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Face Feature Processing in Children: What Develops and What Does Not?

ABSTRACT

Children’s recognition of familiar own-age peers was investigated. Four-, 8-, and 14-year-old Chinese children 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. In contrast to previous findings, 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. Previous observations of a shift in reliance from external to internal facial features can, thus, be attributed to experience with faces rather than to age-related changes in face processing. Consistent with results from other studies, children from all age groups were best at recognizing the eye region relative to either the nose or the mouth regions. However, children’s recognition of inner faces, outer faces and isolated facial features (i.e., eyes, nose, and mouth) did improve with age. Cross-gender effects were also found among the 14-year-olds, with females showing better recognition of female features, and males showing better recognition of male features, suggesting an interaction between experience and maturation.

Face Feature Processing in Children: What Develops and What Does Not?

Faces are one of the most important visual stimuli in one's social life. Faces contain socially relevant information, some of which are relatively permanent and stable (i.e., "face 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, or 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 facial stimuli at test (Baenninger, 1994), or when featural 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, Le Grand, & Maurer, 2002; Mondloch, Geldart, Maurer, & Le Grand, 2003; Mondloch, Dobson, Parsons, & Maurer, 2004).

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 age10 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, while the reliance on internal facial features (i.e., "inner-face advantage") emerges at about 14 to 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, is 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.

It is also important to note that the studies by Campbell and colleagues, Want and colleagues, and Wilson and colleagues, used adult faces – a class of stimuli that may be generally unfamiliar to children. Moreover, 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, while 9-year-olds showed an inner-face advantage. Consistent with these findings by Campbell and colleagues (1995), Mondloch, Leis, and Maurer (2006) showed that 4-year-olds are sensitive to changes in the external facial contour when using familiarized children's faces as stimuli. 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. In line with Bonner and Burton's (2004) observation of an inner-face advantage in 7-year-olds, Mondloch and colleagues (2006) also found that 4-year-olds are sensitive to changes in the internal features of faces (but not to changes in the spacing of the internal facial features).

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 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 increase, they 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). It is thus possible that the age-related shift from outer to inner features may actually be due to experience with familiar faces rather than 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, children in grade 3 have most likely been with their classmates for a longer period of time relative to children in kindergarten. 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: i) changes in face processing with age (e.g., a switch in focus from external to internal features), and ii) unequal experience with familiar faces. The present study will address the face processing constraint/familiarity confound in the literature by not only 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 eyes than the mouth regions (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). To compare children's relative use of different internal features, the present study will thus also examine children's recognition of the eyes, nose and mouth regions.

To study possible developmental changes in children's featural processing, the present 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. The present study 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: i) the whole face, ii) the outer face only (i.e., ears, forehead, hair, and facial contour), iii) the inner face only (i.e., eyebrows, eyes, nose, mouth, cheeks, and chin), iv) the eyes only, v) the nose only, or, vi) 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, then 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, while younger participants should show the opposite pattern. If, however, superior performance on 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 alone condition relative to the nose and mouth alone conditions.

Method

Participants

Forty-eight 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) participated in the study. The students were Han Chinese recruited from a metropolitan city in China. Four-year-olds (M = 4.88, SD = .328) were recruited from 2 second-year kindergarten classes with 25 students in each class. The 8-year-olds (M = 8.14, SD = .319) were recruited from a second-year elementary classroom of 50 students, and the 14-year-olds (M = 14.34, SD .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, respectively.

Stimuli

The stimuli consisted of 10 full face color photographs (5 boys and 5 girls) of students with neutral expressions from each class. Adobe Photoshop was used to crop the faces as needed. Each photograph was used to create 6 different versions: i) whole face, ii) outer face only (i.e., contour, hair, forehead, and ears), iii) inner face only (i.e., eyebrows, eyes, nose, mouth, cheeks, chin, and internal outline of the face cropped 3 pixels from the external contour at 160 pixels per inch), iv) eyes only, v) nose only, and vi) mouth only (see Figure 1). A total of four sets of 60 color photographs were printed and pasted onto individual pieces of 13 x 18 cm white cardboard and laminated. There were 4 different booklets, each containing all 60 photographs, in which the photographs were presented in a different random order except for the whole face photographs which were always last.

Procedure

Four-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."* Except for whole faces which were always presented last, the other photographs were presented in a random order. For photographs showing isolated features, 4-year-olds were asked *"Whose eyes/nose/mouth is this?"* If unable to answer, 4-year-olds were asked who the child/feature in the photograph looked like. An experimenter recorded the participants' responses. Participants were given a 2 minute break if they indicated that they were tired. With no time restrictions, it took 4-year-olds approximately 20 minutes to complete the task.

Eight- and 14-year-olds were tested in groups of 4 with 2 experimenters present per group. Each participant was given 1 of the 4 booklets with the photographs presented in a different order (i.e., except whole faces were always presented last) and asked to identify the child in each photograph. Participants were told that the booklets were comprised of photographs of their classmates. Participants were also given a sheet to record their responses. Eight- and 14-year-olds took about 15 minutes 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 (see Table 1) were calculated by determining the probability of identifying 10 students (i.e., the 10 faces used as stimuli) from the total number of students in the classroom. For example, to determine the chance of identifying 1 student from a class with 25 students, 1 is divided by 25. To determine the chance of identifying 10 students from a class with 25 students, 1 is divided by 25 and the resulting figure is multiplied by 10. Because class sizes varied across the different age groups, the chance scores for each age group were different. One-sample t-tests (2-tailed) showed that 4-, 8-, and 14-year-olds' recognition of familiar peers' whole faces were significantly above chance, $t(47) = 167.14$, $p < .001$, $t(49) = 182.38$, $p < .001$, and $t(38) = 215.20$, $p < .001$ respectively.

For those participants who also served as face stimuli, self-identification scores were excluded from the face/feature conditions and total scores were adjusted via linear transformation (i.e., total recognition score was divided by 9 instead of 10 and the resulting figure was multiplied by 10). There were also a few cases ($n = 4$) in which participants in the 2 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 only provided with familiar face stimuli, such correct identifications were excluded from their inner/outer face and eyes recognition scores and scores were adjusted via linear transformation.

Inner Face Condition vs. 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 (2-tailed) verified that 4-, 8-, and 14-year-olds performed at above chance levels in recognizing their peers' inner faces, $t(47) = 26.39$, $p < .001$, $t(49) = 40.67$, $p < .001$, and $t(38) = 59.78$, $p < .001$ respectively. Four-, 8-, and 14-year-olds were also above chance in recognizing their peers' outer faces, $t(47) = 14.25$, $p < .001$, $t(49) = 20.44$, $p < .001$, and $t(38) = 15.47$, $p < .001$ respectively.

The second set of analyses examined the influence of stimulus gender, participant gender, and participant age in the recognition of inner and outer faces. Recognition scores were adjusted by subtracting chance scores from the total inner and outer face recognition scores. A 2 (stimulus type: inner vs. outer face) x 2 (stimulus gender) x 2 (participant gender) x 3 (participant age) mixed factorial ANOVA with number of correct identifications as the dependent variable revealed a significant main effect of type of stimulus, $F(1, 131) = 349.92$, $p < .001$, $\eta^2 = .73$. That is, recognition of inner faces ($M = 8.41$, $SD = 1.72$) was higher than recognition of outer faces ($M = 4.96$, $SD = 2.28$). There was also a significant main effect of stimulus gender, $F(1, 131) = 12.62$, $p < .05$, $\eta^2 = .09$, showing that recognition was higher for female photographs than for male photographs. A significant main effect of age, $F(2, 131) = 11.09$, $p < .001$, $\eta^2 = .15$, also shows that performance generally improved with age. A priori comparisons show that relative to 4-year-olds, 8- and 14-year-olds were better at recognizing familiar peers' inner and outer faces (p values $< .001$).

The significant 2-way interaction between type of stimulus and stimulus gender, $F(1, 131) = 20.45$, $p < .001$, $\eta^2 = .14$ was qualified by the significant 3-way interaction between type of stimulus, stimulus gender, and participant age, $F(2, 131) = 8.64$, $p < .001$, $\eta^2 = .12$. The 3-way interaction was further analyzed by examining the interaction between type of stimulus and participant age 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-samples t-tests with sequential Bonferroni correction showed the following significant results: i) better recognition of male inner faces by 8-year-olds relative to 4-year-olds ($p < .05$), ii) better recognition of male outer faces by 14-year-olds relative to 4-year-olds ($p < .001$), iii) better recognition of female inner faces by 14-year-olds relative to 4-year-olds ($p < .05$), and iv) better recognition of female outer faces by 8-year-olds relative to 4-year-olds ($p < .001$). Results from the remaining comparisons were not significant (p values $> .05$). Most importantly, the main effect of type of stimulus along with the non-significant ($p > .05$) interaction between type of stimulus and participant age verified an inner-face advantage for participants from all age groups (see Figure 2).

Isolated Internal Features

One-sample t-tests (2-tailed) were conducted to determine whether participants' recognition of isolated internal features is significantly above chance. In the eyes only condition, 4-, 8-, and 14-year-olds were able to recognize their peers at above chance levels, $t(47) = 12.25$, $p < .001$, $t(49) = 12.32$, $p < .001$, and $t(38) = 23.84$, $p < .001$ respectively. In the nose only condition, only 14-year-olds were significantly above chance in recognizing their peers, $t(38) = 7.64$, $p < .001$, while 4-year-olds were at chance, $p > .05$, and 8-year-olds were significantly below chance, $t(49) = 3.16$, $p < .05$. In the mouth only condition, 4-, 8-, and 14-year-olds were significantly above chance in recognizing their peers, $t(47) = 2.78$, $p < .05$, $t(49) = 3.23$, $p < .05$, and $t(38) = 6.60$, $p < .001$ respectively.

To examine whether certain facial features are more useful in children's processing of familiar faces, a 2 (participant gender) x 2 (stimulus gender) x 3 (stimulus type: eyes, nose, or mouth) x 3 (participant age) mixed factorial ANOVA was conducted. The recognition scores entered into the ANOVA were adjusted so that chance scores were subtracted from the total eyes/nose/mouth recognition scores. Results revealed a significant main effect of participant gender, $F(1, 131) = 10.50$, $p < .05$, $\eta^2 = .07$, with females performing better than male participants. A significant main effect of type of stimulus with Greenhouse-Geisser correction, $F(1.51, 262) = 382.19$, $p < .001$, $\eta^2 = .75$, was further analyzed with paired-samples t-tests and the sequential Bonferroni correction. Paired-samples t-tests indicated that, as expected, participants were better at recognizing eyes ($M = 5.27$, $SD = 2.79$) compared to their recognition of noses ($M = .23$, $SD = 1.34$) and mouths ($M = .64$, $SD = 1.64$), $p < .001$. Participants were also significantly better at recognizing mouths than noses ($p < .05$). There was also a significant main effect of age, $F(2, 131) = 36.84$, $p < .001$, $\eta^2 = .36$. A priori comparisons with the 4-year-olds as the comparison group show no difference in performance between 4- and 8-year-olds ($p > .05$). However, 14-year-olds performed better than 4-year-olds ($p < .001$); see Figure 3.

The 2-way interaction between type of stimulus and participant gender, $F(2, 262) = 7.86$, $p < .001$, $\eta^2 = .06$ was further analyzed with paired-samples t-tests and the sequential Bonferroni correction. Male and female participants were better at recognizing the eyes relative to the nose and mouth (p values < .001). However, although females were also significantly better at recognizing mouths relative to noses ($p < .05$), males showed no difference in their recognition of mouths and noses ($p > .05$). The remaining significant 2-way interactions between stimulus gender and participant age, $F(1, 131) = 5.72$, $p < .05$, $\eta^2 = .08$, stimulus gender and participant gender, $F(1, 131) = 17.39$, $p < .001$, $\eta^2 = .12$, and type of stimulus and stimulus gender, $F(2, 262) = 32.74$, $p < .001$, $\eta^2 = .20$ were all qualified by the significant 3-way interactions to be described next.

The significant 3-way interaction between stimulus gender, type of stimulus, and participant age, $F(4, 262) = 14.48$, $p < .001$, $\eta^2 = .18$, was further analyzed by examining the interaction between stimulus gender and type of stimulus across participant age. This interaction was significant for 4-, 8-, and 14-year-olds, $F(1, 134) = 88.53$, $p < .001$, $F(1, 134) = 78.38$, $p < .001$, and $F(1, 134) = 333.26$, $p < .001$, respectively. Following the sequential Bonferroni correction, there were no significant differences in 4-year-olds' recognition of male and female isolated internal features. However, 8-year-olds were significantly better at recognizing female eyes over male eyes ($p < .05$), and female mouths over male mouths ($p < .001$). Fourteen-year-olds' were also significantly better at recognizing male noses over female noses ($p < .001$), and female mouths over male mouths ($p < .001$).

A second 3-way interaction between 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 the 8- and 14-year-olds, $F(1, 48) = 8.81$, $p < .05$, and $F(1, 37) = 17.92$, $p < .001$, 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 ($p < .001$). Fourteen-year-old boys were also significantly better at recognizing male features over female features ($p < .05$), whereas 14-year-old girls were significantly better at recognizing female over male features ($p < .05$).

Item Analysis

An item analysis was conducted to ensure that the stimuli used in all face conditions were roughly 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 (i.e., $z = 2.25$) from the mean recognition score in the nose only condition, which suggests that this female 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 versus female noses. The remaining 4-, 8-, and 14-year-old stimuli were all under 2 standard deviations from the mean face/feature recognition scores.

Discussion

The results show that 4-, 8-, and 14-year-olds were above chance in their 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 3 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 respectively and extends this finding to 4-year-olds.

However, our findings are inconsistent with those of Campbell, Walker, and Baron-Cohen (1995) who found an outer-face advantage in 7-year-olds. The present findings are also inconsistent with findings by Campbell and colleagues (1999) who found an outer-face advantage in 5- to 13-year-olds. One explanation for this inconsistency in findings concerns the slight variability in the nature of the inner and outer features used. Campbell, Walker, and Baron-Cohen (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 identical features in their inner face condition using adult faces, 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 present study also included a larger portion of the cheek area, the chin, and followed the outline of the facial contour of children's faces. The inner face condition in the study by Bonner and Burton, however, more closely resembled the inner face condition in the studies by Campbell and colleagues (1995; 1999). That is, Bonner and Burton 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 present study. It therefore seems unlikely that the inconsistent findings are due to variability in the inner and outer face conditions across studies. Bonner and Burton, Wilson and colleagues, and the present 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 more likely that the findings by Campbell and colleagues (1995; 1999) differ from the findings in the present study because of their child participants' unequal familiarity with the face stimuli used. The present study thus 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. Given the critical nature of the type of stimuli used in relation to these findings, the present study highlights the importance of using equally familiar faces as stimuli when investigating how children at different age groups process faces.

It is interesting to compare children's inner-face advantage in familiar face recognition in the present study to 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- to 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), which 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 and familiar faces).

The present 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 3 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 which have examined the development of facial recognition (Carey & Diamond, 1977; Ellis & Flin, 1990; Goldstein & Chance, 1964; Goldstein & Mackenberg, 1966; Flin, 1985; Hay & Cox, 2000; Mondloch et al., 2002; 2003; Mondloch, Maurer, & Ahola, 2006). 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 only among the oldest age group. The significant main effect of type of stimuli, however, shows that the eyes were better recognized than the nose and mouth regions. Superior performance in the eyes only condition across the 3 age groups is consistent with previous studies which suggest that children are better at recognizing the eye region relative to either the nose or the mouth (Hay & Cox, 2000; Pellicano & Rhodes, 2003; Pellicano et al., 2006). Above chance performance in the mouth only condition among 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 present 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 are all 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).

There was also an interaction between stimulus gender and type of isolated feature for the 2 older age groups. Four-year-olds showed better recognition of female mouths compared 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, while female mouths are better recognized than male mouths. The maturation of sexually dimorphic facial features that occur during the adolescent years (Enlow & Hans, 1996) might account for 14-year-olds'greater recognition of male noses relative to female noses. That is, male noses tend to be larger and therefore possibly more salient than female noses. Greater recognition of female mouths relative to male mouths by 8- and 14-year-olds is relatively more difficult to explain. One possibility is that mouths are the more salient feature for female faces.

Further examination of children's recognition of isolated facial features also reveals some gender and cross-gender effects. At 8 years of age, girls were better at recognizing own-age female facial features than 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 to 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 present study found a cross-gender effect at 14 years when girls were better at recognizing own-age female over male facial features, while boys were better at recognizing own-age male over female facial features.

This observed cross-gender effect might be due to the universal sex-typed behavior and preference for same-sex peers (Martin & Little, 1990; Bukowski, Gauze, Hoza, & Newcomb,

1993) 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 explain adolescents' superior recognition of familiar same-sex peers. Thus, this cross-gender effect once again alludes to the role of differential experience in face processing. However, it should be noted that the cross-gender effect was only observed in the oldest age group that 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 became increasingly better able to recognize the more familiar same-sex face features.

It is, however, interesting to note that a number of previous studies report an own-gender advantage in adolescent females' recognition when using familiarized rather than familiar facial stimuli (Cross et al., 1971; Ellis, Shepherd, & Bruce, 1973). The cross-gender effect in adolescents that is observed in the present study might, therefore, be limited to familiar faces. This would be consistent with evidence that the own-gender advantage in recognition is specific to female adults only when tested with familiarized facial stimuli (Going & Read, 1974; Lewin & Herlitz, 2002; Rehnman & Herlitz, 2007). Other studies, however, have found a cross-gender effect in adults with female participants showing better recognition of learned female faces relative to their recognition of learned male faces, and male participants showing better recognition of learned male faces relative to their recognition of learned female faces (McKelvie, 1987; McKelvie, Standing, St. Jean, & Law, 1993; Witryol & Kaess, 1957; Wright & Sladden, 2003). It is, thus, also possible that the cross-gender effect seen in the present study is a precursor to the adult phenomenon. On the other hand, the cross-gender effect in adolescents' recognition of familiar faces in the present study is difficult to integrate with the mixed findings in the adult literature.

Despite the significant findings, a number of limitations about the present 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 only, nose only, and mouth only raises the possibility that the results might be specific for these particular faces. The use of only 10 faces across all face/feature conditions might also have inflated recognition. Thus, although our item analyses showed that only one female nose was particularly distinctive, it remains necessary to replicate our findings from the present study with the use of a larger set of familiar faces.

A second limitation involves the procedural differences in testing the youngest age group and the older age groups. Four-year-olds were tested individually, while 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 the 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. It, thus, seems unlikely that the results from the present study are attributable to the discussed procedural differences. The conclusions from the present study regarding children's recognition of inner and outer faces are also limited to the specific procedures used in the present study (i.e., inner faces only presented in the absence of external features and outer faces only presented 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 present study.

In summary, there appear to be genuine developmental changes in face processing as is evident by the observed age effects in the present 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. Finally, the cross-gender effect observed in the oldest age group 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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Figure Captions

Figure 1. Example of stimulus across 6 conditions.

Figure 2. Four-, 8-, and 14-year-olds' recognition of inner and outer faces.

Figure 3. Four- 8-, and 14-year-olds' recognition of isolated internal features.

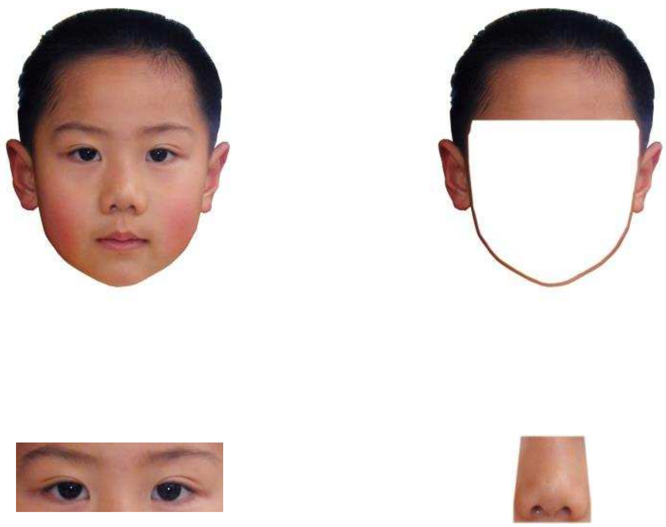
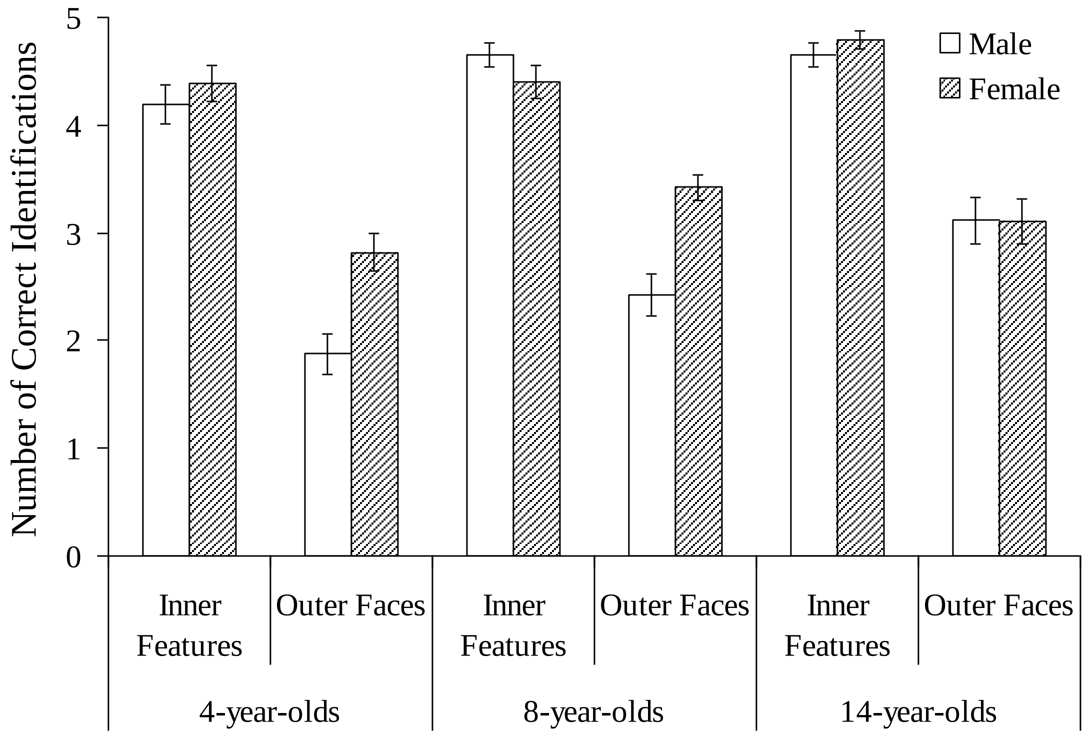


Figure 1



Number of Correct Identifications
5
4
3
2
1
0
Male
Female
Inner Features
Outer Faces
Inner Features
Outer Faces
Inner Features
Outer Faces
4-year-olds
8-year-olds
14-year-olds

Figure 2

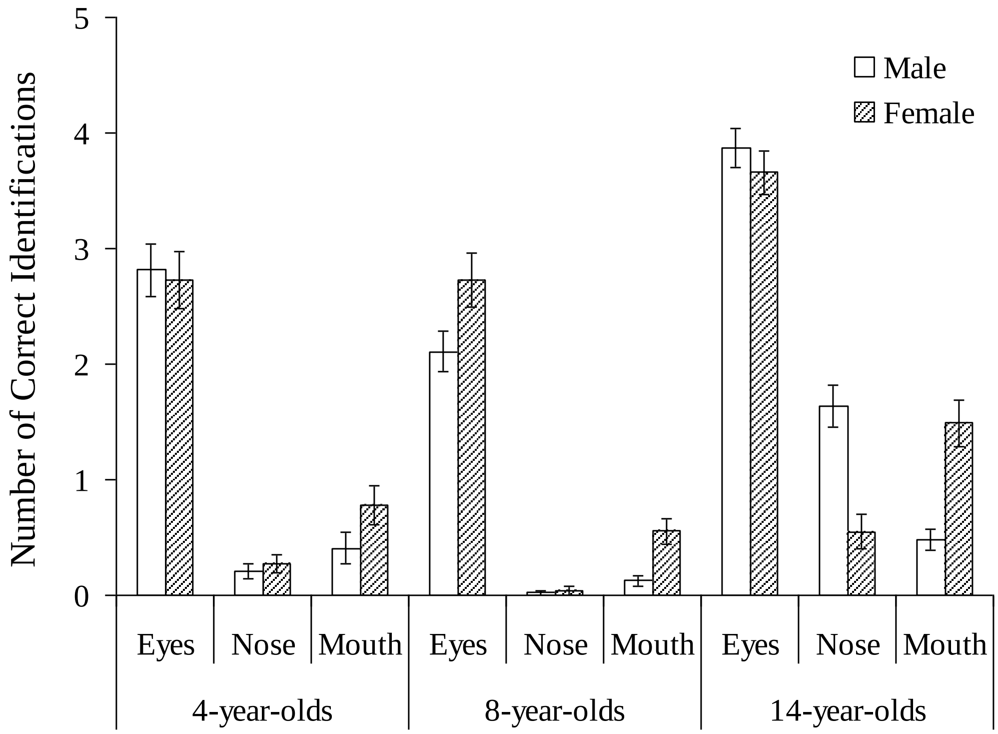

Number of Correct Identifications
5
4
3
2
1
0
Male
Female
Eyes
Nose
Mouth
Eyes
Nose
Mouth
Eyes
Nose
Mouth
4-year-olds
8-year-olds
14-year-olds

Figure 3