Vision Research 63 (2012) 69–80

Contents lists available at SciVerse ScienceDirect

Vision Research

journal homepage: www.elsevier.com/locate/visres

Male and female faces are only perceived categorically when linked to familiar identities – And when in doubt, he is a male

Regine Armann *, Isabelle Bülthoff

Max Planck Institute for Biological Cybernetics, Tübingen, Germany

ARTICLE INFO

Article history:
Received 21 July 2011
Received in revised form 21 February 2012
Available online 14 May 2012

Keywords:
Face perception
Categorical perception
Sex (gender)
Identity

ABSTRACT

Categorical perception (CP) is a fundamental cognitive process that enables us to sort similar objects in the world into meaningful categories with clear boundaries between them. CP has been found for high-level stimuli like human faces, more precisely, for the perception of face identity, expression and ethnicity. For sex however, which represents another important and biologically relevant dimension of human faces, results have been equivocal so far. Here, we reinvestigate CP for sex using newly created face stimuli to control two factors that to our opinion might have influenced the results in earlier studies. Our new stimuli are (a) derived from single face identities, so that changes of sex are not confounded with changes of identity information, and (b) "normalized" in their degree of maleness and femaleness, to counteract natural variations of perceived masculinity and femininity of faces that might obstruct evidence of categorical perception. Despite careful normalization, we did not find evidence of CP for sex using classical test procedures, unless participants were specifically familiarized with the face identities before testing. These results support the single-route hypothesis, stating that sex and identity information in faces are not processed in parallel, in contrast to what was suggested in the classical Bruce and Young model of face perception.

Besides, interestingly, our participants show a consistent bias, before and after perceptual normalization of the male–female range of the test morph continua, to judge faces as male rather than female.

1. Introduction

When we look at the world around us, we do not see gradual transitions between elements, be they different wavelengths of light, or different face expressions. Instead, the visual system carves our environment into separate, meaningful categories, like red or yellow colors and sad or smiling faces, via the cognitive process called categorical perception (CP). This process is fundamental to complex behavior, since it spares us from having to learn anew each time we encounter unknown objects or individuals and thus helps to reduce the overwhelming number of entities in the world to more manageable proportions (e.g., Harnad, 1987, chap. 1; Rosch et al., 1976).

For the specific case of face perception, CP has been found using continua of images (morphs) created by morphing between realistic human faces of different (familiar) identities (Beale & Keil, 1995), expressions (Calder et al., 1996), and races (Levin & Angelone, 2002). However, on the question whether the facial dimension "sex" is also perceived naturally as one of two different categories, i.e. male and female faces, conflicting psychophysical results have been reported so far (Bülthoff & Newell, 2004; Campanella, Chrysochoos, & Bruyer, 2001).

Campanella and colleagues showed CP for sex (Campanella, Chrysochoos, & Bruyer, 2001) using an image-morphing procedure to generate continua of face stimuli in which sex information was varied linearly between male and female faces. Additionally, however, their face stimuli were morphs between different (opposite-sex) identities. Furthermore, only few face pairs were used, and the same stimuli appeared many times per task, so that participants were being familiarized with the faces in the course of the experiment. The CP effect could thus result from categorical perception of the familiar test face identities (as in, e.g., Beale & Keil, 1995) rather than from CP for male and female faces.

Bülthoff and Newell likewise investigated if male and female faces are discrete categories at the perceptual level, and whether familiarization plays a role in the categorical perception of sex (Bülthoff & Newell, 2004). They used a morphing algorithm to create artificial sex continua not only between male and female faces, but also based on single face identities that are created by changing only the sex of a face while keeping its identity constant. When using these sex continua and while increasing the number of original face identities (from 6 to 12) to reduce a potential familiarization effect, the authors could not find CP for sex. The effect only appeared when participants were either familiarized with the

* Corresponding author. Address: Max Planck Institute for Biological Cybernetics, Spemannstrasse 38, 72076 Tübingen, Germany. Fax: +49 7071 601 616.
E-mail address: regine.armann@tuebingen.mpg.de (R. Armann).

0042-6989/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.visres.2012.05.005

endpoint (i.e., most male and most female) faces of the morph continua or trained to classify all faces of the continua as male or female using a feedback procedure.

So the question whether or not there is CP for sex as a dimension of human faces remains open. As suggested by Leopold and colleagues (Leopold, Bondar, & Giese, 2006), both the time to learn as well as the storage capacity in the brain for faces can be spared by applying common transformations (changes in e.g. scale, viewing angle, expression) not to each face identity, but instead to the "template", or reference, to which incoming face stimuli are compared. In the same vein, one can assume that the brain compares newly encountered faces to a male and female face reference, if "male" and "female" are discrete categories at the perceptual level. Classifying the faces of unknown individuals by their sex seems to be a prerequisite for social behavior and communication. Moreover, since it has been shown that different facial expressions and races are perceived as discrete categories (Calder et al., 1996; Levin & Angelone, 2002), it seems surprising that there should be no CP for sex.

Is it possible, however, that these other CP effects are also a result of confusing race/expression manipulations with identity changes and of familiarizing participants with the test face identities, as Bülthoff and Newell (2004) suspected when revisiting CP for sex while controlling for these potential confounds? Calder and colleagues (Calder et al., 1996) used continua between different expressions performed by the same person, thus manipulating only expression-relevant information in the faces. The authors did not use enough face identities to rule out the possibility that being familiar with the test identities might lead to or enhance a categorical effect. They took care, however, in ruling out that the effect depends on knowing the *endpoints* of the test continua, by also testing along continua including three different expressions performed by the same person. Furthermore, the authors discuss some differences between their discrimination data and an earlier study on CP for expressions by Etcoff and Magee (1992), where line drawings instead of photo-realistic faces were used. Calder and colleagues argue that these line drawings contain just sufficient information to identify expressions, but lack most of the additional more idiosyncratic cues that the photo-realistic faces provide. The categorical effect was nevertheless found in the original study, making it unlikely that being familiar with the test face identities was what triggered it in the study by Calder and colleagues (Calder et al., 1996). As to CP for faces of different races, Levin and Angelone (2002) morphed between individual faces, manipulating race information with identity information, which makes it difficult to attribute a CP effect to a change in one or the other. However, the authors prevented participants from memorizing individual (unfamiliar) face identities in the course of the experiment, by mixing continua within testing blocks. Note that they tested discrimination and classification of individual faces, not race categories directly. However, having precluded participants from showing CP for familiar face identities, they nevertheless find categorical perception, and primarily on cross-race continua, suggesting that it results from previously defined race categories.

However, unlike these categorical effects for expressions and race, CP for sex, as reported in Campanella, Chrysochoos, & Bruyer, 2001; completely disappeared when identity and sex information were manipulated independently and when familiarization with the test face identities was not provided (Bülthoff & Newell, 2004). The Bülthoff and Newel study rather suggests that processing of the sex of a face is directly linked to processing of the face's identity (as proposed before by Ganel and Goshen-Gottstein (2002) and Rossion (2002)). Yet, it seems counterintuitive to not have discrete perceptual categories for male and female faces, given the biological and social relevance of this face characteristic.

Therefore, here, we revisit CP for sex using new face stimuli to deal with another potential confound that, to our opinion, might have influenced the results of earlier studies – and one that has never been raised or controlled for in earlier studies on categorical perception of faces. The face stimuli in former studies were generated from 2D images (Campanella, Chrysochoos, & Bruyer, 2001) or 3D head scans of original face identities (Bülthoff & Newell, 2004). Face continua were either generated by morphing one face identity with another identity of the other sex (Bülthoff & Newell, 2004; Campanella, Chrysochoos, & Bruyer, 2001), or by manipulating the sex of a male or female face, while keeping its identity constant (Bülthoff & Newell, 2004). This was done using 3D laser scans of real heads and the "Morphable Model" of Blanz and Vetter (Blanz, 2000; Blanz & Vetter, 1999). Since each face in this database is represented as a high-dimensional vector in correspondence to a reference (the average) head, we can first calculate an average male and an average female face of the whole face population, then calculate the difference between these two, the so-called "sex vector", and apply this vector onto each individual face. With both procedures, depending on how strongly male or female the original faces look, the continua derived from them vary in the range of "maleness" and "femaleness" they cover. Hence morph levels, as they are calculated relative to the original face of each continuum, are not comparable across continua. Even if there is a category boundary between male and female at the perceptual level, its position between the extremes would vary for each individual face morph continuum. Averaging performance in CP tasks over continua based on faces with different levels of perceived masculinity and femininity might thus cancel out any evidence for CP.

To avoid the problem of having potentially different locations of the sex boundary for each continuum, we equated the level of maleness and femaleness of all face identities by modifying the original faces before creating test continua. By using "normalized" endpoint faces, all continua should cover a similar range of maleness and femaleness and the category boundary between male and female should then be located at the same place along all face continua, with similar steps in between. We performed extensive rating experiments (as specified in the methods section) to carefully create and choose these "controlled" male and female endpoint faces. By doing this, variations of femininity and masculinity of the endpoints of each continuum and – as a consequence – variation of the location of the category boundary was kept to a minimum. An alternative to equating femininity and masculinity of the endpoint faces before creating continua would be to adjust the continua after the experiment, according to the category boundary that participants' performance reveals. By pre-equating, however, we make sure that (1) the morphing steps along the continua are of equivalent size, and that (2) for each morph level, the same number of data points is collected and entered into the analysis.

Once the "blurriness" of the location of the category boundary was reduced to a minimum, our goal was to test if CP for sex does occur naturally, without reference to identity-related facial information. To this end, we followed the classical procedure to define categorical perception, as described for example in Beale and Keil (1995), Etcoff and Magee (1992), and Bülthoff and Newell (2004). In brief, a classification task was used to locate the potential category boundary between male and female faces. A discrimination task using pairs of stimuli from different positions along the stimulus continua was used to test if faces from one side of the boundary were indeed perceived as more similar to each other than to faces on the other side of the boundary, as expected for CP.

Classification and discrimination tasks were performed in four sub-experiments, only differing in the familiarization procedure that participants went through before the actual testing phase. In a "naïve" experiment, participants were tested on CP for sex without previous exposure to any faces. By this, we tested whether