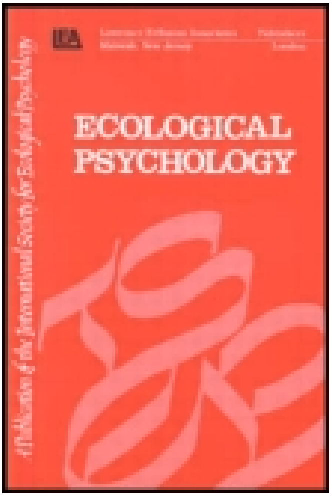

Ecological Psychology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/heco20

Starting School Improves Preschoolers' Ability to Discriminate Child Faces

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Published online: 02 May 2014.

To cite this article: Adélaïde de Heering, Ana Bracovic & Daphne Maurer (2014) Starting School Improves Preschoolers' Ability to Discriminate Child Faces, Ecological Psychology, 26:1-2, 16-29, DOI: 10.1080/10407413.2014.874866

To link to this article: http://dx.doi.org/10.1080/10407413.2014.874866

Ecological Psychology, 26:16–29, 2014

ISSN: 1040-7413 print/1532-6969 online
DOI: 10.1080/10407413.2014.874866

Routledge
Taylor & Francis Group

Starting School Improves Preschoolers' Ability to Discriminate Child Faces

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Children take many years to become as skilled as adults in differentiating among faces and there is debate about the role of face experience in improving their skills. Here we tested whether the increase in exposure to the faces of children associated with entering school leads to improved face discrimination for this face category. To do so, we compared the face discrimination abilities of 3- to 4-year-old children who began attending school for the first time with those of age-matched controls not yet in school. Both groups completed a 2-alternative forced-choice matching task with adult and child faces, presented both in an upright and inverted orientation, at Time 1 (within the first month of entering school for the school group) and at Time 2 (5 months later). Between Time 1 and Time 2, both groups improved in discriminating between adult faces, but only the preschoolers improved for child faces. These effects were not modulated by inversion. Overall, these results suggest that, during the preschool years, a natural increase in exposure to the faces of 1 face category leads to improved discrimination of novel exemplars of this face category.

Adults are experts at recognizing faces (Carey, 1992). They are able to remember hundreds of faces; recognize a familiar face within half a second; and at the same time accurately extract information about gender, age, emotional expression and direction of gaze (e.g., see Bruce & Young, 2000, for a review; Carey, 1992). Although some face-processing skills are present surprisingly early in life (e.g., Goren, Sarty, & Wu, 1975; Johnson, Dziurawiec, Ellis, & Morton,

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1991), children and even adolescents are not as accurate as adults in recognizing the identity of faces (e.g., Blaney & Winograd, 1978; Carey, 1992; Carey, Diamond, & Woods, 1980; Flin, 1985; Germine, Duchaine, & Nakayama, 2011), probably because of general immaturities in both cognition and visual sensitivity (e.g., Crookes & McKone, 2009) and the continued refinement of face-specific mechanisms into adolescence (Baudouin, Gallay, Durand, & Robichon, 2010; Brace et al., 2001; de Heering, Rossion, & Maurer, 2012; Diamond & Carey, 1986; Germine et al., 2011; Mondloch, Le Grand, & Maurer, 2002).

To date, most studies have concentrated on documenting the emergence of these skills in infancy and their refinement, if any, after 6 years of age. The few studies that focused on preschoolers' (i.e., 2- to 5-year-olds) ability to recognize faces indicate that performance improves during this period (Brace et al., 2001; Sangrigoli & Schonen, 2004) and that preschoolers rely on several markers of adult expertise when recognizing the identity of unfamiliar faces. For example, they are able to process faces as wholes or holistically (de Heering, Houthuys, & Rossion; 2007; Macchi Cassia, Picozzi, Kuefner, Bricolo, & Turati, 2009; Pellicano & Rhodes, 2003; Picozzi, Macchi Cassia, Turati, & Vescovo, 2009) and based on their features or the spacing between these features (Macchi Cassia, Turati, & Schwarzer, 2011; Pellicano, Rhodes, & Peters, 2006; but see Mondloch, Leis, & Maurer, 2006). As adults do when identifying familiar faces, preschoolers rely more on internal facial features than on external features, at least when the chin is included as an internal feature (Ge et al., 2008). Finally, they are already sensitive to facial distinctiveness (i.e., how much an individual stands out in a crowd; McKone & Boyer, 2006).

In this study, we investigated the effect of a change in experience on the ability of preschool children to discriminate facial identities. Visual experience already shapes face processing during infancy by leading to its progressive tuning to the characteristics of faces encountered in everyday life, namely, upright human faces, often only of one's own race (e.g., Kelly et al., 2007; Kelly et al., 2005). During the preschool years, children show an other-race effect: they are better able to recognize a face they learned earlier the same day (ages 3–5: Sangrigoli & de Schonen, 2004) or the day before (age 5: Pezdek, Blandon-Gitlin, & Moore, 2003) if it is of their own race than if it is of a different race (but see contradictory results for 5- to 7-year-olds in Goodman et al., 2007). They also show an other-age effect (Anastasi & Rhodes, 2005): at ages 5 to 8, children more accurately recognize own-age faces than other-age faces (but see contradictory results for 4- to 6-year-olds; Hills & Lewis, 2011). However, this tuning to the categories of faces most commonly encountered can still be modulated easily by experience during the preschool years. For example, 3-year-olds are better at discriminating between upright adult faces than between newborn faces or inverted faces of either age group (Macchi Cassia, Kuefner, Picozzi, & Vescovo, 2009) unless they had been exposed to at least one newborn face because they had a younger sibling born after their first birthday (at 15-41 months). Those with a younger sibling are equally good at discriminating upright adult faces and newborn faces and much less accurate for inverted faces of either age group. The same type of exposure in new mothers (without a younger sibling) was ineffective. Macchi Cassia, Kuefner, et al. (2009) concluded from these results that experience at a young age with one individual infant face was sufficient to modulate the tuning of the face-processing system. Similarly, the other-race effect can be reversed by a change in exposure resulting from adoption between ages 3 and 9 (Sangrigoli, Pallier, Argenti, Ventureyra, & de Schonen, 2005). Specifically, Korean adults adopted between 3 and 9 years of age by Caucasian families are better at recognizing Caucasian (other-race) than Asian (same-race) faces, with the size of the difference between races as large as that shown by Caucasian adults who had been exposed to Caucasian faces from birth (for other evidence of plasticity of the other-race effect in children, see de Heering, de Liedekerke, Deboni, & Rossion, 2010).

The ages of 2 to 5 also correspond to the period when many children begin attending school, a change that drastically increases the number of faces they need to discriminate and remember. According to face space theory (Valentine, 1991), an increase in number is likely to alter the face recognition system because adults appear to code faces on multiple dimensions in reference to a face prototype that represents the average of faces the individual has encountered. The more faces encoded, the more the prototype, or the norm, becomes stable and the more closely it resembles the population mean. At the same time, the dimensions of the face space, which represent the characteristics that differentiate facial identities from one another, become more refined. Thus, a sudden increase in the need to differentiate and remember many new individuals is likely to have a large impact on the refinement of face space. That is the hypothesis we tested in the current study.

Specifically, we compared the accuracy of children entering school (preschool group) for the first time and of age-matched controls not yet in school (no-preschool group) at two time points: at the beginning of the school year (Time 1) and 5 months later (Time 2). At both times, children were tested on their ability to pick out a face matching a target face from two alternatives of a smaller size, using both adult and child faces presented in upright and inverted orientations. To ensure that they understood the instructions, they were first required to match color patches. We chose child and adult faces because we hypothesized that the improvement in performance induced by starting school might be restricted to the category with multiple new exemplars, namely, upright children's faces. We also included inverted faces at Time 1 and Time 2 as well as nonface stimuli at Time 2. Inverted faces were used as a control condition because we predicted that preschooler children were unlikely to gain significant experience with this face category during the 5 months of the study. Nonface stimuli were used at Time 2 to evaluate whether school attendance per se had caused general improvements in the ability of the preschool group to match stimuli to a target. If so, we planned to include their performance with nonface stimuli at Time 2 as a covariate in the analyses. Finally, preschoolers' parents were asked to provide an estimate of the number of child and adult faces their child was exposed to on a regular basis.

In summary, we tested whether the sudden increase in exposure to child faces for the group attending school would lead, compared with the no-preschool group, to improvement with novel exemplars of this face category after 5 months spent at school (Time 2). No such difference was expected for adult faces or inverted faces because we did not expect the school group to experience more exposure than the no-school group to these categories across the 5 months.

METHODS

Participants

We tested 20 preschoolers (preschool group) who entered school for the first time in September 2010 (Time 1) and 5 months later (Time 2). These children were either recruited from a Montessori school in Cambridge (Ontario, Canada) and tested in a quiet and well-lit room at school or recruited from a database of mothers who, at the time of the child's birth, had volunteered the child to participate in developmental studies. The latter were tested at McMaster University. For comparison, we recruited 20 children matched in age who had not yet started school. For both groups, we included only children whose exposure to children's faces was limited before Time 1. The exclusion criteria were attending a daycare facility with more than 6 children, being involved in recreational activities involving other children for more than 4 hr per week, or attending more than one summer camp per year. Parents reported their children to have normal or corrected-to-normal vision.

From this sample, we excluded the data of 2 children in each group because of their unavailability for testing at Time 2. We also excluded the data of 5 other participants from each group in order to equate the groups' baselines accuracy at Time 1.[1] Thus the final sample consisted of 13 preschoolers and 13 age-matched controls not yet at school. All participants were Caucasian. The mean age at Time 1 was 45 months for the preschool group ($SE = 1$; 4 males) and 43 months for the no-preschool group ($SE = 1$; 4 males) ($t(24) = 1.127$, $p = .271$). Both groups showed similar baseline accuracy for upright child faces ($t(24) = .465$, $p = .646$) and upright adult faces ($t(24) = .841$, $p = .409$).

[1]The results were identical when the data of these participants were included in the analyses.

Material

Jungle. To make the task enjoyable for the young children, we told them that they would be playing a game in a jungle. A presentation board (122 cm × 91 cm) painted with trees and monkeys to depict a jungle was set up in front of the child and a green rug, to mimic grass, was laid out on the ground in front of it. Two small chairs facing each other were placed approximately 50 cm apart on the rug in front of the presentation board, one for the participant and the other one for the experimenter. The experimenter, with her back facing the board, held a set of pages, each of them displaying three stimuli (the target at the top and two probes at the bottom). She was blind to the stimuli that were presented on each trial. A second experimenter sat behind the child and coded his or her responses. The pages were laminated and printed onto 8.5″ × 11″ card stock using a Xerox DC252 printer. Participants were tested first on color stimuli and then on face stimuli. At Time 2, they were also tested on nonface stimuli at the end of testing.

Questionnaire. Participants' parent(s) were given a questionnaire to complete at Time 2.[2] Besides background information (e.g., date of birth, ethnicity, handedness, and visual acuity), it inquired about the child's involvement (duration and frequency) in organized daycare, school, camp or other recreational activities. Parents were also asked to estimate how many very familiar, familiar, and nonfamiliar adult and child faces their child was exposed to on a typical day, on the day of testing (Time 2), and 1 year before the testing (Time 1). Finally parents were asked to report the number of siblings their child had and, for those in the preschool group, the number of classmates.

Stimuli

Color matching stimuli. The stimuli used for the color-matching criterion trials were images of four colored stars (green, blue, yellow, and red) created using Adobe Photoshop 8.0. The target stars measured 7.3 cm × 8 cm and were slightly bigger than the probe stars, which measured 6 cm × 5.5 cm. The stars were pasted onto a black rectangle and organized on the pages so that the target star was centered at the top of the page above two probe stars, one that matched the color of the target star and the other that served as a distractor.

Face-matching stimuli. The upright and inverted face stimuli were created based on 64 digitized color images of the faces of 32 Caucasian adults (16 males;

[2]A preliminary version of the questionnaire was also administered at Time 1.

age range = 18–20 years) and of 32 Caucasian children (16 boys; age range = 4–5 years), each posing with a neutral expression. The face images were presented either in an upright or inverted orientation and in full-front views with the external features (i.e., hair, ears, neck) cropped out using Adobe Photoshop 8.0 in order to encourage processing of the internal physiognomy. Their luminance was equalized. The cropped images were duplicated and manipulated in size with Adobe Photoshop 8.0 so that the width of the target face was 8 cm whereas it was 6 cm for the probe faces, with commensurate changes in the length of the faces. We did not equate the length of the target faces to each other (or do so for the probes) in order to keep the natural proportions of the faces. Each face was pasted onto a black rectangle. The upright and inverted faces were organized on the laminated pages so that the target was centered at the top of the page above the probes, one that matched the target and the other one that served as a distractor. The target and the probes were of the same age, of the same gender, and in the same orientation. Each probe face was used once as the matching face and once as a distractor. In total, there were 64 upright trials and 64 inverted trials divided into two sets of 32 trials so that each participant could be tested with different faces at Time 1 and Time 2.

Nonface stimuli. These stimuli were created from 16 photographs of houses (6 grayscale photographs and 10 color photographs) and from 16 photographic reproductions of color abstract paintings. The targets and probes measured 11 cm × 8 cm and 8 cm × 6 cm, respectively. Like the faces, these images were pasted onto a black rectangle in a triangle configuration with the target at the top and the probes at the bottom of the laminated pages. In total, 16 trials were created.

Procedure

The study was given ethics clearance by the Research Ethics Board of McMaster University (Canada). Parents signed a consent form after being given an explanation of the study.

At Time 1, participants were first administered a two-alternative forced-choice matching task with colors and then a similar task with faces. Age and sex of faces were randomized within block whereas orientation (upright or inverted) was blocked, with order counterbalanced across participants. At Time 2, participants completed the task in the same order, but with a new set of faces, and completed a similar task with nonface stimuli at the end of testing.

At the beginning of the experiment, children were told the following:

> Today we are going to go on an adventure in a magical jungle together. The jungle is full of tropical trees and monkeys that hang off them. They are swinging off

of those branches. Sometimes they are upright and sometimes they are really silly and hang upside down. There are also people in this jungle. All of these people have a special twin; a brother or a sister who looks exactly like them. Today there was a big party in the jungle and everyone got mixed up and lost their twin. They need your help to find them! Remember, twins have the exact same face, so when I show you a face, all you have to do is match it to the other face that is the exact same as the one you saw.

The experimenter presented the laminated pages to the participant one by one. At the beginning of each trial, the child could only see the target stimulus and when the experimenter was certain that the child was carefully looking at the target, she lifted the cover so that all three stimuli (the target and the two probes) were visible. Children started the experiment with 4 color-matching trials to ensure that they understood the instruction to find the matching stimulus and indicated their response by pointing to the color matching the target color. They reached the criterion only if they responded correctly on at least 3 out of the 4 trials and they were allowed up to three attempts to meet this criterion. All participants met the criterion, usually on the first attempt. Then children were administered the first block of 32 upright or inverted faces in randomized order (1/4 child male faces; 1/4 child female faces; 1/4 adult male faces; 1/4 adult female faces). Each face block started with 4 criterion trials. If participants were not correct on 3 out of the 4 trials after three attempts, they were assigned a score of 50% (chance level) and they moved on to the second block of 32 randomized inverted or upright faces. At Time 2, participants were also given 16 nonface trials presented in randomized order (8 house trials and 8 abstract painting trials) at the end of the testing. They were introduced as magical gates that they had to unlock so the twins could go back home together. There were no criterion trials for this part of the test.

RESULTS

The repeated measures ANOVA on participants' accuracy (% correct; see Table 1 for averaged data) with the face stimuli with *time* (Time 1 vs. Time 2), *age* of the face (child vs. adult), and *orientation* (upright vs. inverted) as within-subject factors and the *group* (preschool vs. no-preschool) as the between-subject factor indicated a main effect of *time* (Time 2 > Time 1: ($F(1, 24) = 22.562$, $p < .0001$); a main effect of *orientation* (upright > inverted: ($F(1, 24) = 33.976$, $p < .0001$); a marginally significant three-way interaction between *time*, *age of face,* and *group* ($F(1, 24) = 3.906$, $p = .060$); and a significant interaction between *time*, *age of face, orientation,* and *group* ($F(1, 24) = 4.986$, $p = .035$). No other interactions or main effects were significant (ps > .05). As a follow-up to this four-way interaction, we performed two repeated measures ANOVAs

TABLE 1
Preschool and No-Preschool Children's Proportion of Correct Responses at Time 1 and Time 2 for Adult Faces, Child Faces, and Non-Face Stimuli

Time	*Age of Face*	*Orientation*	*Preschool Group*	*No-Preschool Group*
Time 1	Adult faces	Upright	0.82 (0.04)	0.78 (0.03)
		Inverted	0.68 (0.05)	0.65 (0.05)
		All adult faces	0.75 (0.04)	0.71 (0.04)
	Child faces	Upright	0.84 (0.03)	0.81 (0.04)
		Inverted	0.66 (0.05)	0.69 (0.04)
		All child faces	0.75 (0.04)	0.75 (0.03)
Time 2	Adult faces	Upright	0.94 (0.02)	0.83 (0.04)
		Inverted	0.79 (0.04)	0.80 (0.04)
		All adult faces	0.87 (0.03)	0.81 (0.03)
	Child faces	Upright	0.96 (0.02)	0.86 (0.03)
		Inverted	0.83 (0.04)	0.74 (0.06)
		All child faces	0.90 (0.03)	0.80 (0.04)
	Nonfaces	Upright	0.90 (0.03)	0.84 (0.04)

for each type of face (child vs. adult) separately, with *time* (Time 1 vs. Time 2) and *orientation* (upright vs. inverted) as the within-subject factor and *group* (preschool vs. no-preschool) as the between-subject factor.

For child faces, there was a main effect of *time* (Time 2 > Time 1: $F(1, 24) = 19.638$, $p < .0001$) and a main effect of *orientation* (Upright > Inverted: $F(1, 24) = 26.323$, $p < .0001$). In addition, there was a significant interaction between *time* and *group* ($F(1, 24) = 4.890$, $p = .037$). As a follow-up to this interaction, we performed two-tailed paired *t* tests for each group separately on their performance with this face category at Time 1 and Time 2. Unlike the no-preschool group ($t(12) = -1.413$, $p = .183$), the preschool group improved significantly for child faces over this time period ($t(12) = -5.431$, $p < .0001$; see Figure 1).

For adult faces, there was a main effect of *time* (Time 2 > Time 1: $F(1, 24) = 18.409$, $p < .0001$) and a main effect of *orientation* (Upright > Inverted: $F(1, 24) = 23.320$, $p < .0001$), but no other main effect or interaction reached significance ($ps > .05$). Similar two-tailed paired *t* tests as those performed for child faces indicated that both the preschool group ($t(12) = -3.447$, $p = .005$) and the no-preschool group ($t(12) = -2.616$, $p = .023$) improved for adult faces between Time 1 and Time 2 (see Figure 2).

The two groups also did not differ in their ability to discriminate between nonface stimuli (houses and abstract paintings) at Time 2 (independent-samples *t* test: $t(24) = 1.345$, $p = .191$), indicating that those who had attended school were not better overall in matching visual stimuli to a target.

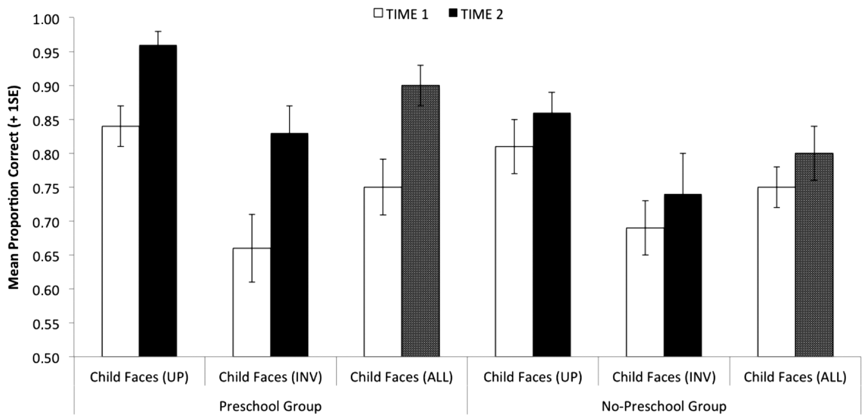

FIGURE 1 The preschool group and the no-preschool group's proportion of correct responses for child faces at Time 1 and Time 2. Bars represent between-subject standard errors.

Finally, we assessed whether children's baseline accuracy (Time 1) or accuracy at Time 2 for child and adult faces was correlated with parental reports of their experience with these face categories. To do so, we performed a number of two-tailed Spearman correlations because most variables were not normally distributed according to the Shapiro-Wilk test of normality. We took

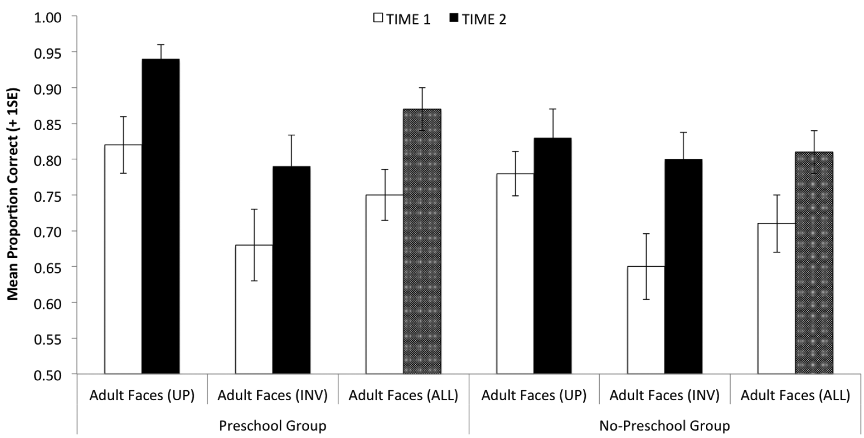

FIGURE 2 The preschool group and the no-preschool group's proportion of correct responses for adult faces at Time 1 and Time 2. Bars represent between-subject standard errors.

into consideration three variables extracted from the questionnaire: the number of siblings, the number of recreational activities, and the number of familiar and very familiar child and adult faces parents estimated their child was exposed to on a regular basis (Time 2) and 1 year before the testing (Time 1). None of these correlations reached significance when the analyses were performed on the 26 participants ($ps > .05$).

DISCUSSION

In this study, we examined the influence of entering school on preschoolers' face discrimination abilities. We found that the preschool group improved significantly more at recognizing child faces after 5 months of being at school than the no-preschool group, who did not improve for this face category. Both groups also improved at recognizing adult faces over the same period of time. The difference between groups is unlikely to have arisen from general improvements in selective attention, motivation, concentration, or other general cognitive skills because there was no difference in accuracy for performing the matching task for nonface stimuli at Time 2 and because both groups improved similarly for adult faces. However, we acknowledge that the case would be stronger if we had included the nonface stimuli at Time 1.

We attribute the specific improvement of the preschool group with child faces to the large number (about 25) of socially salient children's faces they had to differentiate and discriminate at school, which was not the case for the no-preschool group. In line with this prediction, it has been shown that 3-year-old children with high levels of peer interaction, but not those with low levels of peer interaction, choose faces with low features, like those of their peers, as significantly more attractive than those with high features, possibly as a result of their increased experience with child faces (Cooper, Geldart, Mondloch, & Maurer, 2006). However, a surprising finding in the current study was that despite a significant effect of orientation overall, the improvement was not modulated by the orientation of the face: unlike our predicted pattern, children from the preschool group did not improve more for upright than inverted child faces after 5 months. This may have occurred because they see their peers from multiple orientations, as they roll on the floor, look between their legs, and so on. In addition, the face-processing system at this age is not yet as finely tuned to upright faces, to the exclusion of inverted faces, as it will become (e.g., Carey & Diamond, 1977; de Heering et al., 2012; Flin, 1985; Robbins, Maurer, Hatry, Anzures, & Mondloch, 2012). As a result, experience-driven improvements for upright faces may generalize to inverted faces.

The generalization of improvement for upright faces to inverted faces during the preschool years was also present for adult faces: both groups showed improvement at recognizing adult faces over 5 months, whether upright or inverted. These improvements may have come from general cognitive improvements, exposure to more adult faces during the 5 months, or paying especial attention to adults because they are figures of authority for children (e.g., parents, teachers, etc.; Fiske, 1993; Walker & Hewstone, 2006).

Interestingly, this study also gives some indication about the speed at which preschoolers' face recognition system can be tuned to a given face category. Two previous studies provided evidence for adaptation over the course of a year. On the one hand, Hills (2012) showed that children recognize 8-year-old faces more accurately when they are 8 than when they are 7 or 9 years old, suggesting fast-adapting face representation during childhood. On the other hand, Macchi Cassia, Kuefner, et al. (2009) found that exposure to a younger sibling over the previous 15 months (range 1–29 months) was sufficient to change the face recognition system of 3-year-old children because, unlike children without a younger sibling, they were equally good at discriminating newborn and adult upright faces. Our results suggest that preschoolers' face recognition system can be shaped within a shorter period of time (5 months), at least if multiple exemplars of a socially relevant face category have to be discriminated. In other words, these results support the possibility that preschoolers' face space can very rapidly produce a more stable and accurate norm of a frequently experienced face category as well as refine its dimensions to optimize coding for the physical differences that covary reliably with identity of these exemplars.

Preschoolers' accuracy with child and adult faces was not correlated with any of the measures collected from the parental questionnaire. One problem was that parents were often unsure of their answers. A second problem was that the questionnaire did not differentiate between exposure at different periods of the child's life, as it is likely that plasticity varies inversely with the complexity of the already established face space. It would also have been interesting to collect qualitative information about children's experience with faces because not only the number of other-race faces but also the quality of the interactions with these faces modulates the size of the other-race effect, at least in adults (Fiske, 1993; Pettigrew, 1997, 1998; Walker & Hewstone, 2006).

Overall, we found that preschool children's ability to discriminate child faces improved significantly after having spent 5 months at school with no such improvement in a control group not at school. Future studies could test the influence of attending school for the first time longitudinally, month by month, to define more precisely the time window required to show differential improvement with child faces and to test whether there might be an initial decrement before the improvement. We suspect that this window may be even shorter than 5 months as long as the number of socially salient faces children have to differentiate is sufficiently large. We also predict that the fast improvement for a face category may depend on the age at which children are starting school and/or the number of faces they have learned previously. More specifically, we suspect that when children start school at an earlier age, or when they have learned the identity of fewer faces, they may show more flexibility in the norm and more readiness for their face space to incorporate new faces.

ACKNOWLEDGMENTS

Herb Pick taught us to carefully observe the environment in order to spot information to which children are exposed that might lead to changes in their perception. The results presented here are an example of the value of that lesson. Preliminary data from this project served as the undergraduate honors thesis for Ana Bracovic and were presented at the 2012 meeting of the Vision Sciences Society. We thank Nimasha Weliwitigoda for helping to create the stimuli and the testing board.

FUNDING

This research was supported by a grant from the Natural Sciences and Engineering Research Council of Canada (NSERC) to Daphne Maurer (9797). Adélaïde de Heering was funded by NSERC.

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