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The Development of Face Processing Skills [and Discussion]

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The development of face processing skills

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SUMMARY

An early orientation to faces is followed by a gradual development of face processing skills. During the course of maturation, children acquire the ability to learn new faces and to deal with facial transformations. Some skills are achieved more quickly than others. Moreover, encoding ability in young children is somewhat different from that shown by older children. The younger groups fail to take advantage of increased inspection time and stimulus characteristics such as facial distinctiveness. They are also more likely to be confused by alterations in background context. Although with familiar faces they reveal very similar identity priming effects to older children and adults, younger children display a relative inefficiency in categorizing faces as being that of a target unless it is noticeably dissimilar. Young children are more likely than older people to prefer positive caricatures of certain faces, which is not consistent with the view that caricature effects are simple reflections of a general expertise with faces.

1. INTRODUCTION

Infants arrive into the world with an undeveloped visual system that, essentially, allows them to see only faint, fuzzy images (Souther & Banks 1979). Their first sight is usually of people. The question is, are they in any way able to make sense of what they see? Or is the picture as totally confusing to them as William James (1890) suggested?

In this paper, the ability of neonates to orient to faces will first be discussed, followed by more extensive discussion of the way face processing skills mature throughout childhood. This will not be in any sense a theory of the development of face recognition. Instead the paper will concentrate on recent results that highlight some of the differences between the way younger and older children do the same tasks of matching faces that are transformed in some natural way, how they encode and store facial images, and how they make identity judgements of familiar faces. In doing so it will also serve to indicate the normal maturation of face-processing skills against which the problems resulting from developmental or acquired disabilities may be measured.

2. INFANCY

Goren *et al.* (1975) found that infants less than 10 minutes old revealed a preference for following a moving schematic face compared with either a blank head shape or one containing scrambled facial features. This result was replicated (Maurer & Young 1983; Dziurawiec & Ellis 1986), and extended by a series of similar experiments in which the age of infants was found to be crucial, the looking preference disappearing over the first month of life (Johnson *et al.* 1992). It is difficult to know to what neonates are responding. Some have argued that it is not facedness as such but the general sensory characteristics of the stimulus as defined by phase and amplitude (Kleiner & Banks 1987). Morton & Johnson (1991), however, argue that it would be a remarkable biological coincidence if the neonate's visual system just happened to match the stimulus properties of a human face, but not one where the internal features were symmetrically arranged in the wrong order. They further suggest that neonates possess a subcortical mechanism that enables them to orient towards objects of biological significance – usually other members of the species – which Morton & Johnson label CONSPEC. Only later do cortical systems allow recognition of individual members of the species: this process is termed CONLERN.

Morton & Johnson's (1991) theory is consistent with much of the data. It may need to be modified to incorporate the findings of Bushnell *et al.* (1989) who found that two-day-old infants can reliably discriminate their mothers' faces from strangers. This finding, if replicable, implies a startling precocity in new born babies. Perhaps there are biosocial imperatives that assist mother–infant bonding from birth by ensuring some sort of face-to-face interaction (Meltzoff & Moore 1977; Ellis & Ellis 1989).

Throughout the first year of life babies gain both in visual maturity and experience with faces. By 7 months they reveal some of the characteristics of adult face processing (Fagan 1978). Little is known, however, about the development of face-processing skills between then and school age (Flin & Dziwawiec 1989).

3. CHILDHOOD

Goldstein & Chance (1964) did the first systematic

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examination of the development of face recognition abilities throughout the school years. They presented faces of 5, 8 and 13-year-olds to children of the same three ages. The children then had to recognize these faces (old stimuli) when randomly mixed in a sequence with distractor faces not previously seen (new stimuli). They found a clear improvement with maturity but no interaction between age of subject and age of face. Feinman & Entwistle (1976) found similar results: after age 11 years, little or no improvement was discerned. Cary *et al.* (1980), however, did find an interesting inflection in the developmental trend at around 12 years when face recognition ability levels off or even declines before it subsequently improves. Flin (1980) found a similar dip in performance for face recognition but also found it for recognition of flags and houses. Others have noted the developmental inflection for recognizing voices (Mann *et al.* 1979) and tonal memory (Spreen & Gaddes 1969).

Carey (1981) has argued that the developmental dip in face recognition marks an important prepubertal shift from perceiving faces in a predominantly piecemeal fashion to one where the full configural information contained within faces is appreciated. The idea that children under 10 years are dominated by feature information in part derives from the finding of Diamond & Carey (1977) that when shown a face bearing a particular expression or wearing some obvious paraphernalia in a two-alternative forced-choice test, younger children may subsequently misidentify another face to which the expression or paraphernalia has been transferred. This phenomenon is markedly reduced when the two faces are appreciably dissimilar (Flin 1983), and it does not occur when the faces are familiar (Diamond & Carey 1977).

In a series of loosely related experiments, Ellis (1990, 1991) examined the abilities of children at different ages to deal with a variety of facial transformations. Using a paradigm similar to that employed by Diamond & Carey (1977), for example, it was shown that children up to 5 years of age could be confused by a simple size transformation. Presented with a face to remember on a computer screen followed almost immediately by two faces, one just seen, but now larger or smaller, and another, young children sometimes identify the wrong face. By the age of 6 years this type of error disappears completely.

By contrast, when asked to match eight faces of people to photographs of the same individuals taken 20 years apart, children of all ages experienced great difficulty. Those aged 5–7 years found the task particularly difficult and performed virtually at chance level. Children aged 8, 9, 10 and 11 years were significantly better at this task but still found it quite difficult. In another experiment, children were asked to rank by age the faces of four men. Because each stimulus set was designed to contain someone in his 20s, another in his 30s, another in his 40s and the last in his 60s, it was a task that adults had no difficulty in completing perfectly, but one that young children in particular found especially hard. Children can have no personal experience of age invariance across large

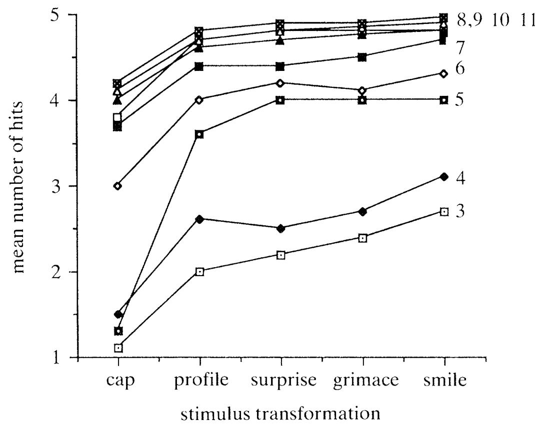

Figure 1. Accuracy in sorting five facial transformations for children aged 3–11.

time spans. Without this experience it must be very difficult for them to acquire the necessary skills.

In a simultaneous matching task, children aged 3–11 years were shown pictures of five faces and were required to match five views of each one. Every view involved a transformation: expression (smile, grimace, surprise); pose (full to three-quarter profile); or the addition of paraphernalia (wearing a bathing cap). As figure 1 shows, there was a clear developmental trend with three-year-olds worst and 11-year-olds best. The bathing cap caused most confusion.

We learn from these findings that coping with facial transformations of whatever kind improves steadily throughout childhood. The ability to discern invariance despite a variety of 'normal' changes to a face is presumably learned with experience. Some lessons, such as the fact that people remain constant even though the image size cast by their faces may alter, are learned early. Others, like the invariance across a 20 year time span, takes much longer to acquire. These developments are unlikely to be confined to faces but represent growing skills in ability to make object-centred judgements.

(*a*) *Encoding faces*

(*i*) *Inspection times*

Perhaps older children encode faces more thoroughly than do younger children. They may form internal representations of greater elaboration which allow them more easily to recognize or match faces that are transformed in some way. In two experiments, Ellis & Flin (1990) compared 10-year-olds' and 7-year-olds' recognition memory for faces by showing them for different exposure durations, and testing recognition memory after varying intervals. As expected, they found that the younger children were generally inferior. But more interestingly they noted that, whereas the older group's performance was improved by allowing a longer time to look at the stimulus, the younger group failed to take advantage of inspection times longer than about 2 s. Whatever information was picked up by the extra exposure, however, did not survive very long. After a week the performance of the two age groups was the same.

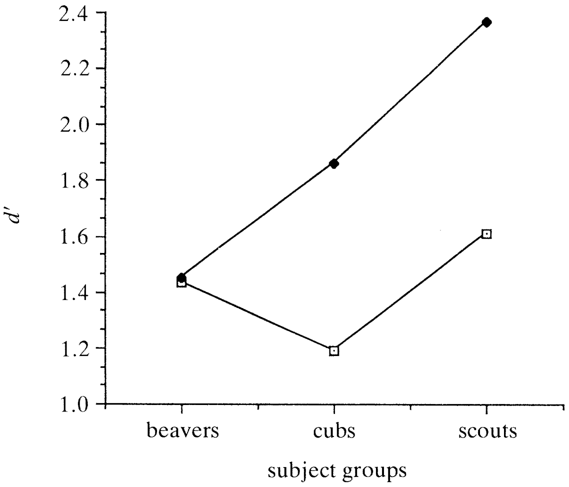

Figure 2. Accuracy (d') in recognizing typical and distinctive faces by boys aged 6–8 years (beavers), 9–11 years (cubs) and 12–14 years (scouts).

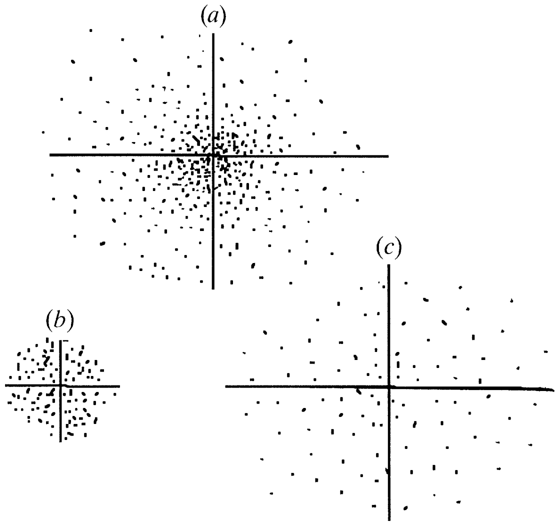

Figure 3. Face-space representations following Valentine (1991). (*a*) represents the putative adult distribution; (*b*) and (*c*), two possible representations for young children.

(*ii*) *Distinctiveness*

One of the most reliable findings in the literature of adult face recognition is that faces judged to be physiognomically distinctive are recognized much more easily than typical faces (Going & Read 1974; Light *et al.* 1979; Valentine & Bruce 1986*a*) and are more easily learned (Ellis *et al.* 1988). Moreover, distinctive distractor faces are less likely to be falsely identified (Bartlett *et al.* 1984). Until very recently these phenomena had not been examined in children. Ellis *et al.* (1992) showed a series of distinctive and typical men's faces to three groups of boys aged 6–8 years, 9–11 years and 12–14 years. As figure 2 illustrates, the youngest group performed equally well with distinctive and typical faces. For older boys, however, there was a definite advantage for recognizing distinctive faces. None of the groups, though, was less likely erroneously to identify distinctive distractor faces. These findings are interesting for a number of reasons. They suggest that below 8 years of age children may either fail to encode the distinctiveness of faces, or they may store distinctive and typical faces in the same way. Furthermore, it would seem that even by age 13 distinctive distractor faces cannot be more easily discounted than typical faces as having been seen before, which is conspicuously different from adults' performance (Bartlett *et al.* 1984; Light *et al.* 1979).

Valentine's (1991) recent model of face memory suggests that facial representations are stored in what may be conceptualized as a multidimensional array, and that the greatest density occurs around the centre of the distribution (where the prototypical face is to be found). These more centrally situated representations are judged to be typical faces; and the fact that the majority of faces do not deviate greatly from the prototypical face makes decisions regarding individual typical faces more error prone than is the case for distinctive faces. It may be conjectured that young children must have a less crowded face space because they have experienced fewer faces. If that is so it would suggest that for them there should be less of a difference between distinctive and typical faces because finding the latter in the multidimensional array is not much harder than for the former. Admittedly this explanation is speculative and needs further support, but one way of advancing our understanding would be to ask children of different ages to make judgements of whether faces were 'legitimate' or jumbled. Here Valentine & Bruce (1986*b*) have found that distinctive faces take longer to judge. If the comparison between children and adult face space shown in figure 3*a*, *c* is true then they too will also take longer to make facedness decisions involving distinctive faces. If, however, children's face space is simply smaller than adults' (figure 3*b*) there should not be a distinctiveness effect for facedness judgements below 8 years of age.†

(*iii*) *Context*

Yet another means of answering questions concerning invariance and encoding is to examine the effects of what may be termed the 'non-person context'. Adults show small but significant decrements in recognition accuracy when the background context for a face changes between study and test (Memon & Bruce 1983; Davies 1988; Schreiber *et al.* 1990). A developmental study of this effect was recently completed by Markham *et al.* (1992). They showed 16 children's faces on a computer screen one after the other, each against a different background (e.g. interior, landscape) to groups of subjects aged 6 years, 8 years, 10 years and 24 years. At test, some of the targets were shown against new backgrounds and some of the distractor faces were shown against backgrounds seen in the target sequence.

The results were striking. Hit rates increased steadily with age (51% for 6-year-olds, 60% for 8-year-

† I am indebted to Gill Rhodes and Tim Valentine for the development of these arguments.

olds, 64% for 10-year-olds, and 80% for 24-year-olds). More interesting were the observations that: (i) younger children were significantly more disrupted by a change in background between study and test; and (ii) younger children were also significantly more likely to make false identifications when a 'new' face was shown against an 'old' background. The latter finding is reminiscent of the paraphernalia effects found by Diamond & Carey (1977). Moreover, it takes this line of research into the realms of forensic psychology, where interest in the reliability of children's eye-witness testimony currently is quite high (see, for example, Davies *et al.* 1989). The results reviewed so far suggest that some caution be exercised before unequivocally accepting identifications made by young children.

4. RECOGNIZING FAMILIAR FACES

Some of the most interesting theoretical work on adult face recognition followed the widespread use of familiar faces as stimuli (Bruce 1979; Ellis *et al.* 1979). Models of face recognition, such as the one put forward by Bruce & Young (1986), are principally concerned with the way people identify familiar faces. Comparable work with children is handicapped by their lack of reliable knowledge concerning famous faces that adults can easily identify. In the following experiments, two strategies were employed to circumvent this difficulty. For the first, faces of children personally familiar to the subjects were used (i.e. classmates); the second employed the faces of two celebrities who at the time of testing were guaranteed to be familiar to children of all ages.

(*a*) *Priming*

Ellis (1991) describes two experiments based upon the repetition priming paradigm that has proved so useful in determining the architecture of models such as that of Bruce & Young (1986) and its more recent connectionist version (Burton *et al.* 1990). The basic questions addressed by these experiments concerned the ways in which children may be similar to or different from adults in a priming situation. In each case, faces of classmates served as familiar stimuli, and children from other schools acted as unfamiliar faces. This allowed a cross-over design in which, at each age, all stimuli were familiar to one group of subjects and unknown to the other.

The first experiment required the children to make either gender or expression judgements about faces, some of which were familiar and some unfamiliar. Later they were asked to make familiarity judgements of faces including some of the classmates shown earlier. These were the primed faces. Bruce & Valentine (1985) and A. Ellis *et al.* (1990) have shown that a previous encounter of a face is very effective in speeding subsequent familiarity judgements, particularly when the picture used on each occasion is the same. In the first experiment, Ellis (1991) tested children aged 5 years, 8 years and 11 years. There was a significant and strong response time advantage for familiar faces that had been primed earlier, although, not surprisingly, the overall mean response times were inversely related to the subjects' age.

In a second experiment, five-year-olds were compared with adults on a task where two types of repetition priming were included. These were identical repetition (as in the first experiment) and non-identical repetition. For the latter, the same person was shown twice but in different pose. The results quite clearly indicated little difference between children and adults. Each group showed the greater priming effect for identical repetition priming. There was a significantly smaller priming effect for non-identical repetition priming. Of course, once again, the overall response times were considerably slower for children, which may reflect a similar underlying processing that is carried out less efficiently. The most important aspect of these data, however, was the similarity of priming effects in young children and adults, because this suggests that, at least in part, the functional architecture responsible for adult recognition is in place by early childhood.

(*b*) *Categorization of faces*

Having discovered close similarities in some aspects of the way children and adults make judgements of face familiarity, the next step was to examine the way children of different ages make other types of decisions about familiar faces (Ellis 1991). One piece of anecdotal evidence is that young children tend to be over-inclusive in categorizing people. Uncle John may have a round face and bald head so other men who look similar are often called 'Uncle John'.

Keil (1987) offered a theoretical analysis of the way children of different ages make categorical judgements. Younger children, he argued, have wider boundaries and therefore include more items within a category. With maturation the critical, defining features for category membership are sharpened so that fewer objects are included. In the following experiment a conceptual leap was made between Keil's theory and face recognition: a particular face was identified as a category member and the ablity of children was examined as they attempted rapidly to classify various real, similar and dissimilar exemplars. The faces of Kylie Minogue and Jason Donovan, two pop stars, served as target stimuli and equal numbers of different faces judged to be similar or dissimilar were randomly presented. On each trial the subject was required simply to classify the face either as Minogue's or Another; or Donovan's or Another. Two dependent variables were established: accuracy and latency of decisions. Subjects were aged 5 years, 8 years, 11 years and 19 years.

The results showed a decrease in error rate with age mainly because the youngest group made twice the errors of older subjects. The five-year-olds were more prone to misclassify the target faces. For similar faces there was an age effect but for dissimilar faces there was no difference in error rates among any of the age groups. This shows that for some stimuli task difficulty was equivalent across age groups and that particular problems occurred for the younger subjects when the faces to be rejected were lookalikes to the targets.

Ellis (1991) also measured response times to make accurate judgements of the faces. As expected, there was an age effect, with mean latencies decreasing according to age. Response times overall were shortest for rejecting dissimilar faces, followed by acceptance of target faces and slowest for similar faces. For children aged 5, 8 and 11 years, similar faces produced the longest response times. The 19-year-olds, however, did not respond any slower for these stimuli, suggesting that, for adults, they did not sufficiently look like the targets to cause any measurable extra processing time.

(*c*) *Caricatures*

Young children seem to be inefficient at coding facial information, and they are more likely than are older children to misclassify a stranger's face as being familiar if it bears a resemblance to someone they know. These, and other observations made earlier, imply that children are comparatively inexpert face recognizers.

Expertise is thought to underly the often reported particular disadvantage people have in recognizing faces that have been inverted (Yin 1969). Diamond & Carey (1986) showed that dog experts were more affected by the inversion of dog pictures than are non-experts. So, paradoxically, expertise does not assist when an unusual stimulus transformation occurs: on the contrary, it is a handicap.

A common transformation is that produced by caricaturists, who exaggerate a face's more unusual characteristics and, in some sense, make it more recognizable than the original (Perkins 1975). Rhodes *et al.* (1987), using computer-generated line-drawn caricatures, discovered that familiar faces are classified more readily from their caricatures compared with accurate line drawings. This work has been extended by Benson & Perrett (1991) using an even more impressive computer system that creates caricatures from coloured photographs. They found that people, on average, rate caricatures with mean distortions of between +4% and +5% exaggeration as providing the best likeness: a rather lower figure than that found by Rhodes *et al.* (1987) but, none the less, strongly supporting their view that caricatures may tell us something about the way ordinary faces are recognized. Rhodes & McLean (1992) have found that such caricature effects are not confined to faces. Ornithologists preferred slightly caricatured drawings of passerines; but non-experts did not show this effect. This observation provides a testable hypothesis: young children are less expert than older children and adults at processing facial images. Therefore they should show less bias towards preferring caricatured images.

By using stimuli produced by Benson & Perrett, Ellis (1991) examined children's and adults' choices of

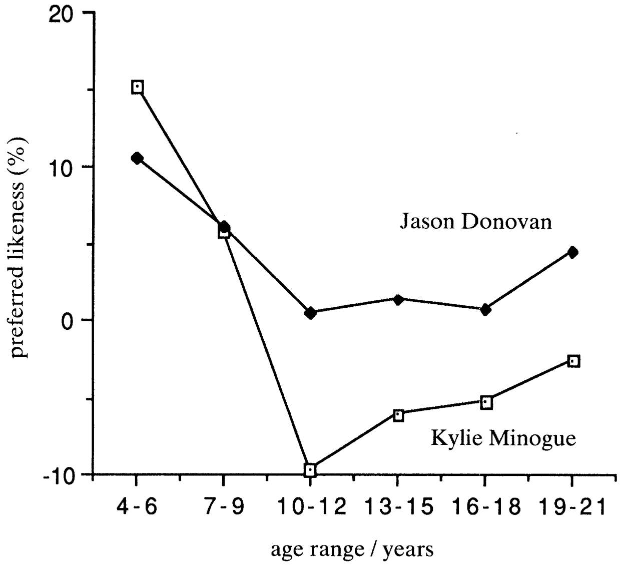

Figure 4. Caricatures and anticaricatures of Kylie Minogue together with mean choice of the best likeness of two target faces by subjects aged between 4 and 19 years. The stimuli were produced by P. Benson & D. Perrett, St Andrews University.

the best likeness of Kylie Minogue and Jason Donovan from the originals (0%) along with three caricatures of progressive exaggeration (+16%, +32%, +48%), and anticaricatures, where the faces' deviations from the norm were progressively diminished (−16%, −32%, −48%). Figure 4 illustrates the effects for Kylie Minogue. It also shows the mean results for the judgement of best likeness. Quite clearly, for the two target faces used, very young children judged the best likeness to be a positive caricature. By the age of 10 years, however, the caricature effect is eliminated entirely.

It would be rash to make too much of these data without further work using more target faces. But it is tempting either to dismiss the expertise hypothesis or to suggest that, contrary to some of the research reviewed earlier, by age 4 years, children have developed expertise sufficient to reveal preferences for caricatures. Why, however, did older children and adults not choose positive caricatures of Minogue and Donovan as best likenesses? Benson & Perrett (1991) found quite large individual differences in susceptibility of target faces to the caricature effect. Familiarity may be the crucial factor. Rhodes & Moody (1990) found that caricatures of relatively unfamiliar faces do not produce faster identifications than do veridical images.

The caricature results may not have supported the particular hypothesis under investigation but they point to a means of explaining the categorical study reported earlier in which the same target faces were used. If young children think that a positive caricature offers better likenesses of familiar faces then they may well make errors both in failing to identify actual photographs of the targets (omissions) and in identifying lookalikes, especially when their faces contain features that in some sense are exaggerations of those in the target face (commissions).

The findings in the caricature study, as well as those found from other experiments using familiar faces, reveal some similarities in the way young children and adults process faces. There are differences, however, sometimes resulting from differential experiences of faces in general or particular faces. Work with unfamiliar faces implies that one of the most salient changes with maturation is the ability to deal with facial transformations. It is also clear that young children do not encode faces with the same efficiency as older children.

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Discussion

V. Bruce (*Department of Psychology, University of Nottingham, U.K.*). In exploring the effect of distinctiveness on recognition of faces by children of different ages. Professor Ellis has used the faces of young adults. Does he think that the dimensions of distinctiveness in adult faces are necessarily salient to the younger children, and would he expect to get the same results using children's faces which were allocated (on whatever basis) to 'distinctive' and 'typical' groups?

H. D. Ellis. I cannot disagree with Professor Bruce. Perhaps the use of children's faces varying in distinctiveness might have produced different results. However, there are two reasons for my not having done as she suggested:
(i) children's faces tend to be more homogeneous than adults', so the distinctiveness dimension is less obvious; (ii) in most studies of face memory there has been no interaction between age of subject and age of face – so I should not expect the lack of a distinctiveness effect in the study I mentioned to be modified by the use of children's faces – but I have to admit the logical possibility, I suppose.

S. de Schonen (Cognitive Neuroscience Unit, L.N.F.1, C.N.R.S., Marseille, France). I wish to come back to an earlier part of your paper. You underscored that it is late in childhood that changes in size of a photograph no longer affect face recognition. In our studies with 4- to 9-month-olds, we used photographs of the mother's face and of strangers' faces. The photographs were much smaller than the real faces. Despite the fact that the women were wearing a black scarf to suppress cues from hair colour and hair dressing, that the face complexion on the photograph did not look exactly like in reality, and that the context was completely abnormal relatively to the daily conditions in which the mother's face is seen (the slides were projected for durations of 300 ms in a dark room where the infant had never been before), the subjects recognized their mother. Doesn't Professor Ellis think that the change he observed in childhood is the continuation of skills that are present much earlier or does he think that another skill is emerging?

H. D. Ellis. I would not disagree at all with Dr de Schonen's statement. Clearly all skills concerning facial transformations are continuously developed throughout childhood. The data I presented indicated the end point (around 4–5 years) of the development of ability to deal with size transformations. The error rates, although low, were significantly higher for 4- and 5-year-olds than for 6-year-olds.

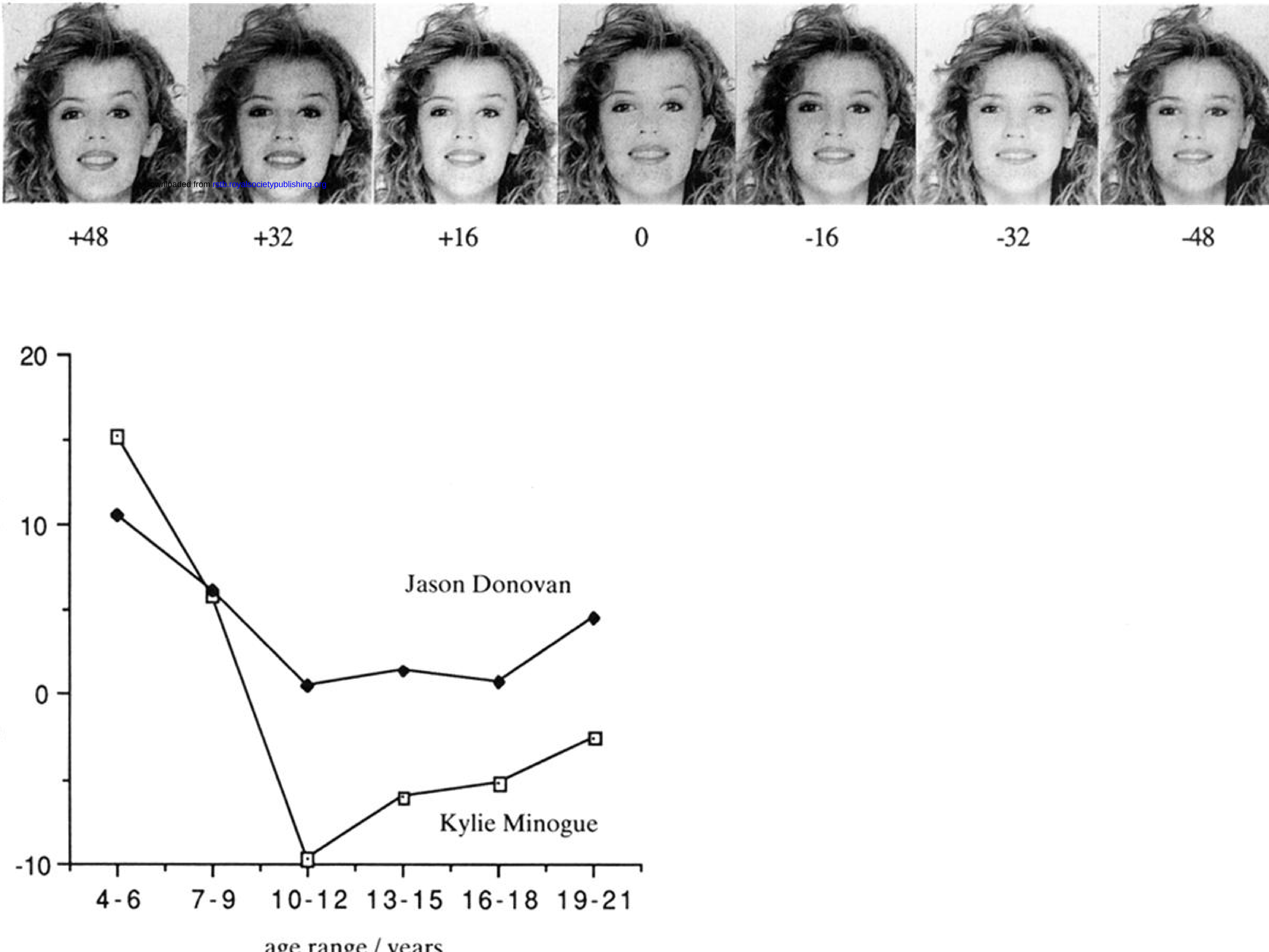

Figure 4. Caricatures and anticaricatures of Kylie Minogue together with mean choice of the best likeness of two target faces by subjects aged between 4 and 19 years. The stimuli were produced by P. Benson & D. Perrett, St Andrews University.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES