Children perceive illusory faces in objects as male more often than female

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Abstract

Face pareidolia is the experience of seeing illusory faces in inanimate objects. While children experience face pareidolia, it is unknown whether they perceive gender in illusory faces, as their face evaluation system is still developing in the first decade of life. In a sample of 412 children and adults from 4 to 80 years of age we found that like adults, children perceived many illusory faces in objects to have a gender and had a strong bias to see them as male rather than female, regardless of their own gender identification. These results provide evidence that the male bias for face pareidolia emerges early in life, even before the ability to discriminate gender from facial cues alone is fully developed. Further, the existence of a male bias in children suggests that any social context that elicits the cognitive bias to see faces as male has remained relatively consistent across generations.

Keywords: childhood development, face perception, social perception, gender, face pareidolia, male bias

1.1 Introduction

Face perception is a complex function that is important for social communication and is prioritized by the visual system. Infants have a preference to look at face-like configurations as early as a few hours after birth[1–6], and the preference to look at abstract faces[7,8] and faces in complex scenes[9] increases over the first year of life. A preferential response to faces in the fusiform gyrus is observable with fMRI in the brains of infants as young as two months old[10], and domain-specific patterns of functional connectivity between the fusiform face area and occipital face area are evident in infants only a few days old[11]. Despite this evidence for the existence of cortical face preferences so early in life, face-selectivity in ventral temporal cortex continues to develop throughout childhood[12–17]. Similarly, it is well known that different aspects of face perception develop at different rates. For example, the ability to recognize face identity[18–21] and facial expressions[22–25] continues to develop throughout the first decade of life, alongside other forms of face evaluation including judgements of trustworthiness from facial cues[26] and preferential memory for threatening faces[27]. Here, we investigated face evaluation during childhood.

Recently, we found that adults have a strong bias to perceive illusory faces in objects (face pareidolia) as male rather than female, even though these faces have no biological sex[28]. This bias could not be accounted for by pre-existing semantic or visual associations with the object containing the illusory face, nor was it reducible to specific visual features of the images. Instead, the male bias appears to arise from the perception of the face itself. After ruling out several perceptual explanations based on low-level visual features in illusory faces such as color, curvature and rectilinearity[29,30], and more complex visual features such as those captured by saliency models[31], the GIST visual feature model[32] and the VGG-19 deep neural network[33], we concluded that the tendency to perceive illusory faces as male rather than female has a cognitive rather than perceptual origin[28]. The cause of this cognitive bias remains unclear, and it remains possible that it is driven by fine-grained perception of the characteristics or configuration of the illusory facial features. In the present study, we investigated whether children show a similar bias for the perceived gender[§] of illusory faces. If children do show a male bias for illusory faces, it will be informative about the origin of the bias in two ways. Firstly, if children show a male bias before their ability to categorize gender from facial features is fully developed, it will suggest that the perception of illusory faces as male rather than female does not depend upon fine-grained distinctions in either facial features or their configuration. And secondly, if children show a bias, it will indicate that the societal context that elicits a bias to see faces as male rather than female has remained stable across recent generations.

The perception of biological sex from facial cues emerges early in development. Infants aged 3-4 months show a visual looking preference for female faces, unless their primary caregiver is male, in which case their preference is for male faces[34]. Human faces are sexually dimorphic[35–40], and adults are able to rapidly and accurately classify the sex of faces even in the absence of typical sex-defining features such as hairstyle, clothing, facial hair, or makeup[41–44]. Children show an increase in the ability to accurately

[§] We use the term "gender" to refer to the perception of illusory faces as male or female since they do not have a biological sex. As gender is nonbinary, we included a third response option ("not sure") in our experiments so participants did not have to select either male or female. In the original study, we found that many illusory faces were not perceived to be either male or female (i.e. perception of gender did not necessarily accompany perception of a face).

classify both children and adult's faces by sex in the absence of external cues such as hair from ages 7 to 9 years of age, although their performance remains below that of adults[41].

Like adults, children experience face pareidolia[45]— the perception of illusory faces in everyday objects. Consistent with the early preference to orient towards face-like patterns soon after birth[1–6], there is evidence from near-infrared spectroscopy that infants develop the ability to see faces in the related phenomenon of fruit deliberately arranged to appear as a face (Arcimboldo images) as young as 7-8 months of age[8]. As their ability to classify gender based on facial cues is still developing, here we were interested in (1) whether children perceive gender for illusory faces in objects, and (2) whether children, like adults, have a bias to perceive illusory faces as male rather than female. To address these questions, in this study we collected face and gender ratings for a large set of 160 illusory faces in objects from over 400 participants aged from 4 to 80 years.

1.2 Data availability.

All visual stimuli, raw data, and analysis code are publicly available on the Open Science Framework (https://osf.io/k4ru2/).

2.1 Material and methods

2.1.1 Participants.

A convenience sample of 453 adults and children ranging in age from 4 years to 80 years of age participated in this study. All experimental procedures were approved by the Human Research Ethics Committee at the University of East Anglia (Project Ref 2020-0198-001972) and participants provided informed consent prior to participation. 241 participants completed the experiment in-person at the Norwich Science Festival in the United Kingdom, and 212 participants completed the experiment online. Of the total sample, 33 participants were excluded from the analysis as they indicated that they had been diagnosed with a neurodevelopmental condition. A further 8 participants were excluded because they answered "no" to a question at the end of the session asking if we could/should use this data in our research project (this question was included for participants to indicate if issues with data quality meant their responses shouldn't be included in the study). This left a total of 412 data sets across both in-person and online versions of the experiment that were combined for the analysis.

As our aim was to determine whether children have a bias to see illusory faces as male rather than female, which we previously demonstrated for a US-based adult sample[28], we focused data collection on individuals under the age of 14 (Figure 1c). The distribution of participant ages and self-reported gender is shown in Figure 1c and Figure 1d respectively. For all analyses, we divided our sample into three age groups which were designed to balance sample size across the lifespan with our interest in separating out older and younger children (4-8 years: n = 103, 8-14 years: n = 142, 14-80 years: n = 167).

2.1.2 Visual stimuli.

The visual stimuli consisted of 160 photographs of naturally occurring illusory faces in everyday objects (Figure 1e) from our previous study investigating the perceived gender of illusory faces in a population of US adults[28]. For control images, we used 32 photographs of objects that were matched as closely as possible to a subset of the illusory face images but did not have an illusory face (Figure 1e) and 22 photographs of human faces (not shown). Images were cropped to the same size (400 x 400 pixels) but no other alterations were made.

The images shown to each participant were sampled from the overall set of images. Participants rated 20 pareidolia images for whether they could see a face, and then rated a further 20 pareidolia images for gender. To allocate the 40 pareidolia images for each participant, the 160 pareidolia images were split into eight sets of 20 images. Each participant rated one of these eight sets for the face question, and then for the gender question an additional 20 images were drawn from the remaining seven sets. In addition to the illusory faces, participants saw 8 (out of 22) human face images and 4 (out of 32) matched object images that were used as controls. For each participant, the control stimuli for the face question were 4 matched object images and 2 human face images (1 female, 1 male), which were allocated based on which of the 8 sets of pareidolia images the participant saw for the face question. The control stimuli for the gender question were 6 human faces (3 female and 3 male), and the same control images were used for all participants.

2.1.3 Experimental procedure.

The experimental design for the in-person and online versions of the experiment was identical except for the following procedural differences described here. The experiment was programmed in Testable (www.testable.org). At the science festival, participants completed the experiment on a laptop at a festival booth, supervised by an experimenter who ran participants one- or two-at a time (Figure 1a). For online child participants, who were asked to complete the task in the presence of a caregiver, instructions were provided via an engaging video aimed at children that explained the task (Figure 1a). The same video was also shown to adult online participants. At the science festival, the instructions were provided in-person by the experimenter.

A challenge with online testing of young children is ensuring their responses are not influenced by their parents, given that parent assistance is required to navigate the online experimental system. To address this, we took the following steps. We asked parents to sit with their child while they completed a short "game" (the experiment). In the consent form there was a check box stating ‘if my child is participating, I will sit with them while they complete this short task and help them make their own, independent responses’. We also offered parents the chance to complete the experiment as an adult if they were interested in contributing their own responses.

After answering the demographic questions and providing consent, participants rated whether they could see a face in their subset of 20 illusory face images by responding "face", "no face", or "not sure". Each image was shown one at a time (Figure 1b). Each participant also answered the same question for six control images: four nonface objects, and two human faces. Next, participants rated the perceived gender of a new subset of 20 illusory face images that they had not yet seen as "male", "female", or "not sure". They also rated the gender of six human face images which served as a control. For both face and gender questions, the images were presented in a random order for each participant.

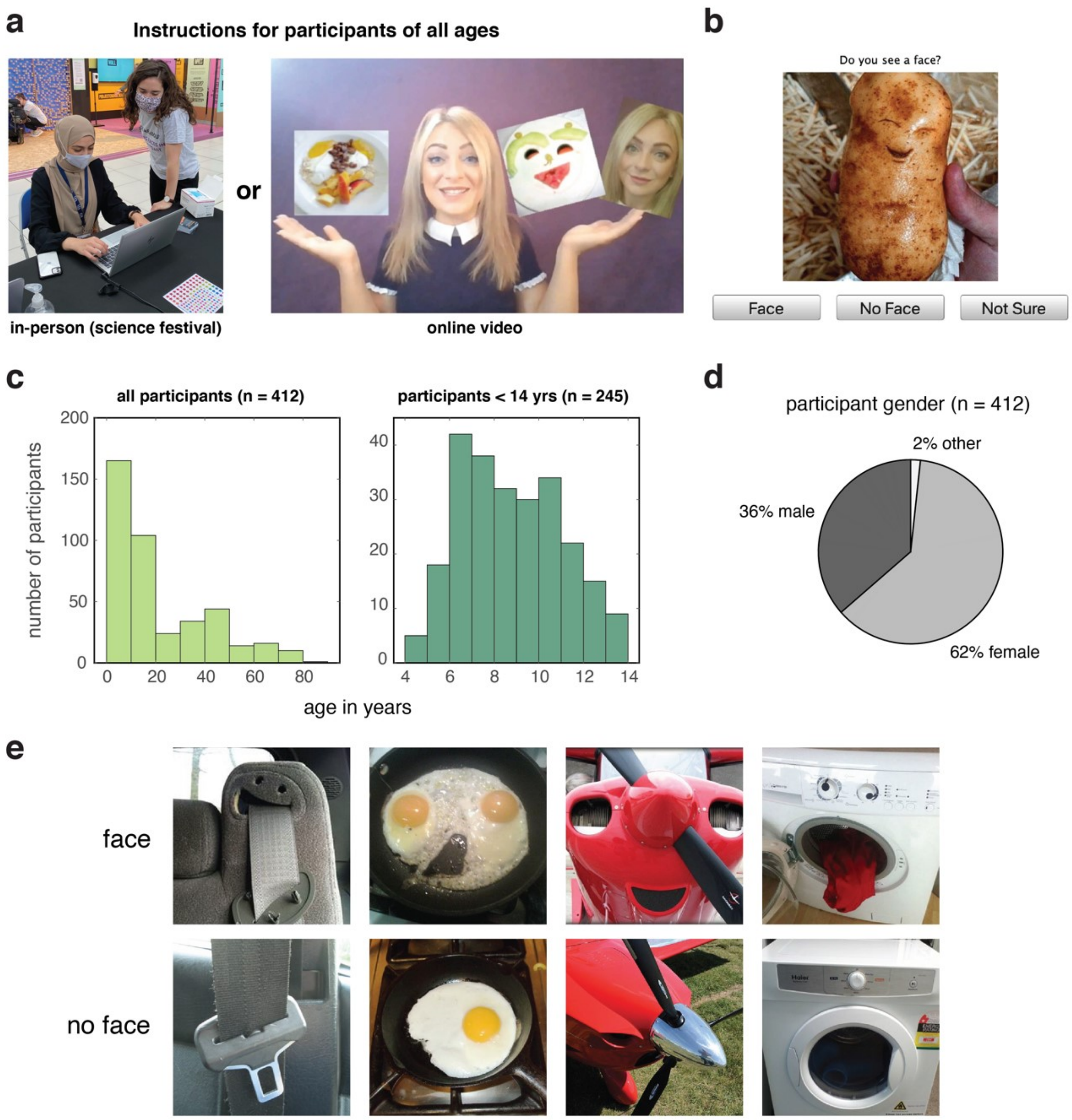

Figure 1. Experimental design and participant demographics. (a) Participants completed the experiment on a computer either in person at a science festival (photo of the setup is shown on the left) or online (a still frame from the

instructional video is shown on the right). (b) Example screenshot for the "Do you see a face?" question. (c) Histograms of the distribution of all participant ages (left) and the distribution of participants aged under 14 years (right). (d) Pie chart shows the distribution of participants' self-reported gender across all ages. (e) Visual stimuli were 160 photographs of illusory faces in objects (top row), with 32 nonface objects matched to a subset of the illusory faces (bottom row) and 22 photographs of human faces (not shown) as control stimuli.

3.1 Results

First, we assessed whether participants perceived illusory faces in objects. The proportion of "face" responses given to the illusory face images and control images (2 human faces and 4 matched objects per participant) is plotted in Figure 2a as a function of age. For each participant, we calculated the proportion of stimuli they gave a "face" response to separately for each of the three categories: illusory faces, human faces, and nonface objects. We then averaged these proportions for each category across all participants in each age group. Averaged across all age groups, very few face ratings were given to the nonface object control images (M_{prop} = 0.07, SD = 0.01) and the proportion of face ratings given to the human face control images approached ceiling (M_{prop} = 1.00, SD = 0.00), confirming that participants of all ages were able to do the task. Similarly, the high proportion of face ratings given to illusory face images averaged across all age groups confirmed that participants saw a face in most of the examples (M_{prop} = 0.90, SD = 0.02). A nonparametric Kruskal-Wallis H test revealed a significant difference in the proportion of illusory faces reported by the three age groups ($H_{(2)}$ = 11.24, p = .004). Follow-up pairwise comparisons with the Dunn-Bonferroni correction applied for multiple comparisons clarified that there was only a significant difference in the proportion of face ratings for illusory faces between the youngest and oldest age groups (p = .002). However, participants in the youngest age group (4-8 years) still reported seeing a face in most illusory face images (M_{prop} = 0.88, SD = 0.16), and there was only a small difference in magnitude compared to the proportion rated as faces by participants in the oldest group aged 14-80 years (M_{prop} = 0.92, SD = 0.15). There was no significant difference in the proportion of face ratings given by children aged 8-14 (M_{prop} = 0.90, SD = 0.15) and that given by either younger children aged 4-8 (p = .117) or older participants from 14-80 years of age (p = .544).

These results demonstrate that participants of all ages saw illusory faces in the examples of face pareidolia that we selected for the experiment. For each age group, we show the image that scored the lowest proportion of face ratings from the group (*prop.* = 0.45-0.62; top row, Figure 2b) and examples of those that scored the highest (*prop.* = 1.0; bottom row, Figure 2b). Since faces were perceived by most participants in most images, multiple images received "face" responses from all participants who saw the image. Consequently, for each age group we selected only one example of an image with a perfect score to display in the bottom row of Figure 2b.

To complement the participant-level analysis, we also conducted an image-level analysis and calculated the proportion of face ratings given to each illusory face image across all participants. Note that as participants only saw a subset of the larger set of images, there is not an equal number of ratings per image. For each of the three age groups, we calculated the proportion of participants who saw a face in each individual illusory face image and plotted the resulting distributions in Figure 2c. The histograms are skewed to the right for all age groups, indicating that participants of all ages saw a face in most of the illusory face images. This is further supported by the inset pie charts showing the distribution of all responses ("face", "no face", and "not sure") given to the 160 illusory face images from every participant. Across all age-groups, participants indicated that they saw a face in most images (88-92%) and gave very few "no face" (4-6%) or "not sure" (3-6%) responses.

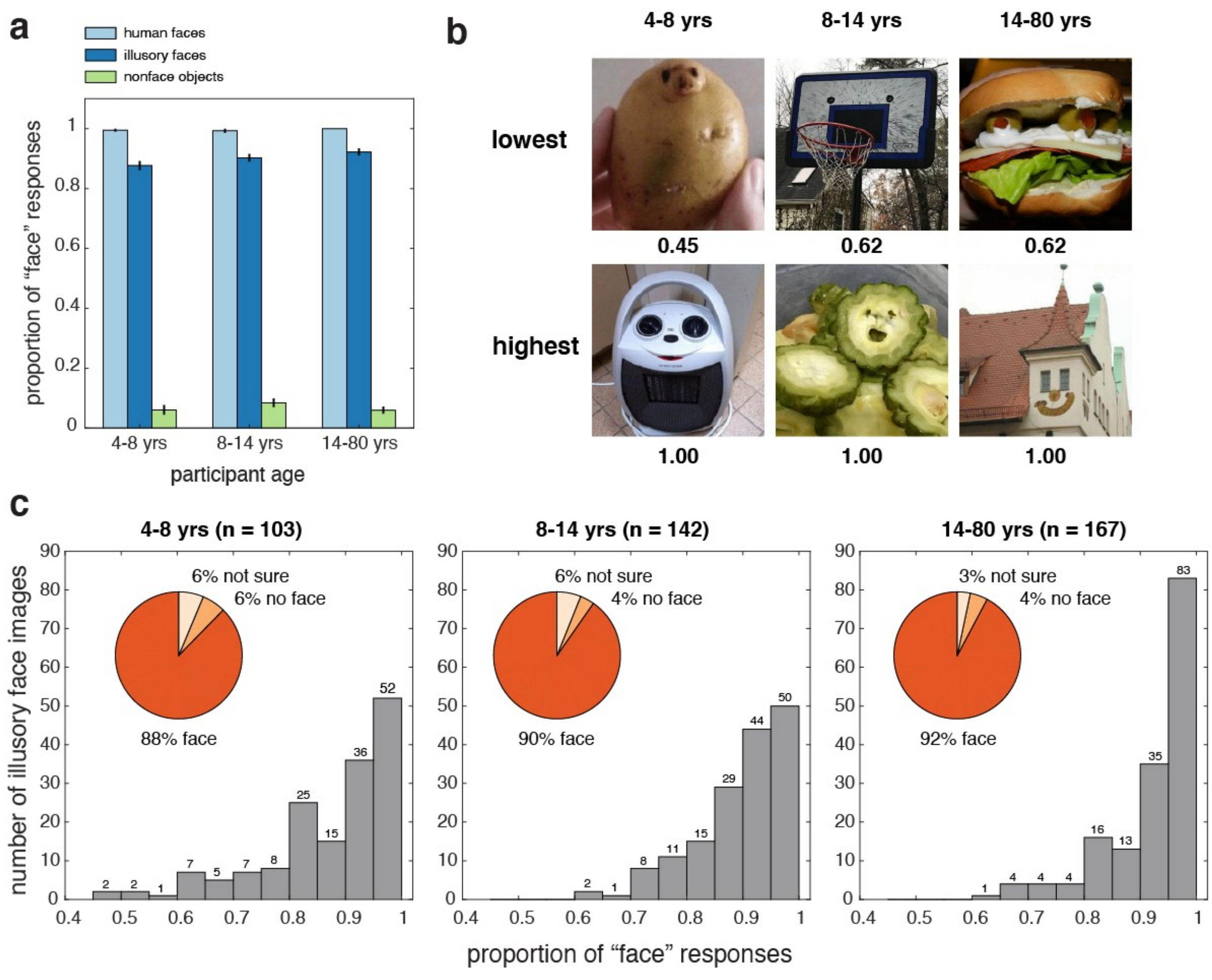

Figure 2. Face ratings for pareidolia images as a function of age. (a) Mean proportion of "face" ratings given by participants of different ages for illusory faces images (n=20 images per participant), human faces (n=2 images per participant) and nonface objects matched to the pareidolia images (n=4 images per participant). Error bars show +/- 1 standard error of the mean. (b) Illusory face images with the lowest and highest proportions of "face" responses as a function of participant age group. For all age groups, multiple images scored the highest rating (proportion = 1.0), so an example image is shown for each group. The proportion of "face" ratings given to each image is shown

underneath (relative to "no face" and "not sure" responses). (c) Histograms of the proportion of face responses given to each of the 160 pareidolia images as a function of participant age. Pie chart insets show the total distribution of responses (face, no face, not sure) given to the 160 pareidolia images across all trials and participants as a function of participant age. Each participant rated a subset of 20 images from a total of 160 pareidolia images.

Next, we examined the gender ratings given to illusory faces. Each participant rated the gender of 6 human face control images, and accuracy approached ceiling for each age group (4-8 years: 97.1%, 8-14 years: 99.1%, 14-80 years: 98.4%), indicating participants of all ages could do the task. To obtain mean gender ratings for each illusory face image, we scored all male ratings as +1, female ratings as -1, and excluded "not sure" responses. Thus, on a scale from -1 to +1, mean gender ratings > 0 for a particular image reflect a male bias, and mean gender ratings < 0 reflect a female bias. The distributions of mean gender ratings for illusory face images as a function of participant age are shown in the histograms in Figure 3a. As for the face question, since participants only rated a subset of the larger set of images for gender there is an unequal number of ratings per image. Nonparametric one-sample Wilcoxon signed rank tests confirmed that the median of the distribution of gender ratings across the 160 illusory face images was greater than 0 (i.e. indicating more male ratings) for all age groups: age 4-8 yrs (Mdn = 0.43, SD = 0.43, Z = 8.10, p < .001, r = 0.64), age 8-14 yrs (Mdn = 0.40, SD = 0.46, Z = 7.16, p < .001, r = 0.60), and age 14-80 yrs (Mdn = 0.62, SD = 0.50, Z = 8.65, p < .001 r = 0.68). Thus, most illusory faces were rated as more male than female by participants of all ages. A nonparametric Kruskal-Wallis H test revealed a significant difference in the mean gender ratings for the 160 pareidolia images reported by the three age groups ($H_{(2)}$ = 13.43, p = .001). Follow-up pairwise comparisons with the Dunn-Bonferroni correction applied for multiple comparisons clarified that there was no significant difference in mean gender ratings for children aged 4-8 years versus children aged 8-14 years (p = 1.0). However, mean gender ratings were significantly higher for older participants 14-80 years of age compared to children aged either 8-14 (p = .002) or 4-8 years of age (p = .017).

To consider the pattern of "not sure" responses in addition to gender ratings for illusory faces, we plotted the distribution of all responses to the gender question for all illusory faces across all participants as a function of age in Figure 3b. All age groups gave more male (42-47%) than female (14-22%) responses when asked to report the gender of an illusory face. Although all age groups had a strong male bias, the response distributions suggest that the participants aged 14-80 years were more likely to answer "not sure" (43%) than participants under 14 years of age (31-34%). A chi-square test of independence confirmed that there was a significant association between participant age and the overall pattern of gender responses ($X^2(4)$ = 130.7, p < .001). Despite these differences in response patterns, there was a clear bias for participants in all three age groups to perceive illusory faces as male rather than female.

To further examine the pattern of responses as a function of age, we conducted a correlation analysis with age as a continuous variable to complement the group analysis. There was no significant correlation between participant age and the proportion of illusory faces perceived as male ($r_s(412)$ = 0.07, p = .13). However, older participants were significantly less likely to perceive illusory faces as female ($r_s(412)$ = -0.22, p < .0001) and more likely to respond “not sure” ($r_s(412)$ = 0.13, p = .01) when rating the perceived gender of illusory faces than younger participants. This is consistent with the analysis of the proportion of responses by the three age groups (Figure 3b) and demonstrates that the tendency to perceive more illusory faces as male than female is consistent across children and adults.

For visualization, the top six female images (Mean gender rating < 0) and the top six male images (Mean gender rating > 0) as rated by participants of all ages are shown Figure 3c and Figure 3d. Notably the mean gender ratings for the top 6 female images (range: -0.39 to -0.74) are closer to zero than the mean gender ratings for the top 6 male images (range: 0.9 to 1.0). We also found this difference in magnitude between male and female ratings for illusory faces in our previous study with US adults[28].

Next, we examined the distribution of gender ratings at the participant level as a function of their age, to assess whether the male bias occurs at the level of individual participants as well as at the image level. For each participant, we tallied the number of male and female ratings they gave to the 20 illusory face images and plotted the resulting distributions separately for each age group (Figure 4a). The total number of male and female ratings given across all participants indicated that across all age groups, participants gave at least twice as many male ratings for pareidolia images than female ratings. We calculated the bias for each participant as the number of male ratings minus the number of female ratings and classified participants as having a male bias, a female bias, or no bias (i.e. an equal number of male and female ratings). Across all age groups, the majority of participants (75.4 - 82.6%) had a male bias (Figure 4b). These results demonstrate that the bias to see illusory faces in objects as male rather than female is consistent across both images and participants.

Given that the male bias for illusory faces is robust across participants and images for all three age groups, we were interested in whether there was any relationship between the gender of the participant (n = 150 male, n = 255 female, n = 7 other) and their gender ratings for illusory faces. For each age group, we separated participants by their self-reported gender: 4-8 years (n = 45 male, n = 55 female), 8-14 years (n = 64 male, n = 77 female), and 14-80 years (n = 41 male, n = 123 female). Participants who listed "other" as their gender (1.7% of total sample) were excluded from this analysis: 4-8 years (n = 3), 8-14 years (n = 1), 14-80 years (n = 3). We calculated the proportion of male and female ratings given by each participant as a function of their own age and gender, and plotted the mean proportions for each age group (Figure 5a). To evaluate whether there was an effect of participant gender on the perceived gender of illusory faces, we conducted nonparametric Independent-Samples Mann-Whitney U tests on the distributions of male and female ratings as a function of age and participant gender. For all three age groups, there was no significant difference in the proportion of male (4-8 years: $U = 1042.0$, $p = .174$; 8-14 years: $U = 2080.5$, $p = .111$; 14-80 years: $U = 2817.0$, $p = .261$) or female (4-8 years: $U = 1163.0$, $p = .604$; 8-14 years: $U = 2148.5$, $p = .189$; 14-80 years: $U = 2395.0$, $p = .626$) ratings given by male and female participants. These results confirm that ratings of the perceived gender of illusory faces were not affected by the self-reported gender of the participant, replicating across a much wider range of ages what we observed with a US-based adult population[28].

Finally, because some participants completed the experiment online (n = 192) and others completed the in-person version (n = 220), we checked whether there was a relationship between experimental modality and participants' gender ratings for illusory faces. For each age group, we separated participants by experiment: 4-8 years (n = 49 online, n = 54 in-person), 8-14 years (n = 35 online, n = 107 in-person), 14-80 years (n = 108 online, n = 59 in-person). Next, we calculated the proportion of male and female ratings given by each participant as a function of their age and which version of the experiment they participated in (Figure 5b). To evaluate whether there was an effect of experiment modality (online versus in-person) on gender ratings for illusory faces, we conducted nonparametric Independent-Samples Mann-Whitney U tests on the distributions of male and female ratings as a function of age and modality. For all three age groups, there was no significant difference in the proportion of male (4-8 years: U = 1320.5, p = .987; 8-14 years: U = 2076.0, p = .334; 14-80 years: U = 2846.0, p = .254) or female (4-8 years: U = 1439.5, p = .439; 8-14 years: U = 1933.5, p = .772; 14-80 years: U = 3531.0, p = .241) ratings given by participants who completed the experiment online or in-person. These results show that participants of all ages perceived more illusory faces as male than female, regardless of the experimental modality.

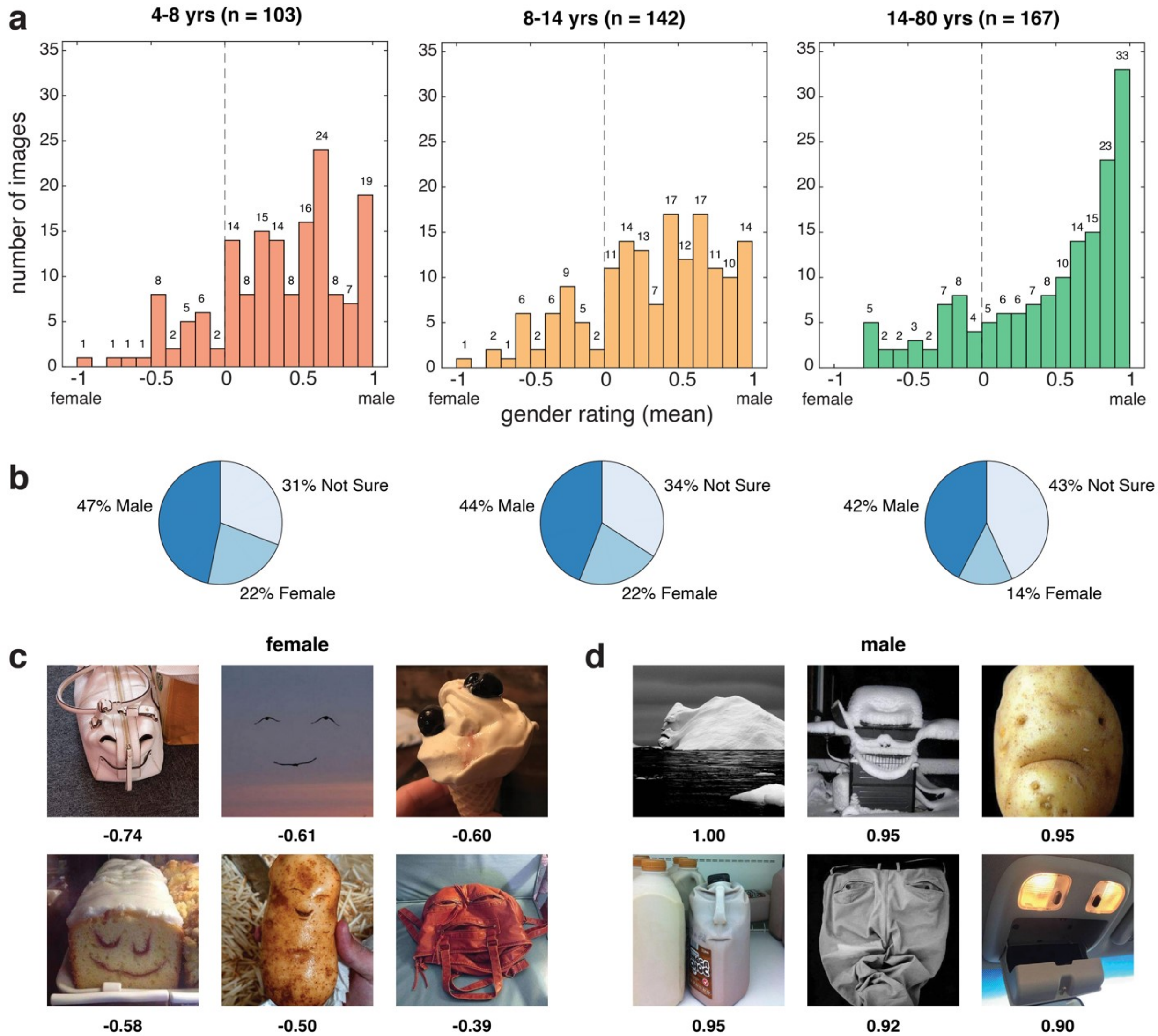

Figure 3. Gender ratings for pareidolia images. (a) Histograms of the mean gender rating per illusory face image (N = 160) by age group. All male ratings were scored as +1, female ratings as -1, and "not sure" responses were excluded. (b) Pie charts show the total proportion of gender ratings of each category (male, female, not sure) made by each age group across all 160 illusory face images. (c) The six images with the largest mean gender rating < 0 (i.e. rated as most "female" across all participants). (d) The six images with the largest mean gender rating > 0 (i.e. rated as most "male" across all participants).

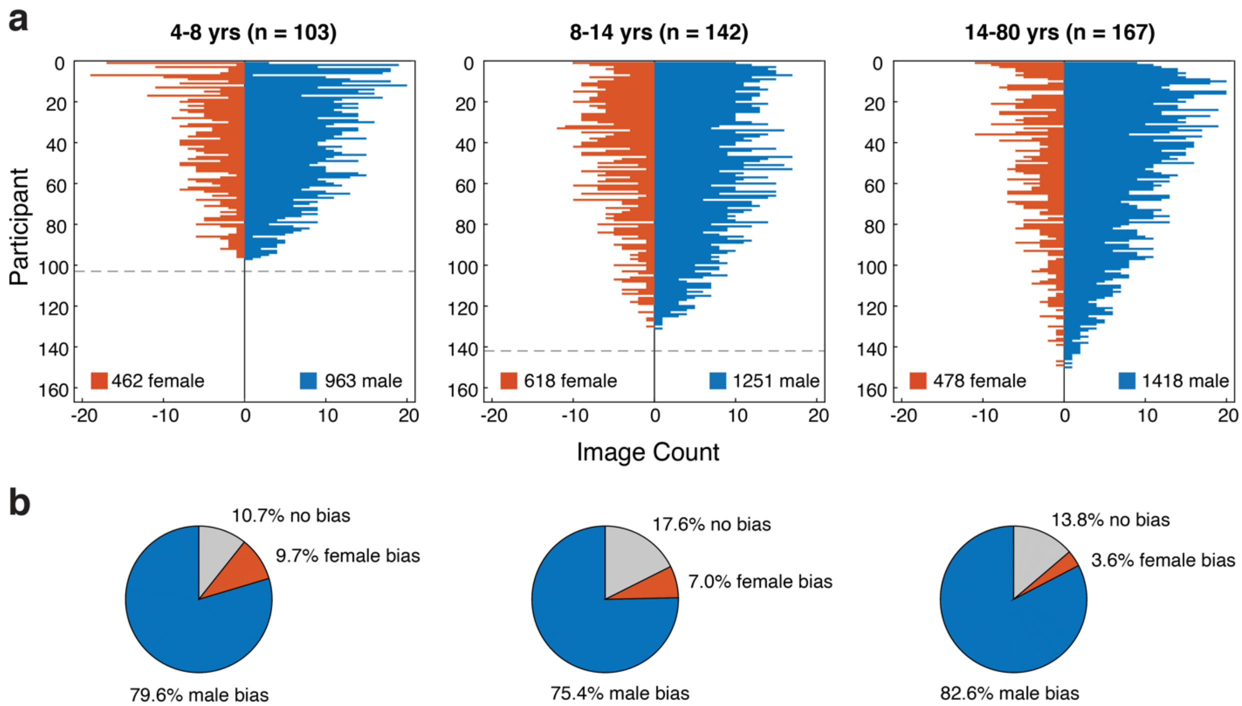

Figure 4. Gender ratings for illusory face images by participant. (a) The distribution of female (orange) and male (blue) responses given by each participant (rows) for the illusory face images. Each participant rated a random subset of 20 images from a total of 160 images. The distribution is sorted by the sum of the male and female ratings given by each participant, such that participants with the lowest number of "not sure" ratings are at the top. Inset numbers are the total number of female and male ratings given by all participants in that age group across all illusory face images. Dashed lines indicate the number of participants in each age group, to mark the difference in sample size between groups. (b) Pie charts show the percentage of participants by age group that had a greater number of male or female responses, or an equal number of male and female responses ("no bias") for the 20 illusory face images that they rated**.**

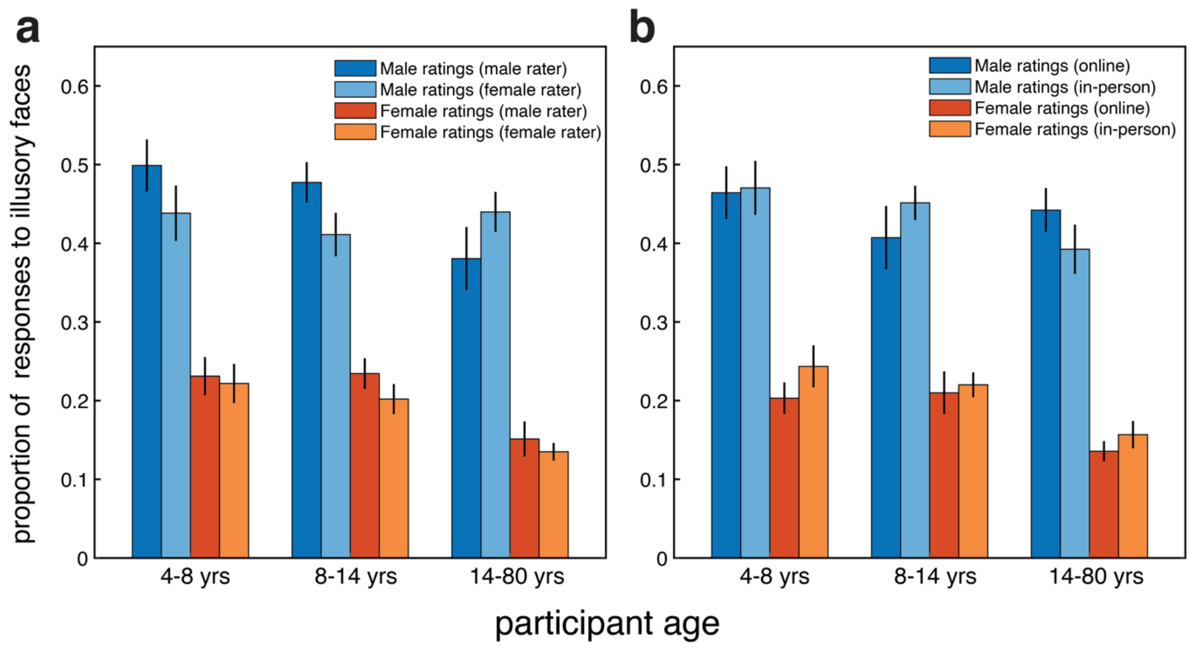

Figure 5. Gender ratings for pareidolia images as a function of participant gender (left) and experimental modality (right). Each participant rated the gender of a subset of 20 illusory face images from a total of 160 images. (a) The mean proportion of male and female responses for illusory faces by participant age and gender. (b) The mean proportion of male and female responses for illusory faces by participant age and experimental modality (in-person or online). Error bars represent +/- 1 SEM.

4.1 Discussion

Here we find that children aged 4-8 years and 8-14 years have a bias to perceive illusory faces in objects as male rather than female, like adults[28]. Children do not perceive a gender for all illusory faces, but when they do, they are more likely to perceive the face as male than female, even though illusory faces do not have a biological sex. The bias occurs at the level of individual images, as well as at the level of individual participants, and is shown by both male and female raters. These results are similar to those for participants aged 14-80 years, and are also consistent with a previous study of US-based adults[28]. Together these data support the idea that the male bias for illusory faces emerges relatively early in development.

Although the origin of the male bias for illusory faces remains unclear[46], our new result replicating it in children significantly constrains the range of possible explanations. First, it shows that the male bias develops by 4-8 years of age, suggesting that children receive sufficient exposure to human faces and societal norms in this time. The face processing system of children continues to develop throughout the first decade of life[18–27], suggesting that a fully matured face system is not required for the development of a male bias. Instead, it is likely that it is driven by early exposure to faces and societal norms. Second, the fact that children as young as 4-8 years of age already show a strong male bias for illusory faces implies that to the extent that societal expectations and context drive this bias, they have not changed enough in the preceding decades to negate the development of a male bias in more recent generations. Even though the children in our study are growing up in a different time and experiencing a different societal context than present-day adults, they still have a bias to see illusory faces as male. This is consistent with the overrepresentation of male protagonists in children's books, which persists even though the proportion of female protagonists has increased over the last 60 years[47]. The generalizability of our results to other cultures remains to be investigated.

Since we found the male bias in even our youngest group of children, it remains an open question at what point in development the male bias emerges. Unfortunately, it is not possible to repeat the experiment in neonates or infants because we cannot ask them about the perceived gender of an illusory face. However, we know that the ability of children to discriminate the gender of human faces continues to develop throughout the age range we tested. For example, when faces are shown with all external cues to gender such as hair removed, there is an improvement in children's ability to categorize them on the basis of sex from age 7 to age 9, but their performance is still not as good as adults[41]. We found the male bias in our youngest group of children from 4 to 8 years of age, evidence that the male bias for face pareidolia emerges before the ability to determine gender from facial cues alone is fully developed. This suggests that the bias to perceive illusory faces as male is unlikely to be driven by a sophisticated ability to discriminate the distinguishing visual features of faces associated with each sex[35–37]. Consistent with this, in our previous study with adults[28] a computational analysis of the visual features in the same examples of face pareidolia we used here did not show an association with their perceived gender, and control experiments ruled out explanations based on pre-existing semantic or visual gender associations with the objects that contain the illusory face.

In addition to a male bias for illusory faces spontaneously perceived in objects[28], a bias to respond male rather than female when the gender of a face is uncertain has been demonstrated in adults for a range of human face stimuli that have been manipulated to introduce ambiguity such as morphed faces[48–50], silhouettes of faces in profile[51], photographs with external features such as hair removed[41,52,53] and faces with added visual noise[48,52]. Both adults and children aged 7-9 respond male more often than female for cropped photographs of both adults and children's faces[41]. Asymmetric responses to male versus female faces have also been shown behaviorally in visual search tasks[54], and in the brain using EEG[55].

An advantage of using naturally occurring examples of face pareidolia to investigate potential gender bias is that unlike with human faces, no decision about how to manipulate the stimuli need to made, since these stimuli have no biological sex. In conjunction with providing an answer option other than male or female ("not sure" in this study, "neutral" in our previous study with adults), this makes it unlikely that any bias found for pareidolia can be reduced to an artifact of the stimuli or task, a concern in previous studies using manipulated human faces[48,49]. We found that like adults, children aged 4-8 and 8-14 do not see a specific gender in all illusory faces, responding "not sure" at least 31-34% of the time. This demonstrates that while face pareidolia can engage the face evaluation system[56,57] of both adults and children beyond the detection of face, gender is not a required attribute for face perception.

In a previous study with adults[28], we found evidence of an interaction between different aspects of face evaluation in illusory faces. We found a small but significant relationship between perceived emotion and perceived gender— happy illusory faces were less likely to be perceived as male, and angry or disgusted illusory faces were more likely to be perceived as male[28]. However, this relationship only explained a small proportion of the variance in gender ratings (4-12%), and the direction of causality is unclear. An illusory face may be more likely to appear angry because it appears male, or it may be more likely to appear male because it is perceived as angry. While we did not measure children’s perception of emotion in illusory faces, in adults the perceived emotional expression of illusory faces cannot explain the male bias.

Finally, our results replicate the finding that children see illusory faces in the same objects as adults[45], with a larger set of images. Illusory faces in objects are known to be processed as rapidly as human faces[58,59] in the brain, although they are represented distinctly in the fusiform face area and occipital face area from both human faces and similar objects which do not have a face[59]. This is consistent with behavioral results showing that illusory faces speed up visual search[60] and break continuous flash suppression faster than similar objects[61]. Illusory faces also show cross-adaptation of emotional expression[62] and eye-gaze direction[63] with human faces, which provides evidence for some common mechanisms between real and illusory faces. Face pareidolia is not unique to humans, rhesus macaque monkeys also perceive illusory faces in the same objects as humans do[64–66], which suggests that mistakenly perceiving faces in objects from minimal visual information is a consequence of the primate face detection system, rather than something uniquely human. The fact that children also misperceive faces in objects is consistent with the idea that face pareidolia is a side-effect of a broadly-tuned face detection system[66]. Infants' preference for looking at face-like configurations soon after birth[1–8] suggests that this broad tuning to face-like stimuli is not the result of extensive experience with real faces.

4.2 Conclusion

We found that both adults and children have a bias to see illusory faces in objects as male more often than female. The discovery that children as young as 4-8 years of age also have a male bias for face pareidolia shows that it emerges relatively early in development, even before children have fully developed their ability to categorize human faces by sex from internal facial cues. Additionally, the finding that the male bias is observable across different generations implies that any societal circumstances that contribute to it have remained stable enough for the male bias to emerge in people who grew up at different times in history. These results suggest that for both children and adults, the visual features that are sufficient for the perception of a face are not always sufficient for the perception of female.

Supplementary material

All visual stimuli, raw data, and analysis code are publicly available on the Open Science Framework (https://osf.io/k4ru2/).

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