Research Report

Becoming a Face Expert

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ABSTRACT—***Expertise in recognizing facial identity, and, in particular, sensitivity to subtle differences in the spacing among facial features, improves into adolescence. To assess the influence of experience, we tested adults and 8-year-olds with faces differing only in the spacing of facial features. Stimuli were human adult, human 8-year-old, and monkey faces. We show that adults' expertise is shaped by experience: They were 9% more accurate in seeing differences in the spacing of features in upright human faces than in upright monkey faces. Eight-year-olds were 14% less accurate than adults for both human and monkey faces (Experiment 1), and their accuracy for human faces was not higher for children's faces than for adults' faces (Experiment 2). The results indicate that improvements in face recognition after age 8 are not related to experience with human faces and may be related to general improvements in memory or in perception (e.g., hyperacuity and spatial integration).***

Adults' expertise in face recognition is mediated by specialized cortical mechanisms (Haxby et al., 2001; Rossion et al., 2000) and facilitated by exquisite sensitivity to subtle differences among individual faces in the spacing of facial features (*second-order relations*) (Freire, Lee, & Symons, 2000; Kemp, McManus, & Pigott, 1990; Mondloch, Le Grand, & Maurer, 2002; Rhodes, Brake, & Atkinson, 1993; Rhodes, Carey, Byatt, & Proffitt, 1998; Searcy & Bartlett, 1996), both of which are slow to develop. The N170, an event-related potential evoked selectively by faces, has a smaller amplitude and a longer latency in children than in adults, even in midadolescence (Taylor, McCarthy, Saliba, & Degiovanni, 1999). In functional magnetic resonance imaging studies, the fusiform face area does not respond more to faces than to other categories until children are around 10 years of age (Aylward et al., 2005; Gathers, Bhatt, Corbly, Farley, & Joseph, 2004), and even in 12- to 14-year-olds, it is not as selectively activated by faces as it is in adults (Aylward et al., 2005). Behavioral results also show differences between children and adults. When asked to make same/different judgments about pairs of faces that differ only in the spacing of facial features, 6-year-olds perform at above-chance levels, but even 14-year-olds make more errors than adults (Mondloch et al., 2002; Mondloch, Le Grand, & Maurer, 2003; see also Freire & Lee, 2001).

One hypothesis is that sensitivity to second-order relations improves as children acquire additional experience differentiating individual faces (Nelson, 2003). Diamond and Carey (1986) argued that children under 10 years of age are like adult novices attempting to recognize individual dogs: Both lack expertise in using second-order relations to differentiate among individuals. Alternatively, children's poor performance may reflect general cognitive limitations (see Gilchrist & McKone, 2003, for a discussion of this hypothesis and Pellicano, Rhodes, & Peters, 2006, for evidence of early skill in using second-order relations under other conditions).

We took a novel approach to investigating the development of expertise in recognizing facial identity. Adults' expertise is limited to stimuli with which they have a wealth of experience—typically upright human faces of their own race. They make more errors when human faces are inverted (Collishaw & Hole, 2000; Yin, 1969) and when faces are of an unfamiliar race (Rhodes, Hayward, & Winkler, 2006; Sangrigoli, Pallier, Argenti, Ventureyra, & de Schonen, 2005). Also, the amplitude of the N170 is larger for human than for monkey faces (de Haan, Pascalis, & Johnson, 2002), and after becoming familiar with a single human face, adults look longer at a novel human face, but after becoming familiar with a single monkey face, they do not look longer at a novel monkey face (Pascalis, de Haan, & Nelson, 2002).

To determine whether the pattern of adultlike expertise emerges by 8 years of age, we asked adults and 8-year-olds to make same/different judgments for two sets of faces—human faces and monkey faces—that differed only in the spacing among features. Between age 8 and adulthood, children have a wealth of experience differentiating individual upright human faces, but except for rare cases (e.g., curators at zoos), no adult or child has experience recognizing individual monkey faces. If the large improvement in sensitivity to the spacing of features in

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upright human faces that occurs between 8 and 14+ years of age depends on years of experience differentiating individual human faces, then children's performance and adults' performance should differ more for human faces than for monkey faces because additional experience discriminating monkey faces is not acquired during adolescence. If the difference between children's and adults' performance is identical for monkey and human faces, then the improvement exhibited by adults must be related to more general visual or cognitive development. The data from adults also provide an opportunity to compare directly their sensitivity to spacing in human versus nonhuman faces. We presented faces both upright and inverted. Inversion disrupts adults' sensitivity to the spacing among facial features more than their sensitivity to other cues to facial identity (Freire et al., 2000; Leder & Bruce, 2000; Mondloch et al., 2002; Rhodes et al., 2006) and provides another measure of expertise.

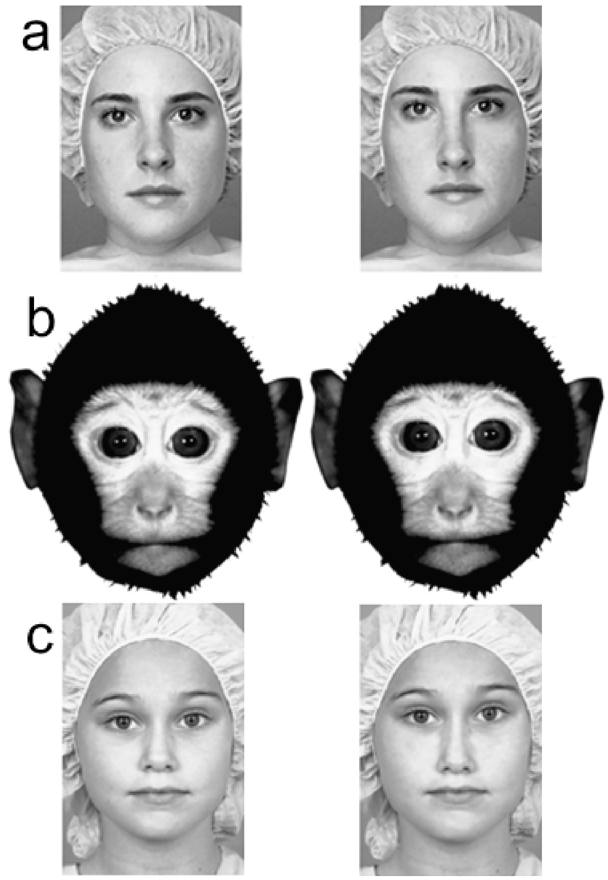

Fig. 1. Examples of faces used in the experiments. Adult human faces (a) were used in both experiments; monkey faces (b) were used in Experiment 1, and 8-year-old human faces (c) were used in Experiment 2. In each set, face variations were created by moving the eyes 4 mm (0.23° from the testing distance of 100 cm) up, down, closer together, or farther apart, relative to the original face, and by moving the mouth 2 mm (0.12° from 100 cm) up or down. According to anthropomorphic norms for humans (Farkas, 1981), we moved the eyes up or down by 0.95 *SD*, the mouth up or down by 1.06 *SD*, and the eyes closer together or farther apart by 2.60 *SD* (see Mondloch, Le Grand, & Maurer, 2002, for additional details). Shown are the original face (left) and one of the sisters (right) from each condition.

EXPERIMENT 1

Method

Subjects

Subjects included twenty-four 8-year-olds (± 3 months; M = 8.06; range = 7.8 to 8.24) and 24 adults (ages 18 to 28 years). All were right-handed, were Caucasian, and had normal vision (for details of the screening tests, see Mondloch et al., 2002). An additional 26 children were excluded from the final analysis because they failed visual screening (n = 13), the practice task (n = 4), or the cousins trials (see Procedure; n = 6) or were uncooperative (n = 3). An additional 9 adults were excluded from the final analysis because they failed visual screening (n = 8) or the handedness test (n = 1).

Stimuli

We created two sets of faces that differed only in the spacing among facial features; each set consisted of one original face (an adult female or a monkey) and four manipulated versions of that face (referred to as *sisters*) in which the eyes and mouth were moved (see Figs. 1a and 1b). We equated the height of the human faces (the distance between the surgical cap and the chin) with the height of the monkey faces (the distance between the fur on the forehead and the chin). The spacing changes were identical across the two face sets, and the same as in our previous studies with human faces (Mondloch et al., 2002). We also created two face sets that consisted of the original human or monkey face plus three completely different human or monkey faces, respectively (referred to as *cousins*).

Procedure

The protocol was approved by the Research Ethics Boards at McMaster University and Brock University, Canada. Informed consent was obtained from each adult participant and the parent of each child; verbal assent was obtained from each child.

The procedure began with a practice task requiring same/different judgments of two identical faces or two radically different versions of the same face (e.g., a face with eyes rotated 45° clockwise; see Mondloch et al., 2002, for details). To participate in the main experiment, participants were required first to be correct on at least 10 of 12 practice trials.

On each trial of the main task, one of five possible faces appeared for 200 ms, followed by a random-noise mask (300 ms) and then by a second face that appeared until the subject responded "same" or "different." Trials were blocked by species; half of the participants were tested with human faces first. Within each species, there were three blocks of trials (for a total of 92 trials) presented in the same order to all participants: upright (n = 30), inverted (n = 30), cousins (n = 32). Four additional practice trials were given prior to each block. Within each block, the correct response was "same" for half of the trials, each face served as a test face as often as the model face, and half of the trials with each face were *same* trials and half were *different* trials. The cousins were included to make some of the trials easier and to provide an opportunity to identify children who did not understand the task or were uncooperative. Participants were included in the study only if they were correct on at least 70% of the human cousins trials; they were not required to be accurate on at least 70% of the monkey cousins trials because these trials might be difficult for all participants (Pascalis et al., 2002).

Results and Discussion

Accuracy was high for both monkey cousins (adults: $M = .88 \pm .02$; 8-year-olds: $M = .76 \pm .03$) and human cousins (adults: $M = .90 \pm .02$; 8-year-olds: $M = .86 \pm .02$). Because the primary question concerned accuracy with upright faces, we analyzed accuracy on upright trials using a 2 (age) × 2 (species) analysis of variance. There were main effects of age, $F(1, 46) = 16.73$, $p_{rep} = .98$, $\eta_p^2 = .267$, and species, $F(1, 46) = 18.37$, $p_{rep} = .99$, $\eta_p^2 = .285$, but there was no significant interaction. As shown in Figure 2a, adults were 14% more accurate than 8-year-olds for both human and monkey faces, and both age groups were more accurate discriminating human faces than monkey faces, despite the fact that the magnitude of the spacing changes was exactly the same in the two sets. The size of this species effect was identical for adults and 8-year-olds: 9% greater accuracy for human than monkey faces, a result indicating that adults' exquisite sensitivity to the spacing among features is restricted to human faces and that this pattern of expertise is already present by the time children are 8 years old. Analyses of reaction times indicated that the pattern of results could not be explained by a speed-accuracy trade-off.

That adults' expertise is restricted to upright human faces is further demonstrated by the finding that among adults, the inversion cost was larger for human faces ($M = .132 \pm .028$) than for monkey faces ($M = .028 \pm .023$), $t(23) = 2.62$, $p_{rep} = .96$, $\eta^2 = .13$. The inversion cost for 8-year-olds is not interpretable because their accuracy on upright monkey trials was close to a chance value of .50.

The findings indicate that the adult pattern of expertise emerges by the time children are 8 years old: Like adults, children are more sensitive to second-order relations in human faces than in monkey faces. This result is consistent with evidence that perceptual narrowing begins during infancy (de Haan et al., 2002; Halit, de Haan, & Johnson, 2003; Pascalis et al., 2002). The results imply that after age 8, improvements on tasks that tap sensitivity to second-order relations in faces may not reflect development of face expertise from additional experience, but rather may reflect more general improvements in cognition (see General Discussion).

To test this hypothesis further, in Experiment 2, we tested a new group of adults and 8-year-olds with the adult faces used in Experiment 1 and a set of faces based on the face of an 8-year-old girl. Children may have more experience differentiating among children's faces than among adults' faces: Whereas they typically have a few teachers and coaches, they have dozens of classmates and teammates. If experience in differentiating individual faces does contribute to improved sensitivity to second-order relations in faces during childhood, then the difference in accuracy between adults and 8-year-old children might be larger for adults' faces than for children's faces because of the greater difference between the two age groups in the amount of experience they have differentiating adult faces.

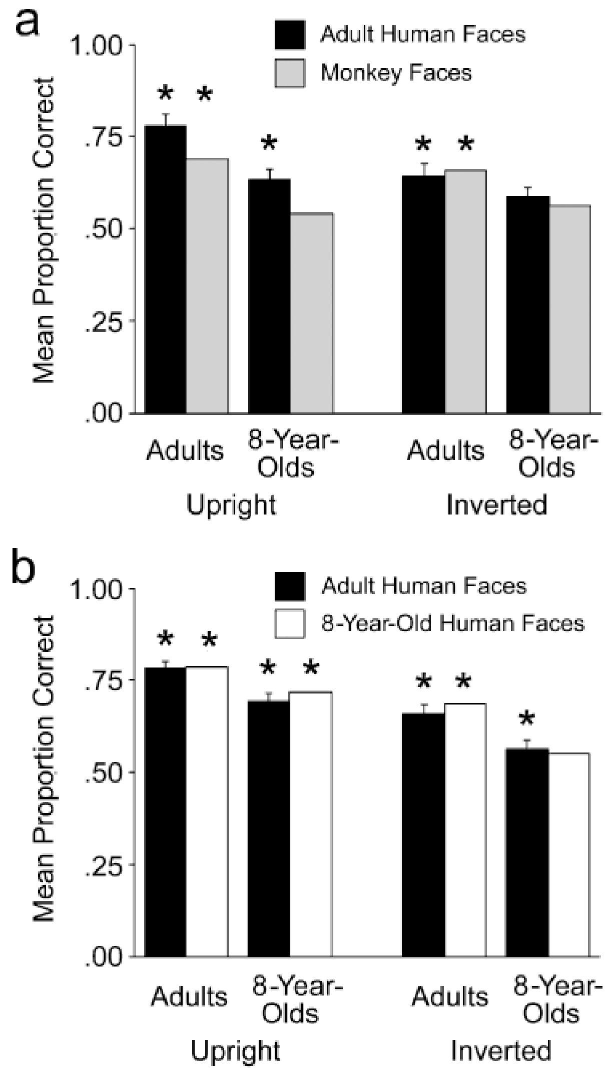

Fig. 2. Mean accuracy of adults and 8-year-olds when stimuli were presented upright and inverted in Experiments 1 (a) and 2 (b). Analyses using d' yielded the same results. Asterisks indicate that accuracy was significantly better than chance ($p < .01$, one-tailed) by d' analysis, with a Bonferroni correction for the number of comparisons (adjusted $\alpha = .012$). Error bars indicate 1 *SEM*; because the analyses emphasize within-subjects comparisons, the standard error bars represent intrasubject variability between conditions.

EXPERIMENT 2

Method

Twenty-four adults (ages 18 to 28 years) and twenty-four 8-year-old children ($M = 8.9$ years; range = 7.94 to 8.24) participated in this experiment. All were right-handed, were Caucasian, and had normal vision. An additional 11 children and 8 adults were excluded from the analysis because they failed either the practice task (2 children) or visual screening (9 children, 8 adults). We presented the same set of adult human faces as in Experiment 1, but replaced each set of monkey faces with a set of 8-year-old human faces (see Fig. 1c). The spacing changes made to create the 8-year-old sisters were identical to the spacing changes made to create the adult sisters and the monkey sisters in Experiment 1. All participants met the inclusion criterion of achieving 70% accuracy in responding to both the adult and the child cousins.

Results and Discussion

Accuracy was high for both adult human cousins (adults: $M = .94 \pm .01$; 8-year-olds: $M = .90 \pm .02$) and 8-year-old cousins (adults: $M = .93 \pm .02$; 8-year-olds: $M = .84 \pm .02$). Again our primary interest was in performance on upright trials. The 2 (age of participant) × 2 (age of face) analysis of variance revealed only a main effect of age of participant, $F(1, 46) = 7.07$, $p_{\text{rep}} = .97$, $\eta_p^2 = .133$; the main effect of age of face and the interaction were both nonsignificant. As shown in Figure 2b, adults were more accurate than 8-year-olds, and the magnitude of this difference did not vary across face sets; 8-year-olds' accuracy did not vary across the two face sets. Furthermore, the analysis of inversion cost did not reveal any significant effects: The inversion cost was not significantly different for adult and child faces nor for the two age groups (8-year-olds for child faces: $M = .165 \pm .026$; 8-year-olds for adult faces: $M = .131 \pm .026$; adults for child faces: $M = .098 \pm .028$; adults for adult faces: $M = .125 \pm .023$). Analyses of reaction times indicated that the pattern of results could not be explained by a speed-accuracy trade-off.

The results show that the additional experience 8-year-olds have recognizing the identity of peers does not make their performance more adultlike for children's faces than for adults' faces. Despite their experience discriminating schoolmates and other children on a daily basis, 8-year-olds were less accurate than adults in discriminating spacing differences in both children's and adults' faces, and the magnitude of the performance difference between 8-year-olds and adults was roughly the same for the two kinds of faces (see Fig. 2b).

GENERAL DISCUSSION

It is well known that adults' expertise in face recognition does not extend to other-species faces (Pascalis et al., 2002). We have shown that adults are especially sensitive to second-order relations in upright human faces; their reduced sensitivity to second-order relations in monkey faces may underlie the other-species effect (i.e., their poorer recognition of the identity of monkey faces compared with human faces; Pascalis et al., 2002; our Experiment 1). Although the spacing changes were identical across face sets in Experiment 1, adults were more accurate when making same/different judgments about pairs of upright human faces than when making those judgments about monkey faces.

Although 8-year-olds were less accurate than adults when making same/different judgments based on second-order relations in all conditions, they showed the same pattern of expertise as adults. Like adults, they were 9% less accurate for monkey faces than for human faces, and they were 14% less accurate than adults for both upright human and upright monkey faces. Furthermore, their sensitivity to second-order relations was the same for 8-year-old faces as for adult faces; that is, their sensitivity did not increase when they were tested with a set of faces from a class they likely had more experience differentiating.

Adults were more accurate than 8-year-olds when discriminating monkey faces despite having minimal exposure to this class of stimuli. This result indicates that adults' better performance on tasks that tap sensitivity to second-order relations in faces cannot be explained by their greater experience differentiating individual faces, as has been postulated previously (e.g., Nelson, 2003). Rather, the difference between adults' and children's performance must be related to more general aspects of cognitive or perceptual development. Although memory improves during later childhood (e.g., Lange-Küttner & Friederici, 2000), 8-year-olds make more errors than adults even when faces are presented simultaneously (Mondloch, Dobson, Parsons, & Maurer, 2004). Two visual skills are known to improve until age 14: Vernier acuity, a hyperacuity involving sensitivity to slight misalignments between stimuli such as abutting lines (Skoczenski & Norcia, 2002), and the ability to link small oriented elements into a flowing contour (Kovacs, Kozma, Feher, & Benedek, 1999). Immaturities in either of these visual skills could limit sensitivity to second-order facial relations during development.

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