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Own- and other-race face identity recognition in children: The effects of pose and feature composition

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Abstract

We used a matching-to-sample task and manipulated facial pose and feature composition to examine the other-race effect (ORE) in face identity recognition between 5 and 10 years of age. Overall, the present findings provide a genuine measure of own- and other-race face identity recognition in children that is independent of photographic and image processing. The present study also confirms the presence of an ORE in children as young as 5 years of age using a recognition paradigm that is sensitive to their developing cognitive abilities. In addition, the present findings show that with age, increasing experience with familiar classes of own-race faces and further lack of experience with unfamiliar classes of other-race faces serves to maintain the ORE between 5 to 10 years of age rather than exacerbate the effect. All age groups also showed a differential effect of stimulus facial pose in their recognition of the internal regions of own- and other-race faces. Own-race inner faces were remembered best when three-quarter poses were used during familiarization and frontal poses were used during the recognition test. In contrast, other-race inner faces were remembered best when frontal poses were used during familiarization and three-quarter poses were used during the recognition test. Thus, children encode and/or retrieve own- and other-race faces from memory in qualitatively different ways.

Keywords

face recognition; other-race effect; development of other-race effect; face pose

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Due to extensive experience with individuals from one's own race, and limited or no experience with individuals from another race, adults have greater recognition memory for own-race faces relative to other-race faces (for a review, see Meissner & Brigham, 2001). This so-called other-race effect (ORE) in face recognition has been consistently found across different cultures (Chiroro, Tredoux, Radaelli, & Meissner, 2008; Chiroro &

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Valentine, 1995). In addition, the ORE has been replicated in adults from different racial backgrounds, including individuals with Caucasian, African, and Asian ancestry (for reviews, see Bothwell, Brigham, & Malpass, 1989, and Meissner & Brigham, 2001).

The ORE in adults has typically been investigated by first familiarizing participants with a subset of faces and then presenting them with a larger subset of faces, during which they are asked to identify each face as old or new (for a review, see Meissner & Brigham, 2001) However, the ORE in adults has also been replicated with line-up identification paradigms (for a review, see Meissner & Brigham, 2001; Pezdek, Blandon-Gitlin, & Moore, 2003), same/different judgments for consecutively presented face pairs (Mondloch et al., 2010; Walker & Tanaka, 2003), and recognition of familiarized faces when paired with distractor faces (Hancock & Rhodes, 2008; Rhodes, Hayward, & Winkler, 2006; Sangrigoli, Pallier, Argenti, Ventureyra, & de Schonen, 2005). Furthermore, the effect appears to be driven by better memory for own-race facial features (Hayward, Rhodes, & Schwaninger, 2008; Rhodes et al., 2006), better memory for differences in the spacing between own-race facial features (Hancock & Rhodes, 2008; Hayward et al., 2008; Rhodes et al., 2006; Sangrigoli & de Schonen, 2004a), and better holistic processing of own-race faces – that is, perceiving a face as a whole rather than as a set of individual features (Michel, Rossion, Han, Chung, & Caldara, 2006; Tanaka, Kiefer, & Bukach, 2004).

The developmental roots of such differential processing of own- and other-race faces have been found to originate as early as infancy (for a review, see Lee, Anzures, Quinn, Pascalis, & Slater, 2011). By three months of age, infants who only have experience with own-race individuals already show a preference for own-race faces over other-race faces (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2005). Such differential processing of own- and other-race faces extends into later infancy, with the ORE in face recognition emerging between 3 to 6 months of age and becoming highly robust by 9 months of age (Hayden, Bhatt, Joseph, & Tanaka, 2007; Kelly et al., 2007, 2009; Sangrigoli & de Schonen, 2004a). That is, 9-month-old infants fail to discriminate between other-race faces but have no difficulty in recognizing unfamiliar own-race faces (Kelly et al., 2007, 2009). Nine-month-olds also show more sophisticated categorization of own- than other-race faces (Anzures, Quinn, Pascalis, Slater, & Lee, 2010), and 8-month-olds already use holistic face processing for own-race faces but not for other-race faces (Ferguson, Kulkofsky, Cashon, & Casasola, 2009). In addition, 9-month-olds treat other-race information as a salient fundamental feature that deviates from their default category of own-race faces, so that they detect a single other-race face within an array of own-race faces more quickly than they detect a single own-race face within an array of other-race faces (Hayden, Bhatt, Zieber, & Kangas, 2009).

Thus, the ORE in infants and adults has been well established. However, investigating own- and other-race face recognition during childhood is important in understanding how the ORE is influenced by increasing experience with familiar face categories and further lack of experience with unfamiliar face categories. To date, there are a number of issues that remain unresolved regarding the development of the ORE during childhood. One issue concerns mixed findings of an ORE in young children. Although the ORE has consistently been found in children older than 7 years of age (Chance, Turner, & Goldstein, 1982; Feinman & Entwisle, 1976; Goodman et al., 2007; Pezdek et al., 2003; Walker & Hewstone, 2006), findings of an ORE in children between 5 to 7 years of age are more variable. Some studies have reported a significant ORE in children as young as 3 to 5 years of age (Pezdek et al., 2003; Sangrigoli & de Schonen, 2004b), whereas other studies have reported an absence of the ORE in children between 5 to 7 years of age (Chance et al., 1982; Goodman et al., 2007).

A second unresolved and theoretically important issue concerns the stability of the size of the ORE. A few studies report an age-related increase in the size of the ORE from 6 to 7 years of age until adulthood, thereby reflecting the possible effect of more and more experience with own-race individuals and continued lack of experience with other-race individuals (Chance et al., 1982; Walker & Hewstone, 2006). However, another study has reported comparable other-race effects in 5-year-olds, 8-year-olds, and adults (Pezdek et al., 2003), hinting that once the ORE is established, further exposure to own-race faces and continued lack of exposure to other-race faces serve only to maintain the ORE rather than enlarge it.

The present paper sought to address these unresolved issues by conducting a series of experiments with children between 5 and 10 years of age. To obtain a more accurate measure of the ORE in children, we used a matching-to-sample paradigm – a procedure that is more sensitive than the traditional face recognition paradigm (see below) to young children's limited memory capabilities. While the matching-to-sample paradigm has been used in studies with adult participants to examine the ORE (Rhodes et al., 2006; Sangrigoli et al., 2005), it has rarely been used with children (see Sangrigoli & de Schonen, 2004b, for an exception). However, the matching-to-sample paradigm is ideal when testing young children and when comparing recognition memory performance across different age groups of children. In contrast to the more traditional face recognition memory paradigm during which faces are identified as old or new after familiarization with a set of faces, the matching-to-sample paradigm requires fewer items to be remembered at a time. In addition, each item is remembered for a shorter period of time. Limiting the number of faces that have to be remembered at any time and the duration during which they have to be remembered may be more suited to the cognitive abilities of younger children. Thus, using a matching-to-sample paradigm would likely provide a more accurate measure of own- and other-race face recognition memory among the youngest group of participants. This would help in clarifying whether or not an ORE is indeed present in 5-year-olds. In addition, the matching-to-sample paradigm being well suited across the participant child age groups may help guard against a possible inflation of age-related differences in the size of the ORE.

We also conducted experiments in which we controlled both photographic processing and view-dependent matching of faces to obtain a more accurate measure of the ORE in children –one that is measuring a more pure form of face identity recognition. In many face recognition studies, recognition may be confounded by a more simplistic form of recognition for the photographs rather than recognition of the face identities per se (Bruce, 1982; Carbon & Leder, 2006; Hay & Young, 1982; Longmore, Liu, & Young, 2008). That is, when identical photographs of faces are used across learning and recognition test phases, individuals may encode more surface aspects of the photographs during the learning phase of the study, so that their later performance in the recognition test may be influenced and likely enhanced by factors such as photographic differences in brightness, color, and texture. Moreover, when faces are unchanged in pose from learning to test, recognition can occur on the basis of simple matching of lower-level attribute values at particular locations in the stimuli. Studies that have investigated adults' face recognition abilities have indeed found that performance decreases in accuracy when different photographs of the same person in different facial poses are used across learning and test trials (Bruce, 1982; Carbon & Leder, 2006; Hill, Schyns, & Akamatsu, 1997; Longmore et al., 2008; O'Toole, Edelman, & Bülthoff, 1998; Patterson & Baddeley, 1977; Troje & Bülthoff, 1996; Woodhead, Baddeley, & Simmonds, 1979; but see Davies, Ellis, & Shepherd, 1978, for lack of decrement in performance). However, altering facial pose across learning and test trials helps to ensure that participants' face recognition is based on their previous abstraction of face identity information rather than on view-dependent matching of images. By conducting experiments in which we used different photographs and facial poses across the familiarization and recognition test trials, we were able to control for children's view-dependent matching of own- and other-race faces.

We conducted three studies with Caucasian 5- to 10-year-olds – all of whom had nearly no direct contact with Chinese individuals. Each experiment used a matching-to-sample paradigm in which participants were given several trials during which they were familiarized with a face and then subsequently asked to identify the familiar face when paired with a distractor face. In Experiment 1, we used the same photos of own- and other-race faces (frontal pose) during both the familiarization and test sessions as was the case for most of the existing own- and other-race face recognition studies involving child participants. The main objective of Experiment 1 was to ensure that the matching-to-sample paradigm is a sensitive measure of the ORE in children. Experiment 2 was conducted to obtain a measure of children's own- and other-race facial identity recognition in a laboratory setting with minimized influence of low-level photographic processing and view-dependent matching of the images. In Experiment 2, we manipulated the pose of the stimulus faces across familiarization and test such that Caucasian children would be familiarized with own- and other-race faces (Caucasian and Chinese, respectively) in one pose (e.g., frontal) and tested in a different pose (e.g., three-quarter). As long as children's recognition memory for own- and other-race faces is driven by their processing of facial identity, then different stimulus poses across familiarization and test should nonetheless result in above chance recognition of familiarized faces. However, similar to previous findings with adults, children in the present study may also show a dual influence of facial identity processing and photographic processing, with a general decrease in recognition performance for both own- and other-race faces when stimulus facial poses are altered across familiarization and test.

In Experiment 3, we sought to verify that the ORE can be obtained via differential processing of the central facial features of own- and other-race faces (e.g., the eyes, nose, and mouth) and the relations between them – despite the absence of peripheral features such as hairstyle, hair color, and facial contour. In this experiment, we presented children with the internal regions of the stimulus faces, while altering the poses across the familiarization and test trials.

Experiment 1

Method

Participants—Twenty-five 5- to 6-year-old (12 males), 25 7- to 8-year-old (9 males), and 25 9- to 10-year-old Caucasian children (14 males) in the UK participated in the study. The children were recruited from a large city in the UK where the Chinese individuals represented less than 1% of the population. An additional group of 19 5- to 6-year-old Caucasian children (12 males) in a large city in Canada also participated in the study. Because individuals of Chinese descent comprise about 11% of the total population in this Canadian city, we used an other-race contact questionnaire to ensure that the children had minimal experience with Chinese individuals.

All children were recruited from local elementary schools and from a database of families who indicated interest in participating in our research. The local elementary schools and the surrounding area were located in middle-class or higher SES neighbourhoods. Children's parents who provided their home addresses were mostly from middle-income or higher SES neighbourhoods.

Stimuli—Colour photographs of 48 Caucasian young adult faces (24 females) and 48 Chinese young adult faces (24 females) showing frontal poses and neutral expressions were used for the recognition task.

Procedure—Children's recognition memory was examined using a computerized two-alternative forced-choice matching-to-sample paradigm. All responses were recorded by the stimulus presentation program (a C-based program created specifically for this study). For each trial, participants were familiarized with a photograph of a target face followed by a presentation of the same photograph paired with a photograph of a distractor face from the same race (see Figure 1A). Participants were asked to choose the familiar face. Participants were told the following: *You will see a picture of a face on the screen. Look at the face and try to remember it. This face will be replaced by two faces – one face on the left and one face on the right side of the screen. If you think the face on the left is the same as the face you saw before, press the 'z' key on the left side of the keyboard. If you think the face on the right is the same as the face you saw before, press the 'm' key on the right side of the keyboard.*

All participants completed the recognition task for Caucasian and Asian faces, with half of the participants completing the Caucasian recognition task first. Each race condition was comprised of a total of 12 trials (six trials with male faces). To avoid potential floor effects in 5-to 6-year-olds' face recognition performance, the youngest age group tested in the UK was given a longer familiarization period relative to the older children. Thus, 5- to 6-year-old participants in the UK were familiarized with the target face for 5000 milliseconds, and 7- to 8-year-olds and 9-to 10-year-olds were familiarized with the target face for 1500 milliseconds. However, an additional group of 5- to 6-year-olds in Canada were given the same procedure as the older age groups – that is, they were familiarized with the target face for 1500 milliseconds – to ensure that any developmental difference in performance was not due to procedural differences in testing. The subsequent target and distractor faces were shown until participants responded via a key press. To ensure that participants understood the task, they were first asked to complete a practice session with six trials of the two-alternative forced-choice matching-to-sample procedure with photographs of toys.

Results

Separate face recognition scores for own- and other-race faces were computed for each participant as the percentage of faces accurately identified. One-sample *t* tests with face recognition scores as the dependent variable revealed that 5- to 6-year-olds in both familiarization conditions (5000 ms and 1500 ms), 7- to 8-year-olds, and 9- to 10-year-olds all showed above chance recognition of both Caucasian faces, $t(24) = 21.61$, $p < .001$, $t(18) = 34.25$, $p < .001$, $t(24) = 38.53$, $p < .001$, and $t(24) = 49.59$, $p < .001$, respectively, and Asian faces, $t(24) = 10.55$, $p < .001$, $t(18) = 14.77$, $p < .001$, $t(24) = 18.00$, $p < .001$, and $t(24) = 17.64$, $p < .001$ respectively. These findings suggest that children from all age groups were able to recognize both own- and other-race faces.

To ensure that the size of the ORE did not differ across testing sites, the ORE was measured by computing the difference in the percentage of own- and other-race faces accurately recognized. This ORE measure was comparable in magnitude between the 5- to 6-year-olds in the UK ($M = 10.00$, $SD = 15.59$) and Canadian ($M = 8.77$, $SD = 8.99$) testing sites ($p > .20$). Subsequent analyses were conducted with only the 5- to 6-year-olds who were given the same 1500 ms familiarization time during the recognition test as the 7- to 8-year-olds and the 9- to 10-year-olds. This ensured that any developmental difference was not due to procedural differences in testing.

We next examined children's differential recognition memory for Caucasian and Asian faces using participants' face recognition scores as the dependent variable. Preliminary analyses showed that the recognition scores were not influenced by participant gender (i.e., no significant main effect or interactions). Thus, participant gender was not included in the subsequent analyses. A 3 (participant age: 5- to 6-year-olds, 7- to 8-year-olds, 9- to 10-year-olds) x 2 (stimulus face race: Caucasian, Asian) x 2 (stimulus face gender) ANOVA revealed a significant main effect of stimulus face race, $F(1, 56) = 21.74$, $p < .001$, $\eta_p^2 = .28$, with higher recognition scores for own-race Caucasian faces ($M = 95.65$, $SD = 5.46$) relative to recognition scores for other-race Asian faces ($M = 89.98$, $SD = 11.40$), see Figure 2. There was also a significant main effect of stimulus face gender, $F(1, 56) = 4.78$, $p < .05$, $\eta_p^2 = .08$, that was qualified by a significant interaction between stimulus face race and stimulus face gender, $F(1, 56) = 4.64$, $p < .05$, $\eta_p^2 = .07$. Although recognition of male and female faces was comparable for other-race Asian faces ($p > .05$), recognition of own-race Caucasian female faces ($M = 98.66$, $SD = 4.58$) was better than recognition of own-race Caucasian male faces ($M = 94.06$, $SD = 8.62$), $t(61) = 21.74$, $p < .001$, $\eta_p^2 = .28$. The main effect of participant age and the remaining interactions were not significant (p values > .05). In addition, the interaction between participant age and stimulus race was not significant, which suggests that the ORE was comparable in size across all age groups ($p > .05$).

Discussion

Experiment 1 replicated the classic ORE in children's recognition memory for own- and other-race faces using a matching-to-sample paradigm. Although children were above chance in their recognition of both own-race Caucasian faces and other-race Asian faces, they were still better in their recognition of own-race faces relative to their recognition of other-race faces. This ORE in face recognition memory was found even in the youngest age group of 5- to 6-year-olds, which is consistent with previous reports of an ORE in children as young as 3 to 5 years of age (Pezdek et al., 2003; Sangrigoli & de Schonen, 2004b).

Experiment 1 also showed that the magnitude of the ORE was similar across the 5- to 6-year-old, 7- to 8-year-old, and 9- to 10-year-old participants. Thus, increasing experience with familiar face categories and continued lack of experience with unfamiliar face categories between 5 to 10 years of age does not lead to a simultaneous increase in the ORE. This is consistent with previous findings of a comparable ORE in 5-year-olds, 8-year-olds, and adults (Pezdek et al., 2003). In addition, better recognition of own-race female faces is consistent with the developmental literature regarding a female recognition bias among infants and children (Feinman & Entwisle, 1976; Quinn, Yahr, Kuhn, Slater, Pascalis 2002) – a recognition bias that may be shaped by a relative abundance in early experience with female caregivers (Rennels & Davis, 2008).

Experiment 2

To obtain a measure of face identity recognition memory for own- and other-race faces that is beyond that of photographic processing and view-dependent matching of images, Experiment 2 manipulated the pose of the stimulus faces across familiarization and test (i.e., there was a mismatch in pose between each familiarization face and the corresponding test faces).

Method

Participants—A different group of 5- to 6-year-old ($n = 25$, 15 males), 7- to 8-year-old ($n = 25$, 11 males), and 9- to 10-year-old ($n = 25$, 15 males) Caucasian children in the UK participated in Experiment 2. An additional group of 18 5- to 6-year-old Caucasian children (12 males) in Canada also participated in Experiment 2. Children were again recruited from local elementary schools and from a database of families who indicated interest in participating in our research. The local elementary schools and the surrounding area were located in middle-class or higher SES neighbourhoods. Children's parents who provided their home addresses were mostly from middle-income or higher SES neighbourhoods.

Stimuli—The colour photographs of 48 Caucasian young adult faces (24 females) and 48 Chinese young adult faces (24 females) showing neutral expressions and frontal poses used in Experiment 1 were also used in Experiment 2. However, this time, an additional version of each face was used – one showing a three-quarter pose.

Procedure—The procedure was identical to the procedure used in Experiment 1, except the pose of the faces across familiarization and test was always different. Each of the Caucasian and Asian recognition tasks was comprised of 24 trials – 12 of which showed the faces in a frontal pose during familiarization and a three-quarter pose at test and 12 with the faces in a three-quarter pose during familiarization and a frontal pose at test (see Figure 1B). The Caucasian and Asian recognition tasks were preceded by six practice trials showing photographs of toys in frontal and three-quarter poses across familiarization and test.

Results

Separate face recognition scores for own- and other-race faces were computed for each participant as the percentage of faces accurately identified. One-sample *t* tests with face recognition scores as the dependent variable revealed that, despite the change in stimulus pose across familiarization and test, 5- to 6-year-olds in both familiarization conditions (5000 ms and 1500 ms), 7- to 8-year-olds, and 9- to 10-year-olds all showed above chance recognition of Caucasian faces, $t(24) = 21.51$, $p < .001$, $t(17) = 11.84$, $p < .001$, $t(24) = 49.94$, $p < .001$, and $t(24) = 53.29$, $p < .001$, respectively, and Asian faces, $t(24) = 10.56$, $p < .001$, $t(17) = 6.11$, $p < .001$, $t(24) = 23.49$, $p < .001$, and $t(24) = 13.35$, $p < .001$, respectively. Thus, children recognized the facial identities of both own- and other-race faces even though they had to match the identities of the faces across different poses.

In addition, the ORE was measured by computing the difference in the percentage of own- and other-race faces accurately recognized. This ORE measure was comparable in magnitude between the 5- to 6-year-olds in the UK ($M = 16.67$, $SD = 11.35$) and Canadian ($M = 20.37$, $SD = 16.54$) testing sites ($p > .20$). Subsequent analyses were conducted with only the 5-to 6-year-olds who were given the same 1500 ms familiarization time during the recognition test as the 7- to 8-year-olds and the 9- to 10-year-olds. This ensured that any developmental difference could not be due to procedural differences in testing.

We next examined whether there was an ORE in children's recognition of own- and other-race face identities using participants' face recognition scores as the dependent variable. Preliminary analyses showed that face recognition scores were not influenced by participant gender and stimulus gender (i.e., no significant main effects or interactions). Thus, participant and stimulus gender were not included in the subsequent analyses. A 3 (participant age: 5- to 6-year-olds, 7- to 8-year-olds, 9- to 10-year-olds) x 2 (stimulus face race: Caucasian, Asian) x 2 (stimulus face pose: frontal during familiarization and three-quarter during testing vs. three-quarter during familiarization and frontal during testing) ANOVA revealed a significant main effect of participant age, $F(2, 65) = 18.75$ $p < .001$, $\eta_p^2 = .37$, with 7- to 8-year-olds and 9- to 10-year-olds showing significantly higher recognition scores relative to 5- to 6-year-olds (p values $< .001$). There was no difference in performance between the 7- to 8-year-olds and the 9- to 10-year-olds ($p > .20$). There was also a significant main effect of stimulus face race, $F(1, 65) = 93.43$, $p < .001$, $\eta_p^2 = .59$, with participants showing higher recognition scores for own-race Caucasian faces ($M = 90.32$, $SD = 7.80$) relative to their recognition scores for other-race Asian faces ($M = 76.53$, $SD = 11.54$), see Figure 3. Thus, participants showed a significant ORE in their face identity recognition when stimulus face pose was altered across familiarization and test.

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The two-way interaction between stimulus face race and stimulus face pose was also significant, $F(1, 65) = 5.87$, $p < .05$, $\eta_p^2 = .08$. Although participants showed comparable recognition of other-race Asian faces regardless of face pose during familiarization/test, recognition of own-race Caucasian faces was better when familiarized in a three-quarter pose and tested in a frontal pose ($M = 92.65$, $SD = 8.82$) than when familiarized in a frontal pose and tested in a three-quarter pose ($M = 87.87$, $SD = 10.02$).

There was also a significant two-way interaction between stimulus face pose and participant age, $F(2, 65) = 4.65$, $p < .05$, $\eta_p^2 = .13$. The youngest and oldest participant age groups showed comparable overall face recognition (i.e., collapsed across stimulus face race) regardless of face pose across familiarization and test. However, 7- to 8-year-olds were better in their face recognition when familiarized with faces in a three-quarter pose and tested in a frontal pose ($M = 89.17$, $SD = 5.10$) than when familiarized with faces in a frontal pose and tested in a three-quarter pose ($M = 84.50$, $SD = 5.31$).

Although the above analyses show that children's recognition of own- and other-race faces and the ORE is determined by facial identity processing, performance in Experiments 1 and 2 was additionally compared to ascertain whether own- and other-race face recognition is also influenced by photographic processing and view-dependent matching of images. As expected, participants in Experiment 1 who were shown the same photograph and the same stimulus pose across familiarization and test had significantly higher overall face recognition scores relative to participants in Experiment 2 who were shown different photographs and stimulus poses across familiarization and test, $F(1, 135) = 56.10$, $p < .001$, $\eta_p^2 = .29$. Independent-samples *t* tests showed a significant decrement in recognition scores from Experiment 1 to Experiment 2 for both own-race Caucasian faces and other-race Asian faces (*p* values $< .001$, see Figure 4). However, a significant interaction between stimulus race and experimental task, $F(1, 135) = 16.31$, $p < .001$, $\eta_p^2 = .11$, suggested that the decrement in recognition was more pronounced for other-race faces than for own-race faces.

Discussion

The results from Experiment 2 indicate that despite a change in the stimulus pose across familiarization and test, children showed identity recognition of Caucasian and Asian faces at above chance levels. In Experiment 2, children from all age groups also showed an ORE derived from measures of own- and other-race face identity recognition with minimal influence of photographic processing and view-dependent matching of images. Similar to the results from Experiment 1, and similar to previous findings of the ORE in 3- to 5-year-olds (Goodman et al., 2007; Sangrigoli & de Schonen, 2004b), the ORE in face identity recognition in the present study was found even in the youngest age group of 5- to 6-year-old children.

A comparison of Experiment 1 and Experiment 2 also showed a significant decrement in overall recognition scores when stimulus facial poses were altered rather than identical across familiarization and test. This result suggests that although children can process facial identities despite changes in facial poses, they use photographic processing and view-dependent matching of images when such additional cues are available. However, the decrement in face recognition was more pronounced for other-race faces. This outcome suggests that other-race face recognition may be more context-dependent relative to own-race face recognition, thereby reflecting more sophisticated facial identity processing for own-race than for other-race faces. These findings also suggest that children's other-race face *identity* recognition may be overestimated when photographic processing and view-dependent matching of images are not controlled.

Experiment 2 also showed age-related improvements in face recognition memory. The 7-to 8-year-olds and the 9- to 10-year-olds were significantly better than the 5- to 6-year-olds in their face recognition memory. This developmental change in recognition memory has been well-established in the existing literature and is likely driven by age-related improvements in detecting differences in facial features and the spacing between facial features (Mondloch, Geldart, Maurer, & Le Grand, 2003; Mondloch, Le Grand, & Maurer, 2002). Despite this age-related increase in face recognition memory, the size of the ORE was again comparable across all age groups. Thus, although increased age is accompanied by increased experience with familiar face categories and further lack of experience with unfamiliar face categories, face identity recognition improves for both own- and other-race faces with age.

In addition, Experiment 2 showed an interesting differential effect of stimulus pose on children's own-race face recognition. Children were better in their recognition of own-race Caucasian faces when familiarized with three-quarter poses and tested with frontal poses than when tested in the alternate condition. In contrast, they showed no difference in their other-race face recognition as a function of stimulus pose.

Although Experiment 2 has already shown that own- and other-race face recognition are driven by children's processing of facial identity, the possibility remains that children in Experiment 2 may have focused on the external features of faces such as hair style, hair color, and facial contour cues to aid in their recognition. Indeed, both adult and child studies on face processing have revealed that when recognizing unfamiliar own-race faces, participants tend to focus more on the external facial cues than the internal facial cues (Bonner & Burton, 2004; Campbell, Walker, & Baron-Cohen, 1995; Campbell et al., 1999; Clutterbuck & Johnston, 2004; Ellis, Shepherd, & Davies, 1979; Ge et al., 2008; Want, Pascalis, Coleman, & Blades, 2003; Wilson, Blades, & Pascalis, 2007; Young, Hay, McWeeny, Flude, & Ellis, 1985). Thus, to examine the extent to which the ORE can be attributed to the processing of internal facial information associated with face identity, we conducted Experiment 3 with a different group of Caucasian children and with a modification of the Caucasian and Asian face recognition tasks so that both familiarization and test faces only contained the internal features of faces.

Experiment 3

Method

Participants—A different group of 5- to 6-year-old (*n* = 25, 14 males), 7- to 8-year-old (*n* = 25, 9 males), and 9- to 10-year-old (*n* = 25, 11 males) Caucasian children in the UK participated in Experiment 3. An additional group of 18 5- to 6-year-old Caucasian children (11 males) in Canada also participated in Experiment 3. Children were recruited from local elementary schools and from a database of families who indicated interest in participating in our research. The local elementary schools and the surrounding area were located in middle-class or higher SES neighbourhoods. Children's parents who provided their home addresses were mostly from middle-income or higher SES neighbourhoods.

Stimuli—The stimuli from Experiment 2 were used except the hair and facial contour of the faces were removed so that participants only saw the internal facial features (see Figure 1C).

Procedure—The procedure was identical to the procedure used in Experiment 2.

Results

Separate face recognition scores for own- and other-race faces were computed for each participant as the percentage of faces accurately identified. One-sample t-tests with face recognition scores as the dependent variable once again revealed that despite the removal of the external facial features, Caucasian 5- to 6-year-olds in both familiarization conditions (5000 ms and 1500 ms), 7- to 8-year-olds, and 9- to 10-year-olds were able to recognize Caucasian faces, $t(24) = 17.24$, $p < .001$, $t(17) = 6.65$, $p < .001$, $t(24) = 21.82$, $p < .001$, and $t(24) = 25.53$, $p < .001$, respectively, and Asian faces, $t(24) = 9.60$, $p < .001$, $t(17) = 3.61$, $p < .05$, $t(24) = 11.53$, and $p < .001$, $t(24) = 14.75$, $p < .001$, respectively, at above chance levels.

In addition, the ORE was measured by computing the difference in the percentage of own- and other-race faces accurately recognized. This ORE measure was comparable in magnitude between the 5- to 6-year-olds in the UK ($M = 9.50$, $SD = 13.09$) and Canadian ($M = 10.82$, $SD = 12.12$) testing sites ($p > .20$). Subsequent analyses were conducted with only the 5-to 6-year-olds who were given the same 1500 ms familiarization time during the recognition test as the 7- to 8-year-olds and the 9- to 10-year-olds. This ensured that any developmental difference was not due to procedural differences in testing.

We next examined whether Caucasian children still showed the other-race effect when they had to process only the internal regions of own- and other-race faces using participants' face recognition scores as the dependent variable. Preliminary analyses showed that face recognition scores were not influenced by participant gender and stimulus gender (i.e., no significant main effect or interactions). Thus, subsequent analyses were collapsed across male and female participants and face stimuli. A 3 (participant age: 5- to 6-year-olds, 7- to 8-year-olds, 9- to 10-year-olds) x 2 (stimulus face race: Caucasian, Asian) x 2 (stimulus face pose: frontal during familiarization and three-quarter during testing vs. three-quarter during familiarization and frontal during testing) ANOVA revealed a significant main effect of participant age, $F(1, 65) = 26.95$, $p < .001$, $\eta_p^2 = .45$, with 7- to 8-year-olds and 9- to 10-year-olds showing greater recognition memory ($M = 82.92$, $SD = 8.16$ and $M = 84.50$, $SD = 6.81$, respectively) relative to the 5- to 6-year-olds ($M = 66.29$, $SD = 11.20$), p values < .001. There was no difference in performance between the 7- to 8-year-olds and the 9- to 10-year-olds ($p > .20$). In addition, there was a significant main effect of stimulus face race, $F(1, 65) = 49.72$, $p < .001$, $\eta_p^2 = .43$, so that participants showed better recognition memory for own-race Caucasian faces ($M = 84.85$, $SD = 12.87$) relative to their recognition memory for other-race Asian faces ($M = 74.08$, $SD = 13.81$). The main effect of stimulus face pose was not significant ($p > .20$).

However, there was a significant two-way interaction between stimulus face race and stimulus face pose, $F(1, 65) = 15.03$, $p < .001$, $\eta_p^2 = .19$ (see Figure 5). Follow-up paired samples *t* tests showed that recognition scores for own-race Caucasian faces were highest when the stimulus faces were presented in a three-quarter pose during familiarization and presented in a frontal pose at test, $t(67) = 2.14$, $p < .01$. In contrast, recognition scores for other-race Asian faces were highest when the stimulus faces were presented in a frontal pose during familiarization and presented in a three-quarter pose at test, $t(67) = 3.28$, $p < .01$. These differential patterns of results for Caucasian and Asian faces suggest that the internal facial regions of own- and other-race faces are perhaps encoded in memory and/or retrieved from memory in different ways.

Performance in Experiments 2 and 3 was also compared to determine whether children's recognition of facial identities is maintained even when the external facial features are removed. Recognition scores were higher in Experiment 2 when participants were shown the internal and external regions of faces and a change in stimulus pose across familiarization and test, relative to recognition scores in Experiment 3 when participants were shown only the internal regions of faces and a change in stimulus pose across familiarization and test, $F(1, 130) = 11.69$, $p < .05$, $\eta_p^2 = .08$. However, a comparison across Experiments 2 and 3 also revealed that the removal of the external facial regions did not have the same effect across the participant age groups, $F(2, 130) = 4.04$, $p < .05$, $\eta_p^2 = .06$. The decrease in face recognition performance from Experiment 2 to Experiment 3 was only significant for the 5- to 6-year-old children, $t(34) = 3.05$, $p < .05$ (see Figure 6). Overall, these results suggest that although 5- to 6-year-olds demonstrate facial identity processing when relying on the internal facial regions alone, external facial cues (e.g., hair and facial contour) likely also contribute to their identity processing of own- and other-race faces and the resulting ORE. In contrast, the removal of external facial cues appear to have had little effect on face recognition performance among 7- to 10-year-olds.

Discussion

Experiment 3 showed that children's recognition memory for the internal regions of own- and other-race faces is indicative of identity processing. However, there was a differential effect of stimulus pose for own- and other-race face recognition memory. Identity recognition for the inner regions of own-race faces was best when familiarized with three-quarter poses and tested with frontal poses. In contrast, identity recognition for the inner regions of other-race faces was best when familiarized with frontal poses and tested with three-quarter poses. Thus, it appears that own- and other-race faces are encoded in memory and/or retrieved from memory in qualitatively different ways.

In addition, Experiment 3 replicated age-related improvements in children's face recognition memory. A comparison of performance in Experiments 2 and 3 also showed a decrease in face recognition performance among 5- to 6-year-olds when the external face regions (i.e., hair and facial contour) are removed compared to when both the internal and external facial regions are present. In contrast, the removal of external facial cues had little impact on the face recognition of older children between 7 to 10 years of age.

General Discussion

The experiments described above show that even when the pose of stimulus faces is altered across familiarization and test in a recognition task, 5- to 10-year-old children nonetheless show above chance recognition of both Caucasian and Asian faces. Such recognition memory for facial identity was found even when the hair and the external contour of the stimulus faces were removed to ensure that participants were attending to the internal facial features of both Caucasian and Asian faces.

The present study also obtained a measure of the ORE from 5- to 10-year-olds' processing of face identity with minimal influence of photographic processing and view-dependent matching of images. However, there was a differential effect of stimulus face pose on children's recognition of the internal regions of own- and other-race faces. As is consistent with previous studies with infants (Ferguson et al., 2009), children (Sangrigoli & de Schonen, 2004b), and adults (Hancock & Rhodes, 2008), our findings suggest that children may also process own-and other-race internal facial information in different ways. It appears that recognition memory for own-race faces (i.e., with or without the external features) is better when faces are encoded in a three-quarter pose and retrieved from memory in a frontal pose. Such findings are consistent with evidence from the adult face recognition literature which generally shows an advantage in recognition memory when own-race faces are learned in a three-quarter pose rather than in a frontal or profile orientation (Baddeley & Woodhead, 1983; Krouse, 1981; Logie, Baddeley, & Woodhead, 1987; Troje & Bülthoff, 1996; Valentin, Abdi, & Edelman, 1997; but see Carbon & Leder, 2006, and Liu & Chaudhuri, 2002 for lack of a three-quarter advantage).

Our results are further consistent with previous findings that show the facilitative effect of direct gaze on children's and adults' recognition of own-race faces (Adams, Pauker, & Weisbuch, 2010; Hood, Macrae, Cole-Davies, & Dias, 2003; Smith, Hood, & Hector, 2006). However, our findings suggest that this facilitative effect of direct gaze is most beneficial upon retrieval of familiarized own-race faces. This effect of gaze direction on face recognition has been linked with increased activation within certain regions of the cortical face processing network in adults (George, Driver, & Dolan, 2001; Kawashima et al., 1999). Although similar studies have yet to be conducted with children, it remains possible that similar increased activation of the cortical face processing network as a function of direct gaze may be most beneficial during children's retrieval of familiarized own-race faces.

In contrast, children's recognition memory for the internal regions of other-race faces is better when faces are encoded in a frontal pose and retrieved from memory in a three-quarter pose. Thus, the potential influence of direct gaze on increased activation of the cortical face processing network in children might be most beneficial during the phase of encoding less familiar other-race faces.

Despite providing a measure of the ORE based on children's face identity rather than picture or image recognition, the current study leaves open the specific mechanism which drives the ORE. Although differential experience with own- and other-race faces lead to a behavioural ORE in face recognition memory, it remains largely unknown how own- and other-race faces are processed differently. Existing studies show that infants demonstrate comparable attention towards own and other-race faces when own- and other-race faces are presented separately (Liu et al., 2011; Wheeler et al., 2011), and adults demonstrate comparable attention towards own-and other-race faces even when presented simultaneously (Hirose & Hancock, 2007). Thus, the ORE in the present study is likely not due to a quantitative difference in attention to own- and other-race faces during the experimental task. Instead, the present study revealed that children's encoding and/or retrieval of own- and other-race faces from memory are qualitatively different from one another. Thus, one possibility is that children encode own- and other-race faces at different levels, so that own-race faces might be privileged to a greater depth of encoding (e.g., encoding at the individual identity level), whereas other-race faces might be encoded at a relatively more superficial level (e.g., in terms of category membership). Indeed, previous studies have shown that although adults are faster and more accurate at individuating between own-race faces than they are at individuating between other-race faces, they are also faster at categorizing other-race faces than they are at categorizing own-race faces (Ge et al., 2009; Levin, 1996, 2000; Valentine & Endo, 1992; see also Caldara, Rossion, Bovet, & Hauert, 2004, for a discussion of the neural correlates of the other-race categorization advantage). Nevertheless, the scant literature that has investigated the effects of depth of processing on the ORE in adults has revealed mixed findings. It appears that adults' natural impressions of own- and other-race faces involve greater depth of encoding for own-race faces and more superficial encoding of other-race faces (Chance & Goldstein, 1981). However, directly manipulating depth of encoding by instructing participants to process own- and other-race faces at different levels appears to have no differential effect on the ORE, but rather, results in better recognition memory for both own-and other-race faces (Devine & Malpass, 1985; Burgess & Weaver, 2003).

A third possibility that may explain children's performance differences in recognition memory for own- and other-race faces involves the use of facial information as a means of discriminating between different identities. An abundance of experience with own-race faces likely leads to the abstraction of certain facial information that is most advantageous in processing identity differences among own-race individuals (e.g., eye color for Caucasian individuals). Indeed, according to the norm-based coding model of face recognition, new faces are encoded relative to a face prototype or norm that has been abstracted from previously encountered faces (Valentine, 1991). Perhaps, other-race faces are encoded relative to an own-race face prototype. Thus, an ORE may arise if the same facial information is generalized to an other-race group if that particular set of facial information is not as useful or diagnostic in processing identity differences among other-race individuals (Chiroro & Valentine, 1995; Valentine, 1991; Valentine & Endo, 1992). This is consistent with previous findings that Caucasian adults are more likely to include eye color and hair color in their descriptions of Caucasian and Black individuals, whereas Black adults are more likely to include eye size, eyebrows, ears, and chin in their descriptions of Black and Caucasian individuals (Ellis, Deregowski, & Shepherd, 1975). Thus, in this case, the ORE in face recognition memory would arise due to processing other-race faces in a non-optimal way.

It is of additional interest to note the consistency in the degree of the ORE across all three age groups from 5 to 10 years. In accordance with findings regarding the development of the ORE in infants (Kelly et al., 2007; 2009; Sangrigoli & de Schonen, 2004a), and a few studies that report an ORE in children as young as 3 to 5 years of age (Pezdek et al., 2003; Sangrigoli & de Schonen, 2004b), findings from the present study show that the ORE in face recognition memory is present in early childhood. Although there were age-related changes in children's recognition memory for faces in general, children from each age group showed a comparable ORE. Thus, although children's differential experience with own- and other-race faces shapes an own-race advantage in face recognition memory, continued experience with own-race faces and continued lack of experience with other-race faces does not appear to lead to increasingly larger disparities in recognition memory for own- and other-race faces. It appears that the asymmetry in own- and other-race experience in later childhood serves to maintain rather than exacerbate the ORE. More general age-related improvements in cognitive abilities – as well as age-related improvements in detecting differences in facial features and the spacing between facial features (Mondloch et al., 2003; Mondloch et al., 2002) – likely drive improved identity recognition memory for *both* own-race and other-race faces.

In summary, the present study showed that the ORE – as measured from genuine identity recognition of own- and other-race faces – remains stable in size between 5 to 10 years of age. This ORE in identity recognition remained even after external facial cues were removed so that children were forced to rely on only the internal facial regions. In addition, although children are able to encode and retrieve own- and other-race facial identities from memory, the differential effect of stimulus pose for own- and other-race face recognition memory is reflective of qualitative differences in processing own- and other-race faces.

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Figure 1A.

Figure 1B.

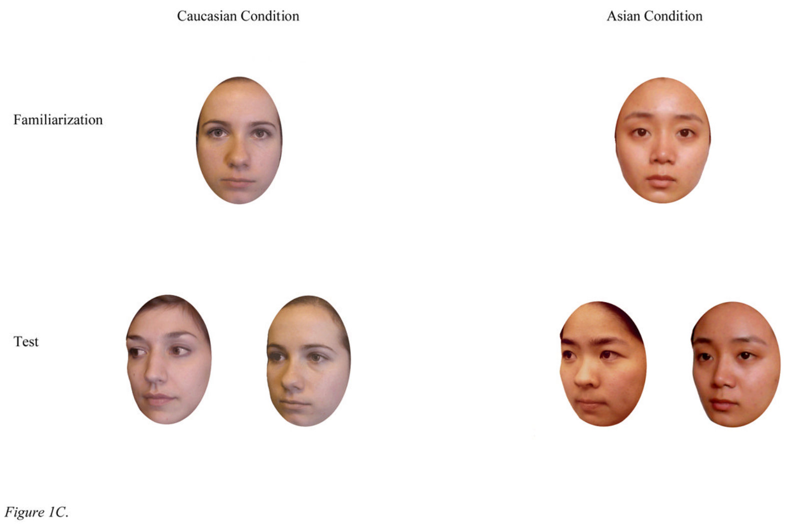

Figure 1.

Figure 1A. Example of female stimulus faces in Caucasian and Asian conditions in Experiment 1.

Figure 1B. Example of female stimulus faces in Caucasian and Asian conditions in Experiment 2.

Figure 1C. Example of female stimulus faces in Caucasian and Asian conditions in Experiment 3.

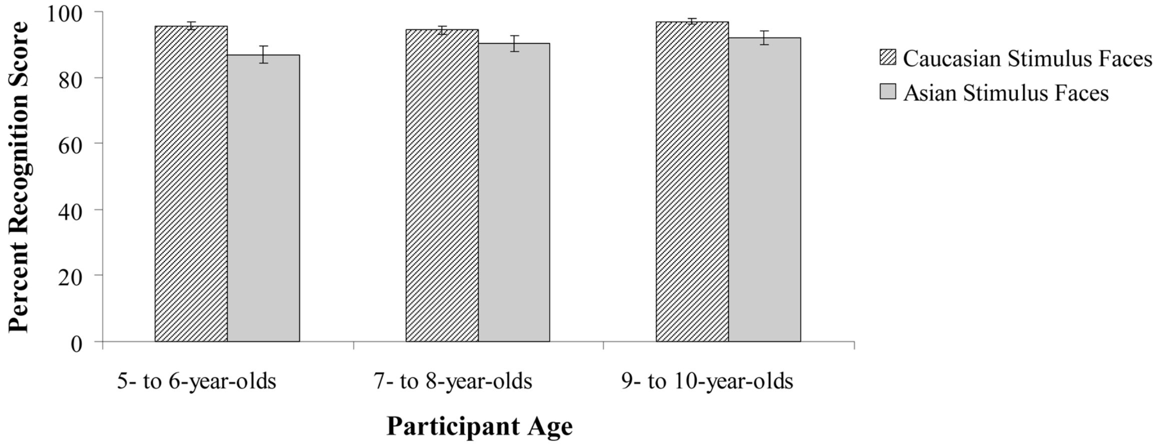

Figure 2.

Participants' recognition scores for own-race Caucasian and other-race Asian faces in Experiment 1 when the same photographs of faces showing frontal poses were used in the familiarization and test phases of the recognition task.

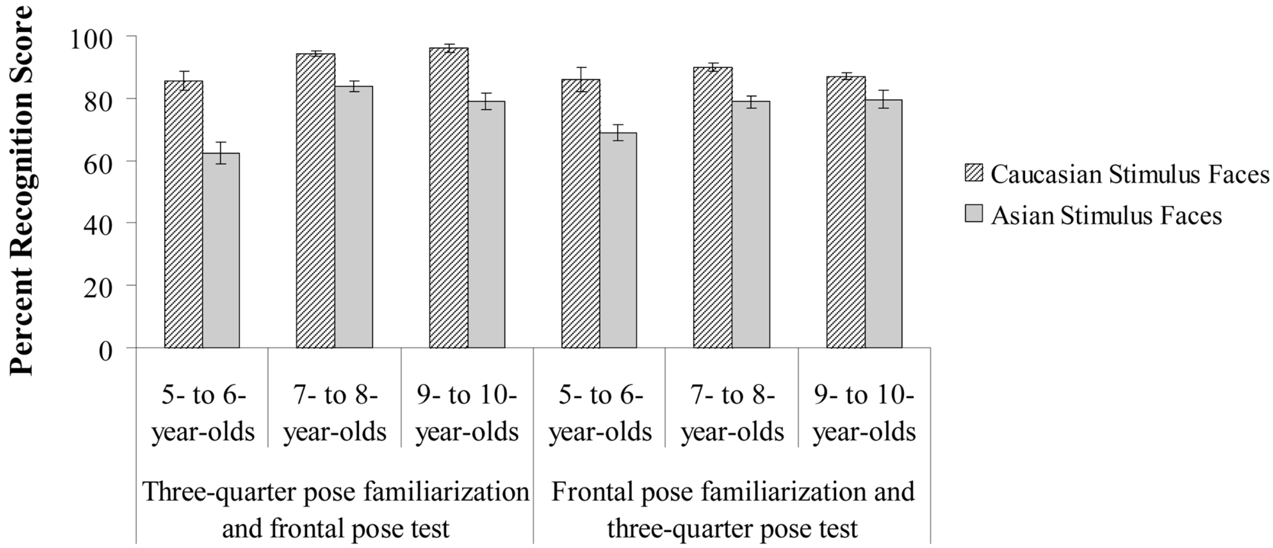

Figure 3.
Participants' recognition scores for own-race Caucasian and other-race Asian faces in Experiment 2 when different photographs and facial poses were used across the familiarization and test phases of the recognition task.

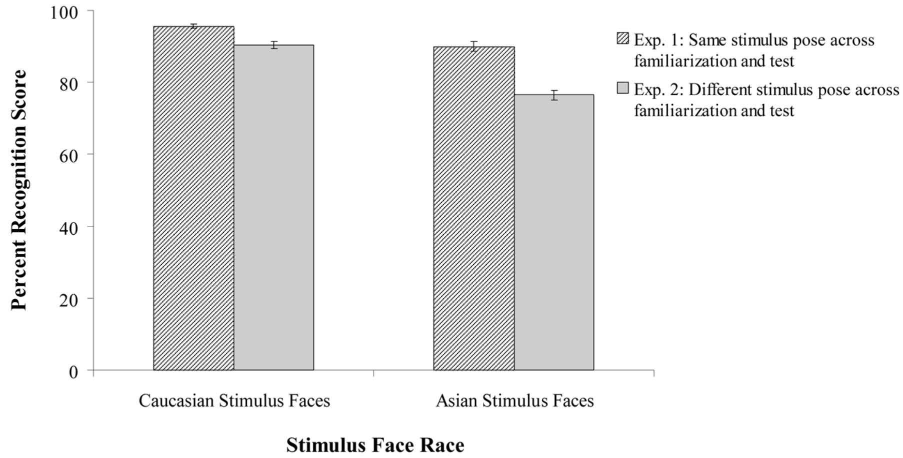

Figure 4.

Participants' recognition scores for own-race Caucasian and other-race Asian faces in Experiment 1 and 2.

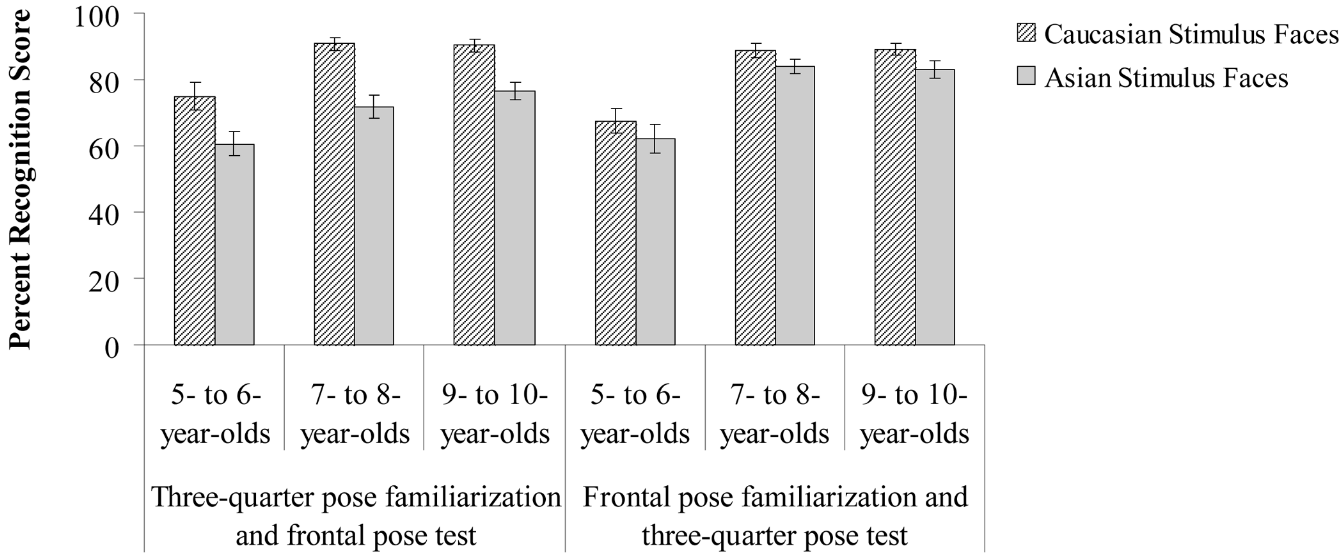

Figure 5.

Participants' recognition scores for own-race Caucasian and other-race Asian faces in Experiment 3 (external facial cues were removed) when different photographs and facial poses were used across the familiarization and test phases of the recognition task.

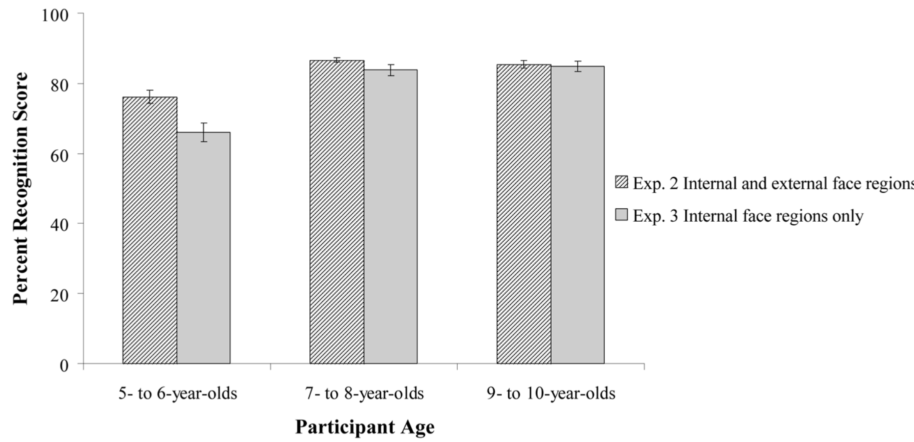

Figure 6.

Participants' recognition scores for own-race Caucasian and other-race Asian faces in Experiment 2 and 3.

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