Face adaptation to gender: Does adaptation transfer across age categories?

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We examined gender adaptation effects for the faces of children and adults and measured the transfer of these effects across age categories. Face gender adaptation is defined by a bias to classify the gender of a gender-neutral face to be opposite to that of an adapting face. An androgynous face, for example, appears male following adaptation to a female face. Participants adapted to male or female faces from the two age categories and classified the gender of morphed adult and child faces from a male–female morph trajectory. Gender adaptation effects were found for children’s and adults’ faces and for the transfer between the age categories. The size of these effects was comparable when participants adapted to adult faces and identified the gender of either adult or child faces, and when participants adapted to child faces and identified the gender of child faces. A smaller adaptation effect was found when participants adapted to a child’s face but identified the gender of an adult’s face. The results indicate an interconnected and partially shared representation of the gender information for child and adult faces. The lack of symmetry in adaptation transfer between child and adult faces suggests that adaptation to adult faces is more effective than adaptation to child faces in activating a gender representation that generalizes across age categories.

Keywords: Adaptation; Face recognition; Facial age; Gender categories; Perceptual learning.

Face adaptation effects have been reported for face configuration (Webster & MacClin, 1999), for facial identity (Leopold, O’Toole, Vetter, & Blanz, 2000).
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2001), and for the gender,\(^1\) race, and expression of faces (Webster, Kaping, Mizokami, & Duhamel, 2004). In all cases, face adaptation effects operate in an opponent fashion, such that adaptation to a face with a particular “feature” biases the perception of a neutral face in an opposing direction. In configural adaptation, for example, adaptation to a horizontally contracted face results in the perception of a normal face as horizontally expanded. Combined, opponent-based face adaptation aftereffects are consistent with a representation of faces in a face space, organized around a prototype or average face (Leopold et al., 2001; Valentine, 1991). The dimensions of this space represent the feature axes along which individual faces are represented. Faces on either side of the average along a continuous dimension that passes through the centre of the space have an opponent relationship to each other on that feature.

The face space metaphor provides a coherent framework for understanding most face aftereffects at an abstract level, but provides a less satisfying explanation of aftereffects for subcategories of faces in which a “feature” is specified in a physically different fashion. The gender of a face, for example, is a readily identifiable feature of both child and adult faces, but has structurally distinct morphological specifications in these different age groups. In the anthropological literature, a number of facial structures that differ for adult male and female faces have been identified, including facial shape, nose size, and brow protrusion (Enlow, 1982). For children’s faces, however, craniofacial differences are thought to be unreliable for discriminating the gender of boys’ and girls’ faces. In a classic anthropological text on craniofacial structure, Enlow states that “The faces of pre-pubertal boys and girls are essentially comparable” (1982, p. 9). One limitation of anthropological studies, however, is that they consider only skeletal information. The shape of a face is determined in part by skeletal structure, but facial shape is also a product of muscle, fat, and the overlying layers of tissue that can vary in thickness and texture.

Morphometric soft-tissue evaluations point to subtle differences in the profiles of male and female prepubescent faces. “Girls appear to have more prominent noses and chins, less protruded lips, and shallower labial sulci. ... The results seem to run contrary to the popular belief that boys have larger noses and more prominent chins than girls” (Halazonetis, 2007, p.

\(^1\) We have chosen to use the term “gender” throughout our paper as our work focuses on the perception and conception of individuals as male or female. This usage is consistent with existing patterns of usage in both the perception and developmental literature (e.g., “gender adaptation”, “gender constancy”) and follows Butler’s (1990) call “to think of gender as a pre-existing system of classification into which biological differences are assimilated and interpreted” (Crawford & Fox, 2007, p. 483). Although we generally opted to use the more inclusive term “gender”, we do use the term “sex” when referring to characteristics of the stimuli (“same sex faces”) and honour original terminology (“sex-contingent aftereffects”).
487). But note that Halazonetis’ comparisons were based on the relative size of these features. People may base their gender decisions on the absolute size of particular features, such as the nose.

Questions concerning the bases of facial dimorphism are further complicated by the fact that physical growth trajectories differ for males and females. Changes in facial shape occur more quickly in girls than boys. In girls, facial growth is nearly complete by 13 years of age, whereas the male face continues to change through adolescence (Bulygina, Mitteroecker, & Aiello, 2006).

Reported differences in boys and girls faces have been described as “small and barely perceptible” (Halazonetis, 2007, p. 487) but global structural differences were readily apparent in the boy and girl morphs that Wild et al. (2000) created from faces of 7- to 10-year-old children. A prototypical boy face and a prototypical girl face were created by morphing together pairs of same-sex faces, and then repeatedly morphing these pairs of morphs together to converge on a single boy prototype and a single girl prototype. The resultant prototypes clearly show global shape differences between the faces of boys and girls (see Figure 1).

To test the extent to which facial dimorphic information overlaps in the faces of children and adults, Cheng, O’Toole, and Abdi (2001) trained several network-based classifiers to discriminate faces by gender. When the classifier was trained on the gender classification task with adult faces, it performed best with adult faces, but was also able to discriminate child faces at levels well above chance. When the classifier was trained on the gender classification task with child faces, it performed best with child faces, but was also able to discriminate adult faces at levels well above chance. In this case, classification accuracy for child faces was comparable to the accuracy achieved by the adult-trained classifier when tested with adult faces. Combined, these two simulations suggest that some gender-specific information is shared between the faces of children and adults and some is age-specific. Cheng et al.’s results also suggest that gender-specific information in children’s faces can theoretically support classification accuracy at levels comparable to that achieved with adult faces.

The results of a perceptual study by Wild et al. (2000), however, do not support the conclusion that humans are equally adept at distinguishing the gender of child and adult faces. Wild et al. found that although children and adults could identify the gender of 7- to 9-year-old children’s faces reliably, both groups achieved higher levels of accuracy with adult faces compared to child faces. These same child and adult faces were identified at comparable levels in a recognition memory task. These results suggest that for humans,

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2 Individual child faces were used as stimuli in Wild et al.’s (2000) experiments. The morphed prototypes were created to illustrate that boys’ and girls’ faces are distinguishable.
the perceptual salience of identity information in child and adult faces is comparable, but that the salience of gender-specific information favours adult faces. The Wild et al. study also offered evidence that the ability to classify faces by gender continues to improve with age for both child and adult faces. All three age groups tested by Wild et al. (first-graders [6- and

Figure 1. The two prototypes produced by morphing: Top, female prototype face; bottom, male prototype face. To view this figure in colour, please see the online issue of the Journal.
7-year-olds], third-graders [8- and 9-year-olds], and adults) identified the
gender of adult faces at performance levels above chance, but only the third-
graders and adults could identify the gender of child faces above chance.

In the real world, observers are exposed to a mixture of faces belonging to
men, women, boys, and girls of varying ages and ethnicities. Exposure
history does seem to affect performance on gender classification tasks. Male
and female faces of one’s own race are discriminated more accurately than
male and female faces of a different race (O’Toole, Deffenbacher, &
Peterson, 1996). Thus, exposure history may affect sensitivity to subtle
variations in gender markers for adult male and female faces. Child faces
present an interesting variation on the question of exposure history. In the
eyears of life, adult faces dominate the child’s perceptual world; with
age, the child’s social circle expands and an increasing number of hours are
spent in the world of peers. However, unlike gender markers for adult faces
of differing ethnicities, the gender markers for child faces remain perceptu-
tually less salient even with continued exposure (Wild et al., 2000). Although
older children and adults classify child faces above chance, they never reach
accuracy levels comparable to those obtained with adult faces.

The gender of a face references a unified and socially relevant aspect of an
individual. Given that gender plays an organizing role in person perception,
it is perhaps surprising that there is little agreement about whether separate
face spaces exist for male and female faces (cf. Johnston, Kanazawa, Kato, &
Oda, 1997; Rhodes, Jeffery, Watson, Clifford, & Nakayama, 2003). Sex-
contingent aftereffects have been interpreted as suggesting separate face
spaces, and separate prototypes, for male and female faces (Little, DeBruine,
& Jones, 2005). In Little et al.’s (2005) study, participants adapted to a
number of male and female faces and a structural aspect of the face, for
example, the separation between the eyes, covaried with the gender of the
face. Participants were asked subsequently to make judgements about the
relative normalcy of pairs of faces varying in eye spacing. Exposure to this
gender-correlated structural change led to sex-contingent adaptation after-
effects (Little et al., 2005). Bestelmeyer et al. (2008) found gender-correlated
structural changes produce similar shifts in normalcy ratings for physically
dissimilar faces on the same side of the category boundary (i.e., female and
“hyperfemale” faces). Hence, opposing aftereffects are only seen in faces
that cross a category boundary (male and female faces). These results are
consistent with Little et al.’s argument that sex-contingent aftereffects
provide evidence that different populations of neurons are involved in
coding male and female faces.

Sex-contingent orientation aftereffects have also been reported. After
viewing adapting faces covarying in gender and orientation, e.g., upright
male faces and inverted female faces, the perceived gender of an androgy-
nous test face changed with its orientation, female when upright and male
when inverted (Rhodes et al., 2004). These findings have been interpreted likewise in terms of separate neural populations coding upright and inverted faces. Leftward and rightward tilting faces produced similar orientation-contingent gender aftereffects (Watson & Clifford, 2006).

Category-contingent aftereffects provide a look at the extent to which category codes can be manipulated selectively through adaptation—thereby measuring the independence of category representations. A complementary approach is to use adaptation to probe the interconnectedness of the representations and evaluate the extent to which representations share common information that would otherwise need to be specified redundantly. “Adaptation transfer” methods, generally applied over changes in viewing parameters (e.g., retinal position, size, etc.), have been developed mostly to demonstrate that face adaptation reflects high-level visual information processing. Here we study the transfer of adaptation across an inherent feature of the face itself—“age”, which changes continuously. The nature of simple categorical information like the gender of a face changes along with the ageing process. As such, the gender of a face must be represented in a way that is robust to the continuous morphological changes that occur over childhood, into adolescence, and throughout the adult life span.

In this study we measured adaptation and adaptation transfer for child and adult faces and for the transfer between the age categories. Participants adapted to male or female faces from the two age categories and classified the gender of morphed adult and child faces from a male-female morph trajectory. Although gender adaptation effects have been tested exclusively with adult faces, the morphing demonstration of Wild et al. (2000) and the ability of participants to accurately classify child faces by gender suggest that it should be possible to obtain gender adaptation effects when child faces serve as both the adapting and test stimulus. Three different predictions can be made about the comparative strength of the adaptation effects for child and adult faces. Given that adults were less adept at discriminating the gender of child faces in Wild et al.’s study, one might predict smaller adaptation effects for child faces by comparison to adult faces. In contrast, adaptation effects of similar magnitude for child and adult faces are predicted by the computational simulations of Cheng et al. (2001), which show equal classification accuracy for child and adult faces. Comparably sized aftereffects would also be predicted if the degree of match between adapting and test stimulus determines the size of the aftereffect. In that case, when the type of adaptation and test stimuli match well (that is, when both are child faces or both are adult faces), the size of the adaptation effects might be comparable even if the salience of the information is not equivalent.

When the age of the adaptation face and test face does not match, the work of Cheng et al. (2001) indicating overlap in the gender-specific
information in adult and child faces suggests that gender adaptation effects should transfer, at least partially, across age. If adaptation transfers as a function of the amount of shared information, then adaptation transfer between age categories should be symmetric with the strength of adaptation from adult to child faces roughly equivalent to the strength of adaptation from child to adult faces. Alternatively, because the gender-specific information is more salient for adult faces (Wild et al., 2000), exposure to male or female adult faces might be more potent in activating a unified gender concept that would generalize better to child faces. This would predict greater adaptation transfer from adult to child faces than the inverse.

**METHOD**

**Participants**

Eighty Lehigh University undergraduate students enrolled in “Introduction to Psychology” participated in the experiments and were compensated with a course credit. A different set of 20 students participated in each experiment. Across all experiments, the participants were predominantly Caucasians. Similar numbers of men and women participated in each experiment (Experiment 1: 12 men, 8 women; Experiment 2: 11 men, 9 women; Experiment 3: 11 men, 9 women; Experiment 4: 12 men, 8 women).

**Design**

In each experiment, we varied the gender of the adapting stimulus (male, female) and the percentage female in the test face, which was a face morph between a male and female face. Five morph levels (10%, 40%, 50%, 60%, 90% female) were employed. Both the gender of the adapting stimulus and morph level of the test stimulus were within-subjects variables. The dependent variable was the proportion of female responses to the test stimulus.

**Stimuli**

The stimuli were constructed from digital photographs of eight child faces and eight adult faces, with a resolution of $256 \times 256$ pixels. The child models were between 7 and 10 years of age and the adult models were college age. All faces were Caucasian. The faces were cropped using Adobe Photoshop to create an elliptical image (3:2 height to width ratio) of the internal area of the face. External regions of the head (hair, jaw line, neck,
and ears) were not present in the cropped face. Each face was presented within a gray rectangular background.

The adapting stimuli were selected from the original (unmorphed) faces. The test stimuli were created by morphing between the faces of two children (a boy and a girl) or two adults (a man and a woman). Five images (10%, 40%, 50%, 60%, and 90% female) were created for each male–female pair. These morph levels were chosen as follows. Two (10% and 90%) morphs were included to provide near-veridical, but “morphed”, endpoints that would be easy to classify as male or female. Because adaptation effects tend to be strongest near the average or “neutral” point of the gender trajectory, three relatively central morphs (40%, 50%, 60%) were chosen to obtain a good sample of the adaptation effects. Combined, the number of faces and morph levels resulted in a total of 20 adult test morphs and 20 child test morphs. The morphs were created using Gryphon Morph 2.5 for Macintosh.

The age of the adapting and test faces differed across experiments. In Experiment 1, participants were adapted with adult faces and were tested with adult faces. In Experiment 2, the participants were adapted with child faces and were tested with adult faces. In Experiment 3, participants were adapted with adult faces and were tested with child faces. In Experiment 4, both the adapting and test stimuli were child faces.

Procedure

The test trials consisted of a 5 s presentation of an adapting face, a 100 ms interstimulus interval, and a 300 ms presentation of the test face. Participants were instructed to indicate the gender of the test face by pressing the appropriately labelled key on the number pad (1 for “man” or “boy” and 2 for “woman” or “girl”). Each participant viewed the same two adapting stimuli throughout the session. The test morphs were created from three male–female pairs that were not presented as adapting stimuli to that particular participant. The identities of the adapting stimuli were counter-balanced across participants. Participants in the first two experiments we conducted (Experiments 1 and 3) completed 150 test trials. A few participants in these initial experiments complained about the length of the session so we shortened the number of trials to 100 for the two subsequent experiments (2 and 4). For Experiments 1 and 3, the data were examined both with and without the extra 50 trials and the means were highly similar. We therefore included the full complement of data in each analysis.
RESULTS

The analysis of the results for each experiment proceeded as follows. The proportion of female responses was calculated for each participant in each face gender adaptation condition and at each morph level. In each experiment, these data were submitted to a two-factor repeated measures analysis of variance (ANOVA) with the gender of the adapting face and the morph level of the test stimulus as independent variables.

We present the results from each experiment first, and then compare the magnitude of adaptation effects across age categories. For clarity, we arranged the order of experiments to group the studies by the age of the test face. This was done because gender classification accuracy was less accurate for child faces than for adult faces, consistent with Wild et al. (2001). The effects of adaptation are therefore easiest to compare visually within the same test face age category. In Experiments 1 and 2, we used adult test faces and in Experiments 3 and 4 we used child test faces.

Experiment 1

In Experiment 1, adult faces served as both the adapting and test stimuli. The proportion of female responses differed as a function of the gender of the adaptation faces, \(F(1, 19) = 42.95, p < .0001\), indicating a strong adaptation effect. The morph faces were more likely to be classified as female following adaptation to a male face than following adaptation to a female face. See Figure 2a for the pattern of results. As expected, morph level was highly significant, \(F(4, 76) = 166.14, p < .0001\), indicating simply that the proportion of female responses increased as the percentage of femaleness increased in the morph test face. There was also an interaction between gender of the adaptation face and morph level of the test stimulus, \(F(4, 76) = 5.04, p < .01\). This interaction is consistent with the fact that face adaptation effects have their strongest effects with test stimuli that are close to the neutral point of the trajectory. When the gender of the face is clear near the endpoints of the morph trajectory (10% and 90% female), the adaptation potency is reduced, leading sometimes to a bow-shaped curve and an interaction. For completeness we report the interactions, but do not interpret them further.

The results of the first experiment simply replicate previous gender adaptation studies that have used adult faces (e.g., Webster et al., 2004).

Experiment 2

In Experiment 2, participants adapted to child faces and were tested with adult faces. The proportion of female responses differed as a function of the
Figure 2. Gender classification decisions for morphed adult test faces following adaptation to adult faces (Experiment 1) and child faces (Experiment 2). The y-axis represents the proportion of trials in which the participants classified the face as female and the x-axis represents the proportion of femaleness in the morph. To view this figure in colour, please see the online issue of the Journal.
gender of the adaptation faces, $F(1, 19) = 9.00$, $p < .005$ (see Figure 2b), indicating adaptation transfer from child to adult faces. Morph level was significant, $F(4, 76) = 174.00$, $p < .0001$; the interaction was not significant, $F(4, 76) = 1.46$, ns.

This result indicates that adaptation to the gender-specific information in child faces alters the perception of the gender of a subsequently presented adult face.

**Experiment 3**

In Experiment 3, participants adapted to adult faces and were tested with child faces. Again, the proportion of female responses differed as a function of the gender of the adaptation faces, $F(1, 19) = 20.20$, $p < .0002$ (see Figure 3a), indicating adaptation transfer from adult to child faces. Morph level was again significant, $F(4, 76) = 31.13$, $p < .0001$, and there was an interaction, $F(4, 76) = 3.81$, $p < .01$.

This result indicates that adaptation to the gender-specific information in adult faces alters the perception of the gender of a subsequently presented child face.

**Experiment 4**

In Experiment 4, participants adapted to child faces and were tested with child faces. The proportion of female responses differed as a function of the gender of the adaptation faces, $F(1, 19) = 20.57$, $p < .0002$ (see Figure 3b), indicating that gender adaptation effects occur for child faces. Morph level was significant, $F(4, 76) = 46.16$, $p < .0001$; the interaction was not significant, $F(4, 76) = 1.54$, ns.

This result extends gender adaptation effects to include child faces.

**Adaptation transfer comparisons**

Adaptation effects were observed when the age category of the adapting and test faces was matched. We also observed significant adaptation effects for both directions of transfer across age categories. In Figure 4, we show the combined data from Figures 2 and 3 as adaptation scores. Adaptation scores were calculated as the difference between the proportion of female judgements in the male adapt condition and the proportion of female judgements in the female adapt condition. The magnitude of adaptation effects is similar in three conditions: (1) Adaptation to adult faces and test with adult faces; (2) adaptation to child faces and test with child faces; and (3) adaptation to adult
Figure 3. Gender classification for morphed child faces following adaptation to adult faces (Experiment 3) and child faces (Experiment 4). The y-axis represents the proportion of trials in which the participants classified the face as female and the x-axis represents the proportion of femaleness in the morph. To view this figure in colour, please see the online issue of the Journal.
faces and test with child faces. The adaptation effect appears weaker when participants adapt to the child faces and are tested with adult faces. A contrast analysis on the adaptation strength scores for this “child-face adapt/adult-face test” condition against the other three conditions confirmed the difference statistically for the 40–60 morph values, $F(1, 240) = 4.20, p < .05$. Note that the neutral gender point for child faces fell between the 60 and 90 morph values (see Figure 2) giving rise to a male response bias similar to that seen in Wild et al. (2000). This is the likely source of the continued strength of adaptation effects for child test faces up to the 90 morph value (see Figure 3).

**DISCUSSION**

The results of this study show that gender adaptation effects can be obtained with the faces of children and adults. This adds to previous work that has established these effects with adult faces and illustrates that the gender-specific information in child faces is sufficiently salient to be manipulated
and attenuated with adaptation. Despite previous findings that people classify child faces by gender less accurately than adult faces (Wild et al., 2000), the magnitude of adaptation effects was roughly comparable for the two age groups of faces.

The comparable strength of these effects is consistent with the hypothesis that the degree of match between adapting and test stimulus determines the size of the effect. This equivalence in the adaptation effect is also consistent with Cheng et al.’s (2001) finding that the quality of gender-specific information in child faces supports classification accuracy that is comparable to that found for adult faces. Although the present data do not allow us to determine which plays a more critical role, the degree of match or the quality of gender-specific information, our findings are consistent with the more general idea that one is equally tuned to the perceptual content that distinguishes the gender of child and adult faces. This seems to be true even though the gender-specific information in these age groups is morphologically different and the ability of humans to classify faces by gender favours adult faces.

When the age of the adapting and test stimulus differed, we found significant adaptation transfer; these effects transferred in both directions. This transfer is consistent with the simulations carried out by Cheng et al. (2001) and suggests that there is partial overlap in the information that specifies gender in child and adult faces. There was also a pronounced lack of symmetry in the adaptation transfer. Adult faces were more effective adapting stimuli for child faces than the inverse. This lack of symmetry indicates that it is not the amount of shared information per se that determines adaptation transfer. Rather, consistent with Wild et al. (2000), it is possible that the greater salience of gender-specific information in adult faces, in comparison to child faces, might be more potent in activating a unified gender representation that generalizes across age.

Although category-contingent aftereffects provide a look at the extent to which neural codes can be accessed and manipulated independently, a complete understanding of representations also requires knowledge about how information is shared in representations of related visual entities. Adaptation transfer methods can provide information about the extent to which activation of a relatively specific representation (e.g., adult male faces) automatically coactivates other related and presumably interconnected representations (e.g., boy faces). The transfer of adaptation we found here suggests that the representation of gender-specific information is partially shared across child and adult faces. Overlap in the gender-specific information for child and adult faces allows for the possibility that the relative mastery of gender discriminations with adult faces might bootstrap perceptual learning of the comparatively subtle gender markers for child faces. Given that experience can increase the strength of
adaptation effects (Jiang, Blanz, & O’Toole, 2006), the observed transfer asymmetry could reflect participants’ higher familiarity with, and greater mastery of, gender markers in adult faces.

The shared nature of the representations does not exclude the possibility that age-contingent gender aftereffects could be obtained. Category-contingent aftereffects may provide additional insight into how gender markers are learned. Information about both relative age and gender can be readily gleaned from a face. Importantly, face-specific markers of gender are typically accompanied by a wealth of cues, both physical and cultural, which clearly disambiguate the model as a boy, girl, man, or woman. Facial dimorphism is more pronounced in adults, but so too are other correlates of gender. Differences in voice, body, and clothing provide a context for learning facial cues to gender. Given that the gender markers for adult faces are mastered first (Wild et al., 2000), decisions about the gender of a child’s face may initially rest on the relative strength of adult male and adult female gender markers in that particular child’s face. Contextual information would then serve to confirm or disconfirm that decision. This contextual information would also provide a context for learning additional correlates of gender that are present in children’s faces. Consistent with this line of reasoning, gender-contingent aftereffects suggest that people are sensitive to subtle differences in facial features when they are paired with cultural cues to gender, such as hairstyle.

More broadly, we would argue that the coexistence of category-contingent effects and cross-category transfer suggest representations that are flexible enough to accommodate independent access when appropriate (for example, when learning the features associated with a category) but that can also share redundant information (e.g., when transferring information that is learned in the context of adult faces to child faces.)

REFERENCES


