of their behaviour (Frith and Singer 2008). I propose that fascination with this should again in an evolutionary context be rewarding, and be associated with pleasure, because of its adaptive value. This may contribute to the enjoyment that many women (who overall relative to men may specialize in social relationships) find in fiction.

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 also I suggest are important contributors to the popularity of novels.

In the cases of both drama and novels, we know that they are fiction, or at least 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.

### **7.17 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. 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 described in this book, 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) (Section 7.2). 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.

### **7.18 Is what is attractive, beautiful and aesthetic?**

I wish to counter a possible objection to the theory of the origin of aesthetics described here. The possible objection 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 unsavoury, and not quite aesthetic. The point I make is that it is not just the gene-specified rewards and punishers that make stimuli have aesthetic value. My proposal is that the reasoning (rational) system also contributes to aesthetic value, in a number of ways.

The reasoning system 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, and problem solving with this reasoning system is encouraged by simple elegant solutions being rewarding and having 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 as described provides 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.

Some art that we regard as good aesthetically may not be beautiful. For example, the paintings of Paul Nash representing scenes of the First World War, or for that matter *Guernica* (1937, in response to the Spanish civil war) by Pablo Picasso, are horrifying. But I think the principle is the same: these paintings make impact because they tap by their representations into our emotional brain systems, in this case our horror produced by the ravages of war. Indeed, they arouse in us moral indignation at what happened, and of course moral indignation at injustice and unfairness is the stuff built into the brain by evolution for our fitness, and makes us feel like doing something about the situation (Chapters 4 and 9). In other cases, where the subject matter may not be pleasant, but is nevertheless Art, such as many of Francis Bacon's paintings, perhaps part of what makes it Art is that it makes us look at the world in a new way, and searching for novelty is itself a gene-specified reward (Chapter 3), and at the phenotypic level, search for new knowledge and understanding

by the reasoning system should be rewarding, as that knowledge may come in useful and help with survival or reproduction in the future (Section 5.4).

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) (as is Darwinian evolution). Thus the particular future trajectories cannot be predicted. In each trajectory though a number of factors guide, including new-ness (novelty is biologically attractive as argued above), wildness (as in Beethoven's late string quartets), as well as what we rationally find aesthetic (as described above), and what survival and sexual selection have also provided in us as some of the origins of aesthetics.

## 7.19 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 Chapter 3 and Fig. 5.1). For example in the inferior temporal visual cortex there is a representation of objects that is independent of whether an object is associated with reward vs punishment, or is made rewarding or not by hunger (Rolls et al. 1977, Rolls et al. 2003a). In the primary taste cortex in the insula and frontal operculum, there is a representation of what taste is present, and of its intensity, that is independent of its reward value as altered by hunger vs satiety, and that is correlated with the subjective intensity but not subjective pleasantness of taste (Rolls, Scott, Sienkiewicz and Yaxley 1988, Yaxley, Rolls and Sienkiewicz 1988, Grabenhorst et al. 2008b). In the primary olfactory (pyriform) cortex, activations are correlated with the subjective intensity but not subjective pleasantness of odor (Rolls et al. 2003c, Rolls et al. 2008b). On the other hand, the affective value of taste, olfactory, visual, thermal, tactile, and auditory stimuli is represented in the orbitofrontal cortex. This is shown by neuronal responses that are modulated by hunger or occur to stimuli when they are associated with a reward, and by correlations of brain activations with subjective ratings of pleasantness but not intensity (Rolls et al. 1989, Critchley and Rolls 1996a, Kringelbach et al. 2003, Rolls 2005a, Rolls 2007d, Rolls and Grabenhorst 2008, Rolls et al. 2010a, Grabenhorst and Rolls 2011).

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 do not go 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. 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 book *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 treated in philosophy, although before this 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 judgement of beauty carries the weight of ‘ought’, that others should judge it beautiful too, so his theory has moral implications. His judgement of beauty is a ‘disinterested’ judgement, 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 good art if it taps into many of the human rational and gene-based reward systems (see further Section 7.18), with therefore individual differences expected, as described in Section 7.17.

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 arises 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), see Miller (2001)), and Miller (2000, 2001) has proposed a sexual selection theory of art. The implication of this 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 ornament 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 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 much 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 (mechanisms i-ii in Section 7.4).

## 7.20 Conclusions

To end this chapter, my theory (Rolls' theory) of aesthetics (Rolls 2011h) thus specifies the roles of (both) Darwinian 'survival or adaptation' selection, and sexual selection, in aesthetics. 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 2005a) (Chapter 3).

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 is complex and multi-faceted, and these factors must include whether the effect of the art is for good or for harm.

It also follows that attempts in aesthetics to produce a systematic account based on consistent explicit beliefs will not succeed, for many factors that are not necessarily consistent with each other are involved in aesthetic values; because there are individual differences in reward systems as part of the variation necessary for evolution; 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.