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An inner face advantage in children's recognition of familiar peers

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A B S T R A C T

Children's recognition of familiar own-age peers was investigated. Chinese children (4-, 8-, and 14-year-olds) were asked to identify their classmates from photographs showing the entire face, the internal facial features only, the external facial features only, or the eyes, nose, or mouth only. Participants from all age groups were familiar with the faces used as stimuli for 1 academic year. The results showed that children from all age groups demonstrated an advantage for recognition of the internal facial features relative to their recognition of the external facial features. Thus, previous observations of a shift in reliance from external to internal facial features can be attributed to experience with faces rather than to age-related changes in face processing.

Introduction

Faces are one of the most important classes of visual stimuli in one's social life. Faces contain socially relevant types of information, some of which are relatively permanent and stable (i.e., "face

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traits"), such as gender, race, and identity, while others are dynamic and transient (i.e., "face states"), such as gaze and emotion (Freire & Lee, 2003).

A review of the literature on the development of face trait processing shows that the majority of studies focus on the processing of configural information (i.e., the spacing between facial features) due to the controversial encoding switch hypothesis (Carey & Diamond, 1977; Diamond & Carey, 1977; Flin, 1985). This hypothesis proposes a shift in reliance from isolated features among young children to a later reliance on configural information among older children. Earlier studies specifically found that young children rely more on isolated features such as paraphernalia (e.g., clothing, presence of hat or glasses) in their recognition of faces (Carey & Diamond, 1977; Diamond & Carey, 1977). Other studies, however, have found limited susceptibility to paraphernalia when paraphernalia was included with the target stimulus *and* with distractor stimuli at test (Baenninger, 1994) or when featural changes rather than configural changes to faces are made (Freire & Lee, 2001). Despite the controversy over the timing of its initial emergence (Baenninger, 1994; Freire & Lee, 2001; McKone & Boyer, 2006; Pellicano, Rhodes, & Peters, 2006), studies have found that adult-like sensitivity to face configural information takes particularly long to mature and is not fully developed even among 14-year-olds (Mondloch, Dobson, Parsons, & Maurer, 2004; Mondloch, Geldart, Maurer, & Le Grand, 2003; Mondloch, Le Grand, & Maurer, 2002).

If children are not adult-like in their use of configural information, they may be relying more on featural information. However, how they are doing so remains unknown. The focus on when configural processing emerges, as well as the ongoing theoretical debate regarding the encoding switch hypothesis, has eclipsed the research on how children process featural information—an equally important part of face processing. Although it has been shown that featural processing is adult-like by 10 years of age (Mondloch et al., 2002), the developmental trajectory for featural processing *before* 10 years of age remains rather limited. The sparse literature on featural processing suggests that different developmental trajectories exist for different facial features. A study that thoroughly examines children's featural processing, however, has yet to be conducted.

The few studies that have examined children's featural processing have found systematic developmental patterns that are independent of configural processing. Campbell and colleagues (1999), for example, found that 5- to 13-year-olds rely more on external facial features (i.e., "outer face advantage") in their recognition of celebrities' faces, whereas the reliance on internal facial features (i.e., "inner face advantage") emerges at around 14 or 15 years of age. Want, Pascalis, Coleman, and Blades (2003) also found that 5- to 9-year-olds show an outer face advantage in their recognition of unfamiliar adult faces. Although these findings suggest that, with age, children's face processing may shift in focus from outer to inner features, it is still premature to conclude that such a developmental shift occurs. Contradictory evidence, for example, was presented by Wilson, Blades, and Pascalis (2007), who found that children as young as 5 years of age relied more on internal face parts than on external face parts in their recognition of familiar adult faces.

Although it has been shown that young children are sensitive to changes in the internal facial features (Freire & Lee, 2001; Mondloch, Leis, & Maurer, 2006) as well as to changes in the external facial contour (Mondloch et al., 2006), the few studies that have used children's faces as stimuli when examining children's differential use of inner and outer features have also found somewhat inconsistent results. Campbell, Walker, and Baron-Cohen (1995) found that, in their recognition of familiar schoolmates, 7-year-olds and younger children showed an outer face advantage, whereas 9-year-olds showed an inner face advantage. Bonner and Burton (2004), however, found an inner face advantage in children as young as 7 years of age on a matching task using faces of familiar schoolmates.

The inconsistent findings regarding the emergence of the inner face advantage between studies that use adult faces and children's faces raise the question of whether the apparent age-related outer to inner shift is due to developmental changes in face processing skills or to increased familiarity of the faces used as stimuli. Studies on adult participants that have used adult facial stimuli show that the relative reliance on internal and external features may be dependent on participants' level of familiarity with faces; as adults' familiarity with faces increases, adults shift their reliance from external to internal features (Campbell et al., 1999; Clutterbuck & Johnston, 2004; Ellis, Shepherd, & Davies, 1979; Young, Hay, McWeeny, Flude, & Ellis, 1985). Thus, it is possible that the apparent age-related shift from outer to inner features may actually be due to experience with familiar faces rather than to a genuine developmental change in face processing skills.

To date, the question of whether the age-related shift from outer to inner features is due to age-related face processing constraints or to differences in familiarity with faces remains unsettled. Although some studies have used familiar children's faces (e.g., schoolmates' faces) rather than unfamiliar adult and child faces as stimuli, the children's length of experience with the familiar faces is left uncontrolled. For example, third graders have most likely been with their classmates for a longer period of time relative to kindergartners. Failing to control children's length of exposure to faces used as stimuli, thus, results in two confounding explanations for the observed differences in children's featural processing: (a) changes in face processing with age (e.g., a switch in focus from external to internal features) and (b) unequal experience with familiar faces. The current study addresses the face processing constraint/familiarity confound in the literature not only by using children's faces as stimuli but also by ensuring that participants have known each other for the same period of time.

Previous studies have also examined children's differential use of individual internal facial features. Such studies suggest that processing of the eyes begins and matures earlier (Taylor, Edmonds, McCarthy, & Allison, 2001), with young infants showing greater fixation on the eyes (Haith, Bergman, & Moore, 1977; Maurer & Salapatek, 1976). Schwarzer and Massaro (2001), however, found that the mouth is relatively more influential than the eyes in 5-year-olds' identity judgments of adult faces. In contrast to the findings by Schwarzer and Massaro, studies that have used unfamiliar children's faces as stimuli have found that children are better at recognizing the eye region over the mouth region (Pellicano & Rhodes, 2003; Pellicano et al., 2006). Studies that have used *familiar* children's faces as stimuli have also found that the eyes are more easily recognized than the nose and mouth regions (Goldstein & Mackenberg, 1966; Hay & Cox, 2000). Therefore, to compare children's relative use of different internal features, the current study also examines children's recognition of the eye, nose, and mouth regions.

To study possible developmental changes in how children process inner faces, outer faces, and individual internal facial features, the current study recruited 4-, 8-, and 14-year-olds. We chose these age groups because the children had been in their respective kindergarten, elementary, and middle schools for only 1 academic year. This ensured that participants from all age groups would have known their classmates for the same period of time. We then examined whether there was an age-related shift in children's reliance on inner versus outer face features. We also examined possible differences in children's processing of isolated internal facial features (i.e., eyes, nose, and mouth). Participants were asked to identify each child depicted in a series of individual photographs of their classmates. The photographs showed one of the following: (a) the whole face, (b) the outer face only (i.e., ears, forehead, hair, and facial contour), (c) the inner face only (i.e., eyebrows, eyes, nose, mouth, cheeks, and chin), (d) the eyes only, (e) the nose only, or (f) the mouth only.

If there is a shift in the processing of familiar faces from external to internal features due to changes in face processing abilities, although participants from all age groups had known their classmates for 1 year, older children should perform significantly better on the internal features relative to the external features condition, whereas younger participants should show the opposite pattern. If, however, superior performance in the recognition of familiar faces is dependent on experience with such faces, similar patterns of performance should be observed across all age groups (e.g., an inner face advantage for all participants). Based on previous studies that have found an advantage in the recognition of eyes over other internal features, it was also hypothesized that children would demonstrate more accurate recognition in the eyes-only condition relative to the nose-only and mouth-only conditions.

Method

Participants

The participants were 48 4-year-olds (28 boys and 20 girls), 50 8-year-olds (29 boys and 21 girls), and 39 14-year-olds (20 boys and 19 girls). The students were Han Chinese recruited from a metropolitan city in China. The 4-year-olds (mean age = 4.88 years, SD = 0.328) were recruited from two second-year kindergarten classes with 25 students in each class (2 students chose to not participate in the study). The 8-year-olds (mean age = 8.14 years, *SD* = 0.319) were recruited from a second-year elementary classroom of 50 students. The 14-year-olds (mean age = 14.34 years, *SD* = 0.502) were recruited from a second-year middle school classroom of 39 students. These specific age groups were chosen because the children had known their classmates for 1 academic school year after their entry into kindergarten, elementary school, or middle school.

The school system in China involves a number of transitions during which children are placed in different classrooms with different students. Kindergarten classrooms consist of students who live in different parts of the city because such classrooms are typically run by the parents' workplace (e.g., company, organization). In contrast, elementary schools receive students from nearby neighborhoods, and junior high students are admitted to their schools according to their citywide entrance exam performance. Thus, in general, children meet their peers for the first time during the first year of kindergarten, elementary, or junior high school. Participants were also asked whether they knew their classmates before entering their schools, and only those who had known their classmates for 1 year were used as participants.

Stimuli

The stimuli consisted of 10 whole face color photographs of students (5 boys and 5 girls) with neutral expressions from each class. Adobe Photoshop was used to crop the faces as needed. Each photograph was used to create six different versions: (a) whole face, (b) outer face only (i.e., contour, hair, forehead, and ears), (c) inner face only (i.e., eyebrows, eyes, nose, mouth, cheeks, chin, and internal

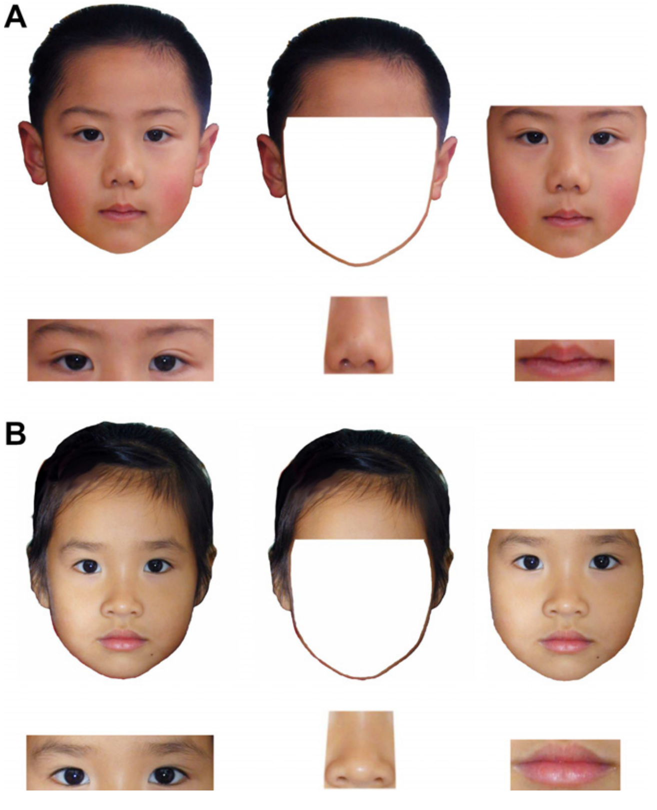

Fig. 1. Example of male (A) and female (B) stimuli across the six conditions.

outline of the face cropped 10 pixels from the external contour at 160 pixels per inch), (d) eyes only, (e) nose only, and (f) mouth only (see Fig. 1). A total of four sets of 60 color photographs were printed and pasted onto individual pieces of 13 × 18-cm white cardboard and laminated. There were four different booklets, each containing all 60 photographs, in which the photographs were presented in a different random order except for the whole face photographs that were always last.

Previous studies that have examined children's recognition of inner and outer face regions of familiar faces presented their inner/outer face stimuli in different ways. Campbell and colleagues (1995), for example, used the eyes, nose, mouth, and innermost portion of the cheeks as inner faces. Bonner and Burton (2004) used the eyes, nose, mouth, and entire cheek area as inner faces. Campbell and colleagues (1999) used the eyes, nose, mouth, cheeks, and blurred external contour in their inner face condition. Previous findings have shown that adults' recognition of external features for both familiar and unfamiliar faces is driven by hairstyle and hairline in the upper contour, whereas detection of changes in the lower contour is either at or below chance levels (O'Donnell & Bruce, 2001). Given the clear demonstration that the lower contour of the face (e.g., the chin) is not helpful in recognizing individuals, the inner faces in the current study were cropped so that they followed the external contour of the lower face. Thus, the main contrast of interest in this study's comparison of outer and inner faces is recognition of the hairstyle, hairline, ears, and forehead versus recognition of the eyes, nose, mouth, cheeks, and chin.

Procedure

The 4-year-olds were tested individually. They were told that they would be shown photographs of their classmates, but they were not told which classmates they would see. They were specifically told the following: "Last time we took some photos of everyone in your class, and today I'm going to play a game with you. See if you can name the children in these photos." For photographs showing isolated features, 4-year-olds were asked, "Whose eyes/nose/mouth is this?" If unable to answer, they were asked who the child/feature in the photograph looked like. An experimenter recorded the participants' responses. Participants were given a 2-min break if they indicated that they were tired. With no time restrictions, it took 4-year-olds approximately 20 min to complete the task.

The 8- and 14-year-olds were tested in groups of four with two experimenters present per group. Each participant was given one of the four booklets and asked to identify the child in each photograph. Participants were told that the booklets were composed of photographs of their classmates. Participants were also given a sheet to record their responses. The 8- and 14-year-olds took approximately 15 min to complete the task.

Results

Whole face condition

Table 1 shows participants' recognition of whole face peers with the chances of correctly identifying the faces from each class. Chance scores were calculated by determining the probability of iden-

Table 1
Mean percentages of correct identification, standard deviations, and chance scores

Age group	Whole face		Inner face		Outer face		Eyes		Nose		Mouth		
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	Chance score
4-year-olds	98.75	3.93	85.93	21.51	46.53	20.68	55.69	29.25	4.77	7.83	11.83	19.55	4.98
8-year-olds	98.96	3.76	90.60	15.40	58.43	19.53	48.25	26.56	60.00	3.14	6.76	10.42	2.21
14-year-olds	99.20	2.80	94.39	9.59	62.02	23.98	75.10	18.99	21.71	15.62	19.63	16.12	2.92

tifying 10 students (i.e., without replacement) from the total number of students in the classroom. For example, the chance of identifying 10 students from a class with 25 students is computed by $\sum_{j=16}^{25} 1/j$. Because class sizes varied across the different age groups, the chance scores for the age groups were different. One-sample *t* tests (two-tailed) showed that 4-, 8-, and 14-year-olds' recognition of familiar peers' whole faces were significantly above chance, $t(47) = 165.41$, $p < .001$, $t(49) = 181.99$, $p < .001$, and $t(38) = 214.49$, $p < .001$, respectively.

For those participants who also served as face stimuli, self-identification scores were excluded from the face/feature conditions. There were also a few cases ($n = 4$) in which participants in the two youngest age groups incorrectly identified a face in the whole face condition but correctly identified the corresponding inner/outer face and/or eyes. To ensure that participants were provided only with familiar face stimuli, such incorrect identification of whole faces along with their corresponding inner/outer face and isolated feature trials were excluded from participants' recognition scores.

Inner face condition versus outer face condition

Two sets of analyses were conducted to examine children's recognition of familiar peers' inner and outer faces. The first set of analyses used one-sample *t* tests to determine whether participants from each age group demonstrated above chance recognition. One-sample *t* tests (two-tailed) verified that 4-, 8-, and 14-year-olds performed at above chance levels in recognizing their peers' inner faces, $t(47) = 26.08$, $p < .001$, $t(49) = 40.57$, $p < .001$, and $t(38) = 59.57$, $p < .001$ respectively. The 4-, 8-, and 14-year-olds were also above chance in recognizing their peers' outer faces, $t(47) = 13.92$, $p < .001$, $t(49) = 20.36$, $p < .001$, and $t(38) = 15.39$, $p < .001$, respectively (see Table 1).

The second set of analyses examined the influence of stimulus gender, participant gender, and participant age in the recognition of inner and outer faces. A 2 (Stimulus Type: inner or outer face) × 2 (Stimulus Gender) × 2 (Participant Gender) × 3 (Participant Age) mixed factorial analysis of variance (ANOVA) with percentage of correct identifications as the dependent variable revealed a significant main effect of stimulus type, $F(1, 131) = 349.92$, $p < .001$, $\eta^2 = .73$. That is, the percentage correct recognition of inner faces ($M = 90.04$, $SD = 16.81$) was higher than the percentage correct recognition of outer faces ($M = 55.28$, $SD = 22.13$). There was also a significant main effect of stimulus gender, $F(1, 131) = 22.26$, $p < .001$, $\eta^2 = .15$, showing that recognition was higher for female photographs ($M = 76.26$, $SD = 17.29$) than for male photographs ($M = 69.22$, $SD = 19.84$). A significant main effect of participant age, $F(2, 131) = 6.06$, $p < .05$, $\eta^2 = .09$, also shows that performance generally improved with age. A priori comparisons show that 14-year-olds had significantly higher recognition scores ($M = 78.21$, $SD = 14.78$) relative to 4-year-olds ($M = 66.23$, $SD = 17.96$), *p*s < .05; however, recognition scores were comparable between 14- and 8-year-olds, $p > .05$.

Significant two-way interactions between stimulus type and stimulus gender, $F(1, 131) = 20.45$, $p < .001$, $\eta^2 = .14$, and between stimulus gender and participant age, $F(2, 131) = 4.00$, $p < .05$, were qualified by a significant three-way interaction among stimulus type, stimulus gender, and participant age, $F(2, 131) = 8.64$, $p < .001$, $\eta^2 = .12$. The three-way interaction was further analyzed by examining the interaction between stimulus type (i.e., inner or outer face) and participant age (i.e., 4-, 8-, or 14-year-olds) for male and female faces—both of which were significant, $F(1, 134) = 292.56$, $p < .001$, and $F(1, 134) = 182.41$, $p < .001$, respectively. Paired-sample *t* tests with sequential Bonferroni correction showed the following significant results: (a) better recognition of male outer faces by 14-year-olds relative to 4-year-olds, $p < .001$, and (b) better recognition of female outer faces by 8-year-olds relative to 4-year-olds, $p < .05$ (see Fig. 2). Results from the remaining comparisons were not significant after sequential Bonferroni adjustment of statistical significance. Most important, the main effect of stimulus type along with the nonsignificant ($p > .05$) interaction between stimulus type and participant age verified an inner face advantage for participants from all age groups.

Isolated internal features

One-sample *t* tests (two-tailed) were conducted to determine whether participants' recognition of isolated internal features was significantly above chance. In the eyes-only condition, 4-, 8-, and

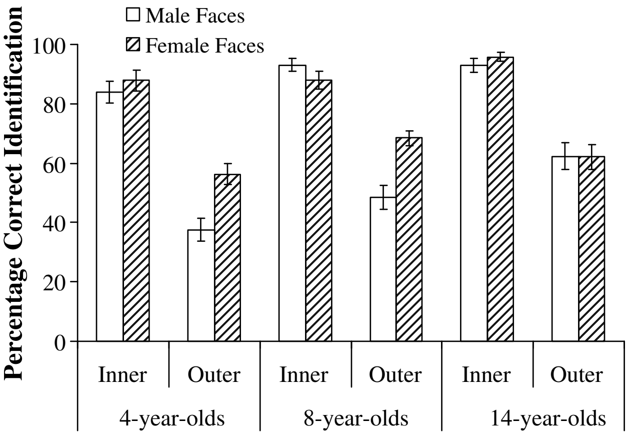

Fig. 2. The 4-, 8-, and 14-year-olds' recognition of inner and outer faces.

14-year-olds were able to recognize their peers at above chance levels, $t(47) = 12.01$, $p < .001$, $t(49) = 12.26$, $p < .001$, and $t(38) = 23.74$, $p < .001$, respectively. In the nose-only condition, only 14-year-olds were significantly above chance in recognizing their peers, $t(38) = 7.51$, $p < .001$, whereas 4-year-olds were at chance, $p > .05$, and 8-year-olds were significantly *below* chance, $t(49) = 3.63$, $p < .05$. In the mouth-only condition, 4-, 8-, and 14-year-olds were significantly above chance in recognizing their peers, $t(47) = 2.43$, $p < .05$, $t(49) = 3.08$, $p < .05$, and $t(38) = 6.48$, $p < .001$, respectively (see Table 1).

To examine whether certain facial features are more useful in children's processing of familiar faces, a 2 (Participant Gender) × 2 (Stimulus Gender) × 3 (Stimulus Type: eyes, nose, or mouth) × 3 (Participant Age) mixed factorial ANOVA was conducted on percentage of correctly identified features. Results revealed a significant main effect of participant gender, $F(1, 131) = 10.50$, $p < .05$, $\eta^2 = .07$, with girls ($M = 30.38$, $SD = 11.73$) performing better than boys ($M = 23.05$, $SD = 15.10$). A significant main effect of stimulus type with Greenhouse–Geisser correction, $F(1.51, 198.04) = 382.19$, $p < .001$, $\eta^2 = .75$, was further analyzed with paired-sample t tests and sequential Bonferroni correction. Paired-sample t tests indicated that, as expected, participants were better at recognizing eyes ($M = 58.50$, $SD = 27.77$) over noses ($M = 8.07$, $SD = 13.06$) and mouths ($M = 12.20$, $SD = 16.45$),

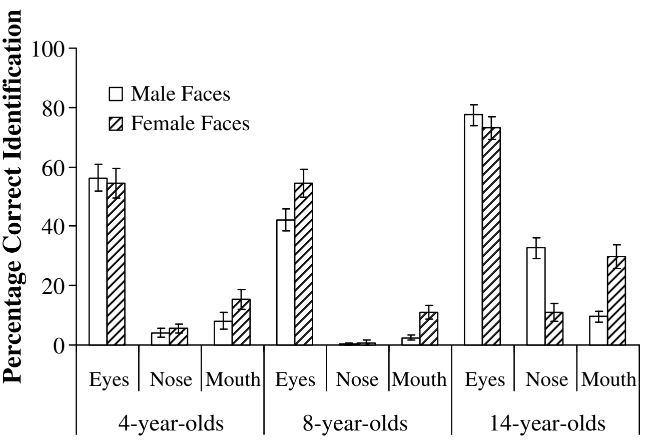

Fig. 3. The 4-, 8-, and 14-year-olds' recognition of isolated internal features.

$p < .001$. Participants were also significantly better at recognizing mouths over noses, $p < .05$. There was also a significant main effect of participant age, $F(2, 131) = 35.12$, $p < .001$, $\eta^2 = .35$. A priori comparisons show that the 14-year-olds ($M = 38.81$, $SD = 12.28$) had higher recognition scores relative to the 4-year-olds ($M = 24.10$, $SD = 11.68$) and 8-year-olds ($M = 18.54$, $SD = 10.86$), $ps < .001$.

A two-way interaction between stimulus type and participant gender, $F(2, 262) = 7.86$, $p < .001$, $\eta^2 = .06$ was further analyzed with paired-sample t tests and the sequential Bonferroni correction. Male and female participants were better at recognizing the eyes relative to the nose and mouth, $ps < .001$. However, although girls were also significantly better at recognizing mouths over noses, $p < .05$, boys showed no difference in their recognition of mouths and noses, $p > .05$. The remaining significant two-way interactions between stimulus gender and participant age, $F(1, 131) = 5.89$, $p < .05$, $\eta^2 = .08$, stimulus gender and participant gender, $F(1, 131) = 17.39$, $p < .001$, $\eta^2 = .12$, and stimulus type and stimulus gender, $F(2, 262) = 32.74$, $p < .001$, $\eta^2 = .20$, all were qualified by the significant three-way interactions to be described next.

A significant three-way interaction among stimulus gender, stimulus type, and participant age, $F(4, 262) = 14.48$, $p < .001$, $\eta^2 = .18$, was further analyzed by examining the interaction between stimulus gender and stimulus type across participant age. This interaction was significant for 4-, 8-, and 14-year-olds, $F(1, 134) = 206.63$, $p < .001$, $F(1, 134) = 128.98$, $p < .001$, and $F(1, 134) = 441.23$, $p < .001$, respectively. Following the sequential Bonferroni correction, 4-year-olds showed better recognition of female mouths than of male mouths, $p < .05$. The 8-year-olds were significantly better at recognizing female eyes over male eyes, $p < .05$, and at recognizing female mouths over male mouths, $p < .001$. The 14-year-olds were also significantly better at recognizing male noses over female noses, $p < .001$, and at recognizing female mouths over male mouths, $p < .001$ (see Fig. 3).

A second three-way interaction among stimulus gender, participant gender, and participant age was also significant, $F(2, 131) = 7.15$, $p < .05$, $\eta^2 = .10$. This interaction was further analyzed by examining the interaction between stimulus gender and participant gender across participant age. The interaction was not significant for 4-year-olds, $p > .05$. However, it was significant for 8- and 14-year-olds, $F(1, 48) = 8.81$, $p < .05$, $\eta^2 = .16$, and $F(1, 37) = 17.92$, $p < .001$, $\eta^2 = .33$, respectively. Pairwise comparisons with sequential Bonferroni correction showed that 8-year-old boys recognized male and female features equally well, whereas 8-year-old girls were significantly better at recognizing female features over male features, $p < .001$. The 14-year-old boys were also significantly better at recognizing male features over female features, $p < .05$, whereas the 14-year-old girls were significantly better at recognizing female features over male features, $p < .05$ (see Fig. 4).

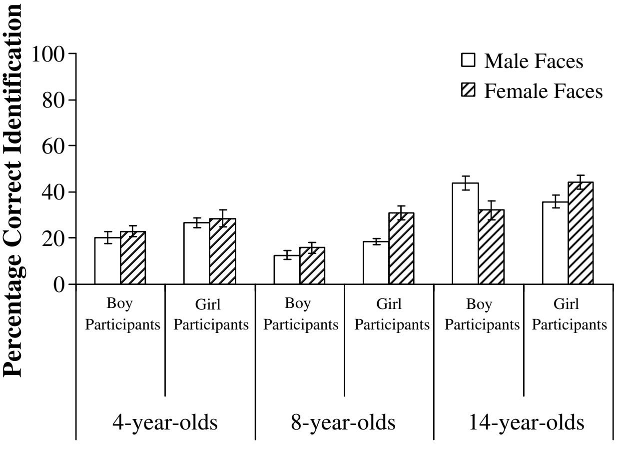

Fig. 4. Male and female participants' recognition of isolated internal features.

Item analysis

An item analysis was conducted to ensure that the stimuli used in all face conditions were approximately equal in recognizability. Standard scores were computed for each face/feature across all face/feature conditions. Recognition of only one 4-year-old female nose was greater than 2 standard deviations from the mean recognition score in the nose-only condition, suggesting that this girl has a relatively more distinctive nose. However, this does not seem to have influenced the results considering the lack of advantage in 4-year-olds' recognition of male noses versus female noses. All of the remaining 4-, 8-, and 14-year-old stimuli were less than 2 standard deviations from the mean face/feature recognition scores.

Discussion

The results showed that 4-, 8-, and 14-year-olds were above chance in the recognition of their peers' faces in the whole face, inner face, and outer face conditions. The main effect of stimulus and the lack of an interaction between stimulus and participant age also shows that participants from all three age groups demonstrated an inner face advantage in their recognition of familiar peers' faces. This finding of an inner face advantage for familiar faces among even the youngest age group is consistent with Bonner and Burton's (2004) and Wilson and colleagues' (2007) findings of an inner face advantage in 7- and 5-year-olds and extends this finding to 4-year-olds.

However, our findings are inconsistent with those of Campbell and colleagues (1995), who found an outer face advantage in 7-year-olds. The current findings are also inconsistent with those of Campbell and colleagues (1999), who found an outer face advantage in 5- to 13-year-olds. One explanation for this inconsistency in findings could be the slight variability in the nature of the inner and outer features used. Campbell and colleagues (1995) included the eyebrows, eyes, nose, mouth, and inner cheek area of children's faces for their inner face condition, and Campbell and colleagues (1999) included the same adult features in their inner face condition but blurred the remaining external features so that the external features were not sharply focused but still somewhat visible. In addition to the internal features used by Campbell and colleagues (1995, 1999), the current study also included a larger portion of the cheek area and the chin and cropped the outline of the facial contour of children's faces. The inner face condition in the study by Bonner and Burton (2004), however, more closely resembled the inner face condition in the studies by Campbell and colleagues (1995, 1999). That is, Bonner and Burton (2004) included children's eyebrows, eyes, nose, mouth, and cheeks in the inner face condition, but their findings remain inconsistent with those of Campbell and colleagues (1995, 1999) and are actually consistent with findings from the current study. Thus, the inconsistent findings cannot be attributed entirely to the variable use of inner and outer faces.

Bonner and Burton (2004), Wilson and colleagues (2007), and the current study made efforts to ensure that the stimuli used were truly familiar to their child participants and found an inner face advantage in their familiar face recognition. Thus, it seems likely that the findings by Campbell and colleagues (1995, 1999) differ from the findings in the current study because of their child participants' unequal familiarity with the face stimuli used. Thus, the current study suggests that the shift in children's relatively greater reliance on external to internal facial features is driven by experience with faces rather than by changes in face processing abilities. Children's experience with their classmates might lead them to rely on the internal facial features for identification purposes because of the internal features' relatively unchanging nature compared with external features that are more easily altered by changing hairstyles and/or the addition of paraphernalia (e.g., hats). Children's relative use of isolated internal features (i.e., superior recognition of the eye region and worst recognition of the nose) also parallels the differential growth of such features. That is, the eyes undergo much less physical change relative to the nasal region (Enlow & Hans, 1996). Thus, children may rely most on the eye region because it is a relatively more invariant cue to identity.

It is interesting to compare children's inner face advantage in familiar face recognition in the current study with previous findings of an outer face advantage in children's recognition of *unfamiliar* faces. Want and colleagues (2003), for example, found an outer face advantage in 5- and 7-year-olds' recognition of unfamiliar adult faces, and Bonner and Burton (2004) found that 10- and 11-year-olds were more accurate in their recognition when provided with the external features rather than the internal features of unfamiliar children's faces. Collectively, these studies suggest that children use different facial cues in their recognition of familiar and unfamiliar faces. Children's reliance on external features for recognition of unfamiliar faces and their reliance on internal features for recognition of familiar faces parallel adult findings by Clutterbuck and Johnston (2004) that suggest a shift in adults' efficiency in processing from external to internal facial features as stimuli increase in familiarity (i.e., unfamiliar to experimentally familiarized faces or previously familiar faces).

The current study's examination of children's recognition of familiar peers' isolated internal features also provides some insight regarding which parts of the inner face are most important for recognition. Although all age groups were above chance in their recognition of their familiar peers' eyes and mouths, noses appear to be the most difficult feature to recognize, with above chance performance by only the oldest age group. The significant main effect of stimulus type shows that the eyes were better recognized than the nose and mouth regions for children across all three age groups. Thus, it seems likely that the inner face advantage for familiar faces is driven primarily by recognition of the eye region. This is consistent with findings by O'Donnell and Bruce (2001) showing that adults are relatively more sensitive to both featural and spacing changes in the eye region for familiarized faces than for unfamiliar faces. Similarly, Heisz and Shore (2008) found that increased familiarity with faces leads to an increase in the scanning of the eyes relative to the scanning of other features.

Superior performance in the eyes-only condition across the three age groups is also consistent with previous studies suggesting that children are better at recognizing the eye region relative to either the nose or mouth region (Hay & Cox, 2000; Pellicano & Rhodes, 2003; Pellicano et al., 2006). Above chance performance in the mouth-only condition by 4-year-olds, however, parallels Schwarzer and Massaro's (2001) findings of 5-year-olds' use of the mouth region in identity judgments. Despite the above chance recognition of the mouth in the current study, it should be noted that recognition was still quite low—particularly for the 4- and 8-year-olds. However, results from the oldest age groups shows that 14-year-olds' recognition of the eyes, noses, and mouths of familiar faces is above chance. This is consistent with findings that 10-year-olds are adult-like in their recognition of faces based on changes in the shape of the eyes and mouth (Mondloch et al., 2002).

The current study also found a main effect of age in the recognition of inner/outer faces and isolated internal features, with older participants showing generally higher rates of recognition. Although the inner face advantage among the three age groups alludes to the importance of experience with faces, the improvement in recognition with age may reflect a general cognitive development (e.g., improvement in memory) or a development in face recognition ability in particular. Such age-related improvements are consistent with findings from previous studies that have examined the development of facial recognition (Carey & Diamond, 1977; Ellis & Flin, 1990; Flin, 1985; Goldstein & Chance, 1964; Goldstein & Mackenberg, 1966; Hay & Cox, 2000; Mondloch et al., 2002, 2003; Mondloch, Maurer, & Ahola, 2006).

There was also an interaction between stimulus gender and type of isolated feature for all three age groups, such that 4-year-olds showed better recognition of female mouths relative to male mouths and 8-year-olds showed better recognition of female eyes and mouths relative to male eyes and mouths. By 14 years of age, however, male noses are better recognized than female noses, whereas female mouths are better recognized than male mouths. Further examination of children's recognition of isolated facial features also reveals some participant gender and cross-gender effects. At 8 years of age, girls were better at recognizing own-age female facial features over male facial features. This own-gender bias in 8-year-old females' recognition of facial features is consistent with previous findings that girls who are 10 years old or younger demonstrate better recognition for familiarized female faces compared with their recognition for familiarized male faces (Cross, Cross, & Daly, 1971; Feinman & Entwisle, 1976). Rehnman and Herlitz (2006) found similar results in that 8- to 10-year-old girls were significantly better than boys in recognizing familiarized female faces.

In addition to the own-gender bias in 8-year-old girls, the current study found an own-gender bias at 14 years of age, when girls were better at recognizing own-age female over male facial features, whereas boys were better at recognizing own-age male over female facial features. This observed own-gender effect might be due to the universal sex-typed behavior and preference for same-sex peers (Bukowski, Gauze, Hoza, & Newcomb, 1993; Martin & Little, 1990) that emerges during the preschool years and develops throughout childhood (Maccoby & Jacklin, 1987; Serbin, Powlishta, & Gulko, 1993; Serbin & Sprafkin, 1986). This universal sex segregation among children might have resulted in differential experience with same-sex and different-sex faces, which in turn explains adolescents' superior recognition of familiar same-sex peers. Thus, this own-gender effect once again alludes to the role of differential experience in face processing. However, it should be noted that an own-gender effect for both male and female participants was observed only in the oldest age group, which also had the highest rates of feature recognition. Thus, it is possible that the effect of differential experience occurs in tandem and interacts with general cognitive development, such that with increased age children become increasingly able to recognize the more familiar same-sex face features.

Previous studies also have reported an own-gender advantage in the face recognition of adolescent girls (Cross et al., 1971; Ellis, Shepherd, & Bruce, 1973) and of adult women (Going & Read, 1974; Lewin & Herlitz, 2002; Rehnman & Herlitz, 2007). Other studies also have shown an own-gender effect in adults, with female participants showing better recognition of learned female faces over learned male faces and male participants showing better recognition of learned male faces over learned female faces (McKelvie, 1987; McKelvie, Standing, St. Jean, & Law, 1993; Witryol & Kaess, 1957; Wright & Sladden, 2003). Thus, it is also possible that the cross-gender effect seen in the current study is a precursor to the adult phenomenon.

Despite the significant findings, a number of limitations about the current study should be noted. One limitation concerns the small number of face stimuli (i.e., 10 faces) used. The limited face stimuli were used because of our consideration of the youngest group's memory capacity and attention span for our tasks. Nevertheless, using only 10 faces to evaluate recognition of inner features, outer features, eyes, nose, and mouth might have inflated recognition. A second limitation involves the procedural differences in testing the youngest age group and the older age groups. The 4-year-olds were tested individually, whereas the 8- and 14-year-olds were tested in small groups. Although it cannot be entirely dismissed that the results might have been influenced by the procedural differences in testing the youngest and older participants, the reported age effect in facial recognition, the superior performance in the eyes-only condition, and the own-gender advantage in facial recognition are consistent with previous findings in the literature. Thus, it seems unlikely that the results from the current study are attributable to the discussed procedural differences. The conclusions from the current study regarding children's recognition of inner and outer faces are also limited to the specific procedures used in the current study (i.e., inner faces presented only in the absence of external features and outer faces presented only in the absence of internal features). As indicated by findings regarding the distracting effects of paraphernalia on children's facial recognition (Carey & Diamond, 1977; Diamond & Carey, 1977; Freire & Lee, 2001), the inclusion of some sort of paraphernalia may potentially alter the results obtained from the current study.

In summary, there appear to be genuine developmental changes in face processing, as is evident by the observed age effects in the current study in terms of children's recognition of inner faces, outer faces, and isolated facial features. The shift from a relative reliance on external to internal facial features, however, is clearly experiential. Even 4-year-olds showed better recognition in the inner face condition relative to the outer face condition when the facial stimuli used were familiar own-age peers. A comparison of children's recognition of isolated facial features also suggests that this inner face advantage may be driven primarily by children's superior recognition of the eye region. Finally, the own-gender effect observed among the 8-year-old female participants and the 14-year-old male and female participants shows how developmental changes in face processing can be modulated by experience with different classes of faces (e.g., same-sex and own-age faces). That is, although face processing may improve with age, superior recognition might be most conspicuous for specific classes of faces with which individuals are most familiar.

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