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# Developmental trajectory of familiar and unfamiliar face recognition in children: evidence in support of experience

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**Abstract**

The ability to recognise faces and where the ability stems from is a much debated topic in psychology. This study sought to replicate Jenkins, White, Van Montfort and Burton's (2011) simple paradigm to investigate the developmental trajectory of face processing. This study was conducted with 234 participants, formed of three age groups; 4-5 year olds (N=78), 8-9 year olds (N=78) and 18-21 year olds (N=78). All participants were provided with two separate piles containing 60 photographs each and were asked to sort them into piles according to their identity. One pile contained photographs of two well known popstars' faces (familiar) and one pile contained photos of two unfamiliar faces. We found that children, like adults, created more piles for unfamiliar faces. However, when controlling for total number of piles made, we found no difference between an adult's ability to recognise familiar and unfamiliar faces, suggesting a flaw in Jenkins et al.'s original study. We also found that children produced more errors with familiar faces, which merits further exploration. We suggest that it is our experience with faces and our practice with face matching that enables us to recognise.

## Introduction

Historically, research has found that adults have difficulty in distinguishing between face variations. With previous research demonstrating our inability to recognise unfamiliar faces, questions arise regarding the recognition of familiar faces. Jenkins, White, Monfort and Burton (2011) produced much cited work that found the use of photographs to be inconsistent indicators of facial appearance. This inconsistency results in a sense of blindness to within-person variability. Jenkins et al. (2011) conducted an experiment which provided participants with an accumulation of familiar faces and unfamiliar faces, whereby they were required to separate each pile into that of the same identification. The study measured both the number of piles in which a participant placed the photographs, along with the classification that the photographs belonged to, for example whether they were a familiar or unfamiliar faces. The face matching task found that participants created more unfamiliar identities than were present. This study provides evidence for experience being vital in face recognition as it suggests that for an accurate recognition of faces, being familiar with the individual is crucial. However, although many texts debate whether recognition is an innate ability or one developed through experience, no research has replicated Jenkin et al.'s study on children. Children provide the ideal frame work to investigate these competing hypotheses, using Jenkins' very simple paradigm.

Previous research demonstrated that a variation of biases has often affected the ability to recognise faces which are both familiar and unfamiliar. Own-age-bias (OAB) has been known to affect a person's ability to recognise faces. OAB suggests memory recognition is superior when engaging with faces of one's own age (Rhodes & Anastasi, 2012). Due to individuals having more extensive contact with members of their own age group, this facilitates the development of recognition expertise (Valentine, 1999). He, Ebner and Johnson (2011) conducted a study on younger and older adults where they were presented with images of same-age and other-age faces. Following this, a recognition test was performed. All participants reported more exposure with same-age faces than other-age faces and the findings demonstrate that both groups exhibited an own-age bias in recognition memory, suggesting recognition stems from experience. However, He et al. (2011) stated that those who reported frequent contact with other-age groups were less impacted by the OAB effect and exhibited enhanced memory for the alternative age group (Cassia, Kuefner, Picozzi & Vescovo, 2009). This suggests age variant is not the sole factor that enhances face recognition, but experience with any age group can enrich an individual's ability to recognise faces more easily.

Additionally, race has been found to have great effect on facial recognition. Face recognition is more superior for one's own race and is often referred to as own-race bias (ORB) (Meissener & Brigham 2001, Malpass & Kravitz 1969). ORB effect has been found to make cross-racial eyewitness identification highly unreliable, resulting in great costs for the criminal justice system (Doyle, 2001). Rhodes, Brake, Tan and Taylor (1989) suggested that cross-racial faces are interpreted in a less holistic way, providing fuel for the own-race bias effect. This suggests that experience with our own race has enhanced our ability to focus on faces as a whole, instead of fixating on features.

An inability to recognise unfamiliar faces has been found to be problematic for eye-witness testimonies (Megreya & Burton 2008). When an event occurs during criminal

investigations, witnesses are often required to identify suspect's months after an event occurs which has been found to be challenging (Megreya, Sandford & Burton 2013). Line ups are frequently used to assist in the process of solving crimes with the aim of a witness being able recognise the suspect in a group of individuals sharing facial similarities. Megreya, Sandford and Burton (2013) conducted a study on students in Egypt which focused on the reliability of line ups. Within the study, participants were shown a target face followed by one-in-ten face matching line up. Participants were required to state whether the target face was present. Results found that when photographs of the same individual were taken months apart, the level of accuracy fell dramatically. This suggests that within-face variability can affect an individual's memory and recall of facial images and suggests that the use of line ups in criminal investigations can be seen as unreliable.

Face recognition has become a valuable and routine forensic tool used by criminal investigators (Jain, Klare & Park, 2011). When no photographs of potential suspects are available, a witness' facial memory needs to be relied on in order for a forensic sketch to be produced (Jain, Klare & Park, 2011). These sketches can often be misleading due to errors in a witness' memory recall. Klare, Li and Jain (2011) developed a framework which matched sketches to photographs allowing investigators to match the sketch against face databases. Although this framework is in place to overcome errors, it also develops new obstacles in accuracy. Due to a witness' inability to accurately recall the appearance of the suspect, the sketches often closely resemble innocent civilians as shown in the Jain, Klare and Park (2011) study.

In environments with high security, photo identification is often used despite previous research demonstrating its unreliability. White, Kemp, Jenkins, Matheson and Burton (2014) conducted a study which compared the abilities of specialist trained individuals represented by passport officers against students in their ability to recognise unfamiliar faces. Prior to testing, the passport officers had undergone training which encouraged a feature-by-feature approach when comparing facial images. Officers were asked to compare photos to live identification card bearers. A high error rate was observed with a false acceptance of fraudulent photos. White et al. (2014) compared this data with that of the students finding equally poor levels of accuracy in both groups. This suggests that experience in face matching tasks does not provide individuals with an enhanced ability to identify unfamiliar faces and implies that experience can only be associated with faces that are familiar to oneself.

Research states that adults are experts with regards to familiar facial recognition but there is much controversy about how this ability develops with age (Maurer, Le Grand & Mondloch, 2002). Adults have been found to have the ability to recognise faces at a glance under a wide range of conditions such as a variety of expressions, viewpoint and aging of individuals. However, according to Burton (2013), the ability to recognise face identity across a set of images that incorporate natural variability in appearance has often been ignored in previous literature with the exception of a study by Mondloch, Geldart, Maurer and Le Grand (2003). With the use of the same camera, a surgical cap and removal of blemishes, Mondloch, Geldart, Maurer and Le Grand (2003) diminished a participant's ability to use non-face cues to identify individuals. This study provides us with important information about a human's ability to distinguish between images and facial identities. Although it provides evidence of

a person's ability to recognise sole faces, it ignores the ability to recognise faces in natural environments.

However, current research suggests that there is a developmental shift in the ability to recognise faces, with face recognition appearing to be adult-like by early childhood. According to Laurence and Mondloch (2016), a person's ability to recognise identities across images which capture natural variability in appearances has been found to be a challenge in society. Laurence and Mondloch (2016) created a child-friendly study, based on the Jenkins et al. (2011) face matching task. During the study, each child between the ages of 4-12 years were required to sort through facial images and place images of their teacher into a house. Children aged six years of age were shown to have the same recognising abilities for familiar faces as an adult. Considerable variability, however, was found in the children's performance in recognising unfamiliar faces, with ability improving with age. This improvement weakens the argument that we are born with innate recognition ability and suggests that experience and environment can develop the ability to recognise. Therefore our study will recruit two different age groups of children to investigate the hypothesis that 8-9 year olds will perform better at matching tasks than 4-5 year olds.

Similarly, De Heering, Rossion and Maurer (2012) found that although there are large improvements between the age of six and eight, it is after the age of twelve that enhancements in facial recognition occur. This suggests that face processing undergoes prolonged development during childhood. We therefore hypothesise that adults will identify faces more accurately than children. This research is supported by Blaney and Winograd's (1978) study which stated that face recognition abilities take years to reach adult level of expertise. However, research has not yet found a concrete age at which facial recognition reaches adult expertise.

Therefore, from previous literature we hypothesise that both adults and children will place unfamiliar faces into more piles as they will be worse at identifying these unfamiliar faces as the same identity, with adults overall identifying faces better and therefore creating less piles. We also hypothesise that children aged 8-9 years will be better at identifying faces compared to 4-5 year olds. Therefore, a replication of Jenkins' et al.'s (2011) study, using its simple paradigm, will be conducted with the aim to discover whether the ability to recognise faces is an innate ability or stems from experience. This will be distinguished through the comparison of data between children and adults.

## Method

### Participants

The study was conducted using 234 participants (148 Females, 86 Males). Participants were segregated into three age groups; 4-5 year olds (N= 78, M=4.42, SD=.497), 8-9 year olds (N=78, M= 8.44, SD=.499) and 18-21 years (N=78, M=19.3, SD=.941). Participants aged 4-9 years were recruited from three schools; Pomphlett Primary School, Morice Town Primary School and Drake Primary School. Participants aged 18-21 years were Psychology Undergraduate Students from Plymouth University. Each participant participated in two conditions; familiar faces and unfamiliar faces.

### Materials

To represent the familiar condition, thirty images were used for each member of One Direction (Louis Tomlinson, see Figure 1A and Liam Payne, see Figure 1B). For the unfamiliar condition, thirty images were used for each Dutch male model (Ton Heulke, see Figure 1C and Malcolm De Ruiter, see Figure 1D). These individuals were well known in the Netherlands, however are unknown within the United Kingdom. Images were collected via Google Images using the celebrities' names as search terms. Photographs were selected on the basis of the following criteria: faces shown roughly through a frontal aspect and in both black and white or colour. Photographs were printed to the measurements of 6x4 inches.


**Figure 1:** Shows a range of facial photographs used to represent both familiar (row A and B) and unfamiliar (row C and D) faces.

### Procedure

Participants were given a randomised deck of 60 photographs at a time. They were asked to sort them by identity, with the aim of producing piles of who they believed was the same person. There was no time restriction to this task, with participants able to produce as many or as little piles as their wished. Piles were given to participants in a counter-balanced order, with either familiar or unfamiliar condition given first. Once participants had completed their piles, experimenters recorded the number of piles, alongside the number of correct or mixed piles. Correct piles were recorded as those that exclusively contained one identity. Mixed piles were piles where the participant had incorrectly sorted both identities together as the same person and can therefore be considered incorrect.

## Results

A mixed analysis of variance (ANOVA) was conducted on familiar and unfamiliar faces (within subjects) with three age groups, 4-5 year olds, 8-9 year olds and 18-21

year olds (between subjects). The main effect of familiarity of faces, on the number of piles made was significant, $F(1,231) = 10.4$, $p=.001$. Findings showed that unfamiliar faces were sorted into more piles (M=9.33, SD=9.87) than familiar faces (M= 11.1, SD=11.1), see figure 2. Therefore, regardless of age, participants sorted the familiar faces into less piles than the unfamiliar, in line with the original results (Jenkins et al., 2011).

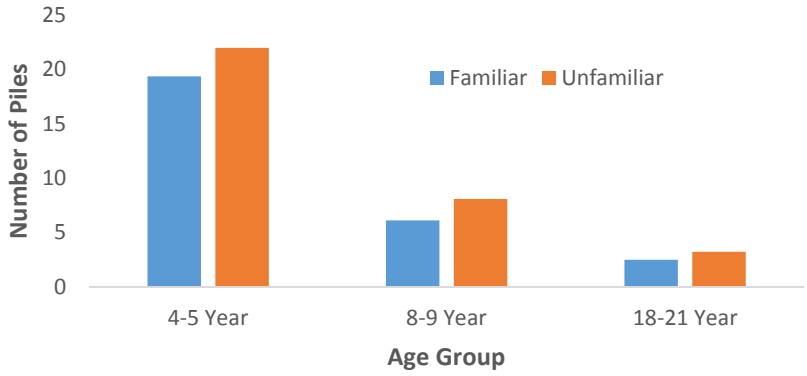


**Figure 2:** Graph showing mean number of piles for each age group, for both familiar (Blue bars) and unfamiliar (Orange Bars) faces.

A significant difference was found with the main effect of age group, $F(2,231) = 72.7$, $p<.001$. We looked into this further using a series of planned contrasts and found that there was a difference between 4-5 year olds and 8-9 year olds, $F(1,231) = 77.3$, $p<.001$. It was found that 4-5 year olds (M=20.7, SD=16.7) organised the faces into more piles than 8-9 year olds (M=7.12, SD=16.7). Findings also showed that 4-5 year olds made significantly more piles than 18-21 year olds (M=2.87, SD=16.7), $F(1,231) = 133$, $p<.001$. Following this, a significant different was found when comparing 8-9 year olds and 18-21 year olds, with 8-9 year olds producing more piles, $F(1,231) = 7.61$, $p=.006$. Overall, children sorted familiar and unfamiliar faces into more piles than adults, $F(1,231) = 68.2$, $p<.001$ (See figure 2.). No interaction was found between the familiarity of faces, regarding the number of piles made and the age group of participants, $F(2,231) = 1.02$, $p=.362$. There was, therefore a significant difference in how many piles each age group made, regardless of whether the photos were of familiar or unfamiliar faces. This followed a developmental trajectory, with less piles made with the increasing age of the participants, supporting a developmental improvement in the ability to face match with age.

In order to investigate our findings in more detail than Jenkins et al. (2011), we conducted an ANOVA on not just the number of piles made, but also the errors made. We calculated a proportion of mixed piles score for each participant by dividing the proportion of mixed piles by the number of total piles. This gives us an indication of not only the raw number of identities each participant believed to be present, but also their accuracy when sorting these identities. The main effect of familiarity on a proportion of mixed piles (or proportion of errors made) was significant, $F(1,231) = 14.9$, $p<.001$. It was found that there were more errors made on familiar faces (M=.277, SD=.291) than unfamiliar faces (M=.201, SD=.275), see Figure 3. This is an interesting result, as we would expect less errors to be made when recognising and matching familiar faces.

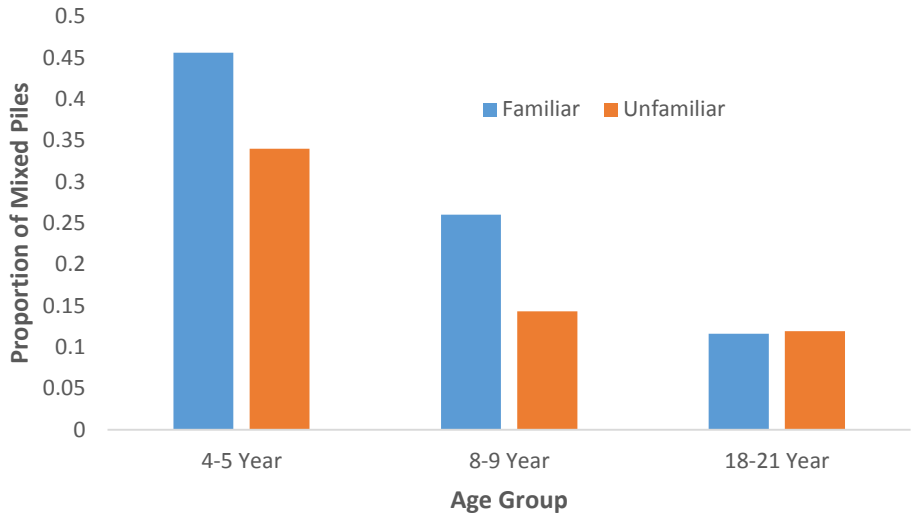


**Figure 3:** Graph showing the mean proportion of mixed piles for each age group, for both familiar (Blue bars) and unfamiliar (Orange Bars) faces.

A significant difference was found with the main effect of age group, $F(2,231) = 29.0$, $p<.001$. To look further into the differences found within age groups we performed a series of planned contrasts. A difference was found whereby 4-5 year olds showed a higher proportion of mixed piles (M=.398, SD=.413) than 8-9 year olds (M=.202, SD=.413), which suggests that there were more errors made by 4-5 year old children, $F(1,231) = 27.0$, $p<.001$. Results found the proportion of mixed piles was higher for 4-5 year olds than 18-21 year olds (M=.117, SD=.413), $F(1,231) = 55.0$, $p<.001$. Findings also showed that 8-9 year olds made more errors during the face matching task, as the proportion of mixed piles was higher than for 18-21 year olds, $F(1,231) = 4.95$, $p=.027$. Overall, it was found that children (aged 4-5 and 8-9 years) made more errors than adults (aged 18-21 years), producing a higher proportion of mixed piles, $F(1,231) = 31.0$, $p<.001$, see figure 3. This again demonstrates a possible developmental trajectory of this process, with errors decreasing with age.

A significant difference was found when testing the interaction between familiarity of faces and age group, regarding the proportion of mixed piles, $F(2,231) = 4.04$, $p=.034$. Numerically, we can see that children aged 4-5 years had a higher proportion of mixed piles for familiar (M =.456, SD =.505) than unfamiliar faces. Contrary to these findings, 8-9 year olds were found to have a higher proportion of mixed piles for unfamiliar faces (M =.143, SD =.474) than familiar (M =.260, SD =.505). However, there was little numerical difference found between the proportion of mixed piles for both familiar (M =.116, SD =.505) and unfamiliar (M =.119, SD =.474) made by 18-21 year olds. This pattern of results will be discussed further in the following section.

## Discussion

In order to distinguish whether the process of recognising faces is caused by innate abilities or through experience, our study was conducted on both children and adults. This study found a significant variation between the ability of an adult and a child to

identify familiar and unfamiliar faces, with a child's performance on a face matching task being considerably worse. In both the number of identities the participants believed to be present, as well as their accuracy in face matching, children aged 4-5 performed less well than older children (aged 8-9) and these children in turn did not perform as well as 18-21 year old adults.

This may be taken to support the hypothesis that proposes experience plays a role in the face recognition process. Results may suggest that we are able to train individuals to exceed their natural ability by providing them with experience in recognising faces. However, the majority of previous research has been found to disagree. Therefore, the development of this skill, while possibly experience based, either cannot be increased at adulthood (i.e. is at ceiling, or is particularly difficult to train), or develops in conjunction with (or indeed as a result of) other mental processes that are acquired throughout childhood.

One such possible mental process may be working memory. A child's capacity to facilitate a global image within memory may be the underlying restriction on a child's ability to match identities accurately. Due to the lack of experience a child has with faces, the ability to store images within their memory may be weak. Observations during the task found children were distracted quickly and were often unable to focus on numerous photographs at one time. According to Kharitonova, Winter and Sheridan (2015), working memory develops slowly, with children aged eight only being able to memorise half the number of items that an adult is able to retain. This provides support for the experience argument as it suggests an adult's experience has benefitted their ability to recall. Further, it was hypothesised that both children and adults would create more piles for unfamiliar identities. Although this was seen to be the case for children, there was not a significant difference found between the number of piles created by adults. Future developments would need to involve testing a child's memory capacity by replicating Jenkins et al.'s (2011) study using multiple photographs of the same image. This would allow researchers to observe the child's ability to recall a previously seen image and match it to the appropriate pile.

With the use of solely adolescent individuals representing both familiar and unfamiliar faces, this could have created an own-age bias (OAB) effect providing ease for 18-21 year olds when attempting to recognise faces. According to Rhodes and Anastasi (2011), memory is often superior for faces of one's own age group. To test whether OAB affected the results, a replication of the study would be necessary using images of children in both familiar and unfamiliar conditions. If children are better than adults, or improved significantly during the task, we control for the possibility that OAB may greatly affect the recognition of faces in this study, and further demonstrate that experience with one's own age group plays an important role in the recollection of facial memory.

Through an incidental observation it was found that race could play a role in the ability to recognise faces. Although no conclusions can be drawn from results, due to no initial tests being carried out, the only two non-Caucasian child participants appeared to perform significantly better in comparison to the Caucasian children. With the non-Caucasian participants (both aged four) obtaining a *z* score of 15.5 and 2.99, both showing a *p* value of less than .05, this provides a thought-provoking

result whereby extended research could be beneficial. The own-race bias (ORB) effect suggests that one is more superior in recognising one's own race (Meissener & Brigham, 2001). However, from these scores we could speculate that the children have not yet established their ORB, as they lack the experience to gain recognition expertise with their own race. There is also a probability that the ability to recognize own race faces is not a result of the ORB effect but the experience we have with those within our society. Therefore, if our society is made up of a majority race, there is a possibility that our experience with them will provide better recognition for their faces.

Historically, face matching experiments have focused solely on our inability to recognise unfamiliar faces, ignoring our ability to recognise familiar faces. Jenkins et al. (2011) found that adults were less successful at identifying unfamiliar faces which implies that experience plays a major role in a person's ability to recall identities – the simple result that more familiarity results in a more fluent recall. However, although adults are found to be better at recognising the familiar we cannot claim to be experts, as shown in White et al.'s (2014) study where results found trained individuals to be no better at recognition than those less experienced. This suggests that it is not our experience with face matching tasks that improves our recognition ability, but our experience with individual faces.

Findings show that 4-5 year olds were worse at identifying familiar faces in comparison to the two alternative age groups. This provides evidence that 4-5 year olds lack the experience that 8-9 and 18-21 year olds have with facial identification. Findings showed that although all three age groups performed negatively whilst identifying unfamiliar faces, it was only the 4-5 year olds who performed poorly at distinguishing familiar faces. To perform worse at something that is familiar to them, this suggests that the images may not have been as recognisable. Therefore, a familiarity checking experiment would be needed to further investigate a 4-5 year olds ability to recognise familiar faces. However, it is also important that future experiments focus on the age of stimuli used as this could have an affect on a child's ability to identify faces. Findings suggest that errors may have surfaced during the study whereby 4-5 year olds have either not recognised the members of One Direction as individuals or because they did recognise them, it caused them to become more confident therefore resulting in a lack of concentration. Further studies would be required to eliminate these factors.

Adults were found to show no significant difference between their ability to recognise familiar and unfamiliar faces. These results contradict the findings of Jenkins et al., (2011) which suggests that adults had the ability to better recognise familiar faces in comparison to unfamiliar faces. Adults may have believed that there were more identities, however, findings show that they still produced the same level of accuracy for the both the familiar and unfamiliar conditions. This merits further research, which would require reanalysing Jenkins et al., (2011) study as these findings suggest a possibility of two distinct mental processes at work. For example, consciously how many people do I think are here (number of piles) and how good I am at face matching (proportion of mixed). Although the proportion of mixed piles provides a more sophisticated result of a persons' ability to recognise, further research would need to be conducted to rule out confounding factors such as age and race bias.

Incidental observations during testing found that children aged 4-5 years may have used alternative face recognition processes or strategies compared to adults. Children aged 4-5 were found to focus on features such as birth marks, facial hair or even clothing when trying to distinguish between identities. Children were even seen separating black and white or coloured images. Opposing this, adults were observed to process faces globally. A developmental shift was found to occur during the ages of 8-9 years old. Observations found that within this age group, a mixture of processes were detected as to how faces were identified, with some children using features whilst the others looking at faces as a whole. We can infer that by the ages of 8-9 years, children have experienced faces to an extent whereby they become more familiar with them, allowing a change in strategy to occur when identifying faces. This could be measured and investigated experimentally using eye tracking software.

The processes used to identify faces could be the sole difference in a person's ability to match identities and this raises concerns for eye-witness testimonies performed by children. For example, a child could identify an individual solely on hair colour or facial feature. In order to overcome this, a replication of the study should be conducted using stimuli similar to that used by Mondloch, Geldart, Maurer and Le Grand (2003) where models were dressed in surgical caps and gowns. This would prevent a child fixating on features within the photographs and create a more reliable account on the foundations of face recognition.

The aim of this experiment was to determine whether the ability to recognise is innate ability or experienced based. Great support for experienced based ability has been provided throughout this study. Through the use of Jenkins et al.'s (2011) simple paradigm, conducted on both children and adults, it was discovered that the ability to recognise faces follows a developmental trajectory, with adults excelling in the face matching task compared to children. Although previous literature has suggested that individuals are worse at recognising unfamiliar faces, in this study, children made more errors in the recognition of familiar faces than unfamiliar, with adults showing no significant difference between either condition. These results contradict previous findings and perhaps reflect issues with the measures taken in earlier experiments. In conclusion, although experience has been found to be a major factor in an individual's ability to recognise faces, further investigation is needed into memory, age and racial bias with both children and adults.

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