Vision Research 50 (2010) 1941–1948

Contents lists available at ScienceDirect

Vision Research

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

The role of skin-related information in pigeons' categorization and recognition of humans in pictures

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ARTICLE INFO

Article history:
Received 5 January 2010
Received in revised form 6 July 2010

Keywords:
Skin color
Skin texture
Picture-object recognition
Categorization
Pigeons

ABSTRACT

Pigeons have previously been shown to readily categorize pictures with and without humans and to also recognize the correspondence between live humans and pictures of them. Here, we investigated the role of skin-related features for their possible influence on pigeons' categorization and recognition of humans in pictures. Pigeons were tested with stimuli that contained parts of humans that were discolored (Test Grayscale) or whose surface was altered (Test Nonhuman Surface), as well as with stimuli showing objects whose outlines were filled with human skin (Test Nonhuman Shape). The results suggested that skin-related features were not critical for correct classification and recognition, but played an important accessory role.

1. Introduction

Herrnstein and Loveland (1964) were the first to show that pigeons can be trained to discriminate between sets of complex real scene color photographs that are distinguished only by the presence of a human being in each member of one set. In a series of experiments we re-investigated and extended their findings (Aust & Huber, 2001, 2002, 2003, 2006, 2010), with a particular focus on identifying the features the pigeons used for classification as well as on the nature of the formed representation. To this end, we trained pigeons in Aust and Huber (2001, 2002, 2003) to discriminate between photographs with (Class P) and without people (Class NP) and subsequently presented them with a variety of test stimuli whose informational content was systematically varied. We found evidence that the pigeons made use of a polymorphous class rule that included a variety of target features from different domains and dimensions and that they were able to use these features in a flexible way, depending on the specifics of the individual tasks.

In Aust and Huber (2006, 2010) we extended our investigations to the question of picture-object recognition (for reviews see, e.g., Aust, 2007; Bovet & Vauclair, 2000; Fagot, Martin-Malivel, & Dépy, 2000; Lea & Dittrich, 2000; Watanabe, 2000). We trained pigeons that were highly familiar with humans to discriminate between photographs showing human figures (Class P) and photographs without humans (Class NP). In Group Nohands the human figures were devoid of hands; in Group Noheads they were devoid of heads. In the subsequent Picture-Object Recognition Test, the birds were presented with pictures of the previously missing parts (unseen parts, UP; hands for Group Nohands, heads for Group Noheads), and, as a control, also with pictures of parts that had already been presented during training (seen parts, SP; hands for Group Noheads, heads for Group Nohands). Furthermore, they were shown pictures of arbitrarily sized and shaped patches of human skin (SK). We found higher response rates to SP and, most importantly, to UP stimuli (which the pigeons could recognize as human parts only from their experience with live humans) than to pictures of nonrepresentative skin patches (SK), and interpreted this as evidence of picture-object recognition (but see Dittrich, Adam, Ünver, & Güntürkün, 2010, for possible limitations of this ability).

But of course, our experiments did not exhaust the conditions under which a stimulus may be recognized as member of Class P. In particular, the possible role of features inherent in human skin for categorization and recognition remains controversial. On the one hand, some of our results suggested that skin was, by itself, not used as a cue. Pigeons failed to classify pictures that contained arbitrary patches of human skin as members of Class P (Aust & Huber, 2002; 2006; 2010) and had difficulties categorizing scrambled pictures of humans, although these still contained skin fragments (Aust & Huber, 2001). In our experiments on picture-object recognition (Aust & Huber, 2006; 2010) it was particularly interesting that peck rates were higher to SP and UP stimuli than to SK stimuli, although all three stimulus types contained human skin. This argues against a critical role of skin features in the recognition of humans (and human parts).

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doi:10.1016/j.visres.2010.07.012

On the other hand, the presentation of grayscale pictures of humans led to performance decrements (Aust & Huber, 2001). It was, however, unclear whether the loss of skin color in particular was detrimental to classification in that test, or whether the absence of color in general impeded singling out the target (i.e., the human figure). Without doubt, color can substantially contribute to structuring a picture by setting boundaries and thereby make target detection easier (see, e.g., Aust & Huber, 2001; Jacobs, 1993; Mollon, 1989; Wurm, Legge, Isenberg, & Luebker, 1993). A similar interpretative problem arose in the test with scrambled pictures (Aust & Huber, 2001). There, classification performance suffered more strongly from scrambling in the case of grayscale stimuli than in the case of full-color stimuli. Also some of our data on picture-object recognition indicated that responding may not have been entirely under the control of the pictures' representational content but may have been influenced, at least, by perceptual features related to human skin (Aust & Huber, 2006; 2010). Namely, transfer to arbitrary skin patches (SK) was – although significantly weaker than to pictures of true human parts (SP, UP) –, nevertheless stronger than to true negatives (i.e., nonhumans).

Two points have to be considered in the discussion of a possible role of skin for categorization and recognition of humans in pictures. First, skin color is a quality that can be used (and, sadly, has frequently been misused in the past) for separating humans into different subcategories. It may, however, be less useful in determining membership of the whole human category. Given the wide range of wavelengths and hues appearing in the skins of different people (with variation being further increased by differences in light conditions and inclusion of pictures of people belonging to different ethical groups), skin color has to be a very flexible and inhomogenous feature in order to make a reasonably good predictor of the human category. Furthermore, it must be considered that, in our experiments, similar colors occasionally appeared also in instances of Class NP, which should have made the use of skin color as a class-defining feature even more difficult.

Second, picture technology is adjusted to the trichromatic human visual system. In pigeons, by contrast, tetrachromatic or even possibly pentachromatic color vision is apparently the norm (Emmerton & Delius, 1980; Thompson, 1995; Varela, Palacios, & Goldsmith, 1993). This means that they will perceive the colors of objects differently in pictorial representations (made for the human eye) than in reality. Nevertheless, pigeons may recognize humans (or parts of them) in such pictures despite their wrong colors, just as we are able to recognize people in black-and-white photographs. Therefore, skin may play an accessory role in two ways. First, surface properties other than skin color, namely texture cues, may be used. Second, the pigeons may recognize the same or similar color(s) in the skin patches shown in the training and in the test stimuli and may use these as a basis of transfer – irrespective of how they may perceive the colors subjectively, or of whether they see any correspondence with true skin color(s) of real people. The design of our previous experiments (Aust & Huber, 2006, 2010) did not allow for a clear distinction between these possibilities, and maybe even both mechanisms were at work simultaneously.

All in all, our studies have, so far, yielded only fragmentary and inconsistent evidence regarding the relevance of skin features for pigeons' categorization and recognition of humans in pictures. In the present experiment we aimed to re-assess the issue in a systematic way. To this end, we extended one of our experiments on picture-object recognition by a series of tests that varied the content of the depicted humans (or human parts) regarding skin-related information in a controlled way. We thereby basically distinguished between two main aspects of skin: Shape, which refers to a skin patch's outline, and surface, which refers to its interior and which comprises color and texture cues. While color is related to the intensity and wavelengths of light in the patch, texture describes the patch's internal structure, which is, e.g., determined by granulation and shading patterns. Separating shape and surface information has already proven useful in an earlier series of experiments, where pigeons had to classify pictures of male and female faces according to sex (Huber, Troje, Loidolt, Aust, & Grass, 2000; Loidolt, Aust, Meran, & Huber, 2003; Troje, Huber, Loidolt, Aust, & Fieder, 1999; see also Vetter & Troje, 1997). There, we found that surface cues were much more important for correct classification than shape information. This is in line with more recent evidence that, with the ranges of stimulus difference conventionally used in experiments color is, relative to shape, the primary cue that pigeons use to guide their decisions when grouping artificial objects (Kirsch, Kabanova, & Güntürkün, 2008). In the present study, we investigated if the same would hold for the categorization and recognition of natural objects in photographs, namely human figures.

Pigeons that had learned to discriminate between pictures of hand- or headless humans and nonhumans were subjected to a series of three tests. In *Test Grayscale* the role of skin color was investigated by presenting the pigeons with pictures of hands, heads, and skin patches the color of which had been digitally removed. The second and the third test investigated the role of surface information (i.e., human skin) compared to shape information. *Test Nonhuman Surface* involved pictures of hands and heads whose surface had been masked by gloves or face packs (i.e., a covering cream treatment for facial skincare), whereas shape information remained intact. Hence, the stimuli combined valid (i.e., human) shape information with invalid (i.e., nonhuman) surface information. Conversely, *Test Nonhuman Shape* provided valid surface but invalid shape information. There, the pigeons were tested with pictures of nonhuman objects (animals, plants, and man-made items) whose outlines were retained, but whose interiors were digitally filled with (full-color and full-texture) human skin.

2. Methods

2.1. Subjects and housing

Eight pigeons *(Columba livia)* were used as subjects. Three of them were homing pigeons, five were *Strasser*. Six birds had already served as subjects in Aust and Huber (2006). In addition, we also trained two novel birds. The pigeons were housed – together with 8–12 conspecifics – in five outdoor aviary compartments, each measuring $300 \times 120 \times 170$ cm. All subjects had extensive visual experience with humans at the outset of the experiment. On testing days, food was provided only during the experimental sessions and some post-testing supplementary feeding. On non-testing days, the pigeons were supplied with extra rations of mixed grain. Water and grit were freely available in the aviary at any time. The birds were maintained at about 90% of their free-feeding weight.

2.2. Apparatus

The apparatus was the same as in Aust and Huber (2006). The experiment was carried out in Skinner boxes that the birds entered from their respective outdoor compartment through a connecting tunnel. In the center of each box's front panel there was a clear perspex pecking key (5 cm diam., ENV-125 M, MED Assoc., USA). Directly below the key there was the 6×6 cm aperture for a 28 V DC solenoid activated hopper of the grain feeder (ENV-205 M). A hopper light illuminated the receptacle area whenever grain was accessible. Except for a dark inter-trial interval preceding stimulus presentation the chamber was weakly illuminated throughout the experimental session by a 2 W house light (ENV-215) located in the rear part of the chamber. Each Skinner box was connected to a PC, equipped with a digital input/output board and with a