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An Inner-face Advantage in Children's Recognition of Familiar Peers

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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 one 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. 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.

Faces are one of the most important classes of 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

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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* age 10 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 et al. (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.

Although it has been shown that young children are sensitive to changes in both the internal facial features (Freire & Lee, 2001; Mondloch, Leis, & Maurer, 2006) as well as 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, while 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 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 apparent 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 & Mackenbergh, 1966; Hay & Cox, 2000). Therefore, to compare children's relative use of different internal features, the present study will also examine children's recognition of the eyes, nose and mouth regions.

To study possible developmental changes in how children process inner faces, outer faces, and individual internal facial features, 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 one 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: 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 only and mouth only 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 two 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 one academic school year after their entry into kindergarten, elementary school, or middle school, respectively.

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 since such classrooms are typically run by the parents' workplace (e.g., company or organization). In contrast, elementary schools receive students from nearby neighborhoods, and junior high students are admitted to their schools according to their city-wide entrance exam performance. Thus, in general, children meet their peers for the first time in 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 one year were used as participants.

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 six 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 10 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 13×18 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.

Previous studies that have examined children's recognition of inner and outer face regions of familiar faces have presented their inner/outer face stimuli in different ways. Campbell et al. (1995), for example, used the eyes, nose, mouth, and the innermost portion of the cheeks as inner faces. Bonner and Burton (2004) used the eyes, nose, mouth, and the entire cheek area as inner faces. Campbell et al. (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 present study were cropped so that they followed the external contour of the lower face. Thus the main contrast of interest in the present study's comparison of outer and inner faces is the recognition of the hairstyle, hairline, ears, and forehead versus recognition of the eyes, nose, mouth, cheeks, and chin.

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.*” 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 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 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., without replacement) from the total number of students in the classroom. For example, the chance of identifying 1 student from a

class with 25 students is computed by $\sum_{j=1}^{25} 1/j$. 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, $t(47) = 165.41, p < .001$, $t(49) = 181.99, p < .001$, 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 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.

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, $t(47) = 26.08, p < .001$, $t(49) = 40.57, p < .001$, and $t(38) = 59.57, p < .001$ respectively. Four-, 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 vs. outer face) $\times$ 2 (stimulus gender) $\times$ 2 (participant gender) $\times$ 3 (participant age) mixed factorial

ANOVA with percentage 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, percent correct recognition of inner faces ($M = 90.04, SD = 16.81$) was higher than percent 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 age, $F(2, 131) = 6.06, p < .05, \eta^2 = .09$, also shows that performance generally improved with age. A priori comparisons show 14-year-olds had significantly higher recognition scores ($M = 78.21, SD = 14.78$) relative to 4-year-olds' ($M = 66.23, SD = 17.96$) recognition (p values $< .05$), however, recognition among 14- and 8-year-olds were comparable ($p > .05$).

The significant 2-way interactions between type of stimulus 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 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 (i.e., inner/outer face) and participant age (i.e., 4-, 8-, and 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-samples t -tests with sequential Bonferroni correction showed the following significant results: i) better recognition of male outer faces by 14-year-olds relative to 4-year-olds ($p < .001$), and ii) better recognition of female outer faces by 8-year-olds relative to 4-year-olds ($p < .05$); see Figure 2. Results from the remaining comparisons were not significant after sequential Bonferroni adjustment of statistical significance. 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.

Isolated Internal Features

One-sample t -tests (2-tailed) were conducted to determine whether participants' recognition of isolated internal features was significantly above chance. In the eyes only condition, 4-, 8-, and 14-year-olds were able to recognize their peers at above chance levels, $t(47) = 12.01, p < .001, t(49) = 12.26, p < .001$, 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, $t(38) = 7.51, p < .001$, while 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) $\times$ 2 (stimulus gender) $\times$ 3 (stimulus type: eyes, nose, or mouth) $\times$ 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 females ($M = 30.38, SD = 11.73$) performing better than male ($M = 23.05, SD = 15.10$) participants. A significant main effect of type of stimulus with Greenhouse-Geisser correction, $F(1.51, 198.04) = 382.19, p < .001, \eta^2 = .75$, was further analyzed with paired-samples t -tests and sequential Bonferroni correction. Paired-samples t -tests indicated that, as expected, participants were better at recognizing eyes ($M = 58.50, SD = 27.77$) compared to their recognition of noses ($M = 8.07, SD = 13.06$) and mouths ($M = 12.20, SD = 16.45$), $p < .001$. Participants were also significantly better at recognizing mouths than noses ($p < .05$). There was also a significant main effect of age, $F(2, 131) = 35.12, p < .001, \eta^2 = .35$. A priori comparisons show that the 14-year-olds ($M = 38.81, SD = 12.28$) had higher

recognition scores relative to the 4- ($M = 24.10$, $SD = 11.68$) and 8-year-old ($M = 18.54$, $SD = 10.86$) participants (p values $< .001$).

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, $F(1, 131) = 5.89$, $p < .05$, $\eta^2 = .08$, 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, $F(1, 134) = 206.63$, $p < .001$, $F(1, 134) = 128.98$, $p < .001$, and $F(1, 134) = 441.23$, $p < .001$, respectively. Following the sequential Bonferroni correction, 4-year-olds showed better recognition of female mouths over male mouths ($p < .05$). Eight-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 ($p < .001$); see Figure 3.

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, $F(1, 48) = 8.81$, $p < .05$, $\eta^2 = .16$ 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 ($p < .001$). 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 ($p < .05$); see Figure 4.

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, 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 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 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 et al.'s (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 et al. (1995) who found an outer-face advantage in 7-year-olds. The present findings are also inconsistent with findings by Campbell et al. (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 et al. (1995) included the eyebrows, eyes, nose, mouth, and inner cheek area of children's faces for their inner face condition, and Campbell et al. (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 et al. (1995; 1999), the present study also included a larger portion of the cheek area, 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 et al. (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 et al. (1995; 1999) and are actually consistent with findings from the present study. Thus, the inconsistent findings cannot be entirely attributed to the variable use of inner and outer faces.

Bonner and Burton (2004), Wilson et al. (2007) 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 likely that the findings by Campbell et al. (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. 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 to external features which are more easily altered by changing hairstyles 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 present study to previous findings of an outer-face advantage in children's recognition of *unfamiliar* faces. Want et al. (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 faces or previously familiar faces).

The present 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 only among the oldest age group. The significant main effect of type of stimulus shows that the eyes were better recognized than the nose and mouth regions for children across all 3 age groups. It thus 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) which show 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 3 age groups is also 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).

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).

There was also an interaction between stimulus gender and type of isolated feature for all 3 age groups, such that 4-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. 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 become increasingly better able to recognize the more familiar same-sex face features.

Previous studies also report an own-gender advantage in adolescent females' (Cross et al., 1971; Ellis, Shepherd, & Bruce, 1973) and in adult females' face recognition (Going & Read, 1974; Lewin & Herlitz, 2002; Rehnman & Herlitz, 2007). Other studies also show 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.

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, 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. 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. A comparison of children's recognition of isolated facial features also suggests that this inner-face advantage may be primarily driven by children's superior recognition of the eye region. 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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A

B

Figure 1.
Example of male (A) and female (B) stimuli across the 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 4.
Male and female participants' recognition of isolated internal features.

Table 1
Mean Percent of Correct Identification, Standard Deviations, and Chance Scores

Age	Whole Face		Inner-face		Outer-face		Eyes		Nose		Mouth		Chance Score
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	
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	(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