Children's ability to recognize their parent's face improves with age

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ABSTRACT
Adults are experts at recognizing familiar faces across images that incorporate natural within-person variability in appearance (i.e., ambient images). Little is known about children's ability to do so. In the current study, we investigated whether 4- to 7-year-olds (n = 56) could recognize images of their own parent—a person with whom children have had abundant exposure in a variety of different contexts. Children were asked to identify images of their parent that were intermixed with images of other people. We included images of each parent taken both before and after their child was born to manipulate how close the images were to the child's own experience. When viewing before-birth images, 4- and 5-year-olds were less sensitive to identity than were older children; sensitivity did not differ when viewing images taken after the child was born. These findings suggest that even the most familiar face, 4- and 5-year-olds have difficulty recognizing instances that go beyond their direct experience. We discuss two factors that may contribute to the prolonged development of familiar face recognition.

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Introduction

Adults recognize thousands of familiar faces (Jenkins et al., 2018)—even when images are of poor quality, distorted, or disguised (Burton et al., 1999; Hole et al., 2002; Noyes & Jenkins, 2019). Their ability to do so is remarkable. Images of the same person vary in appearance (e.g., due to changes in lighting, viewpoint, expression, makeup, age)—so much so that perceptions of attractiveness and first impressions of traits vary as much across different images of the same person as across different people (Mileva et al., 2019; Todorov & Porter, 2014). Further, images of two different people can look very similar. Nonetheless, we can recognize friends, family and famous people—even when their appearance changes (e.g., Leonardo DiCaprio in Titanic vs. The Revenant).

The challenge of discriminating within- vs. between-person variability in appearance is evident when people are asked to identify wholly unfamiliar faces. Adults make identification errors when photos of unfamiliar faces incorporate systematic changes in lighting or expression (Duchaine & Nakayama, 2006; Nordt & Weigelt, 2017) or are taken only moments apart (Megreya et al., 2013). The stark difference in adults’ ability to identify familiar vs. unfamiliar faces was demonstrated when Jenkins et al. (2011) asked adults to sort 20 face images of each of two Dutch celebrities into piles based on identity. The images were ambient (i.e., captured natural within-person variability in appearance) and the identities were unfamiliar to some participants, but familiar to others. Whereas participants who were unfamiliar with the identities made an average of seven piles (i.e., perceived that the images belonged to seven different people), participants who were familiar with the two identities easily sorted the images into two piles.

Recognizing familiar faces despite within-person variability in appearance defines expert recognition and recently it has led to important advances in theoretical models and research with adults (O'Toole et al., 2018; Young & Burton, 2018). Despite an ever-increasing amount of research investigating these processes in adults, only one study has examined children's ability to recognize familiar faces in ambient images (Laurence & Mondloch, 2016). This is an important gap in the literature as children need to be able to recognize familiar faces (e.g., their parents, teachers, and classmates) across changes in appearance during daily social interactions. This is particularly important for children's safety such as when recognizing their caregiver at the school gate or when out together in a crowded public place. In certain forensic settings, children may be the only eyewitness to a crime (e.g., in child sexual abuse cases), and be asked to identify a familiar suspect. Thus, understanding the development of this skill during childhood is crucial. Doing so will also enrich our understanding of processes underlying adults’ expertise.

Much of the research examining identity recognition during childhood has focused on children’s ability to identify unfamiliar faces. The vast majority of such studies have presented children with tightly controlled images (i.e., one or two nearly identical images taken under similar lighting conditions, on the same day, and with the same camera), limiting the extent to which the findings generalise to real-world viewing conditions (see Burton, 2013 for a discussion). Nonetheless, such studies suggest prolonged development of face recognition. Children’s ability to recognize newly learned faces and match unfamiliar faces across systematic changes in lighting, viewpoint or expression improves across childhood (e.g., Bruce et al., 2000; Carey et al., 1980; Croydon et al., 2014; de Heering et al., 2012; Megreya & Bindemann, 2015; Mondloch et al., 2003).

Only two studies focused on children's ability to match the identity of unfamiliar faces in images that incorporate natural within-person variability in appearance (Laurence and Mondloch, 2016; Neil et al., 2016); both reported age-related improvement. Neil and colleagues (2016) administered Jenkins et al.’s sorting task in which adults and children aged 6–14 were asked to sort 20 images each of two people into piles based on identity. Younger children (aged 6–11) mistook images of the same person as belonging to different people, creating more piles than older children and adults. Laurence and Mondloch (2016) created a child-friendly version of Jenkins et al.’s sorting task. Children aged 5–12 were given a toy house, on the front of which was a picture an unfamiliar woman named Mrs. Smith. Children were given a stack of photographs that included new images of Mrs. Smith and images of a similar-looking woman; children were asked to put all the images of Mrs. Smith into the house and to keep everyone else out. Performance improved with age across childhood.
Relatively little is known about children’s ability to recognize familiar faces. As with studies investigating children’s ability to identify unfamiliar faces, most research investigating children’s ability to recognize familiar faces has presented children with tightly controlled images. Like adults, children as young as four show an internal-feature advantage; when recognizing familiar faces, they rely on internal (rather than external) features (Bonner & Burton, 2004; Ge et al., 2008; Wilson et al., 2009, but see Newcombe & Lie, 1995). Like adults, 4-year-olds recognize the veridical image of a familiar face when paired with a distractor in which feature shape or the external contour is altered; unlike adults, 4-year-olds do not recognize the veridical image of familiar face when paired with a distractor in which feature spacing is altered—even when tested with their own face or their friend from daycare (Mondloch et al., 2006, Mondloch & Thomson, 2008).

To date, only one study has examined children’s ability to recognize a personally familiar face in ambient images. In Laurence and Mondloch’s (2016) study, some children (aged 4–12) were given a toy house with a photo of their own teacher—someone they had known for 3–9 months. Children were asked to put all the images of the teacher into the house and to keep everyone else out. By the age of 6, children sorted the images (nearly) without error. In contrast, many 4- and 5-year-olds made errors. Misidentification errors (putting the stranger into the house) were rare (Mean false alarms = 0.5 of 9), but 19 of 32 4- to 5-year-olds failed to place all nine images of the teacher into the house (Mean hits = 7.06 of 9). These young children made no errors on control trials, suggesting that their inability to recognize their teacher was not attributable to general cognitive immaturity. Despite interacting with their teacher almost daily for several months, many 4- and 5-year-olds had difficulty tolerating variability in the teachers’ appearance. The current study was designed to provide insights into why young children had difficulty recognizing this personally familiar face; our hypotheses were based on extensive research investigating how adults become familiar with individual faces.

Adults become familiar with a face via exposure to variability in its appearance; as a newly encountered face is learned, adults build a robust representation of identity—a representation that generalizes to novel instances (Dowsett et al., 2016; Matthews & Mondloch, 2018a, 2018b; Ritchie & Burton, 2017). Whereas representations of unfamiliar faces are image-based, representations of familiar faces allow adults to extrapolate beyond the instances they have encountered of a familiar person, to recognize them despite changes in appearance (see Burton, 2013; Burton et al., 2005, 2011; Hancock et al., 2000; Johnston & Edmonds, 2009).

Adults’ representations of facial identity are shaped by their particular exposure to a person’s appearance. Ritchie and colleagues (2018) showed that viewers’ perceptions of image likeness (i.e., how well an image matches a person’s appearance) are idiosyncratic and tied to their representations of a person. Images of actors from movies participants had seen were rated as having higher likeness and were identified faster in a name verification task than images of the actors taken from movies participants had not seen. Nonetheless, errors in the name verification task were low. Adults were still able to recognize images of actors from movies they had not seen, suggesting their representations of familiar identities were flexible enough to tolerate unseen variability in appearance. Laurence and Mondloch’s (2016) findings suggest that young children’s representations of their teacher were not robust enough to allow them to tolerate the variability in new images that were outside of their direct experience. This may explain why the younger children had more difficulty in recognizing images of their teacher.

Like adults, children benefit from exposure to variability in appearance when learning a newly encountered face. Children 4 years and older recognize new images of a newly encountered target identity better after viewing six images compared to one image in a perceptual task (Matthews et al., 2018; Matthews & Mondloch, 2022). However, perceptual matching tasks do not require building a representation in memory (Ritchie et al., 2021)—the type of representation required to recognize familiar faces. To date, no study has examined 4- and 5-year-olds’ ability to build a representation of a newly encountered face in memory, but the one study to do so with older children suggests that young children require exposure to more variability than adults to learn a new face. Baker and colleagues (2017) showed children (aged 6–13) a video of a woman reading a story that contained either low or high variability in her appearance. The low-variability video was filmed on a single day, incorporating some changes in expression and viewpoint, whereas the high-variability video was filmed across 3 days, adding additional changes in camera, lighting, hairstyle, and makeup. After watching the video,
participants were asked to identify novel images of the newly learned identity. Whereas adults show showed evidence of learning from both videos, children only showed evidence of learning the new identity after viewing the high-variability video. One possibility is that children under the age of six might require even more variability than older children to successfully recognize a familiar face across changes in appearance—variability that was not encountered in the classroom. Teachers may look relatively similar from day-to-day at work (e.g., minimal changes in make-up and hairstyle) and are encountered under similar lighting conditions in the classroom. Children do not see their teacher after working out at the gym, when they wake up in the morning, or when dressed for a special occasion. Although this exposure was sufficient for older children to recognize their teacher in unseen images, younger children may have needed more varied exposure to their teacher’s appearance to build a robust representation.

In the current study, we examined 4- to 7-year-olds’ ability to recognize ambient images of a face with which they have had abundant exposure—that of their own parent. Most children have more experience with their parent than any other person. At 3 months of age, infants’ primary caregiver (often the mother) accounts for 44% of their face exposure and is more likely to be viewed across locations and context than any other face (Sugden & Moulson, 2018). Over the first year of life, 80% of infants’ face experience is with only three faces, including their parent(s) (Jayaraman et al., 2015). Thus, children have had quantitatively more experience with their parent than their teacher. Children’s experience with their parent’s face also differs qualitatively from their experience with their teacher because exposure to their parent is more varied (e.g., when they’ve just rolled out of bed, are dressed up for a wedding, over time). Thus, testing children with images of their parent provides the best opportunity for them to demonstrate successful recognition of images that fall outside of their direct experience.

We collected images of each child’s parent taken both before and after the child was born to manipulate how similar photos were to the child’s own experience. Images taken after the child was born might more closely reflect the appearance of the parent to which children have been exposed, whereas images taken before the child was born allow us to explore whether younger children might require a more robust representation to tolerate unseen variability in their appearance. If 4- and 5-year-olds simply lacked exposure to enough variability in their teacher’s appearance to recognize her in unseen images, they should perform like older children when tested with images of their parent—regardless of when the photos were taken. If abundant exposure to a familiar face is still insufficient to facilitate the formation of a robust representation in young children, 4- and 5-year-olds’ should make more errors than older children, especially for before-birth images which lay outside the child’s direct experience.

Method

Participants

Our sample comprised 28 4- and 5-year-olds (14 female; $M_{age} = 4.83$ years, SD = 0.55) and 28 6- and 7-year-olds (14 female; $M_{age} = 6.80$ years, SD = 0.68). A power analysis using GPower software (Faul et al., 2007) indicated that this sample was sufficient to detect a medium effect with at least 96% power ($\alpha = .05$). Twenty-eight of these children were tested in person (17 4- and 5-year-olds and 11 6- and 7-year-olds). As a result of the COVID-19 pandemic, the remaining children were tested online via video call with the researcher (11 4- and 5-year-olds and 17 6- and 7-year-olds). Two additional children were excluded from analyses: one because they failed control trials (see below) and the other because they made total of 15 false alarms (all other children made four or fewer). The child’s parent or guardian provided written informed consent and children provided verbal assent. Children were given either a toy or gift card for their participation. Each child’s parent (55 Mothers, 1 Father) provided photos of themselves to be used for testing.

Stimuli

Stimuli were collected and prepared based on the methods used by Laurence and Mondloch (2016). Twenty images of each parent were collected that met the following criteria: the face was at least 150
pixels in height, was shown from a mostly frontal view, free from occlusions and each picture was taken on a different day. We asked parents to choose photos that were not displayed in their home or regularly shown to their child. Parents were told that they could provide images that contained other people; all images were cropped so that only the parent was visible. Half of the images were taken before the child was born, and the other half were taken after the child was born. One before and one after image were randomly selected for each parent to serve as the reference photo during the task; each reference photo was affixed to a toy house into which children were asked to sort photos. The remaining 18 images were used as test images. Each parent was matched with a similar-looking identity (i.e., similar age, hair color, and face shape) to be used as a distractor in the recognition task; all distractors were minor celebrities from other countries. Eighteen images of the similar-looking identity were collected from Google Images, selected using the same criteria as for the parent images. Half of these images were paired with before images of the parent (before block), and the other half were paired with after images (after block). These 36 images (18 per block) comprised the images used for analysis. All images were cropped so that only the head was visible and were converted to grayscale. For children tested in the lab, images were printed on cards measuring 38 × 50 mm in size.

In addition to the test stimuli, we included two types of control trials to verify that children understood the task and were paying attention throughout. First, each parent was matched with a dissimilar-looking identity (i.e., different hair color, and face shape). One image of the dissimilar-looking identity was selected from Google Images. Four copies of the dissimilar-looking identity image were included in each block. Children needed to reject all four dissimilar distractor images in each block to be included in our analysis. Second, four copies of the reference image were included in each block. Children needed to correctly identify at least three of the four identical images in each block to be included in our analysis.

To create a training task, five pictures of Buzz Lightyear and four pictures of Noddy were obtained using a Google image search.

Procedure

This study received clearance from the research ethics boards at Keele University and Brock University. The procedure was adapted from Laurence and Mondloch (2016).

The task was divided into two counterbalanced blocks: The before block included images of the parent before the child was born and the after block included images of the parent after the child was born. Each block comprised a total of 26 trials: eight control trials (four images identical to the reference image on the front of the house and four identical images of the dissimilar distractor) and 18 test trials (nine novel images of the parent and nine images of a similar-looking distractor). The images in each block were divided into three segments. In each segment, there were three pictures of the parent, three pictures of the similar-looking distractor, and two control trials (one identical image and one image of the dissimilar-looking identity). The images in each segment were presented in a random order. After completing the three segments, each child completed two final control trials: one identical image and one dissimilar-looking identity. This was to verify that each child had remained attentive throughout the experiment.

In-lab testing. In each block, each participant was presented with a cardboard house. A reference image of the child’s parent was attached to the front of the house. Children were first asked if they knew who was in the picture on the house. If children indicated that they were unsure, they were told it was an image of their parent. The experimenter then explained “I have this pile of pictures. Some are of your mom [or dad], and some are of other people. They got all mixed together and I need your help to put all the pictures of your mom [or dad] in the house but leave all pictures of other people out. Do you think you can help me put all the pictures of your mom [dad] in the box? Great!” Children were reminded that sometimes their parent might look different than they do in the picture on the house and that they were looking for any picture of their parent, not just a match to the reference image. The experimenter handed the pictures to the child one at a time and asked the child “Is this a picture of your mom [or dad] or someone else?” Children placed images they thought were of their parent in the
box and all other images in a pile next to the box. To ensure that children did not look at their parent while completing the task, parents waited in a separate room.

Prior to beginning the experimental task, children completed a training task in which they were presented with Buzz Lightyear’s spaceship and a pile of nine pictures comprising five pictures of Buzz (one of which was identical to the image on the spaceship) and four pictures of another character (Noddy). The child was asked to place all images of Buzz into the spaceship but to keep Noddy out. To ensure that the child understood both the importance of discriminating between identities and that Buzz’s appearance could change, the child was required to put four of the five images of Buzz inside the house and to place all pictures of Noddy aside to be included in our analyses.

Online testing. A few modifications were made to the procedure for the children who were tested online. Children interacted with a researcher via video call. The researcher shared their screen with the child so that the child could see the PowerPoint presentation that contained the images. At the beginning of each block, children were shown a slide with an image of a house that had their parent’s picture on the front. After indicating or being told that the image belonged to their parent, the task began. Each trial was presented on a separate slide. On each slide, the house and reference image appeared on the left side of the screen and the test image appeared on the right. Children indicated to the researcher verbally whether each image belonged to their parent or to someone else. The training task was also converted online using PowerPoint slides. To ensure that children did not look at their parent while completing the task at home, parents were asked to sit behind the child, and hold a book in front of their face, pretending to read. The data for this research are available at: https://osf.io/jgp3u/?view_only=0a8646f02f644848a6ebce6107e4cad2.

Results

We defined hits as the number of images of the parent correctly identified by the child and defined false alarms as the number of images of the distractor that were incorrectly perceived to belong to the parent. To compare 4–5- and 6–7-year-olds’ ability to recognize images of their parent taken before and after they were born, we conducted separate 2 (Age Group: 4- and 5-year-olds vs. 6- and 7-year-olds) by 2 (Image Type: Before vs. After birth) mixed ANOVAs for $d’$ and criterion. $d’$ provides a measure of sensitivity to identity; higher values indicate greater sensitivity to identity. Criterion provides a measure of response bias; higher values indicate a more conservative bias.

To explore children’s ability to recognize vs. discriminate images of their parent, we also conducted these analyses separately for hits and false alarms. When analyzed in isolation hits and false alarms should be interpreted with caution, as they are not independent of one another (i.e., a difference in either measure might simply reflect a difference in criterion). Nonetheless, these metrics provide hints about differences in $d’$ or criterion. Hits provide insights into children’s ability to recognize new instances of their parent despite variability in appearance, whereas false alarms provide insights into children’s ability to tell their parent apart from a similar-looking person.

Only the 36 test images were included in our analyses. All tests are two-tailed. When analyzing pairwise comparisons, we used the Bonferroni correction to correct for multiple comparisons. Preliminary analyses revealed that there were no differences between children tested in the lab versus online on any of our dependent variables ($p < .123$). Thus, all subsequent analyses are collapsed across testing location. Fig. 1 shows individual scores for $d’$ and criterion as a function of age for before- and after-birth images.

The analysis of $d’$ revealed both a main effect of age group, $F (1, 54) = 10.28, p = .002, \eta^2_p = .16, B_{10} = 35.79,$ and image type, $F (1, 54) = 18.28, p < .001, \eta^2_p = .25, B_{10} = 464.87.$ These main effects were superseded by an age group by image type interaction, $F (1, 54) = 5.47, p = .023, \eta^2_p = .09, B_{10} = 8.86.$ Pairwise comparisons revealed that 4- and 5-year-olds were less sensitive to identity ($M = 2.21, SE = .13$) than 6- and 7-year-olds ($M = 2.84, SE = .13$) when viewing before-birth images.

$1\ d’ = \frac{z(H) - z(FA)}{\sqrt{\frac{1}{2} z(H)^2 + \frac{1}{2} z(FA)^2}}.$ Criterion = $\frac{1}{2} \left( z(H) + z(FA) \right)$. $z(H)$ and $z(FA)$ are the $z$ transformations of hits and false alarms. Hit and false alarm rates of 0 or 1 were replaced with $1/2N$ and $1-1/(2N)$ respectively, with $N$ being the maximum number of hits and false alarms.
There was no difference in sensitivity between the two age groups for after-birth images (4–5: $M = 2.78$, $SE = .09$; 6–7: $M = 3.01$, $SE = .09$; $p = .086$, $BF_{10} = 0.01$). One-sample $t$-tests revealed that 4- and 5-year-olds’ sensitivity was significantly greater than zero for both before- ($p < .001$, $BF_{10} = 3.22 	imes 10^{11}$) and after-birth ($p < .001$, $BF_{10} = 6.74 	imes 10^{16}$) images. To examine differences in performance for before- vs. after-birth images in each age group, we calculated a difference score for each participant by subtracting their $d'$ for before-birth images from their $d'$ for after-birth images. Exploratory one-sample $t$-tests revealed that this difference score was significantly greater than zero for 4- and 5-year-olds’ ($M = .57$, $SE = .76$; $t(27) = 3.94$, $p <.001$, $d = .74$, $BF_{10} = 60.01$) but not for 6- and 7-year-olds ($M = .17$, $SE = .49$; $t(27) = 1.78$, $p = .086$, $BF_{10} = 0.81$) suggesting that younger, but not older, children were less sensitive to identity in before- vs. after-birth images.

The analysis of criterion revealed a main effect of age group, $F (1, 54) = 4.46$, $p = .039$, $\eta^2_p = .08$, $BF_{10} = 2.25$. Four- and five-year-olds showed a more conservative response bias than 6- and 7-year-olds. There was also a main effect of image type, $F (1, 54) = 16.23$, $p <.001$, $\eta^2_p = .23$, $BF_{10} = 117.71$. Children adopted a more conservative response bias when judging images in the before-birth block ($M = .28$, $SE = .05$) vs. the after-birth block ($M = .12$, $SE = .04$). There was no interaction between age group and image type, $F (1, 54) = 2.66$, $p = .108$, $BF_{10} = 2.15$.

The analysis of hits revealed both a main effect of age group, $F (1, 54) = 7.58$, $p = .008$, $\eta^2_p = .12$, $BF_{10} = 10.14$ and image type, $F (1, 54) = 14.93$, $p <.001$, $\eta^2_p = .22$, $BF_{10} = 121.17$. These main effects were superseded by an age group by image type interaction. $F (1, 54) = 4.42$, $p = .040$, $\eta^2_p = .08$, $BF_{10} = 5.61$. Pairwise comparisons revealed that 4- and 5-years made fewer hits ($M = 6.43$, $SE = .39$) than 6- and 7-year-olds ($M = 8.07$, $SE = .39$) when viewing before-birth images, $p = .005$, $BF_{10} = 8.68$. There was no

![Fig. 1. Individual scores for $d'$ (A) and criterion (B) as a function of age for before- and after-birth images.](image-url)
difference in hits between the two age groups for after-birth images (4–5: 8.00, SE = .27; 6–7: M = 8.54, SE = .27; p = .160, BF_{10} = 0.01).

The analysis of false alarms revealed no main effects of age group, $F(1, 54) = 3.65$, $p = .061$, BF_{10} = 1.07, or image type, $F(1, 54) = 1.03$, $p = .314$, BF_{10} = 0.30, and no interaction $F(1, 54) = 2.87$, $p = .096$, BF_{10} = 0.49. Collectively, these findings suggest that lower sensitivity in 4- and 5-year-old children for before-birth images is attributable to their failing to recognize some images of their parent rather than misidentifying another adult as their parent.

Discussion

By the age of 6, children are adultlike when recognizing ambient images of their teacher, but many younger children make errors (Laurence & Mondloch, 2016). In the current study, we investigated whether 4- and 5-year-olds would perform like older children when shown images of a face with which they have longer and more varied experience than their teacher—that of their own parent. We collected images taken both before and after the child was born to investigate whether children can recognize their parent even when their appearance varies from the child's direct experience. Whereas there was no difference in $d'$ between the two age groups for after-birth images, 4- and 5-year-olds were less sensitive to identity than were 6- and 7-year-olds for before-birth images. Consistent with Laurence & Mondloch’s (2016) findings, 6- and 7-year-olds were able to recognize images of their parent, regardless of whether they were taken before or after the child was born. Age differences in sensitivity were largely driven by young children failing to recognize some before-birth images of their parent, rather than misidentifying the stranger.

A strength of our design is that each child was tested with one of the faces with which they are most familiar – that of their own parent. Testing young children with this highly familiar face provided the most sensitive measure of their ability to recognize people they know and avoided the difficulty finding famous faces with whom all children as young as 4 years are highly familiar. A potential limitation of this design is that children were tested with all different stimulus sets; hence, some parents' images may have been more variable than others. It is unlikely that our results are attributable to 4- and 5-year old's before-birth parent being more difficult to recognize than 6- and 7-year old's; this alternative explanation would require a systematic difference in stimulus variability between our two age groups that was limited to before-birth images. Further, the before-birth images for 6- and 7-year-olds on average would have been older than the before birth images for 4- and 5-year-olds (i.e., taken at least 6–7 years prior to test vs. at least 4–5 years prior). Further, our results align perfectly with Laurence & Mondloch’s (2016) finding that 4- and 5-year-olds have difficulty recognizing their teacher in novel images, suggesting a shift in the ability to recognize familiar faces at age 6.

Our findings suggest that 4- and 5-year-olds’ difficulty recognizing their teacher (Laurence & Mondloch, 2016) was not solely attributable to insufficient exposure to their teacher’s face. From infancy, most children have more experience with their parent than any other person (Jayaraman et al., 2015; Sugden & Moulson, 2018). Testing 4- and 5-year-olds with images of their own parent provided them the best opportunity to demonstrate successful familiar face recognition. Before-birth images of parents are comparable to the teacher’s images that young children had difficulty recognizing in Laurence and Mondloch’s study. Images of the teacher were taken outside of the classroom, capturing variability that children had not directly encountered. Thus, it is unlikely that more exposure to their teacher would have helped 4- and 5-year-old perform like older children. Collectively, these results suggest that young children have difficulty extrapolating beyond the variability to which they have had direct exposure.

It is noteworthy that even young children made very few false alarms. Twenty-two of the 28 4- and 5-year-olds made no false alarms; all children made fewer than four. Thus, young children’s errors were mostly in failing to recognize their parent in images taken before the child was born as opposed to mistaking an image of a similar-looking identity as belonging to their parent. This provides evidence that young children’s reduced sensitivity to identity is attributable to their difficulty perceiving similarity between their stored representation of their parent and images of their parent that
incorporate previously unencountered variability in appearance rather than difficulty telling their parent apart from other people.

**What develops?**

Our findings raise the question of what develops between the ages of 4 and 7 that allows older children to recognize familiar faces despite variability in appearance. One possibility is that the ability to build robust representations of identity improves with age. Becoming familiar with a new face involves learning the idiosyncratic ways in which that face can vary through copious exposure to variability in appearance (see Burton et al., 2016). This exposure allows adults to recognize an identity even in unseen instances. Although adults rate images of actors from movies that they have not seen as having higher likeness to the actor and identify these images quicker in a name verification task than images of the actors from movies they have not seen, they can still recognize images of actors from movies that they have not seen (Ritchie et al., 2018). Children might fail to recognize their parent in pictures taken before they were born because their representation is not robust enough to help them link images that lie outside their direct experience to their representation. We discuss two potential, and not mutually exclusive, explanations for the development in familiar face recognition between 4 and 7 years of age: a conceptual understanding of changes in appearance and number of known faces.

**Conceptual understanding.** To tolerate within-person variability in appearance, we must have a conceptual understanding that a change in appearance does not signal a change in identity (e.g., mom with a different hair colour is still mom; see Piaget & Inhelder (1969) appearance reality distinction). Four- and five-year-olds have at least some understanding of this concept, as they were easily able to tolerate variability in their parent’s appearance in after-birth images. Whereas changes in expression and viewpoint happen from moment-to-moment many times per day, changes in appearance due to aging happen slowly and are not reversible. Young children’s difficulty recognizing their parent in before-birth images might reflect the combined effects of this fragile understanding augmented by their lack of experience with facial aging.

Adults need to tolerate the effect of aging to recognize actors across movies and former colleagues and classmates when encountered after a delay; such changes are tolerated by adults, perhaps because adults have extensive experience with the effects of aging. Indeed, a recent study provides evidence that adults incorporate visual changes in facial appearance into one common mental representation for familiar face (e.g., Paul McCartney), even when such changes include changes associated with aging across decades (Laurence et al., 2022). It is possible that young children lack experience with how appearance can change with age, such that facial changes attributable to age signal a change in identity to young children. It is unlikely that 4- and 5-year-olds’ difficulties recognizing familiar faces can be fully explained by their lack of experience with facial aging, however. Teachers in Laurence & Mondloch’s (2016) study were not specifically instructed to find images from several years ago and so images likely did not vary as greatly in age; 4- and 5-year-olds still failed to recognize some images of their teacher. Thus, both domain-general knowledge combined with limited experience with facial aging likely contributed to 4- and 5-year-olds’ errors.

**Number of known faces.** Research investigating adults’ ability to learn and recognize faces has emphasized the role of experience with a particular identity, citing the difference between their ability to identify familiar vs. unfamiliar faces. However, adults experience with each new identity they encounter is built against a backdrop of experience with approximately 5000 other faces that they actually know (Jenkins et al., 2018). Jenkins defined actually knowing as being able to form a clear mental image of a person’s face, or recognize them if they were to be encountered. This type of experience may also play a crucial role in their ability to learn and recognize faces. Recent evidence from Deep Convolutional Neural Networks (DCNNs)—state-of-the-art computer algorithms that have a human-like capacity to recognize familiar identities across wide variability in appearance—provides a hint that experience with many faces is critical to building robust representations of identity that facilitates recognition across variability in appearance (O'Toole et al., 2018). Accurate recognition of trained identities depends on high-quality training, including initial training with millions of variable images representing thousands of identities (face knowledge history) and training with multiple images...
of to-be-recognized identities. Both types of training are essential: Object-trained DCNNs make more errors than face-trained DCNNs and the performance of face-trained DCNNs improves as the number of trained identities and number of images per identity increases (Blauch et al., 2021; Hill et al., 2019; Rosemblaum et al., 2021). Rosemblaum et al. found that the number of different identities the model learned had a greater effect on the performance than did the number of images learned per identity.

The hypothesis that experience with many faces plays an important role is also supported by evidence that adults from small towns make more errors on face learning and matching tasks and demonstrate an N170 that is less specific to faces compared to adults from large towns (Balas & Saville, 2015, 2017). Similarly, adults who were home-schooled make more errors when sorting ambient images of unfamiliar faces than adults who attended school with their peers (Short et al., 2017). Thus, experience with both between- and within-person variability might be essential for learning a new face—a pattern that is evident when DCNNs are tested with faces in disguise (Noyes et al., 2021).

Four- and five-year-olds’ lack of experience with faces in general might limit their ability to form robust representations of identity—even for faces with which they have abundant and variable experience and especially when faces have aged. Relative to older children, 4- and 5-year-old’s face experience is limited to a relatively small number of faces that they know quite well (e.g., parents, siblings, grandparents, a few same age peers). Young children have exposure to lots of instances of their parents but lack experience with lots of different people. Children might gain the ability to form robust representations of both between- and within-person variability as they start school and are exposed to a large cohort of peers and many new adults. Although very young children may see lots of faces in their environment (e.g., at the grocery store), before they enter school, their exposure is quite passive; social interactions in which they are required to label faces are limited.

Individuating faces is important for learning. Despite having abundant exposure to newborn infants, neonatal nurses do not show an advantage for recognizing newborn faces over adults with limited exposure—an effect attributable to nurse’s lack of experience individuating infants (Yovel et al., 2012). Computer models using principal components analysis (PCA) are enhanced when linear discriminant analysis (LDA) is applied (Kramer et al., 2017, 2018; Mileva et al., 2020). Whereas PCA relies on unsupervised learning based on similarity of image properties across images, LDA introduces guided learning, and reshapes the perceptual space created by PCA such that distance between images of the same identity is decreased but distance between different identities is increased. When children enter school, they are required to learn to differentiate their peers and teachers. This increase in face experience might provide essential scaffolding to form robust representations of identity.

Future directions

Some 4- and 5-year-old (n = 12) performed like older children, recognizing eight or nine before-birth images of their parent. Understanding individual differences in familiar face recognition at this age could provide valuable insights into the development of the ability to form robust representations in memory. We see several avenues for future research to examine individual differences in this age group. First, the current study did not measure children’s face experience. When children start school, they are exposed to a large cohort of their peers, as well as several new adults. The age at which children enter school depends both on their birthdate and the country in which they live. To increase the generalizability of our findings, future research could examine whether children who enter school at a younger age show an advantage at recognizing familiar faces. Second, some children might recognize familiar faces better than others because they are more sensitive to facial features that are most diagnostic of identity. Abudarham and Yovel (2016) identified a set of critical features that are most reliable for adults when recognizing identity. Future research could examine whether differential sensitivity to critical features during childhood influences their ability to recognize a familiar face in ambient images. Finally, future studies should collect measures of general cognitive abilities (e.g., memory, attention, executive function) to examine their relationship to familiar face recognition. Understanding what predicts better familiar faces recognition during childhood has important implications for children’s daily social interactions, for theoretical models of adults’ expertise and for improving state-of-the-art computer algorithms (see Smith & Slone, 2017 for discussion).
Six- and seven-year-olds easily recognized pictures of their parent, regardless of whether the photo was taken before or after they were born. There appears to be a significant shift in children’s ability to recognize a familiar face between the ages of 5 and 6. Future research examining the extent of older children’s ability to recognize familiar faces is crucial to understanding the developmental trajectory of this skill. It is possible that children 6 years of age and older would not perform like adults if the task was made more challenging. Future research could examine children and adults’ ability to recognize a familiar face when presented with images that were taken several decades ago (e.g., images of a grandparent taken when they were a young adult). Adults can recognize familiar faces even when disguised (Noyes & Jenkins, 2019). Future research could also examine whether children can do so by the age of six. If the ability to form robust representations of identity continues to be refined throughout childhood, even children 6 years and older might be less sensitive to identity than adults in these more difficult tasks.

Author note
Sarah Laurence started this project while at Keele University and is now at The Open University. Work on the project was conducted at both institutions.

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