Perception, 2006, volume 35, pages 229‘ – 246

DOI:10.1068/p3449

Aesthetic phenomena as supernormal stimuli: The case of eye, lip, and lower-face size and roundness in artistic portraits

Marco Costa, Leonardo Corazza
Department of Psychology, University of Bologna, viale Berti Pichat 5, I 40127 Bologna, Italy;
e-mail: marco.costa@unibo.it
Received 2nd September 2002, in revised form 11 September 2005; published online 18 January 2006

Abstract. In the first study, eye and lip size and roundness, and lower-face roundness were compared between a control sample of 289 photographic portraits and an experimental sample of 776 artistic portraits covering the whole period of the history of art. Results showed that eye roundness, lip roundness, eye height, eye width, and lip height were significantly enhanced in artistic portraits compared to photographic ones. Lip width and lower-face roundness, on the contrary, were less prominent in artistic than in photographic portraits. In a second study, forty-two art academy students were requested to draw two self-portraits, one with a mirror and one without (from memory). Eye, lip, and lower-face roundness in artistic self-portraits was compared to the same features derived from photographic portraits of the participants. The results obtained confirmed those found in the first study. Eye and lip size and roundness were greater in artistic self-portraits, while lower-face roundness was significantly reduced. The same degree of modification was found also when a mirror was available to the subjects. In a third study the effect of lower-face roundness on the perception of attractiveness was assessed: fifty-three participants had to adjust the face width of 24 photographic portraits in order to achieve the highest level of attractiveness. Participants contracted the face width by a mean value of 5.26%, showing a preference for a reduced lower-face roundness. All results are discussed in terms of the importance of the ‘supernormalisation’ process as a means of assigning aesthetic value to perceptual stimuli.

1 Introduction

A pictorial cue that is often violated in works of art is the relative size (Deregowski 1984). In Egyptian art, for example, the relative size of coplanar figures is an index of their social ranking. A king slaying his enemies is usually depicted much larger than the enemies, not because he is intended to be seen as nearer to the viewer, but because of his role as the king. In art history, the use of size to indicate differences in power was common even after the widespread adoption of perspective. Social status, however, was not the only determinant of size. This effect is one of a number of effects subject to the general rule that what is important and salient has been drawn larger since the times of prehistoric art. In a cave painting of Cueva de la Aranta, for instance, a female figure is shown up a rudimentary ladder or rope, near an opening in the rock face, with a utensil in her hand. Huge bees, some as large as the honey-seeker’s head, swarm around the intruder. This exaggeration of bee dimensions has been constant in bee-focused illustrations throughout history.

The studies illustrated in this paper focus on size modifications and roundness of the eyes, lips, and lower face. The choice of these facial features is due to the key role they play in face perception and processing (Haig 1985; Bruce and Young 1998), and their importance in artistic representations (König 1975; Gombrich 1994; Gregory et al 1995). Their importance has also been confirmed by studies of exploratory ocular movements in face scanning (Gandelman 1986), and in studies that have linked facial anthropometry to the perception of attractiveness (McArthur and Apatow 1983/1984; Berry and McArthur 1985; Cunningham et al 1990).

Several studies have demonstrated the key role played by chin length, width, and area in the perception of facial attractiveness (see, for example, Berry and McArthur 1985; Cunningham 1986; Cunningham et al 1990), but it is still unclear which morphology of jaw – chin is best related to attractiveness. While for eyes and lips the ratio between height and width is unambiguously a parameter of roundness since these features have an explicit oval shape, for the jaw and chin the same ratio (height/width) could result in a squared jaw – chin or in a perfectly round jaw – chin appearance. For this reason, in the present study the jaw and chin were not assessed as a ratio between facial measurements but as a ratio between the horizontal and vertical axes of an ellipse that best fitted the lower-face outline.

The hypothesis underlying these studies is that the distortions encountered in visual arts can be interpreted as the formation of supernormal stimuli, and, equally, that supernormal stimuli often contribute to the formation of aesthetic and artistic stimuli. A supernormal stimulus (Staddon 1975) is defined as a stimulus, generally visual, which exceeds in efficacy a sign stimulus which is biologically normal. In many animals there are particular responses in their behavioural repertoire which occur only in the presence of particular stimulus features which are referred to as sign stimuli. Beginning with Tinbergen (1953), many experimental studies have shown that it was often possible to isolate and exaggerate a sign stimulus to produce a supernormal stimulus which elicited a supernormal response. ten Cate and Bateson (1989) and Ryan et al (1990) have shown the importance of sensory exploitation (ie the preference for signals that deviate from the population mean) in sexual selection and mate preference. They hypothesised that males evolve traits that exploit pre-existing biases in the female's sensory system. In a similar attempt to understand the evolution of exaggerated traits and conspicuous displays used by males to attract females, Enquist and Arak (1993) showed, in an evolutionary simulation with neutral networks, an increase in preference for longer tails in males, alongside a decrease in female responsiveness to conspecific males with the original tail length. This exaggeration occurred even in cases when increased tail length reduced the survival capacity of males, but the extent of exaggeration was inversely related to the cost of survival. Darwin (1871) also noted that traits that give an advantage in mating can evolve to such extremes that they decrease male survival. It is well known that sensory organs often show biases in their response to signals of certain dimensions. It follows that such biases could act as important agents of selection in the form of signals.

Ethological studies have shown that the process of exaggeration in sign stimuli is not confined to signals used for the attraction of potential mates, but can be applied with equal force to all contexts of signalling, including interspecific communication (such as warning coloration), and may offer a general explanation for the elaboration of signals that occurs during the process of ritualisation.

Latto (1995) maintained that aesthetic primitives are connected to powerful triggers of neural activity in the cortical visual pathways. For example, the preference for vertical and horizontal lines could be derived from the importance of orientation detectors in the visual cortex that respond to these two directions. On a higher level, he further maintained that the human form is a high-level aesthetic primitive because it stimulates activity further along the cortical pathways in neuronal systems specialised in analysing the human body. On an artistic level, he suggested that the simplifications and transformations of the human face and form in African art and by Brancusi, Giacometti, Picasso, Moore, Bacon, and many twentieth-century artists were not arbitrary, and were perceived as aesthetically attractive because they corresponded to simplifications and transformations of processes used by the brain to analyse and represent human anatomy.

The same kind of exaggeration and process of 'supernormalisation' that is here suggested as a means of ascribing artistic features to a stimulus can be found in a previous study of head canting in artistic portraits (Costa et al 2001). Examination of the complete works of eleven well-known painters from the XIV to the XX century showed that head canting was much more pronounced in religious and mythological subjects, with a mean of 18.5°, and almost absent in military and noble portraits, with a mean of only 1.9°. In ecological observations of students self-posing for a photograph, a mean head canting of 4.6° was observed (Costa and Ricci Bitti 2000). It appears, therefore, that painters have exploited the relationship between head canting and expression of submission, appeal for protection, adoration, and ingratiation when depicting religious and mythological figures.

In the present paper, two studies are reported demonstrating a constant distortion in eye, lip, and lower-face roundness and size in artistic portraits when compared to normative, physiognomic data in photographic portraits. A third study is introduced showing that lower-face roundness, parametrised with a new methodology of ellipse interpolation of the lower-face outline, significantly influences the perception of face attractiveness. In the first study, the anthropometric data related to eye, lip, and lower-face roundness for a large sample of faces from artistic works encompassing the entire history of art were compared, and normative data were extrapolated from a large sample of photographic portraits. In the second study, a comparison was conducted in a within-subjects design, requesting a group of art academy students to draw two self-portraits, one from memory and one with the use of a mirror, and comparing the anthropometric data with those derived from photographic portraits.

2 Experiment 1

2.1 *Materials*

A total of 1065 portraits belonging to two categories (289 photographic portraits and 776 art portraits) were examined. Photographic portraits belonged either to a database collected by the authors in a previous study ($N = 79$) (Costa and Ricci Bitti 2000), or to an archive of a local photographic club ($N = 210$). In both cases, the camera used for the photographs was not equipped with a wide-angle lens, and subjects were not at a close-up distance from the camera. This was done to avoid barrel distortion of the image, and therefore an increment of roundness in the graphical components of the photograph. All portrayed individuals were Caucasians. The photographic portraits depicted 140 males and 149 females in frontal view.

The art portraits were selected from the Scala Picture Library, the most complete on-line collection of visual art comprising around 80 000 colour reproductions of works of art (http://www.scalarchives.com). The Scala Group is the official photographic agency of the most prestigious art museums in the world, and particular attention is paid to faithfulness and accuracy in photographic reproduction of the artwork. A thematic search service allows one to scan the archive through 7000 key words. The archive encompasses paintings, sculptures, architecture, and decorative pieces of art from all over the world, from every period, and every artistic current. From the 4453 records which resulted from searching the archive with the keyword 'portrait', 776 were selected according to the following criteria: (a) the face had to be represented in frontal view or slightly turned left or right (both cheeks had to be visible); (b) the portrayed figure had to belong to the Caucasian race (in order to allow a comparison with the photographic sample); (c) the 'Scala Picture Library' overprint should not conceal the main facial landmarks; (d) the face should not be partially masked by other figures; (e) the style should not be abstract. The oldest art work belonged to Egyptian art and dated back to the 3rd millennium BC. The art portraits represented 498 males and 278 females.

2.2 *Facial anthropometry*

A total of seven face measurements were collected from each artist or photographic portrait whenever possible. Measurements were made on digital images with a function of the Xfig software following guidelines in Farkas (1981). They were made independently by the author and by a collaborator who was naive to the aims of the study. Correlation between the two measurement sets was $r = 0.97$. Statistical analyses were performed on mean values. As illustrated in the example depicted in figure 1, facial measurements included: (a) right-eye width (endocanthion – exocanthion); (b) right-eye height (palpebrale superioris – palpebrale inferioris); (c) lip width (right cheilon – left cheilon); (d) lip height (labiale superioris – labiale inferioris); (e) face height (nasion – menton). If the face was not depicted fully frontally and was slightly turned, then only the data of the more frontal eye (left eye in case of turning right and vice versa), and the measurement of face height were collected. Data were also omitted when one anatomical marker was not clearly detectable because it was covered by hair, a beard, or was roughly drawn. The missing data were distributed as follows: 3 for eye width, 4 for eye height, 365 for lip width, 374 for lip height, and 23 for face height.

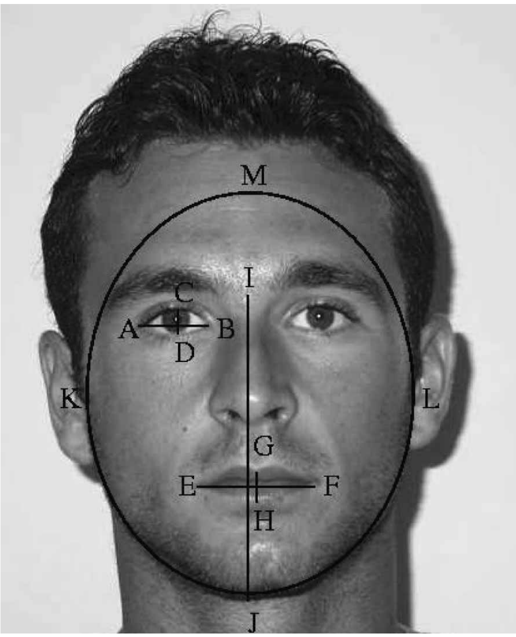

Figure 1. Facialmetric parameters in experiments 1 and 2. AB = eye width; CD = eye height; EF = lip width; GH = lip height; IJ = face height; KL/MJ = lower-face roundness.

Since absolute values are not directly comparable because of size variability in artworks, statistical analyses were conducted on the following anthropometric ratios, as recommended and described by Jones (1996): (a) eye roundness (eye height/eye width); (b) lip roundness (lip height/lip width); (c) eye width ratio (eye width/face height); (d) eye height ratio (eye height/face height); (e) lip width ratio (lip width/face height); and (f) lip height ratio (lip height/face height). A seventh index was computed as a parameter of lower-face roundness by using a new method. The lower-face outline below the ear level (left and right otobasion inferioris) was graphically fitted with an ellipse with the use of a function of the Xfig software. The parameter of lower-face roundness was computed as the ratio between the horizontal axis and the vertical axis of the ellipse (see figure 2). An index of 1 is equivalent to a lower-face outline that can be inscribed in the circumference arc, an index smaller than 1 indicated an ellipse with the vertical axis greater than the horizontal axis and the reverse applies to an index greater than 1.

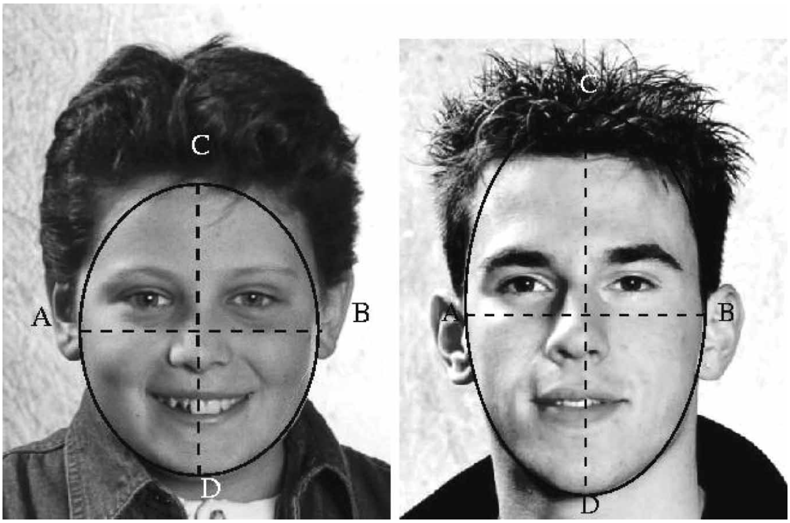

Figure 2. Lower-face roundness was computed as the ratio between the horizontal axis (AB) and the vertical axis (CD) of the ellipse that best fitted the lower-face outline.

2.3 *Age and historical classification*

In addition to gender, two other categorical variables of the face were employed: age category and, only for art portraits, historical period. Portrayed individuals were classified for age (in years) in four categories: $\leqslant 10$, 11–25, 26–45, > 45. Classification was based on work captions whenever available, otherwise on physical appearance. The numbers of portraits according to gender and age category of the face are reported in table 1.

Table 1. Numbers of photographic and artistic portraits analysed in experiment 1 according to gender and age category of the face.

Category	Males (age/years)				Females (age/years)				Total
	$\leqslant 10$	11–25	26–45	> 45	$\leqslant 10$	11–25	26–45	> 45	
Photographic	22	47	35	36	17	77	39	16	289
Artistic	20	74	290	114	16	84	164	14	776
Total	42	121	325	150	33	161	203	30	1065

When age was not explicitly mentioned in the caption, age was rated independently by the author and the collaborator, and the age category attribution was taken to be the mean value. The agreement between the two raters was $r = 0.95$.

Artistic portraits were further classified according to the historical period they belonged to. Three categories were adopted: before XI century (Egyptian, Greek, Roman, Etruscan, and Byzantine art) ($N = 78$), XI–XVIII centuries ($N = 447$), and modern art (XIX and XX centuries) ($N = 251$).

2.4 *Statistical analysis and results*

The global model for the comparison between photographic and artistic portraits was submitted to a multiple analysis of variance (MANOVA) with gender, portrait category (photographic versus artistic), and age category ($\leqslant 10$, 11–25, 26–45, > 45) of the face set as factors and the seven anthropometric indexes related to facial proportions set as dependent variables. Results were significant for gender ($R_{7,322} = 3.45$, $p < 0.001$), portrait category ($R_{7,322} = 15.34$, $p < 0.001$), age category ($R_{21,925} = 6.82$,

$p < 0.001$), interaction between gender and age category ($R_{21,925} = 2.23$, $p < 0.001$), interaction between portrait category and age category ($R_{21,925} = 2.49$, $p < 0.002$), and triple interaction between gender, portrait category, and age category ($R_{21,925} = 1.62$, $p < 0.03$).

Single testing was performed with an ANOVA for each anthropometric parameter. Each ANOVA included gender, portrait category, and age category as factors and one anthropometric index as dependent variable.

The global model for historical-period analysis was tested with a MANOVA including gender and historical period (before XI, XI–XVIII, modern) as factors, and the seven anthropometric indexes as dependent variables. Gender was not significant, whereas historical period was ($R_{14,278} = 3.14$, $p < 0.001$), making it necessary to perform further analyses by single ANOVAs. These included historical period as a factor and one anthropometric index as a dependent variable.

A posteriori analyses were performed by the Tukey HSD test where appropriate.

2.5 *Results: portrait category, age, gender*

Mean values for each anthropometric parameter for the four age categories considered in this study are shown in figure 4, left graphs.

2.5.1 *Eye roundness.* Portrait category was highly significant ($F_{1,1044} = 151.91, p < 0.001$), eye roundness being more pronounced in artistic than in photographic portraits. Also, age category was critical ($F_{3,1044} = 11.45$, $p < 0.001$) and a posteriori analyses highlighted that the effect was due to the higher eye roundness in the age category '$\leqslant 10$' in comparison to all other age categories. Also the interaction between portrait category and age category was significant ($F_{3,1044} = 4.49$, $p < 0.003$). Eye roundness typical of the group '$\leqslant 10$' was extended, in artistic portraits, to subjects belonging to all the other age categories.

2.5.2 *Lip roundness.* As in the case of eye roundness, portrait category ($F_{1,674} = 40.31$, $p < 0.001$) and age category ($F_{3,674} = 31.06$, $p < 0.001$) were significant. Lip roundness was more pronounced in artistic than in photographic portraits and was higher in the groups '$\leqslant 10$' and '11–25' than in the age category '26–45' ($p < 0.001$) and '> 45' ($p < 0.001$). The interaction between gender and portrait category was significant ($F_{1,674} = 7.29$, $p < 0.007$). Lip roundness in photographs was more pronounced in females than in males ($p < 0.01$). In artistic portraits, lip roundness was undifferentiated between males and females.

2.5.3 *Eye width ratio.* All main effects, and the interaction between portrait category and age category, were significant. As regards gender ($F_{1,1022} = 8.95$, $p < 0.002$) eye width ratio was higher in females ($M = 0.24$) than in males ($M = 0.23$). Eye width was significantly greater in artistic portraits ($F_{1,1022} = 15.78$, $p < 0.001$) than in photographic portraits ($F_{1,1022} = 23.07$, $p < 0.001$). Eye width ratio was at a maximum in the age category '$\leqslant 10$', decreased in the group '11–25' ($p < 0.001$), remained constant in the group '26–45', and further decreased in the group '> 45' ($p < 0.001$). The interaction between portrait category and age category ($F_{3,1022} = 6.97$, $p < 0.001$) was significant. Eye width ratio in artistic portraits was increased in the group '$\leqslant 10$' ($p < 0.01$) and in the group '11–25' ($p < 0.001$).

2.5.4 *Eye height ratio.* Gender, portrait category, age category, and the interaction between portrait category and age category were significant. Eye height ratio was higher in females ($M = 0.088$) than in males ($M = 0.095$) ($F_{1,1021} = 11.41$, $p < 0.001$). As regards portrait category ($F_{1,1021} = 156.01$, $p < 0.001$), eye height ratio was higher in artistic portraits than in photographic ones. The results for age category ($F_{3,1021} = 38.28$, $p < 0.001$) mirrored those found for eye width ratio: eye height ratio was at a maximum in the group '$\leqslant 10$', decreased in the group '11 – 25' ($p < 0.001$), remained constant in the group '26 – 45', and further decreased in the group '> 45' ($p < 0.001$).

2.5.5 *Lip width ratio.* Lip width ratio was greater in photographic portraits than in artistic ones ($F_{1,662} = 66.77$, $p < 0.001$). Age category was significant ($F_{3,662} = 11.96$, $p < 0.001$). Lip width ratio was inferior in the group '11 – 25' than in the groups '$\leqslant 10$' ($p < 0.001$), '26 – 45' ($p < 0.001$), and '> 45' ($p < 0.001$). Lip width ratio in these three age categories remained constant with a mean value of 0.39. The interaction between portrait category and age category was significant ($F_{3,662} = 4.81$, $p < 0.001$). Lip width ratio in artistic portraits was significantly lower in all age categories.

2.5.6 *Lip height ratio.* Gender was significant ($F_{1,653} = 7.35$, $p < 0.006$); lip height ratio was greater in females ($M = 0.112$) than in males ($M = 0.103$). Portrait category was also significant ($F_{1,653} = 9.4$, $p < 0.002$); lip height ratio was greater in artistic portraits than in photographic ones. Age category was significant ($F_{3,653} = 30.58$, $p < 0.001$): lip height ratio exhibited a linear decreasing trend according to age, reaching a maximum in the groups '$\leqslant 10$' and '11 – 25' ($p < 0.07$), and then decreasing in the remaining two age groups ($p < 0.001$ for '26 – 45', and $p < 0.001$ for '> 45'). The interaction between gender and portrait category was significant ($F_{1,653} = 5.99$, $p < 0.001$). The magnification of lip height ratio in artistic portraits was significant only for males ($p < 0.001$), whose lips were depicted with the same height ($M = 0.112$) as for females ($M = 0.113$).

2.5.7 *Lower-face roundness.* Portrait category was significant ($F_{1,341} = 79.23$, $p < 0.001$). Artistic portraits were characterised by a less round and more extended lower face (jaw – chin) in all age categories ($M = 0.69$), than photographic portraits ($M = 0.78$). Lower-face roundness was significantly influenced by age ($F_{3,341} = 6.45$, $p < 0.001$).

2.6 *Results related to historical period*

2.6.1 *Lip roundness.* Historical period was significant ($F_{2,446} = 4.03$, $p < 0.01$). A posteriori analyses revealed an augmented lip roundness in modern art ($M = 0.34$) in comparison to artistic portraits dating from the XI to the XVIII century ($M = 0.30$) ($p < 0.01$).

2.6.2 *Eye width ratio.* Historical period was significant ($F_{2,765} = 14.04$, $p < 0.001$). The eye width ratio was at a maximum before XI century ($M = 0.26$), then decreased at XI – XVIII centuries ($M = 0.23$) ($p < 0.001$), and increased in modern art ($M = 0.24$) ($p < 0.001$), but only in female portraits, the interaction between historical period and gender being significant ($F_{2,765} = 8.04$, $p < 0.001$).

2.6.3 *Eye height ratio.* Historical period ($F_{2,764} = 9.79$, $p < 0.001$), and the interaction between gender and historical period ($F_{2,764} = 10.44$, $p < 0.001$) were significant. Eye height ratio was at a maximum before the XI century ($M = 0.11$), then decreased in XI – XVIII centuries ($M = 0.09$) ($p < 0.001$). In modern art it increased in female portraits ($M = 0.11$) ($p < 0.001$), but not in male ones ($M = 0.08$).

2.6.4 *Lip width ratio.* Historical period was significant ($F_{2,445} = 5.43$, $p < 0.004$). Lip width ratio was at a maximum before XI century ($M = 0.38$), it decreased in XI – XVIII centuries ($M = 0.35$) ($p < 0.002$), and remained unchanged in modern art ($M = 0.35$).

2.6.5 *Lower-face roundness.* Historical period was significant ($F_{2,155} = 5.46$, $p < 0.005$), and a posteriori analyses showed that lower-face roundness was significantly reduced in modern art ($M = 0.84$) in comparison to portraits belonging to both pre-XI century ($M = 0.87$) ($p < 0.02$), and XI – XVIII centuries ($M = 0.88$) ($p < 0.005$).

Table 2. Correlations between the seven facialmetric parameters in experiment 1.

Feature	Feature						
	ER	LR	EWR	EHR	LWR	LHR	LFR
Eye roundness (ER)	–	0.21***	0.09	0.77***	−0.21***	0.19***	−0.06
Lip roundness (LR)		–	0.12*	0.22***	−0.60***	0.75***	−0.27***
Eye width ratio (EWR)			–	0.69***	0.08	0.17***	0.06
Eye height ratio (EHR)				–	−0.11*	0.24***	0.01
Lip width ratio (LWR)					–	−0.08	0.37***
Lip height ratio (LHR)						–	−0.09
Lower-face roundness (LFR)							–

Note: * $= p < 0.05$, ** $= p < 0.01$, *** $= p < 0.001$.

2.7 *Correlations between the anthropometric indexes*

Considering both artistic and photographic portraits, Pearson's correlations between the seven anthropometric indexes are reported in table 2.

2.8 *Discussion*

Facialmetric parameters related to eyes, lips, and lower-face roundness, when comparing faces found in art works to real faces of approximately the same age, tend to be characterised by larger and rounder eyes, higher and rounder lips, and a reduction in lower-face roundness.

These distortions to normative facialmetric data are in accordance with the attractiveness literature which demonstrates that larger and rounder eyes and lips, and a reduced and more pointed chin play a significant role in the perception of attractiveness (McArthur and Apatow 1983/1984; Berry and McArthur 1985; Cunningham et al 1990). Artists, therefore, tend to apply these rules to their subjects as a means of conveying their attractiveness.

When examining artistic portraits in a historical perspective, a cubic trend can be observed in which both in ancient and in contemporary art there has been a maximum 'distortion' of the facial parameters related to beauty. An explanation for this trend could be that ancient portraits depicted mainly emperors, kings, and nobles who were assumed to have religious connotations, with a tendency to idealise them as canons of attractiveness and youth. In modern portraits, after the invention of photography, the artist is no longer constrained to realism and can freely express his/her creativeness in modifying physiognomic traits in order to convey particular meanings.

A weakness of this study is the comparison of facialmetric parameters between different groups, even if matched for age, and not within each particular individual. For the artistic portraits, in fact, it has not been possible to make a direct comparison with the parameters of 'real' faces, if only because many artistic faces are a product of the imagination, and do not have a real counterpart.

In order to arrive at a more stringent conclusion and obtain a cleaner experimental design, a second study was therefore conducted in which the facialmetric parameters of artistic portraits were directly compared with those of the original faces. A group of art academy students, unaware of the aims of the study, were requested to make two paper-and-pencil self-portraits, the first from memory, and the second with the use of a mirror. The facialmetric parameters of the two self-portraits were compared with those of the photographic portrait of each student. It was, therefore, possible to make a direct investigation of the type and amount of distortion of real physiognomic traits in order to translate them into an artistic form.

3 Experiment 2

3.1 *Participants*

Participants were recruited on a voluntary basis from students of the Art Academy in Milan, Italy. The sample was composed of nineteen males (mean age: 23.8 years; SD: 5.2 years) and twenty-four females (mean age: 22 years; SD: 3.02 years). They had a mean duration of training at the academy of 3 years in the case of males and 2.7 years in the case of females. Participants were not told that the study concerned eye, lip, and lower-face proportions and roundness in artistic portraits. All participants gave a formal consent for the use of photographs of their face for further analyses.

3.2 *Procedure*

Participants were seated in front of a drawing board in an academy atelier and were provided with a pencil and two blank A4 drawing sheets. They were first instructed to draw their full-frontal self-portrait without a mirror, trying to recall their face image from memory. They were asked to give details of their faces, avoiding an abstract style, and to draw their head facing straight ahead. A maximum of 45 min was given to complete their task. The participants were told that their drawings would not be presented to or evaluated by their classmates or teachers.

After 45 min all drawings were collected, and each participant was provided with a square mirror (45 cm $\times$ 45 cm) placed on the drawing board. The participants were instructed to draw a self-portrait in up to 45 min, this time with the possibility of continuously monitoring their faces in the mirror.

After this second self-portrait was collected, a photograph of the face of each participant was taken. The participants were asked to sit in a chair facing the camera that was at a distance of 2 m. The camera was mounted on a tripod and its height was adjusted so that the focus frame (a black frame visible in the viewfinder) was centred on the subject's eyes. The camera was equipped with a 70 mm lens in order to avoid barrel distortion. The film was black-and-white. Participants were instructed to look directly into the camera, not to smile, and to assume a neutral expression. At the end, they were asked to fill in a questionnaire for the collection of their biographical data.

An example of the self-portraits and the photograph of one student who participated in this second study is shown in figure 3.

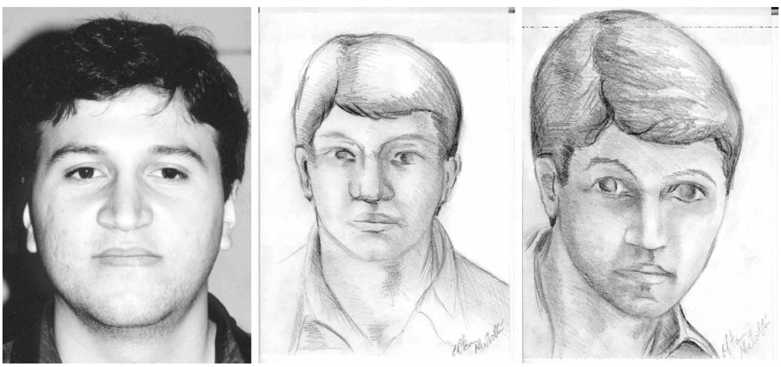

Figure 3. Photographic portrait (left), memory self-portrait (centre), and mirror self-portrait (right) of a male art academy student who participated in experiment 2. In both artistic self-portraits, an exaggeration of eye and lip size and roundness, and a reduction of lower-face roundness with a more geometrical and V-shaped jaw – chin can be observed.

3.3 *Anthropometry*

The same seven indexes used in the first experiment were computed for all self-portraits and photographs. The portraits and the photographs were first digitised with a scanner with a 300 dpi resolution. Measurements were collected with a utility of the Xfig software following guidelines in Farkas (1981). They were independently collected from the first author and the second author. Correlation between the two measurement sets gave $r = 0.99$. Statistical analyses were performed on mean values. When anatomical markers were not clearly detectable because they were missing, covered by hair, a beard, or were roughly drawn, the corresponding data were omitted (missing data: 1/258 data in photographic portraits, 23/258 in memory self-portraits, 14/258 in mirror self-portraits).

3.4 *Statistical analyses*
The same anthropometric ratios as those used for the first study were adopted for statistical analyses.

Since skeletal growth influences facial morphology (Susanne 1977; Enlow 1990), the participant's age was set as covariate in all parametric analyses.

Three memory self-portraits, and two mirror self-portraits were discarded since the drawing style was too abstract to allow an assessment of facialmetric parameters.

The statistical validity of the global model was first tested with a Multiple Analysis of Covariance (MANCOVA) which included the 3 portrait category levels (memory self-portrait, mirror self-portrait, photographic portrait) as within-subjects factor; gender of participant (2 levels) as between-subjects factor; the seven anthropometric indexes as dependent variables; and participant age as covariate. The MANCOVA result was significant for portrait category ($R_{2,23} = 140.78$, $p < 0.001$).

A posteriori analyses, when appropriate, were conducted with Tukey HSD.

3.5 *Results*
The means for each anthropometric index are reported in table 3 and the results are shown in figure 4, right graphs

Table 3. Mean values of the facialmetric parameters in photographic, memory, and mirror self-portraits (experiment 2).

Index	Photographic	Memory	Mirror
Eye roundness	0.37	0.43	0.43
Lip roundness	0.30	0.32	0.34
Eye width ratio	0.23	0.26	0.25
Eye height ratio	0.09	0.11	0.11
Lip width ratio	0.39	0.40	0.39
Lip height ratio	0.12	0.13	0.13
Lower-face roundness	0.73	0.61	0.59

3.5.1 *Eye roundness.* The interaction between portrait category and gender of participant was significant ($F_{2,74} = 6.98$, $p < 0.001$). Eye roundness was greater in memory self-portraits ($p < 0.0002$), and mirror self-portraits ($p < 0.0002$) than in the photographic portraits in male subjects. In females, eye roundness in self-portraits mirrored that found in photographs.

3.5.2 *Lip roundness.* Portrait category was significant ($F_{2,74} = 3.07$, $p < 0.05$). Lip roundness was greater in mirror self-portraits than in photographic portraits ($p < 0.04$).

3.5.3 *Eye width ratio.* Both gender of participant ($F_{1,36} = 6.36$, $p < 0.01$) and portrait category ($F_{2,74} = 7.44$, $p < 0.001$) were significant. Eye width ratio was greater in females ($M = 0.24$) than in males ($M = 0.26$). In comparison to photographs, eye width ratio was greater in memory self-portraits ($p < 0.001$), and in mirror self-portraits ($p < 0.02$).

3.5.4 *Eye height ratio.* Portrait category was significant ($F_{2,74} = 24.19$, $p < 0.001$). Eye height ratio was higher in both memory ($p < 0.0001$) and mirror ($p < 0.0001$)

self-portraits than in photographs. Also the interaction between gender of participant and portrait category was significant ($F_{2,74} = 3.32$, $p < 0.04$). This effect was caused by the physiologically greater eye height ratio in females in comparison to males in photographic portraits ($p < 0.05$).

3.5.5 *Lip width ratio.* There were no significant results.

3.5.6 *Lip height ratio.* Portrait category was significant ($F_{2,74} = 3.35, p < 0.04$). Lip height ratio in mirror self-portraits was higher than in photographic portraits.

3.5.7 *Lower-face roundness.* Gender of participant was significant ($F_{1,37} = 6.45$, $p < 0.01$). Lower-face roundness was higher in females ($M = 0.67$) than in males ($M = 0.61$). Portrait category was significant ($F_{2,76} = 31.95$, $p < 0.001$). Lower face was depicted with significantly lower roundness in both memory ($p < 0.0001$), and mirror ($p < 0.0001$) self-portraits.

3.6 *Correlations between the anthropometric indexes*

Pearson's correlations between the seven facialmetric parameters were computed on mean values between photographic, memory, and mirror self-portraits, and are shown in table 4.

Table 4. Correlations between the seven facialmetric parameters in experiment 2.

Feature	Feature						
	ER	LR	EWR	EHR	LWR	LHR	LFR
Eye roundness (ER)	–	0.15	−0.26	0.52***	−0.03	0.15	−0.35*
Lip roundness (LR)		–	−0.19	−0.08	−0.35*	0.86***	−0.30
Eye width ratio (EWR)			–	0.68***	0.23	−0.10	0.40**
Eye height ratio (EHR)				–	0.20	0.01	0.09
Lip width ratio (LWR)					–	0.16	0.28
Lip height ratio (LHR)						–	−0.19
Lower-face roundness (LFR)							–

Note: * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$.

3.7 *Discussion*

The results of the second experiment mirrored those obtained in the first study. The 'within' experimental design allowed more control in the comparison of facialmetric parameters between artistic and photographic portraits, making the results more stringent. In artistic self-portraits the eyes were depicted as being rounder, wider, higher; the lips were depicted as being rounder and higher; lower-face roundness was reduced.

Interestingly, these modifications were made even when participants had a mirror which allowed a continuous feedback of their real facial features. This demonstrates the robustness of the modifications and that they were performed implicitly.

An innovative facialmetric parameter used in this and the previous experiment was that of the best-fitting ellipse for a quantification of lower-face roundness. Since one of the main hypotheses of this paper was to show that painters usually tend to modify facial features in a direction that tends to augment their attractiveness, it was necessary to investigate if there was a significant relationship between modification of lower-face roundness and perception of attractiveness.

A systematic variation of lower-face roundness can be obtained by varying the width of a digital image portraying a full-frontal face. As shown in figure 5, these modifications affect only the horizontal axis of the ellipse. This methodology was used in a third experiment in which a group of subjects were presented with photographic portraits of males and females belonging to different age categories. For each face, they

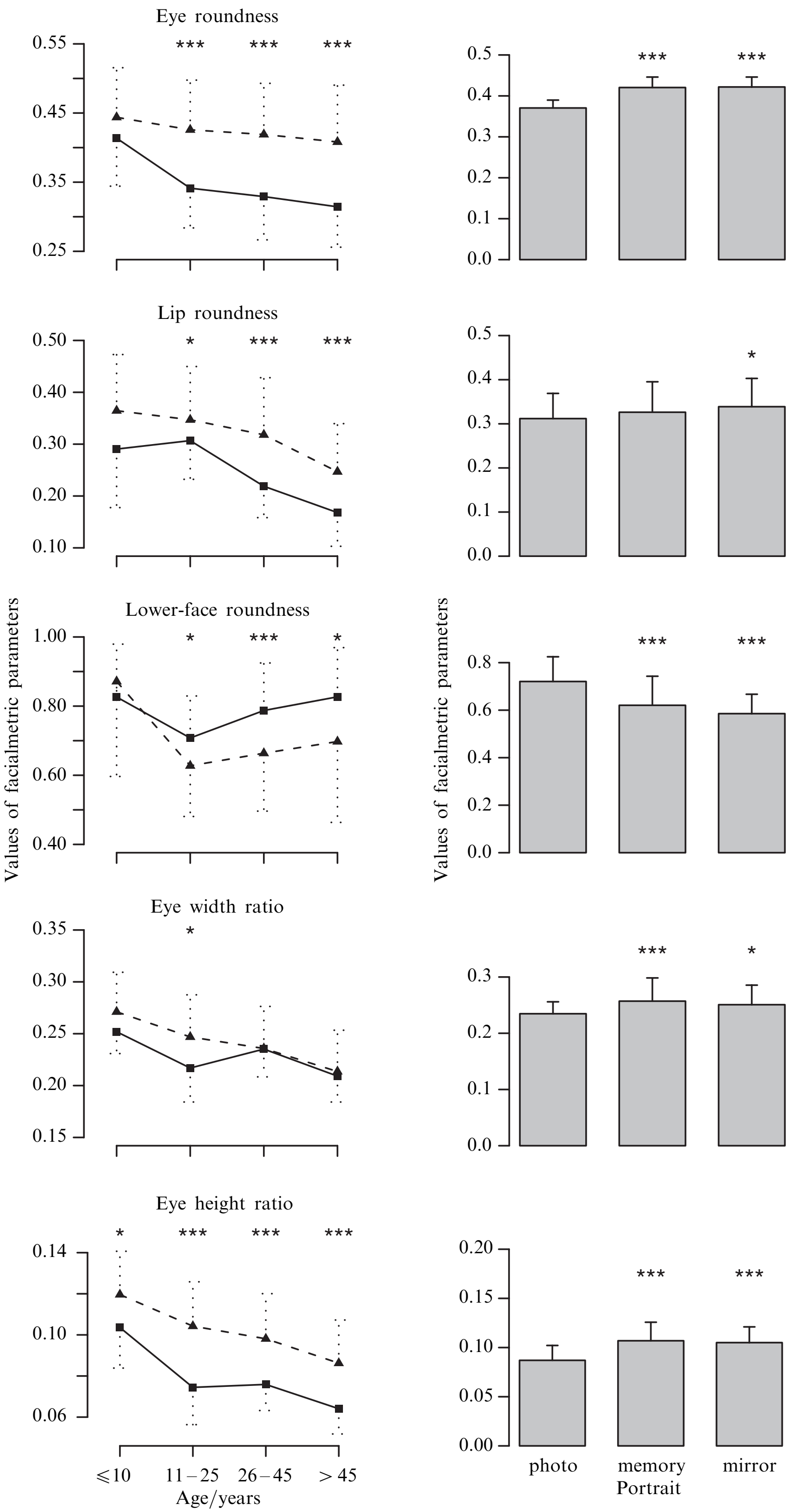
Eye roundness
Lip roundness
Lower-face roundness
Eye width ratio
Eye height ratio
Values of facialmetric parameters
≤10
11 – 25
26 – 45
> 45
Age/years
photo
memory
mirror
Portrait

Figure 4 (continued)

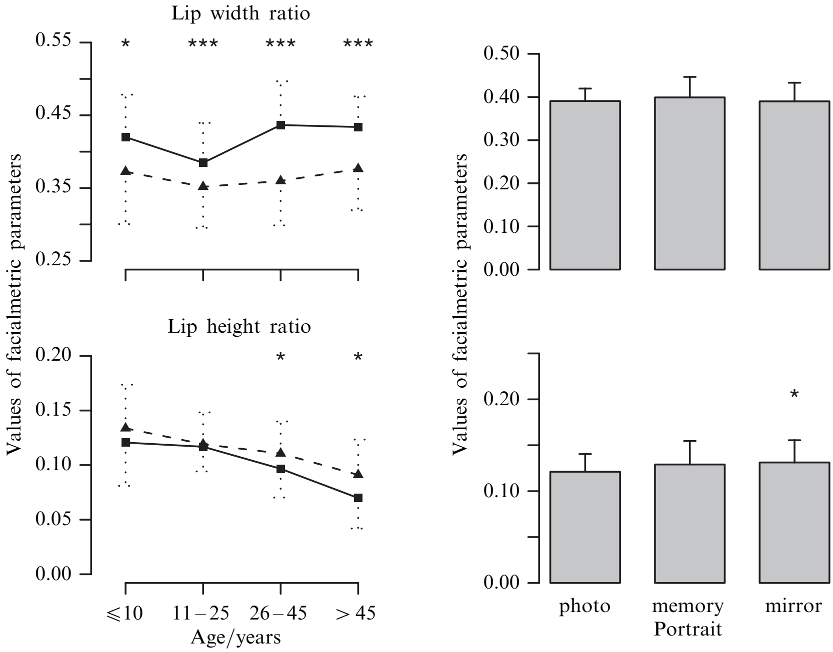

Figure 4. Results for experiments 1 (left) and 2 (right). In left graphs, the continuous line (with solid squares) refers to photographic portraits, and the dashed line (with solid triangles) refers to artistic portraits. Asterisks indicate the significance of the comparison between photographic and artistic portraits for a particular age class. In right graphs the first bar refers to control measures obtained by the photographic portraits, and the second and third bars refer, respectively, to memory and mirror self-portraits. Here, asterisks indicate the significance level of the comparison between each type of artistic self-portrait and the control measure shown in the first bar. Error bars in all graphs indicate the standard deviation. $* = p < 0.05$, $** = p < 0.01$, $*** = p < 0.001$.

Figure 5. Example of a stimulus adopted in experiment 3 in its original width (centre), contracted (left), and enlarged (right) by 5%. Each participant had to modify each image width until the highest degree of attractiveness was obtained.

could freely modify the image width until they reached the highest degree of attractiveness. The hypothesis was that a slightly restricted image was preferred to the original one. As a consequence of this phenomenon, a linear relationship between the original face roundness, and the degree of face-width contraction was also hypothesised.

4 Experiment 3

4.1 *Method*

4.1.1 *Participants.* Twenty-two males (mean age: 28 years; SD: 11.4 years), and thirty-one females (mean age: 26 years, SD: 8.8 years) volunteered to take part in the study. Age range was 15 – 57 years.

4.1.2 *Stimuli.* Twenty-four colour photographic portraits depicting twelve males and twelve females in full-face frontal view were selected from the photographic portraits used in experiment 1. Each group of twelve included four children, four adolescents, and four adults. Image height was 400 pixels.

4.1.3 *Procedure.* The experiment was run with a Java applet developed by the authors. Each image was presented once in a random order and each participant was instructed to adjust the image width by means of the left arrow (enlarge) and right arrow (narrow) on the keyboard until the face depicted in the image reached its highest degree of attractiveness. Each arrow-key pressure modified the image width by 1 pixel. No temporal limits were imposed on the participants to modify the stimuli. Figure 5 shows an example of a stimulus used in the study in its original width and modified by ±5%. Statistical analyses were computed on percentages of deviation from the original width of each image.

4.2 *Results*

A three-way ANOVA included these independent variables: gender of participant (2 levels), gender of face (2 levels), and age class of the depicted person (3 levels). The dependent variable was the deviation, in percentage, from the original width.

The interaction between gender of face and age class was significant ($F_{2,102} = 52.89$, $p < 0.001$). Mean deviations are reported in table 5. A mean reduction of lower-face roundness of 5.26% was observed. A posteriori tests showed that female faces were contracted by a mean value of 6.93%, independently from the age class. As opposed to this, age class was critical in male faces: child and adult male faces were significantly contracted, but adolescent faces were slightly enlarged by a mean value of 3.25%. Overall, male and female participants did not apply different criteria, and their deviations were on average not significantly different.

Lower-face roundness of each face stimulus was linearly regressed with the mean percentage of deviation from the original width. The regression model was significant ($\beta = -0.67$; $R^2 = 0.46$; $F_{1,22} = 18.36$, $p < 0.0003$). An examination of the data scatter-plot revealed that a lower-face roundness of 0.77 was the preferred ratio since it was associated with preservation of the original roundness. Greater ratios led to a progressive contraction of the face whereas lower ratios led to an enlargement.

Table 5. Mean deviations (%) from the original stimulus width, according to gender of the face (rows), and age class (columns) of the depicted person.

Subject	Subject			
	child	adolescent	adult	mean
Male	−6.63	3.25	−7.37	−3.58
Female	−5.94	−8.21	−6.63	−6.93
Mean	−6.29	−2.48	−7.00	−5.26

5 General discussion

The results of these studies show that in the artistic 'translation' of faces there is a constant deviation from the normative physiognomic parameters which expresses itself in an enlargement of eye size and roundness, lip height and roundness, and a reduction of lower-face roundness. This results in a face Gestalt that is less wide, more vertical, and with a more pointed chin.

The exaggeration of eye and lip roundness and relative size, and the reduction of lower-face roundness in art portraits could be interpreted as an attempt to create supernormal stimuli which tend to elicit an aesthetic response in observers. Eye and lip sizes and lower-face roundness can be considered as sign stimuli for attractiveness. Adults rate drawings or photographs of faces with larger eyes as more attractive than faces with smaller eyes, and this is true across faces of different ages (infants, adults), gender, and race (Sternglanz et al 1977; McArthur and Apatow 1983/1984; Keating 1985; McArthur and Berry 1987; McKelvie 1993; Paunonen et al 1999). A small chin, high forehead, big eyes, and full lips have been mentioned in many studies as traits of facial babyishness and neoteny, and for this reason evaluated as more attractive (Lorenz 1950; Sternglanz et al 1977; Hildebrandt and Fitzgerald 1979; McArthur and Apatow 1984; Berry and McArthur 1985; Cunningham 1986; Johnston and Franklin 1993; Zebrowitz 1997; Geldart et al 1999; Ishi et al 2004). If retaining baby features in adulthood is a strong determinant of the perception of attractiveness, this principle is not valid for all facial features. In particular, features related to sexual immaturity have to be lost. An example, also found in the experiments described here, is that facial roundness, which is typical in children, has to be replaced by high cheek bones, a long jaw, and a pointed chin in order to increase attractiveness in adolescents and adults. In artistic portraits, the lower-face outline was significantly less round than in photographic portraits, and, as shown in the third experiment, in order to increase the attractiveness of portrayed persons, face width is usually reduced, especially in young and old persons, who tend to be characterised by having a round face.

There is also evidence that average or prototypical faces are optimally attractive (Langlois and Roggman 1990). The argument in favour of this theory is that natural selection ensures that morphological characteristics close to the population means will be preferred by conspecifics. Alley and Cunningham (1991), on the contrary, have maintained that average faces are relatively attractive, but atypical characteristics can enhance facial attractiveness resulting in very attractive faces (Cunningham et al 2002). Although stabilising selection may be responsible for some preferences, biologists have documented numerous examples of directional selection for extreme characteristics such as peacock feathers, large deer antlers, vivid coloration, long tail (Enquist and Arak 1993), male's call in *Physalaemus pustulosus* (Ryan et al 1990). There is ample evidence that many animals prefer modifications of familiar stimuli that are outside the natural range of variation (Tinbergen 1951; Baerends and Drent 1982). Enquist and Arak (1993), in particular, have shown that a simple artificial neural network trained to discriminate long-tailed birds from short-tailed birds and random images, when tested, shows the strongest response (supernormal response) to bird-like images with longer tails or longer wings than it has been trained to recognise during the training. The preference for exaggerated features that directly relate to attractiveness, such as large round eyes, full lips, high cheek bones, and a small chin, can emerge, according to Enquist et al (2002) as a byproduct of how recognition mechanisms work. An important determinant of stimulus control is, in fact, the need for discrimination between stimuli, and this can shift our preference towards more exaggerated appearances. These effects can be interpreted as the consequence of simple generalisation experiments (Mackintosh 1974). If an animal is trained to discriminate between two stimuli along a particular dimension (eg the frequency of a sound), and, subsequently, the generalisation gradient is determined by testing the animal's response toward a number of stimuli along the same dimension, then the gradient will often show a response bias. If, for instance, a 1000 Hz sound wave was experienced as positive during the learning phase, and a 800 Hz one as negative, then the peak of the response during the testing phase would be in correspondence to a frequency slightly higher than 1000 Hz. Another example, offered by Ramachandran and Hirnstein (1999), is that once a rat has been trained to respond to a rectangle of aspect ratio 3 : 2, the rat's response to a rectangle that is even longer and thinner (eg of aspect ratio 4 : 1) would be even greater than it was to the original prototype on which it was trained. Such a bias in responding is known as peak shift or supernormal stimulation and has been found in humans and animals (Baron 1973; Mackintosh 1974; Baerends and Drent 1982). Several studies have shown that perception of faces is biased in this way. The impact of a face can be magnified by exaggerating those components that make that face unique among other faces. The existence of such biases has been firmly established in the recognition of individual faces (Rhodes et al 1987; Rhodes 1996). If the process of exaggeration of eye and lip size and roundness found in the present studies is extended, the results would be caricatures (Rhodes 1996). Sexual preference, and judgments of beauty, femininity, or masculinity also seem biased in this sense. Rensch (1963), for example, has shown that Europeans' preferences for faces do not match the actual appearance of Europeans. Several studies have shown that female faces that, on a morphing continuum, have more feminine attributes than average ones, are rated as more attractive than the averaged female face (Gillen 1981; Keating 1985; Perrett et al 1994, 1998; Rhodes et al 2000). Johnston et al (2001) have shown that females during the high-risk phase of their menstrual cycle prefer male faces that have more masculine attributes than average ones.

The peak-shift effect has been summed up by Ramachandran and Hirnstein (1999) in the slogan "All art is caricature" (page 18). This effect shows that the visual system learns tendencies rather than characteristics, and thereby reacts more strongly to an exaggeration of the original characteristics than to the characteristics themselves. An exploitation of this peak-shift effect can be found in drawings for children, where usually the process of supernormalisation of eye and lip sizes is extreme (Eibl-Eibesfeldt 1988). Eibl-Eibesfeldt (1988), and König (1975) have described other examples of supernormal object presentation such as conspicuous eye spots and bulging, staring eyes in designs meant to ward off evil.

Gombrich (1972) argued that, since visual art cannot rely on movements for expressive purposes, artists introduce modifications in order to improve the legibility of their works. Movements must result in configurations that can be easily understood and must stand in contexts which are sufficiently unambiguous to be interpreted. Greek art developed devices which compensated for the absence of movement, not by symbolic expression, but by the creation of images of maximal instability, exaggerating body gestures resulting in highly artificial positions. The need for legibility and for clear contextual clues is also invoked in the explanation of the exaggeration and hypercoding of movements and gestures which occur in most performing art.

We suggest, as maintained by Latto (1995) and Jones (1996), that an exaggeration of the features of a stimulus which have a clear biological meaning, such as in this case eye and lip size for attractiveness, could result in an aesthetic stimulus. Natural aesthetic response to stimuli can be increased by exaggerating sign stimuli, ie forming supernormal stimuli, and some of the distortion in representational art depends in the isolation and exaggeration of local features in this way in order to obtain this effect. Following the same line, Ramachandran and Hirnstein (1999) have maintained that aesthetic pleasure originates from the reinforcing qualities of exercising the most important mechanism the brain employs to construct our visual world. Similarly Pinker (1997) has interpreted aesthetic phenomena as technologies for pleasure, as exploitation and stimulation of some intrinsic mental processes. Given, for example, our disposition to perceive sugar as pleasant, we can exploit this bias through exaggeration of sugar combinations and concentrations such as in elaborate cakes (in 'cheesecake' for example, according to the proper terminology used by Pinker), which are technological products not present per se in nature, but artificially built to exploit the sensory system of our taste. In this sense, a cake would be the aesthetic result of our sugar-preference bias.

This interpretation exempts us from searching for an adaptive value in aesthetic phenomena that, in this perspective, can be considered as byproducts of sensory biases and basic cognitive processes such as the peak-shift effect. To date, in fact, there is no convincing scientific support for maintaining that aesthetic phenomena, such as music, visual arts, and performing arts, have a direct and substantial impact on survival rate, life span, or cognitive and perceptual abilities that are not directly connected with the aesthetic domain. A subject trained in music, for example, does not show any advantage in abilities other than music, such as mathematic or language skills (Costa-Giomi 2004), that would have justified an evolutionary advantage in those populations where some form of aesthetic appreciation was present.

References

Alley T R, Cunningham M R, 1991 "Averaged faces are attractive, but very attractive faces are not average" *Psychological Science* **2** 123–125

Baerends G P, Drent R H, 1982 "The herring gull and its eggs: The responsiveness to egg-features" *Behaviour* **82** 416

Baron A, 1973 "Postdiscrimination gradients of human subjects on a tone continuum" *Journal of Experimental Psychology* **101** 337–342

Berry S D, McArthur L Z, 1985 "Some components and consequences of a babyface" *Journal of Personality and Social Psychology* **48** 312–323

Bruce V, Young A, 1998 *In the Eye of the Beholder: The Science of Face Perception* (Oxford: Oxford University Press)

Cate C ten, Bateson P, 1989 "Sexual imprinting and a preference for supernormal partners in Japanese quail" *Animal Behavior* **38** 356–358

Costa M, Ricci Bitti P E, 2000 "Face-sim effect and head canting in one's own and other's photographs" *European Psychologist* **5** 293–301

Costa M, Menzani M, Ricci Bitti P E, 2001 "Head canting in paintings: An historical study" *Journal of Nonverbal Behavior* **25** 63–73

Costa-Giomi E, 2004 "Effects of three years of piano instruction on children's academic achievement, school performance and self-esteem" *Psychology of Music* **32** 139–152

Cunningham M R, 1986 "Measuring the physical in physical attractiveness: Quasi experiments on the sociobiology of female beauty" *Journal of Personality and Social Psychology* **50** 925–935

Cunningham M R, Barbee A P, Philhower C L, 2002 "Dimensions of facial physical attractiveness: The intersection of biology and culture", in *Facial Attractiveness: Evolutionary, Cognitive, and Social Perspectives* Eds G Rhodes, L Zebrowitz (Westport, CT: Ablex) pp 193–238

Cunningham M R, Barbee A P, Pike C L, 1990 "What do women want? Facialmetric assessment of multiple motives in the perception of male facial physical attractiveness" *Journal of Personality and Social Psychology* **59** 61–72

Darwin C, 1871 *The Descent of Man and Selection in Relation to Sex* (London: Murray)

Deregowski J B, 1984 *Distortion in Art* (London: Routledge & Kegan Paul)

Eibl-Eibesfeldt I, 1988 "The biological foundation of aesthetic", in *Beauty and the Brain* Eds I Reutschler, B Herzberger, D Epstein (Berlin: Birkhäuser) pp 36–68

Enlow D H, 1990 *Facial Growth* (Philadelphia, PA: Harcourt Brace Jovanovich)

Enquist M, Arak A, 1993 "Selection of exaggerated male traits by female aesthetic senses" *Nature* **361** 446–448

Enquist M, Ghirlanda S, Lundqvist D, Watchmeister C A, 2002 "An ethological theory of attractiveness", in *Facial Attractiveness: Evolutionary, Cognitive, and Social Perspectives* Eds G Rhodes, L Zebrowitz (Westport, CT: Ablex) pp 127–152

Farkas L G, 1981 *Anthropometry of the Head and Face in Medicine* (New York: Elsevier)

Gandelman C, 1986 "The 'scanning' of pictures" *Communication and Cognition* **19** 3–26

Geldart S, Mauer D, Carney K, 1999 "Effects of eye size on adults' aesthetic ratings of faces and 5-month-olds' looking times" *Perception* **28** 361–374

Gillen B, 1981 "Physical attractiveness: A determinant of two types of goodness" *Personality and Social Psychology Bulletin* **7** 277–281

Gombrich E H, 1972 "Action and expression in western art", in *Non-verbal Communication* Ed. R Hinde (Cambridge: Cambridge University Press) pp 373–395

Gombrich E H, 1994 *The Image & the Eye: Further Studies in the Psychology of Pictorial Representation* (London: Phaidon Press)
Gregory R, Harris J, Heard P, Rose D, 1995 *The Artful Eye* (Oxford: Oxford University Press)
Haig N D, 1985 "How faces differ—a new comparative technique" *Perception* **14** 601 – 615
Hildebrandt K A, Fitzgerald H E, 1979 "Facial feature determinants of perceived infant attractiveness" *Infant Behavior and Development* **2** 329 – 339
Ishi H, Gyoba J, Kamachi M, Mukaida S, Akamatsu S, 2004 "Analyses of facial attractiveness on feminised and juvenilised faces" *Perception* **33** 135 – 145
Johnston V S, Franklin M, 1993 "Is beauty in the eye of the beholder?" *Ethology and Sociobiology* **14** 183 – 199
Johnston V S, Hagel R, Franklin M, Fink B, Grammer K, 2001 "Male facial attractiveness: Evidence for hormone-mediated adaptive design" *Evolution and Human Behavior* **22** 251 – 267
Jones D, 1996 *Physical Attractiveness and the Theory of Sexual Selection* (Ann Arbor, MI: University of Michigan, Museum of Anthropology)
Keating C F, 1985 "Gender and the physiognomy of dominance and attractiveness" *Social Psychology Quarterly* **48** 61 – 70
König O, 1975 *Urmotiv Auge. Neuentdeckte Grundzüge menschlichen Verhaltens* (Munich: Piper)
Langlois J H, Roggman L A, 1990 "Attractive faces are only average" *Psychological Science* **1** 115 – 121
Latto R, 1995 "The brain of the beholder", in *The Artful Eye* Eds R Gregory, J Harris, P Heard, D Rose (Oxford: Oxford University Press) pp 60 – 94
Lorenz K, 1950 "Ganzheit und Teil in der tierischen und menschlichen Gemeinschaft" *Studium Generale* **3** 455 – 499 [Reprinted in *Studies in Animal and Human Behavior* volume 2 (Cambridge, MA: Harvard University Press, 1971) pp 115 – 195]
McArthur L Z, Apatow K, 1983/1984 "Impressions of baby-faced adults" *Social Cognition* **2** 315 – 342
McArthur L Z, Berry D S, 1987 "Cross-cultural agreement in perceptions of babyfaced adults" *Journal of Cross-cultural Psychology* **18** 165 – 192
McKelvie S J, 1993 "Perceived cuteness, activity level, and gender in schematic babyfaces" *Journal of Social Behavior and Personality* **8** 297 – 310
Mackintosh N J, 1974 *The Psychology of Animal Learning* (London: Academic Press)
Paunonen S V, Ewan K, Earthy J, Lefave S, Goldberg H, 1999 "Facial features as personality cues" *Journal of Personality* **67** 555 – 583
Perrett D I, Lee K J, Penton-Voak I, Rowland D, Yoshikawa S, Burt D M, Henzil S P, Castles D L, Akamatsu S, 1998 "Effects of sexual dimorphism on facial attractiveness" *Nature* **394** 884 – 887
Perrett D I, May K A, Yoshikawa S, 1994 "Facial shape and judgments of female attractiveness: Preferences for non-average characteristics" *Nature* **386** 239 – 242
Pinker S, 1997 *How the Mind Works* (London: Norton & Co)
Ramachandran V, Hirnstein W, 1999 "The science of art" *Journal of Consciousness Studies* **6** 15 – 51
Rensch B, 1963 "Versuche über menschliche 'Auslöser-Merkmale' beider Geschlechter" *Zeitschrift für Morphologie und Anthropologie* **53** 139 – 164
Rhodes G, 1996 *Superportraits: Caricatures and Recognition* (Hove, Sussex: Psychology Press)
Rhodes G, Brennan S, Carey S, 1987 "Identification and ratings of caricatures: Implications for mental representations of faces" *Cognitive Psychology* **19** 473 – 497
Rhodes G, Hickford C, Jeffery L, 2000 "Sex-typicality and attractiveness: Are supermale and superfemale faces super-attractive?" *British Journal of Psychology* **91** 125 – 140
Ryan M J, Fox J H, Wilczynski W, Rand A S, 1990 "Sexual selection for sensory exploitation in the frog *Physalaemus pustulosus*" *Nature* **343** 66 – 67
Staddon J E R, 1975 "A note on the evolutionary significance of supernormal stimuli" *American Naturalist* **109** 541 – 545
Sternglanz S H, Gray J L, Murakami M, 1977 "Adult preferences for infantile facial features: An ethological approach" *Animal Behavior* **25** 108 – 115
Susanne C, 1977 "Individual age changes of the morphological characteristics" *Journal of Human Evolution* **6** 181 – 189
Tinbergen N, 1951 *The Study of Instinct* (Oxford: Oxford University Press)
Tinbergen N, 1953 *The Herring Gull's Worlds* (London: Collins)
Zebrowitz L A, 1997 *Reading Faces: Window of the Soul?* (Boulder, CO: Westview Press)

ISSN 0301-0066 (print) ISSN 1468-4233 (electronic)

PERCEPTION
VOLUME 35 2006

www.perceptionweb.com