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The Development of Differential Use of Inner and Outer Face Features in Familiar Face Identification

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Adults recognize familiar faces better from their internal than external parts (Ellis, Shepherd, & Davies, 1979). Children from 4 to 10 years old made familiarity judgments of part-face and whole-face photographs of their schoolmates. In contrast with results reported for adult judgments of familiarity, external face features were more accurate than internal features for younger children, with a switch to the adult pattern after 9 years of age. All children showed an advantage for whole-over part-face identification. The switch in sensitivity in later childhood coincides with the period at which expertise in face recognition is believed to be achieved. This coincidence suggests some underpinnings for the basis of the development of such expertise in face recognition in adults.

INTRODUCTION

Faces provide the most important visual stimulus for a range of human behaviors. The development of the ability to read faces and to identify individuals by the face is a critical aspect of cognitive and social development. This paper is concerned with the child's developing ability to

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identify other known children, as a function of the part of a face presented in a face photograph.

There are specific changes in face recognition skills throughout childhood. While infants may be sensitive to individual faces from birth (Bushnell, Sai, & Mullin, 1989), the typical adult ability explicitly to recognize many hundreds of individual faces develops slowly through childhood, reaching a peak at around the age of 10, followed by a "dip" in early adolescence before a further improvement, and reaching asymptote in young adulthood (Goldstein & Chance, 1964; Carey, Diamond, & Woods, 1980; Flin, 1985). One notion (see Diamond & Carey, 1977) was that a slow-developing ability to process configurations rather than individual features was an important functional constraint on the development of face recognition skills. One problem with this proposal is that it can be empirically difficult to disentangle a notion of configuration that specifies second-order relational aspects ("higher order" features such as eye distance or spatial relationships between features) from a simpler one that equates a configurational with a holistic, "gestal" representation (see, e.g., Carey, 1992; Tanaka & Farah, 1991, 1993). Moreover, reasonable configurational encoding can be demonstrated in a range of visual tasks in infancy (see Flin & Dziurawiec, 1989). Some therefore argue that the strategic use of all potentially discriminating aspects of faces is critical in the development of face identification abilities (Thomson, 1989; Flin, 1985; Pedelty, Levine, & Shevell, 1985).

Carey and her colleagues have since proposed that the development of face expertise is a more complex matter than a general improvement in configural visuospatial skills (although these may contribute to it). For instance, general configurational abilities do not appear to correlate with face-recognition development particularly well (Carey et al., 1980). Moreover, expertise in visual discrimination can develop in realms other than face processing and seems to share a similar time course and characteristics. Thus, Diamond and Carey (1986) showed levels of recognition skill among experts viewing photographs of sporting dogs similar to those among adults viewing (unfamiliar) human faces. Moreover, both are similarly and negatively affected by inverting the photograph (Brooks & Goldstein, 1963; Scapinello & Yarmey, 1970; Goldstein, 1975) and appear to take 10 years of concerted exposure to develop to expert levels. This contrasts with much smaller effects of inversion for less expert dog viewers and for younger children viewing faces. The implication is that the development of the ability to recognize myriad individual human faces is not just a general human maturational process, keyed in at birth and with fixed age parameters, but a truly developing skill, dependent on exposure to many faces and motivation to discriminate them effectively. This skill, moreover, makes use of orientation-sensitive representational devices for faces considered as wholes and for the features in faces (Bartlett & Searcy, 1993).

Internal and External Features in Recognizing Faces

No experiment is needed to show that the inner face parts (eyes, nose, and mouth) are more important than the outer face parts (eyebrows, chin, ears, and hair) for effective display of emotion, let alone direction of gaze and speech. Yet particular sensitivity to the inner parts of the face is not apparent at birth. Studies of scanning patterns of faces show some developmental progression in where the child looks. Infants look more at the outer parts (the face outline) in the first month of life, with a change to more concerted scanning of the inner face in older infants (Maurer, 1983). This may be related to developmental changes in visual sensitivity over the first few months of life. For example, sensitivity to higher spatial frequencies (which may be needed to resolve many fine inner-feature discriminations) increases over the first 4 to 6 months of life (Slater & Bremner, 1989).

What is more interesting for present purposes is the finding that, in adults, familiar faces are more accurately recognized from their internal configuration (eyes–nose–mouth) than from their external features (hair, jawline and chin, forehead, and ears), while for unfamiliar faces both internal and external features are equally useful (Ellis, Shepherd, & Davies, 1979). Identification of a face from internal features could be claimed to rely more on configural than on piecemeal processes, because the spatial configuration of features such as eyes, nose, and mouth is at least as distinctive for individuating faces as the dimensions of the features themselves. Alternatively (or additionally), Ellis et al. (1979) suggested that this dissociation demonstrates that we represent familiar faces in terms of the relatively unchanging properties of the (internal) eye–nose–mouth region. While the shape and delineation of the eyes, eyebrows, nose, and mouth are fairly stable, hairstyle can change easily to alter radically the disposition and definition of the outer features. The chin can be disguised by a beard or clothing such as a scarf. A further reason for reliance on inner features in identifying known individuals could be that the internal features are more useful for making judgments about people as people: their likeability, personality, and so on. This manipulation also improves memory for the inner parts of unfamiliar faces (Endo, Takahashi, & Maruyama, 1984, as cited in Young & Ellis, 1989). Young, Hay, McWeeny, Flude, and Ellis (1986) confirmed the importance of internal features in matching familiar faces: adult subjects were faster at matching familiar (whole) face photographs to photographs of the inner features than the outer ones. For unfamiliar face matches between whole face and part face, there was no such effect of type of feature. These findings held only when the face match was performed across different views of the face (from three-fourths to full face, for example), suggesting that the inner features contribute more than the outer features to the construction of an invariant representation of the individual that can support matching across different views, a "structural" rather than a "pictorial" description in Bruce and Young's (1986) terms. De Haan and Hay (1986) confirmed the importance of the inner face parts in a study of adult patients with unilateral brain damage. Here, *all* subjects (middle-aged controls and left-brain- and right-brain-injured patients) were better at recognizing famous faces from internal than from external features, with no effect of face part on judgments of unfamiliar faces. Since in right-brain-damaged people there are established difficulties in the processing of objects presented in unfamiliar views (Warrington & James, 1986), thereby implicating problems in establishing view-invariant representations, the advantage to internal features in face recognition may not be limited to this specific structural factor. Be that as it may, the advantage to internal features is a robust and reliable one for identifying familiar faces, appearing across different test paradigms and in a range of populations.

Our aim in the study reported here was to chart the possible developmental progression of sensitivity to parts of the face in recognizing familiar people through childhood. No studies to date have explored the "internal features advantage" in terms of growing expertise in face recognition, which is otherwise well documented through the childhood years. Our strategy was to investigate classes of children in mainstream preschool and school education using, for each age group, two classes from different schools in different areas of southeast England. Thus, for each class, half the faces seen were those of their own schoolmates (familiar), and half were schoolchildren from a class of comparable age but from another school. Ethnicity and gender were balanced across all groups as much as possible (however, equal numbers of boys and girls, and of children of different ethnic groups, could not be used throughout).

METHOD

Subjects

Details on the subjects are given in Table 1.

Materials

Three sets of 32 individual portrait-style, matt-finish color photographs of 16 familiar and 16 unfamiliar faces were produced for each experimental group. The members of each group were all in the same school year, so the tests were of peer-face familiarity. One set was of whole faces, one set was of internal features, and the remaining set was of external features. For each group the unfamiliar faces were those of children of the same age range as the subjects being tested. Closeup, frontal head, and partial

TABLE 1
SUBJECT STATISTICS: CHRONOLOGICAL AND MENTAL AGES

		Age in months		
Group	Number	Mean	*SD*	Range
3–5 years	20	51	4.3	45–54
5–7 years	20	74	8.4	60–89
7–9 years	20	103	8.8	95–111
9–11 years	20	116	8.3	106–124

shoulder shots were taken against a neutral defocused background, using a Canon AE-1 camera with a 200-mm telephoto lens and a Hanimex TZ328 flash-gun for lighting each shot. The original photographic prints measured 12.5 × 18.5 cm. Internal and external features were separated and each was mounted on white cards measuring 15.5 × 20.5 cm. Internal features included eyebrows, eyes, nose, cheekbones intermediate between the eyes and the mouth, and the mouth itself and were cut out in a parallelogram, wider at the top (eyebrows) than at the bottom (mouth). The shape of the cuts varied with the disposition of these features; it was determined by locating the outer points of these features for each individual face. The remaining external features included hair, forehead, ears, outer cheek area, and chin (see Fig. 1, used with parental permission). No attempt was made to conceal normal additional identification marks, such as hairstyle, spectacles, earrings, nose studs, forehead caste-marks, or tattoos.

Procedure

All testing occurred in the spring term of the school year, when all students were well known to each other. Subjects were tested individually by one experimenter in a quiet corner of the schoolroom. The instructions were: "I am going to show you some photographs, and I want you to tell me whether the child in the picture goes to your school." Once the subject had indicated her/his understanding of the task, the experimental trials began. Photographs were presented individually, with blocked presentation. Whole faces were always presented first. The subsequent order of presentation of the internal and external sets was counterbalanced across subjects, and a different individual was shown in each of the photographs. Instructions were repeated as required. The rate of presentation was set by the subject's speed of response. Responses for each trial were noted by hand, but no specific feedback was given. After the experimental session, each child was asked how long s/he had attended school and how long s/he had been in that particular year group. All subjects reported here had been with their year group for at least 4 months.

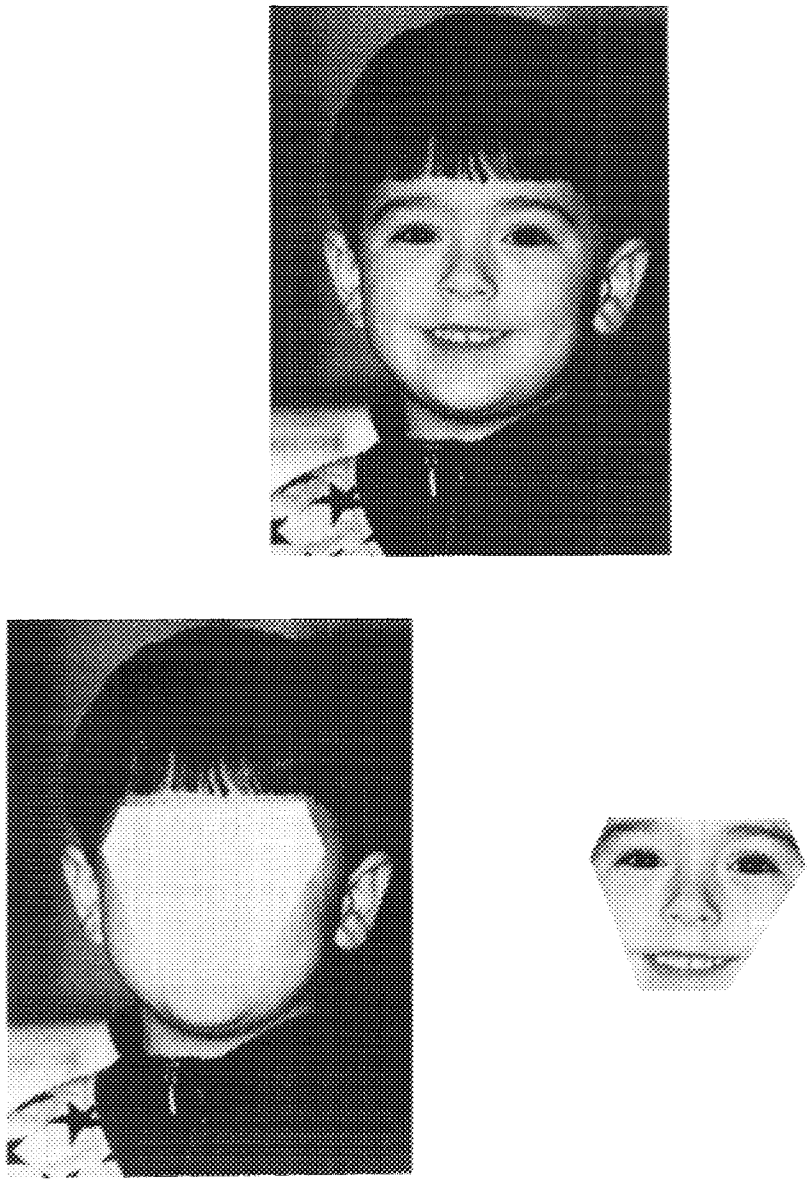

FIG. 1. An example of the face pictures used in the study; whole face (above), external features, and internal features.

TABLE 2
WHOLE- AND PART-OF-FACE FAMILIARITY JUDGMENTS: MEAN NUMBER CORRECT OUT OF 16

	Whole		External		Internal	
Group	Yes	No	Yes	No	Yes	No
3–5						
Mean	13.40	15.6	13.15	14.55	10.95	14.10
SD	1.81	1.89	1.73	2.87	2.48	2.40
5–7						
Mean	14.95	15.5	14.35	14.55	12.50	13.20
SD	1.87	0.69	2.25	2.16	2.44	3.56
7–9						
Mean	15.50	15.65	13.40	14.15	13.8	14.2
SD	3.16	1.08	3.36	2.636	2.986	2.568
9–11						
Mean	15.20	15.20	12.45	14.55	14.00	15.2
SD	2.59	1.76	2.307	2.501	3.17	1.56

RESULTS

Table 2 shows the mean accuracy scores for each experimental condition for each subject group for each variable tested. In the overall analysis of variance, age group was entered as the between-subjects variable (four levels) and the two within-subject factors were part-of-face (external, internal, and whole-face conditions) and decision type (correct recognition and correct rejection). The main effect of age did not reach significance: $F(3, 76) = 1.98$, $p = .125$. Considering the within-subject factors, part-of-face had a significant effect on accuracy ($F = 46.25$ (2,152), $p < .001$). Contrast analysis showed whole faces to be significantly more accurately recognized than external features ($F = 66.79$ (1,79), $p < .001$) and external features than internal ($F = 25.57$ (1,79), $p < .001$). The other within-subject factor, decision type, also affected results significantly ($F = 11.37$ (1,76), $p < .001$). Correct rejection decisions were more accurate than correct recognition decisions.

Of the other effects within the overall analysis of variance, only the interaction between age and part-of-face was significant ($F = 6.85$ (6,152) $p < .001$). Separate analyses of simple effects for part-of-face within each age group tested the reliability of this interaction further. These were *all* significant. For 4-year-olds, $F = 16.19$; for 6-year-olds, $F = 12.19$; for 8-year-olds, $F = 14.92$; and for 10-year-olds, $F = 12.19$. (For $df = 2{,}152$, these values are all significant at $p < .01$ and above.) A second simple effects analysis tested whether the different face parts were all sensitive to age. For whole faces, $F(3, 76) = 2.80$ ($p < .05$); for internal features, $F = 6.43$ ($p < .01$); and for external features, $F = 2.82$ ($p < .05$).

Thus part-of-face had a significant effect on recognition at each of the age levels tested, and each part-of-face contributes to this effect. Overall, the results suggest that in children, unlike in older people, *external,* not *internal,* features contribute more to the recognition of known people.

The next question, therefore is, what is the pattern of the effect of part of face at the different ages tested? The clearest way to examine this is through separate analysis for each age group.

3- to 5-Year-Olds

Within-subjects analysis of variance, with three levels of the part-of-face factor (whole face, external features, internal features) and two of the response-type factor (correct yes decisions and no decisions), was performed on the youngest group. This confirmed a significant part-of-face effect ($F = 15.72$ (2,38), $p < .001$) and also showed a significant effect of decision type ($F = 15.33$ (1,19), $p = .001$) and a significant interaction of part-of-face and decision type ($F = 3.51$ (2,38), $p = .04$). Contrast analysis for the part-of-face factor showed that whole-face recognition was better than external, which was better than internal, at $p < .01$ ($F = 33.17$ and 9.32, respectively, for 1, 19 *df*).

In this group, correct rejections were more accurate than correct recognitions of familiar faces, but this effect was moderated by part-of-face: it was most marked for *internal* face features, which were also least accurate in this group, and least marked for *external* features, which were more accurately judged. These children appear to have been especially cautious in making familiarity judgments on faces when presented only with the inner features.

5- to 7-Year-Olds

Identical within-subject analyses were performed with this group. Once again, the effect of part-of-face was confirmed ($F = 16.20$ (2,38), $p < .001$). In this group the effect of decision was not significant, nor was the part-of-face by decision interaction. Contrast analysis for the part-of-face factor showed that whole-face recognition was significantly better than external which was better than internal features at $p < .01$ and above ($F = 32.35$ and 9.85, respectively, for 1, 19 *df*).

In this group, the pattern of part-of-face effects was similar to that in the younger group (whole > external > internal) and this was not moderated by decision.

7- to 9-Year-Olds

Once again, within-subject analyses of variance confirmed the effect of part-of-face ($F = 18.21$ (2,38), $p < .001$). There was no effect of decision type nor an interaction of this with part-of-face. Contrast analysis for part-of-face showed a significant advantage for whole-over part-of-face ($F =$

48.77), but no significant difference between internal and external features (F = .39).

9- to 11-Year-Olds

In the oldest group, within-subject analysis of variance again confirmed the part-of-face effect (F = 17.31 (2,38), $p < .001$) and a decision by part interaction (F = 3.73 (2,38), p = .33). Contrast analysis on the part-of-face factor showed a significant advantage for whole over internal features (F = 34.65) and for internal over external features (F = 9.825).

Thus, examining each age group in turn, while there is a marked advantage in all groups for whole-over part-of-face, age has an important effect on which part-of-face is most accurately used. In the younger age groups external features are significantly better recognized than internal features. The adult pattern of internal feature superiority emerges only at around 10 years, and there is a period at around 8 years when *either* internal or external features seem equally accurate.

Whole-Face Recognition over the Age Range

While whole faces appear to show some general improvement over the age range tested, the means do not suggest that this is a linear increase. One-way analysis of variance examined the extent to which differences at each age were significant, where the dependent variable was whole-face recognition (correct rejections + correct recognitions) and the grouping factor was age group. The overall analysis gave F = 2.802 (3,76), p = .0456, confirming a small overall change across the tested ages for these familiar faces. However, Scheffe multiple-range tests were 4.04 for each comparison and failed to reach significance at $p < .05$.

While there is some improvement with age for these children's recognition of their schoolmates, it could not be detected for each specific age comparison.

Part-Face Recognition over the Age Range

Similar one-way analyses were performed for external and for internal feature recognition separately. Once more, compound accuracy scores comprising correct rejection and recognition were used. For external features, age failed to affect accuracy (F = 1.204 (3,76), p = .31). For internal features, however, there was a marked effect of age (F = 6.43 (3,76), $p < .001$), which Scheffe tests showed to be due to a significant difference between the oldest (9–11 years) and some of the younger groups (3–4 and 5–7 years). The differences between the three younger groups (3–4, 5–7, and 7–9) were not significant on these (conservative) tests, nor were the differences between the two older groups (7–9 and 9–11).

TABLE 3

MULTIPLE REGRESSION ON WHOLE-FACE RECOGNITION (VARIABLES ENTERED IN ORDER: INTERNAL, EXTERNAL, AGE GROUP)

Correlation matrix

Whole	1.00			
Internal	.500	1.000		
External	.590	.260	1.000	
Group	.229	.441	−.119	1.000
	Whole	Internal	External	Group

Variables in the equation

Variable	*B*	*SE Bβ*	*T*	Sig. *T*	
Internal	.18735	.06302	.28755	2.973	.0040
External	.40049	.06546	.53492	6.118	.0000
Group	.36183	.20503	.16602	1.765	.0816
Constant	13.16063	1.99548		6.595	.000

Note. Multiple $R = .705$, [$F(3, 76) = 25.06$, $p < .001$]

Further Analysis

The analyses of variance show clear changes in sensitivity to face part through the school years. But how are these related to general face-recognition skill (whole-face performance)? Simple (linear) regression analysis was performed, with whole-face accuracy (correct recognition + correct rejection) as the dependent variable and internal feature accuracy (correct recognition + correct rejection), external feature accuracy, and age group as the independent variables. Table 3 shows the relevant data for this analysis. Both the correlations and the simple regression suggest that external and internal feature performance, rather than age group, is more strongly related to familiar face recognition in these children. At the very least, this indicates that factors extrinsic to test (for instance, specific strategies that might change with age) had no additional effect on face recognition. Put otherwise, for the part-face tasks, children were not using any special strategy that they did not use in the whole-face task. Familiar face recognition in this age range is associated strongly, but somewhat independently, with both external and internal face-feature accuracy (the correlation between external and internal scores was only .26).

DISCUSSION

All children performed this task accurately with performance well above chance (indeed nearing ceiling in many cases). Nevertheless, systematic departures from perfect performance were observed, and the raw data fell within the parameters for reliable analysis of variance. There was an advantage for whole-face over part-face recognition. That is, recognition of the face features (or the whole facial configuration) was better at every age than recognition of specific parts. The second main finding was that children up to the age of about 7 years were better at recognizing their classmates from *external,* not internal, features. This is a completely unexpected finding and has not been reported for adults or any other group. These individuals were not less familiar to the viewers: if anything, the younger children were more familiar with their classmates, having been tested later in the school year. In slightly older children (around 8–9 years), neither external nor internal features were better for recognition, echoing the pattern reported for *un*familiar faces in adult groups (Ellis et al., 1979). Finally, in the oldest group (around 10 years) there was a switch to greater accuracy for internal face features (the adult pattern for familiar faces).

Further analyses confirmed this general pattern. When viewed from the perspective of age-related changes (separate one-way analyses of variance for each experimental factor), whole-face accuracy, tested with these materials, improved slightly over the age range tested. External features led to similar levels of accuracy by all youngsters across the age range, but internal features were more accurately recruited only in the older children, with a significant difference between the oldest (10-year-old) group and 8-year-olds in this respect.

What processes underlie this developmental progression? There is a clue from studies cited in the Introduction. The pattern of results reported here fits with other reports, using a different paradigm, suggesting a process at work in the development of face skills that is based on two factors, one that is age-sensitive and one that is not. Carey and Diamond (in press) have recently confirmed the possibility that two rather different sorts of configural processing contribute to the development of children's increasing ability to recognize faces, using another type of face recognition task. They studied susceptibility to the illusion reported by Young, Hellawell, and Hay (1987). This occurs when the upper and lower halves of two different full-face photographs align. The illusory face seems to be a new face rather than an identifiable compound of the two others. The extent of the illusion can be measured in terms of a *disadvantage* in recognizing the upper part of a "fused" face compared with recognizing the upper part of the same face in an isolated (or unused) condition. Carey and Diamond (in press) found children susceptible to this illusion at all ages tested, with no sign of increasing sensitivity with age. Sensitivity to face inversion in the same testing paradigm, however, increased with age, reaching adult levels at around 10 years.

In the study reported here a similar dissociation may be indicated. Whole-face advantages occurred, with only slight changes in performance across the age range. Moreover, external face features were equally accurate across the whole age range. What varied significantly with age was reliance on internal face features. Furthermore, the switch to the adult pattern of reliance on internal features appeared to occur at around 10 years, the age at which the adult pattern of sensitivity to face inversion occurs. Thus, the present study can be construed as providing closely converging evidence for Carey and Diamond's "two-process" theory of configural processes in face recognition and suggests a possible reason for their findings. Since external features are those concerned with face shape or external face contour, and since susceptibility to the face-composite illusion of Young et al. requires alignment of the face contour across the upper and lower parts, any process concerned with the representation of the face contour—the defining shape of the face—involves external feature analysis. In neither Carey and Diamond's report nor the present one was there age sensitivity in this process.

This hypothesis, moreover, is open to testing by investigating the extent to which the illusion holds when external contour and internal features are separately manipulated.

Configural Face Processing in Younger Children?

The findings reported here should not be taken to indicate that children under the age of 10 are unable to make effective use of the configural information delivered by the inner parts of the face.

Newcombe and Lai (1994) have recently repeated Young et al.'s (1986) study of face–photograph matching of inner and outer face features across two different face views, varying the familiarity of the face with young children (5–6 years). They report that the children's accuracy in this task echoed the adult pattern. That is, familiar face matching was better than unfamiliar face matching for internal face-feature arrays, while external feature arrays showed no such sensitivity to face familiarity.

At first sight, this would appear to go against the hypothesis advanced here that expertise develops slowly and specifically for inner face features. However, this finding is compatible with our suggestions. First, in Newcombe and Lai's study, the task was a *covert* one of face identity (are these two photographs of one person or two different people?). Second, although familiarity affected internal feature matching more than external feature matching, there was also a main effect of external face features generating better recognition than inner face scores. It would therefore appear that while aspects of the inner faces of familiar people are represented from a young age, access to this representation (is this someone you know?) may be limited to covert tasks and, moreover, the internal face is not yet the most informative part for even such covert tasks.

More on Facial Inversion

One aspect of the renewed interest in contrasting external and internal face features is to cast further light on the effects of inversion of faces. If expertise is a common process underlying both the identification of individuals from their inner face parts and the sensitivity to face inversion (Carey, 1992), it may follow that the processing of internal features is particularly sensitive to inversion. The "Thatcher illusion" may demonstrate this. It occurs where an upright face appears monstrous through inversion of just the eyes and mouth, whereas an inverted picture of this type of face composite (as well as an inverted face picture of a naturally grotesque facial expression) does not (Bartlett & Searcy, 1993). One strong prediction from the findings reported here is that there will be a marked developmental trend in susceptibility to the Thatcher illusion.

Why should such an age-sensitive pattern of response to the inner face parts occur? What is it that underlies such expertise? It is possible that visual aspects of the face play a role. Inner features require a finer grain of spatial resolution than the face as a whole (Watt, 1993). While the relative position of the eyes, nose, and mouth can be well preserved under conditions of low spatial frequency, their discriminating aspects—the hoodedness of an eye, the crook of a nose, or the mouth—may not. The ability to set the visual analyzers to the appropriate spatial frequency, in order to store appropriate descriptions of a known face and to match it to one presented, may develop relatively slowly over the tested age range, although a 6-month-old infant has a sufficiently mature visual system and, as has been indicated, 6-year-olds can show adult sensitivity to the familiar inner face in covert face-matching tasks.

What *structural* processes contribute to the increasing discriminability of face parts, to the increasing sensitivity to the idiosyncratic aspects of the face that distinguish it from other, similar ones? One answer might be "an increase in power in the vector descriptions of face features in representational space." This aspect of face discriminability has been explored using caricatures which increase face feature differences from experimentally derived norms for a population of faces (Brennan, 1985; Rhodes, Brennan, & Carey, 1987). Under some conditions, these can be identified more readily than "real" faces and are always more readily identified than "anticaricatures," achieved by reducing the feature distance of the exemplar from the norm. Susceptibility to caricature, then, might be proposed as another example of increasing expertise with faces. Interestingly, Ellis (1992) reported that 6-year-olds chose caricatures of famous faces as "best likenesses" more often than older children (and with a "dip" in preference at 10 years). While this may be taken to indicate that caricature sensitivity is not an indicator of developing face expertise, the findings of the present study suggest that Ellis' findings could be otherwise interpreted. Six-year-olds in this study were less sensitive to inner-face than to outer-face features in recognizing known individuals. If we assume that the inner-face features bear more caricaturization—because there are more of them, or because they have a greater number of feature values, or because they are simply more discriminating between faces—the effect of caricature for 6-year-olds may be to enhance the discriminability of the inner parts of the face. On this account, it is because younger children are less sensitive to the inner face parts that they are more likely to match face caricatures to real faces; the caricatures, by enhancing the distinguishing face features, may serve as "superstimuli," accessing the face representation more effectively. A systematic test of caricatures of outer and inner face parts across the age range would be required to test this. Tests of memorability of caricatures themselves are also in order (current studies in our laboratory are exploring children's memory for faces and face parts of well-known TV cartoon characters).

Whatever the reasons underlying the developmental differences in familiar face recognitions reported here, the exploration of the development of face recognition through childhood is by no means complete. Forthcoming studies should be able to assess more authoritatively the value of some of the speculations advanced here.

REFERENCES

Bartlett, J. C., & Searcy, J. (1993). Inversion and configuration of faces. *Cognitive Psychology*, **25**, 281–316.

Brennan, S. (1985). The caricature generator. *Leonardo*, **18**, 170–178.

Brooks, R. M., & Goldstein, A. G. (1963). Recognition by children of inverted photographs of faces. *Child Development*, **34**, 1033–1040.

Bruce, V., & Young, A. W. (1986). Understanding face recognition. *British Journal of Psychology*, **77**, 305–327.

Bushnell, I. W. R., Sai, F., & Mullin, J. T. (1989). Neonatal recognition of the mother's face. *British Journal of Developmental Psychology*, **7**, 3–15.

Carey, S. (1992). Becoming a face expert. In V. Bruce, A. Cowey, A. W. Ellis, & D. I. Perrett (Eds.), *Processing the facial image: Proceedings of a Royal Society discussion meeting* (pp. 95–103). Oxford UK: Clarendon Press.

Carey, S., & Diamond, R. (in press). Are faces perceived as configurations more by adults than by children? *Visual Cognition*.

Carey, S., & Diamond, R. (1977). From piecemeal to configurational representation of faces. *Science*, **195**, 312–314.

Carey, S., Diamond, R., & Woods, B. (1980). The development of face recognition—A maturational component. *Developmental Psychology*, **16**, 257–269.

De Haan, E. H. F., & Hay, D. (1986). The matching of famous and unknown faces, given either the internal or external features: A study on patients with unilateral brain lesions. In H. D. Ellis, M. A. Jeeves, F. Newcombe, & A. Young (Eds.), *Aspects of face processing* (pp. 302–309). Dordrecht, Netherlands: Nijhoff.

Diamond, R., & Carey, S. (1977). Developmental changes in the representation of faces. *Journal of Experimental Child Psychology*, **23**, 1–22.

Diamond, R., & Carey, S. (1986). Why faces are and are not special: An effect of expertise. *Journal of Experimental Psychology, General*, **115**, 107–117.

Ellis, H. D. (1992). The development of face processing skills. In V. Bruce, A. Cowey, A.

W. Ellis, & D. I. Perrett (Eds.), *Processing the facial image: Proceedings of a royal society discussion meeting* (pp. 105–110). Oxford: Clarendon Press.

Ellis, H. D., Shepherd, J. W., & Davies, G. M. (1979). Identification of familiar and unfamiliar faces from the internal and external features: Some implications for theories of face recognition. *Perception*, **8**, 431–439.

Flin, R. (1985). Development of face recognition: An encoding switch? *British Journal of Psychology*, **76**, 123–134.

Flin, R., & Dziurawiec, (1989). Developmental factors in face perception. In A. W. Young & H. D. Ellis (Eds.), *Handbook of research on face processing*. North Holland, Netherlands: Elsevier.

Goldstein, A. G. (1975). Recognition of inverted photographs of faces by children and adults. *Journal of Genetic Psychology*, **127**, 109–123.

Goldstein, A. G., & Chance, J. F. (1964). Recognition of children's faces. *Child Development*, **35**, 129–136.

Goldstein, A. G., & Mackenberg, E. J. (1966). Recognition of human faces from isolated facial features: A developmental study. *Psychonomic Science*, **6**, 149–150.

Maurer, D. (1983). The scanning of compound figures by young infants. *Journal of Experimental Child Psychology*, **35**, 437–448.

Newcombe, N., & Lai, L. (1994). *Young children's ability to recognise familiar and unfamiliar faces*. Manuscript submitted for publication.

Pedelty, L., Levine, S. C., & Shevell, S. K. (1985). Developmental Changes in face processing: Results from multidimensional scaling. *Journal of Experimental Psychology*, **39**, 421–436.

Rhodes, G., Brennan, S., & Carey, S. (1987). Identification and ratings of caricatures: Implications for mental representations of faces. *Cognitive Psychology*, **19**, 473–479.

Scapinello, K. F., & Yarmey, A. D. (1970). The role of familiarity and orientation in immediate and delayed recall of pictorial stimuli. *Psychonomic Science*, **21**, 329–330.

Sergent, J. (1989). Structural processing of faces. In A. W. Young & H. D. Ellis (Eds.), *Handbook of research on face processing* (pp. 57–91). North Holland, Netherlands: Elsevier.

Slater, A., & Bremner, G. (Eds.). (1989). *Infant development*. Hove, UK: Erlbaum.

Tanaka, J. W., & Farah, M. J. (1991). Second-order relational properties and the inversion effect: testing a theory of face perception *Perception and Psychophysics*, **50**, 367–372.

Tanaka, J. W., & Farah, M. J. (1993). Parts and wholes in face recognition. *Quarterly Journal of Experimental Psychology*, **46a**, 225–245.

Thomson, D. M. (1989). Issues posed by developmental research. In A. W. Young & H. D. Ellis (Eds.), *Handbook of research on face processing* (pp. 391–399). Netherlands, Elsevier.

Walker, J. (1992). *Face processing in children with autism: identity, gender and lipspeech decisions*. Unpublished manuscript, Goldsmiths' College, University of London.

Warrington, E. K., & James, M. (1986). Visual object recognition in patients with right hemisphere lesions: axes or features? *Perception*, **15**, 355–366.

Watt, R. (1993). *Spatial frequency analysis and face perception*. International conference on face processing: Welsh BPS meeting, Cardiff, Wales, September 21–23.

Young, A. W., & Ellis, H. D. (1989). Semantic processing. In A. W. Young and H. D. Ellis (Eds.), *Handbook of Research on Face Processing* (pp. 235–262). North Holland, Netherlands: Elsevier.

Young, A. W., Hay, D. C., McWeeny, K., Flude, B., & Ellis, A. W. (1986). Matching familiar and unfamiliar faces on internal and external features. *Perception*, **14**, 737–747.

Young, A. W., Hellawell, D., & Hay, D. C. (1987). Configural information in face perception. *Perception*, **16**, 747–759.

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