Pictures at an exhibition
The science of the face

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Andy Young *and* **Vicki Bruce** *report on their exhibition at the Scottish National Portrait Gallery.*

FOR centuries, the face has provided artists with a subject which is both technically demanding and rich in social significance. Many of the most famous works of Western art have been portraits or self-portraits.

The face has also become an object of scrutiny to scientists as well as artists. Anatomists have charted cranio-facial development and explored the operation of the many facial muscles. Evolutionary biologists have discussed the functional arrangement of facial features (the basic face pattern common to so many animal species) and the relation of facial attractiveness to mechanisms of sexual selection. Neurologists and neuroscientists have examined the brain regions and neural pathways involved in our responses to faces.

Not the least of these efforts have come from psychologists, who have studied an enormous number of face-related questions. These range from the physical features that enable us to tell a man's face from a woman's face, to assess a person's age or to recognize particular individuals, to recognize facial expressions of emotion, to judge gaze direction and signals of interest, through to multifaceted explorations of factors involved in eye-witness testimony, the detection of lying or deception, social stereotyping, or the effects of appearance on social interaction.

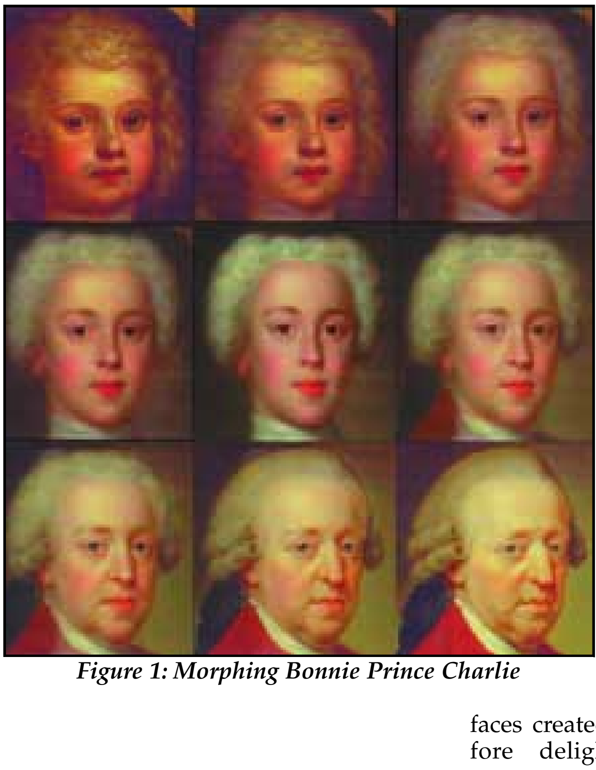

Figure 1: Morphing Bonnie Prince Charlie

Potentially, much of this scientific work has implications for understanding some of the things that go on when we view representations of faces created by artists. We were therefore delighted when the Scottish National Portrait Gallery (SNPG) accepted our suggestion of an exhibition on 'The Science of the Face' which juxtaposes works of art from the Gallery's extensive collections of paintings, prints, sculptures, drawings and photographs with specially created scientific exhibits intended to inform their interpretation. The exhibition has been put together with the enthusiastic assistance of James Holloway, the Keeper at the SNPG, and his staff. It will run from 12 March until the end of May (or possibly later) in the Gallery's premises in Queen Street, Edinburgh, with a series of associated public lectures linked to the Edinburgh Science Festival.

We present here just a few of the pictures from this exhibition, to illustrate some of the themes explored and give a selection of what can be seen by those able to get to Edinburgh during this period. Many of the images will also appear in a book published by Oxford University Press (Bruce & Young, 1998), and the possibility that parts of the exhibition may travel to other locations in Britain is under discussion, thanks to generous financial support from the Society's Scientific Affairs Board.

Age, sex and appearance

When we look at a face we are able to evaluate almost effortlessly the person's age and sex. A mathematical description of the physical changes in the shape of the skull produced by ageing was achieved earlier this century by the naturalist D'Arcy Thompson (1917), and this has formed the basis for several studies during the last 20 years following the seminal work of Pittenger and Shaw (1975).

Portraits of Bonnie Prince Charlie at different ages demonstrate the changes in the shape of his face, and computer image-manipulation techniques can be used to blend successive images in a process known as 'morphing'. Peter Hancock of the University of Stirling has used this technique to create intermediate steps between the Bonnie Prince's face at different ages, as illustrated in Figure 1. The three faces along the diagonal from top left to bottom right are details from portraits of the Prince as an infant, youth and old man. The intermediate images have been produced by computer morphing between these images. Because ageing produces gradual changes in appearance, the morphing operation does a reasonable job of creating images of the Prince as he might have appeared as a boy or a younger man.

Very sophisticated use of image manipulation was made by Michael Burt and David Perrett of the University of St Andrews to investigate how different sources of information affect the apparent ages of faces (Burt & Perrett, 1995). First, they collected a number of full-face photographs of different male faces spanning a range of ages. Faces of similar age were then averaged together — by careful alignment of a large set of reference points identified on each individual face, the faces can be averaged without blurring due to the mis-alignment of features from different faces.

Figure 2: Growing old before your time

By calculating how the average for each age group differed from neighbouring ages, Burt and Perrett were able to describe these differences in terms of their shape and in terms of their surface pigmentation (texture and colour). This made it possible to manipulate these cues independently, to age the appearance of an individual face in a most convincing way. In Figure 2, the face shown in the top left panel has been aged by changing its shape toward that of an older person (top right), changing its pigmentation (bottom left), or changing both (bottom right).

Exactly the same methods can be adopted to shift appearance toward a more averagely feminine or masculine form. The central image in Figure 3 is a detail from a portrait of Mary Queen of Scots. David Perrett and his colleagues have used computer techniques to make the face more feminine (left-hand image) and more masculine (right-hand image) in appearance, by distorting the original image in a manner which moves it closer to the average female or male appearance.

A striking thing about these images is that the more feminine version looks considerably younger than the others — there is some overlap between the characteristics of a face judged particularly feminine and the 'baby-faced' characteristics of the juvenile face (Bruce *et al.*, 1993). It is interesting to ponder how this may contribute to the pressure many women feel to use cosmetics, or even cosmetic surgery, in order to look youthful.

Figure 3: A sex change for Mary Queen of Scots

Light, shape and identity

The visual system has evolved to respond to changes in light and dark. Images are analysed at different spatial scales, keeping separate a description of coarse variations in light and shade from a more precise description of detailed features. The overall patterns of light and dark within the coarse-scale representations are as important as precise information about individual features. For example, photographic negatives preserve the shapes and layout of features, yet are very difficult to recognize (Bruce & Langton, 1994). Similarly, line drawings of faces preserve feature information, but are difficult to recognize unless they capture something about variations in light and dark (Bruce *et al.*, 1992).

Artists often make use of unusual and unexpected hues in their work, but the image is still perfectly recognizable because they take care to preserve the relative luminances of the colours they use. Thus in painting a shadow region on a face an artist can use orange, red or even green pigments provided they ensure that the chosen pigment is darker than the surrounding areas which are not in shadow.

What happens if we change the balance of hue or luminance in portraits? Richard Kemp and Graham Pike of the University of Westminster have demonstrated the results using the portrait of Sean Connery shown in Figure 4. This portrait is presented in its original colour (top left), in hue-negative (top right), luminance negative (bottom left), and full negative (bottom right). Although the hue-negated image does not show the colours as the artist intended, it has retained the relative lightness and darkness of the various parts of

Figure 4: Colour and brightness transforms

the image, and thus it continues to look like Sean Connery because the visual system is still able to interpret the pattern of shadows and shading. For example, the shadows that appear under the eyes of the original and the areas of shadow on the left side of the face are still apparent in the hue-negated image. In contrast, in the luminance- and full-negative images (bottom two patterns), these areas of shadow now appear brighter than the surrounding parts of the face, and we have great difficulty in recognizing its identity. A similar set of transforms using an unfamiliar face is also given in Figure 4, with the same result.

Our skill at recognizing faces also involves sensitivity to the configuration of the face as a whole — the spacing and relationship between different features. If we alter the positions of facial features even a little, as in Figure 5 (created by Helmut Leder of the University of Fribourg), the effect on appearance is immediately noticeable. This ability to perceive subtle aspects of face configuration itself depends upon faces being seen in their normal, upright orientation. In Figure 5 you will find it more difficult to notice the changes in the placement of the face features of Tom Conti in the inverted panels. Upside-down faces look strange to us, and we find them very difficult to recognize.

Determinants of attractiveness

As well as categorizing and recognizing faces, we respond to them more or less positively according to how attractive they seem to us. The appearance of an individual face is a complicated result of a number of different kinds of genetic influence, moderated by environmental and cultural factors and individuals' own choices about how to present their faces. Whilst there are wide differences between individuals and across cultures in what is considered attractive, there is also a surprising core of agreement if one uses averaged responses.

Figure 6 shows images created by Judith Langlois and her colleagues at the University of Texas, Austin, which are averaged across four, eight, 16 or 32 faces going from the top to the bottom of each column. This was done by dividing each photograph into a very large number of tiny squares (pixels), and the brightnesses of corresponding pixels in different faces of the same sex were averaged to create computer-composite images.

When people are asked to judge the attractiveness of these composite faces, they generally rate them as increasingly attractive the more faces go into each image — in other words, perceived attractiveness increases as one moves downwards in the display.

The mathematical consequence of increasing the number of faces used to create a composite image is to move the brightness values in that image closer to the average brightness values of the entire set. It seems, then, that moving a facial image closer to the average increases its perceived attractiveness (Langlois & Roggman, 1990).

Although we do not fully understand the interplay of factors that affect attractiveness, a number of interesting

Figure 5: Feature positions.

Figure 6: Attractiveness and averageness

Figure 7: Art and the computer

hypotheses have been suggested to account for such findings. Attractive facial features may be attractive because they signal sexual maturity and fertility, and this can in part account for the fact that attractiveness is linked to features which indicate a certain youthfulness (Jones, 1995). Another hypothesis is that attractiveness is part of a mechanism which promotes an optimal degree of variety in the gene pool of a species for maximal resistance to potential parasites (Thornhill & Gangestad, 1993). Alternatively, a case can be made that attractiveness relates to mechanisms involved in family resemblance and paternity confidence (Salter, 1996).

Some of the techniques used in modern scientific studies of the face are finding their way into the repertoires of contemporary artists. Figure 7 shows images from an exhibition staged by the artist Rosemarie Trockel — similar faces were placed on 3,000 billboards in Vienna. Trockel used computer software to transform the 'organic beauty' of each model to a more idealized beauty by removing surface blemishes, correcting contours, and making some features more symmetric. Her intention was that the faces 'should be as beautiful as nature and the computer allow'.

In the brain of the beholder

The philosopher René Descartes made a clear separation between mental and physical events, but this led him into difficulties in accounting for how our mental lives relate to the physical structure of the brain. The mind-body problem identified by Descartes continues to be widely discussed, even though the majority of scientists and philosophers accept that the mind is indeed a product of the brain. The central thrust of the question has shifted to that of what kind of product the mind might be, and what kind of physical structure the brain must be to produce it.

Because faces are of such fundamental social importance to a creature that lives in a complex society, extensive areas of the brain are involved in their perception. The functions of these areas are being revealed in studies of the effects of different types of brain injury, and in studies using modern neuro-imaging methods to picture face processing in the normal brain. One of the most interesting points that emerges is that the brain seems to 'farm out' different aspects of the task to different specialized areas; for example, some regions of the brain are more closely involved in determining an individual's identity from their facial appearance, others in interpreting facial expressions of emotion (Young *et al.*, 1993).

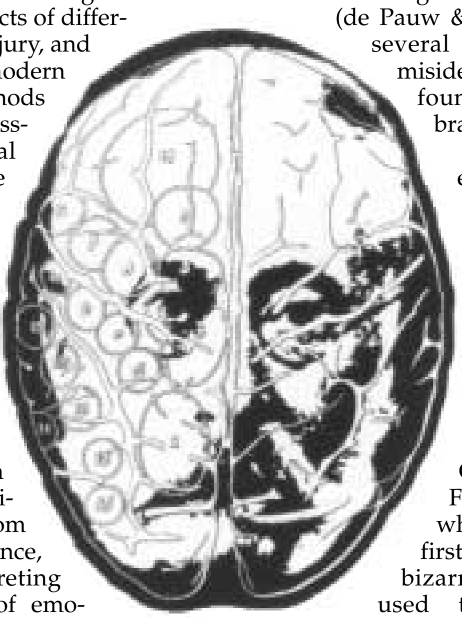

Figure 8: Sir David Ferrier

A key figure in the development of such ideas was Sir David Ferrier, who was born near Aberdeen in 1843. The picture by Nicholas Wade (of the University of Dundee) shows Ferrier peering out from his diagram of brain sites with identifiable functions, denoted by different numbers (Figure 8). Whilst modern knowledge is not in entire agreement with all of Ferrier's findings, they are mostly not that far from the mark.

A privileged insight into the intimate relation between our minds and our brains can be gained from studying the effects of brain diseases, which sometimes lead to highly disconcerting mental symptoms, including different types of delusion.

The striking portrait of the 'alienist' (psychiatrist) Sir Alexander Morison was painted by Richard Dadd (Figure 9). Dadd had been an artist of great promise, but he spent most of his life in Bethlem and Broadmoor Hospitals after he killed his father in 1843. This was a premeditated murder of someone who was trying to care for him against medical advice that he should be put under restraint because of his delusions, which included the belief that he was an envoy of the god Osiris and the idea that his father was the devil.

Dadd's most famous works, his fairy pictures, were created when he was a mental patient. His younger brother George was also a patient in Bethlem Hospital at the same time.

When he killed him, Dadd thought his father was someone else (the devil). This is a form of delusional misidentification — a psychiatric symptom which involves thinking that other people are not who they appear to be. Psychiatrists have identified a number of distinct forms of delusional misidentification, and recognize that some of them present a small but significant risk of violence (de Pauw & Szulecka, 1988). In several cases, delusional misidentification has been found to be linked to brain disease.

One of the most extensively investigated forms of delusional misidentification has been the Capgras delusion — the claim that one or more close relatives have been replaced by near-identical impostors. Joseph Capgras was a French psychiatrist who gave one of the first descriptions of this bizarre phenomenon. It used to be considered extremely rare, but studies of people with dementing illnesses show that it is not as uncommon as was supposed (Förstl *et al.*, 1994).

Many recent reports show that the Capgras delusion is associated with certain types of abnormal brain activity or can follow brain injury. Figure 10 shows the distribution of blood flow in the brain of a person with Capgras delusion studied by Florence Lebert of the University of Lille and her colleagues (Lebert *et al.*, 1994). Abnormalities were noted in parts of the right parietal lobe considered likely to be involved in our emotional reactions to visual stimuli, and faces in particular.

The neurological abnormalities found in cases of Capgras delusion are exactly as would be expected from a hypothesis suggested by Hadyn Ellis and Andy Young (1990). When we look at faces of people we know, we recognize who they are and parts of our brains set up preparatory emotional reactions for the type of interaction that is likely to follow — Russian psychologists named these preparatory reactions the orienting response. In Ellis and Young's account, recognizing who it is and preparing for what you are likely to do (orienting responses) involve separable neurological pathways, and the Capgras delusion can happen when the pathway responsible for the orienting response is affected. The consequence of an impaired orienting response to familiar faces will be that faces can be recognized, but seem somehow odd because they do not provoke the usual reactions. The impostor claim

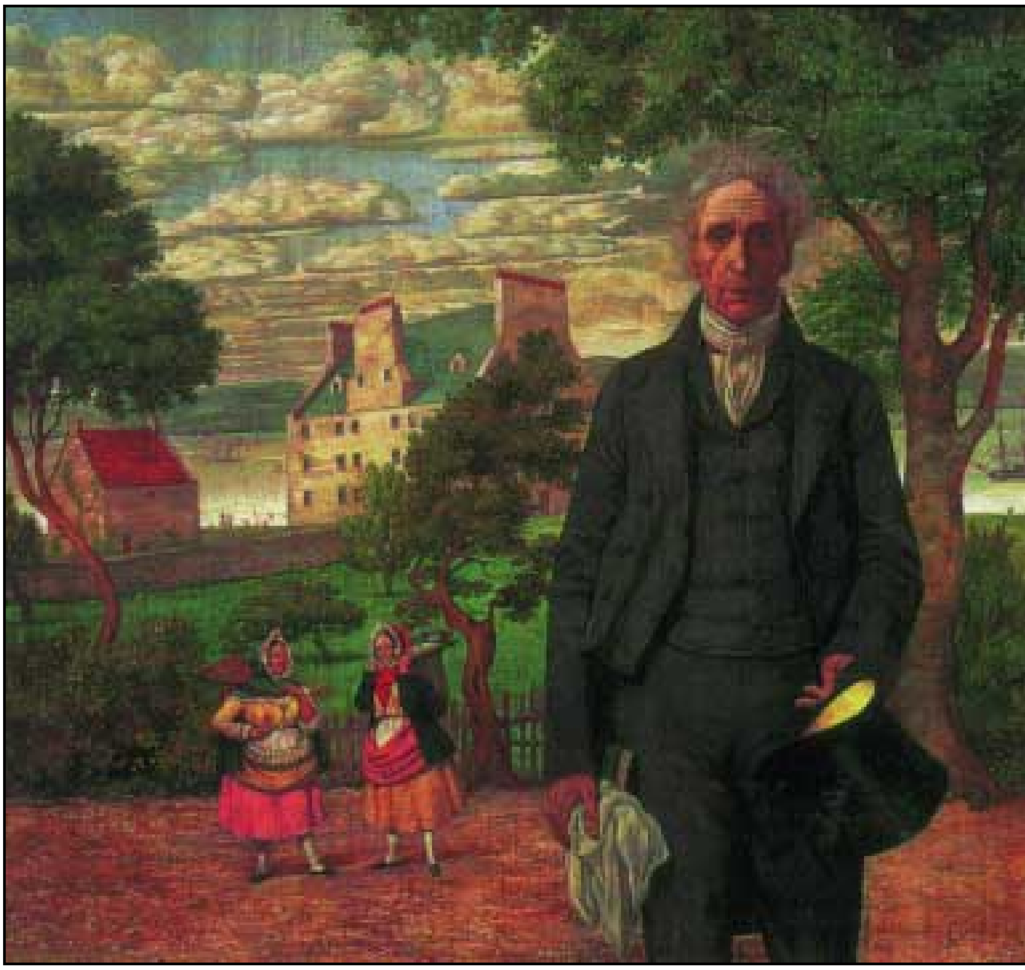

Figure 9: Sir Alexander Morison

made by people experiencing the Capgras delusion is a rationalization of this highly disquieting sense of strangeness.

The shadow of the past

Assembling this exhibition has increased our own awareness of the many contributions made by Scottish scientists. The interplay of science and art was a theme which had been explored in the 19th century — often by Scottish scientists and artists. Sir Charles Bell added the subtitle 'as connected with the fine arts' to his book on *The Anatomy and Philosophy of Expression* (Bell, 1844). His aim was to put the practice of drawing and painting onto a more secure anatomical basis, especially in the portrayal of the face and facial expressions. He described how he thought greater knowledge of anatomy might be useful to artists, and included a somewhat undiplomatic foray into the faults he considered to follow from a lack of such knowledge. Through the paintings of his fellow Scot, Sir David Wilkie, Bell's ideas began to influence artists.

The Edinburgh-based phrenologist George Combe published a book on *Phrenology Applied to Painting and Sculpture* (Combe, 1855). He held similar overall views to Bell on the importance of grounding art in science, but he gave them a broader treatment — covering all forms of fine art, not just the representation of the face.

We have become conscious of treading some of the same paths as Bell and Combe, albeit with more modern scientific insights. The difference is that we do not have a prescriptive agenda — we present scientific findings because we believe these can inform our understanding of what goes on when anyone (artist or non-artist) looks at a face or a realistic portrait, not because we want to constrain what artists do. It has been a lot of fun for us to be involved with this exhibition, and we hope it will help in bringing science to a wider audience than we are usually able to address.

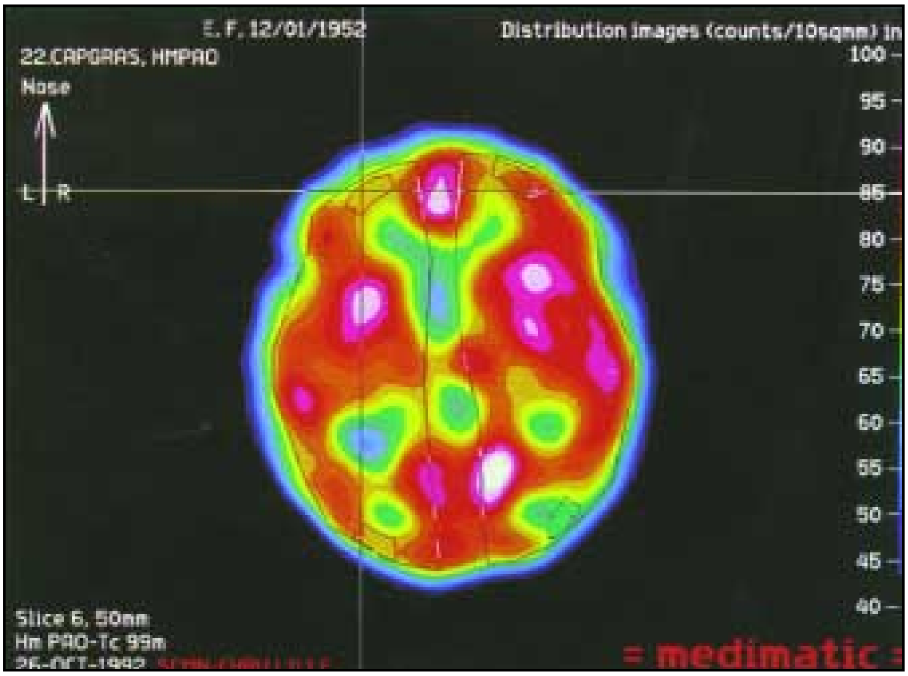

Figure 10: SPECT brain blood flow image for a person with Capgras delusion

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Picture credits

Figure 1: Morphing Bonnie Prince Charlie. Details from portraits of Prince Charles Edward Stewart by courtesy of the Scottish National Portrait Gallery: top left by unknown artist; centre by Antonio David; bottom right by Hugh Douglas Hamilton. Computer manipulation by Peter Hancock, University of Stirling.

Figure 2: Growing old before your time. Computer-manipulated images by Michael Burt and David Perrett, University of St Andrews. Reproduced from Burt and Perrett (1995).

Figure 3: A sex change for Mary Queen of Scots. Detail from a portrait of Mary Queen of Scots (centre) by an unknown artist after François Clouet, by courtesy of the Scottish National Portrait Gallery. Computer-manipulated images by David Perrett, Duncan Rowland and Rachel Edwards, University of St Andrews.

Figure 4: Colour and brightness transforms. Picture of Sean Connery by John Bellany, courtesy of the Scottish National Portrait Gallery. Computer-manipulated images by Richard Kemp and Graham Pike, University of Westminster.

Figure 5: Feature positions. Detail from portrait of Tom Conti by Ishbel McWhirter (top left), by courtesy of the Scottish National Portrait Gallery. Computer-manipulated images by Helmut Leder, Institute of Psychology, University of Fribourg.

Figure 6: Attractiveness and averageness. Images by courtesy of Judith Langlois, Univesity of Texas.

Figure 7: Art and the computer. From an exhibition by Rosemarie Trockel.

Figure 8: Sir David Ferrier, by Nicholas Wade. Courtesy of Nicholas Wade, University of Dundee.

Figure 9: Sir Alexander Morison, by Richard Dadd. Courtesy of the Scottish National Portrait Gallery

Figure 10: SPECT brain blood flow image for a person with Capgras delusion. By courtesy of Florence Lebert, University of Lille.