Have we met before? Pigeons recognise familiar human faces

Claudia Stephan[a]*, Anna Wilkinson[a,b] and Ludwig Huber[a, c]

[a]*Department of Cognitive Biology, University of Vienna, Althanstrasse 14, 1090 Vienna, Austria*
[b]*School of Life Sciences, University of Lincoln, Riseholme Park, Lincoln LN2 2LG, UK*
[c]*Messerli Research Institute, University of Veterinary Medicine Vienna, Medical University Vienna, University of Vienna, Veterinärplatz 1, 1210 Vienna, Austria*
**E-mail: claudia.stephan@univie.ac.at*

ABSTRACT

Despite growing evidence for the recognition of conspecifics, studies on heterospecific recognition are still scarce. There is some evidence that birds living in urban habitats are able to distinguish between specific humans, depending on their previous experience with them. Nonetheless, the features by which the birds actually discriminated among humans remain unclear. This study investigated whether pigeons are capable of performing such a sophisticated categorisation and the features relevant to making this discrimination. The results revealed that pigeons are able to discriminate reliably between familiar and unfamiliar humans and provide evidence that facial features are important for this recognition. Furthermore, our results suggest that the ability to discriminate between individual heterospecifics is not restricted to bird species that are considered highly cognitive.

Keywords: *heterospecific recognition, Columba livia, human face recognition, concept of familiarity*

1. INTRODUCTION

Several animal species are able to discriminate between subcategories of conspecifics (*e.g.* Levey *et al.*, 2009; Tricarico *et al.*, 2011). However, evidence for the recognition of individuals, or classes of individuals, among heterospecifics is scarce. Interestingly, most studies of heterospecific recognition have either focussed on predator recognition or on the recognition of humans by either farm animals or by wild animals in urban environments (*e.g.* Slobodchikoff *et al.*, 1991; Munksgaard *et al.*, 1997; Taylor and Davis, 1998; Ferrari *et al.*, 2008; Bogale *et al.*, 2010; Stone, 2010).

Many animal species living in human environments benefit from reduced predation rates, year round food availability and new opportunities for breeding sites. Although food is largely available throughout the whole year, animals have to learn to exploit multiple different food sources. Consequently, if individuals flexibly adjust to many different circumstances in various locations, foraging becomes less costly in terms of searching and handling time. Nonetheless, the presence of specific humans may represent a potential threat, especially if a species is regarded as a pest. This suggests that the recognition of individuals beyond species borders may be facilitated by the ecological need to memorise individual features of heterospecifics. Accordingly, urban bird species like magpies, mockingbirds and crows have been reported to discriminate and remember humans based on their previous experience with them (Levey *et al.*, 2009; Marzluff *et al.*, 2010; Lee *et al.*, 2011). The explanations for such advanced discrimination abilities are twofold. On the one hand, Marzluff *et al.* (2010) have suggested that corvids are predisposed for rapid learning because of their high general cognitive abilities. On the other hand, it could be argued that species that live in human areas and that are frequently exposed to many human individuals benefit if they can recognise individually distinct features and adjust their behaviour accordingly. This "pre-exposure" hypothesis, proposed by Lee *et al.* (2011), suggests that all urban living species with much exposure to humans should rapidly learn to discriminate among humans, depending on their pre-experience with those particular individuals. Although both hypotheses are not mutually exclusive, recent studies with pigeons challenge the idea that these advanced recognition abilities predominately occur in species with "higher cognitive" abilities. Belguermi *et al.* (2011) revealed that foraging feral pigeons spatially avoid human feeders that had previously shown hostile behaviour (*e.g.* arm waving or chasing) during foraging. Further, Dittrich *et al.* (2010) showed that pigeons react with higher levels of activity whenever the person that usually fed the birds entered the housing environment but responded less when individual humans wore masks, indicating that facial cues served as reliable discrimination criterion. Nonetheless, when the pigeons were asked to transfer the recognition of their real-life feeder to 2D-images of the latter, the birds completely failed to distinguish familiar from unfamiliar humans.

Despite this negative result, the presentation of photographic images can still be considered advantageous. Previous studies revealed that birds could discriminate

 doi: 10.3184/175815512X13350970204867

between photographs of conspecifics (Nakamura *et al.,* 2003; Wilkinson *et al.,* 2010) although the exact discriminative features remain unknown (Ryan and Lea, 1994). There is also evidence that they can discriminate heterospecifics (*e.g.* Marzluff *et al.,* 2010). Dittrich *et al.* (2010) emphasised the importance of human facial cues for discrimination whereas other studies indicated a facilitating effect of different clothing or acoustic cues on discrimination (Belguermi *et al.,* 2011; Sliwa *et al.,* 2011; Wascher *et al.*, 2012). Consequently, the use of pictorial representations offers the opportunity to restrict and select all cues given during discrimination.

In the present study, we investigated the pigeon's ability to recognise familiar heterospecifics, namely humans, when only presented with pictorial representations of facial features. We used the familiarity discrimination acquired in a previous experiment (Stephan *et al.,* submitted) that used objects as stimuli and examined the impact of different stimulus properties that influence concept application. The focus of the experiment presented here laid on whether pigeons could transfer this to novel stimuli that are perceptually very different and with which the birds had a very different kind of pre-experience than with the objects.

Although the use of objects during the training might appear somewhat bewildering, it emphasised the main aspect of the present study, namely the extent to which the birds are able to transfer the abstract concept of familiarity when confronted with completely different stimuli. The object discrimination study investigated the factors that trigger the application of this concept. By using objects during the training we were able to control for any perceptual cues in the human faces that might have triggered classification on this basis rather than that of familiarity. The experiment was designed to exclude any basic forms of social learning *e.g.* observational learning, which is likely to influence the birds' responses (Marzluff *et al.,* 2010). This was made possible by testing the birds individually in an operant chamber. We restricted the stimuli so that only visual information of human heads was available; this allowed us to disentangle the impact of facial cues for recognition from additional features.

2. METHODS

2.1 Subjects

Fifteen homing pigeons were assigned to either a control ($N = 7$) or an experimental group ($N = 8$). The entire group of experimental birds lived together in an outdoor aviary (2.9 x 2 x 3 m^3), as did all birds of the control group (2 x 1 x 2 m^3). The aviaries were visually isolated from each other. Both aviaries contained perches, nesting boxes and a water dispenser. Water and grit were freely available throughout the whole experiment whereas food was only provided during experimental sessions and over the weekend. All birds were maintained at 90% of their free feeding weight.

2.2 Stimuli

2.2.1 Real objects and humans

Within the training phase, birds were presented with photographs of objects (of various kinds, including various colours, shapes and sizes; *e.g.* a kettle, a torch, a fork, sunglasses, *etc.*; for examples see Figure 1) that were either familiar (to the experimental group) or completely unknown to both groups of birds. Two weeks prior to the first training session the familiar objects were placed either in the aviary of the experimental birds or in the aviary opposite the experimental group (so they only had visual access to them). All of the familiar objects remained *in situ* throughout the experiment. The control birds could not see or interact with any of these objects.

For the Human Faces Familiarity test, eight people were photographed; four were in frequent contact with the pigeons and four had never been in physical or visual contact with them. Interaction with the familiar people included cleaning, feeding and capturing of the birds. The minimum criterion for a person to be familiar was either to interact with the birds (*e.g.* feeding or catching them) at least twice a week or to enter the aviary on a daily basis for at least five minutes.

All of the objects were unfamiliar to control birds but all birds had seen the familiar humans before. In the critical test, control birds should not be able to successfully discriminate between familiar and unfamiliar human faces, as they will not have acquired the underlying logic of the task during the trainings phase.

2.2.2 Photographic stimuli

During the acquisition phase, pigeons were presented with photographs that showed different objects (Figure 1a). Photographs were taken of 16 familiar and 16 completely unknown objects and were controlled for colour, shape and size. Fourteen photographs of each object were taken from at least 10 different angles.

In the Human Face Familiarity test, all photographs showed only the head and part of the neck (Figure 1b). Photographs of humans depicted four familiar and four unfamiliar humans. Again, 14 photographs were taken from at least 10 different angles and included both sexes. There were no discriminative features shared between the objects and human faces in general or between familiar objects and familiar human faces (*e.g.* overall shape, colour).

All pictures were taken under different light conditions and the same stimulus was photographed under both indoor and outdoor lighting. Photographs were presented on a touchscreen in an operant chamber. During stimulus presentation all photographs were displayed at a size of 3.8 x 3.8 cm (449 x 449 pixel). All pictorial representations of objects and human faces were modified and presented on a homogenised background colour using PhotoShop software package (© Adobe Inc.). Thus, any salient a)

b)

Figure 1 Examples of the familiar and unfamiliar stimuli shown during (a) the acquisition phase (objects) and (b) the face familiarity test (human faces). The right stimulus of each pair represents a familiar stimulus, the left one an unfamiliar. Across stimuli, various perceptual differences were controlled for (*e.g.* for objects: shape, size, colour, light conditions and for human faces: sex, hair colour, orientation of the head and light conditions).

background features were excluded. The background colour was chosen to provide the highest level of contrast to all stimuli.

2.3 Apparatus

The entire experiment was carried out in Skinner Boxes, measuring 50 x 30 x 40cm. An IR touch frame was mounted in front of a 15 inch monitor at one end of the box and a piston (lifted by a motor unit after each correct response) provided food. The feeder system and touch screen presentations were controlled by a specialist software package ("CognitionLab", M. M. Steurer).

2.4 Procedure

2.4.1 Discrimination training

The pigeons had already been trained to discriminate between familiar and unfamiliar objects (Stephan *et al.*, submitted) and this experiment extended this by investigating whether they could generalise the learning about objects to novel stimulus forms (faces). The object training consisted of presentation of photographs of ten familiar objects and ten unfamiliar objects. The pigeons were trained using a two-alternative forced choice procedure in which two photographs were presented on a touch-screen computer monitor, one positive and one negative. Pecking at the positive stimulus led to an auditory signal, the screen clearing and 3 seconds access to food. Choice of the negative stimulus led to a different auditory signal, the screen flashing red (3 seconds) and a correction trial (a repeat of the same trial). This continued until the positive stimulus was selected. Each trial was separated by an inter trial interval of 6 seconds; during this time the screen was dark. Reward contingencies were counterbalanced, so half of the experimental group were rewarded for choosing the familiar object and half for choosing the unfamiliar one. To ensure that there were no perceptual cues in the images each control bird was presented with identical stimuli and contingencies as a corresponding experimental bird.

Each training session comprised 50 trials. The acquisition criterion was met when a pigeon made correct first choices in 80% of the trials (40/50 trials) in four out of five consecutive sessions and at least 75% (38/50) in the remaining session. As the subjects had previous training on this task (for training performances see Figure 2) all subjects reached criterion again within a maximum of 12 training sessions.

2.4.2. Human faces familiarity test

After the birds reached the acquisition criterion, they were presented with a critical test in which we investigated whether the pigeons were able to transfer their learned discrimination to human face stimuli. Test trials which contained human faces were pseudo randomly intermixed with the object training trials. There was no test trial at the start and at the end of each session and test trials could not appear in a row. One of the human faces was familiar to the pigeons and the other one was not. Pecking at the familiar or the unfamiliar human face indicated the choice behaviour of pigeons. Within each test session, eight test trials were randomly intermixed with 50 training trials, resulting in 58 trials per session. If the birds did not respond to criterion on the training trials that were intermixed with the test trials the session was repeated. There was no differential feedback in test trials, meaning that both stimuli disappeared after the first peck was emitted, independently of whether the choice was correct. A total of 56 different test trials were presented to each bird, distributed among seven test sessions in total. Although both the experimental and control birds were familiar to the humans, it was predicted that only the experimental birds should categorise the faces correctly as the control birds did not have any visual experience with familiar objects and thus could not (and did not) learn the initial familiarity discrimination. They were, therefore, expected to perform at chance during this test, pecking randomly at one of the two presented human faces.

2.5 Data analysis

The discrimination performance was assessed by means of two-tailed binomial tests. All statistical analysis was conducted in SPSS v.17.

3. RESULTS

On a group level, birds of the control group required a median of 36 (range: 25–70) sessions to reach criterion whereas experimental birds reached the acquisition criterion in a median of 28 (range: 26–42) sessions (Figure 2). However, this apparent difference was not significant. The results of the Human Faces Familiarity test revealed that four out of eight experimental birds successfully categorised pictorial representations of human faces on the basis of familiarity and, critically, all control birds failed (for individual performances please see Table 1).

Throughout the test sessions all birds in experimental and control group maintained their highly significant performance in training trials. Thus the birds had not been disturbed by the presentation of perceptually very different stimuli during test sessions.

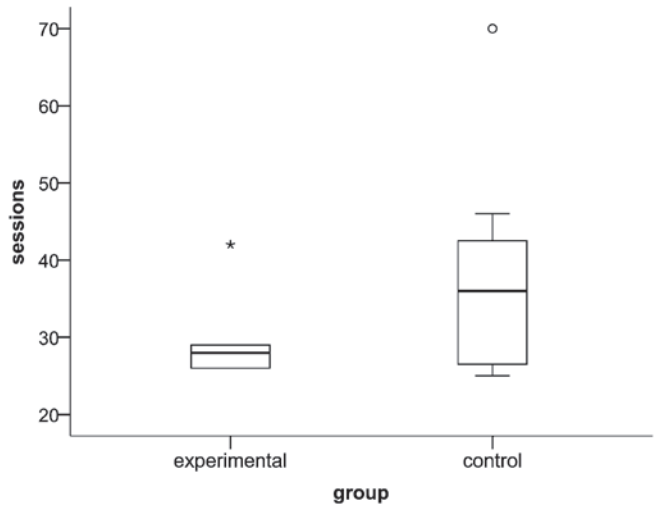

Figure 2 Number of sessions to reach acquisition criterion for experimental and control group. Boxplots include the median, first and third quartile and extreme values (circle and asterix).

4. DISCUSSION

The present results show that some pigeons are able to recognise and correctly classify individual heterospecifics on the basis of facial information. Moreover they were able to do this when the human faces were presented as photographic stimuli and only 2D information was available. Four out of eight pigeons in the experimental group succeeded in correctly classifying the pictures even though the birds were not previously trained with familiar and unfamiliar human face stimuli. Critically, all subjects of the control group failed to discriminate familiar from unfamiliar human faces in the transfer test revealing that a perceptual rule or preference did not underlie the successful performance of the experimental group.

All the birds were trained on photographs of objects, half of which were familiar and half unfamiliar to the experimental group (both were unfamiliar to the control birds). The training was part of a previous experiment that investigated the pigeons' ability to discriminate individual objects on the basis of familiarity and the object features

Table 1 Individual performances in the discrimination of familiar and unfamiliar human faces

Pigeon name	$N_{correct\ choices}$	$N_{incorrect\ choices}$	P
Experimental group			
Bobby Tom	29	27	0.894
Dorothy	28	28	1
Bobby Tim	37	19	**0.022**
Toby	39	17	**0.005**
Mata Hari	43	12	**< 0.001**
Harry	42	14	**< 0.001**
Mr. Speckle	34	22	0.141
Snape	30	26	0.689
Control group			
Dr. Wilson	33	23	0.229
Claire	23	33	0.229
Wiliam	26	30	0.689
Mag	29	27	0.894
Keira Gru	31	25	0.504
Dr. House	21	35	0.081
Paul Parker	29	27	0.894

Significant classification is indicated by *P*-values in bold and was assessed by means of two-tailed binomial tests. The level of significance was set to $P < 0.05$.

that were important for concept formation. In the present experiment, we wanted to investigate whether the birds could transfer the complex discriminative rule of familiarity to heterospecifics. The fact that control birds saw familiar humans, as did the experimental birds, but were not able to classify them reliably, supports the interpretation that pigeons acquired the abstract feature of familiarity for discrimination. Consequently, all control birds mastered the training by rote learning and thus showed random choice behaviour in the critical test.

In contrast to previous studies (e.g. Dittrich *et al.,* 2010; Belguermi *et al.*, 2011) we did not artificially manufacture encounters with specific humans involving exclusively negative or positive events. In fact, two of the familiar humans captured, released and fed the birds on a regular basis, one was only involved in cleaning the aviaries and one was entering the aviaries but not handling the birds directly. Thus the present results suggest that in a long-term relationship between pigeons and humans, the memorisation and recognition of humans is not necessarily mediated by previous interactions that have been explicitly hostile (e.g. catching) or friendly (e.g. feeding). Given the context of encounters and long-term exposure to humans, we can exclude fear conditioning and predator avoidance as mechanisms of recognition (Griffin, 2004; Marzluff *et al.,* 2010). For the birds tested here, humans appear to be relevant in a broad sense and this may be sufficient to maintain recognition of the subset of humans that interact with the birds on a regular basis. Hence, this study provides support for the impact of visual pre-experience in facilitating the recognition of ecologically relevant heterospecifics (Marzluff *et al.,* 2010; Lee *et al.,* 2011). For the successful discrimination of familiar humans, pigeons had to separate features that are constant within individual humans over several encounters (e.g. facial cues) from those that vary and/or overlap considerably between humans (e.g. clothing, movement, body size). Marzluff *et al.* (2010) already found a strong indication that crows paid attention to peoples' faces and suggested that these features might provide a valuable discriminative feature as they vary little within a human but reliably vary between humans. The present results suggest that facial information alone is sufficient for pigeons to discriminate among humans, although the exact features that are used to do this still need to be identified.

As pigeons are not known for their abstract cognitive abilities but possess extraordinary visual discriminative abilities (e.g. Huber *et al.,* 2000; Aust and Huber, 2006; Huber, 2010; Huber and Aust, 2011), it seems unlikely that pigeons are predisposed for rapid learning by their high cognitive abilities as has been suggested for corvids (Emery 2006). Instead we suggest that for some species, the extensive exposure to ecologically relevant heterospecifics might be sufficient for cross-species individual recognition. At least for pigeons, urban living or captive care may meet this prerequisite.

Although experiments that are conducted on wild populations have the advantage of exploring behavioural responses under natural conditions, controlled experimental conditions provide the opportunity to systematically restrict and control the information given to individual animals. By training our pigeons under controlled captive conditions we were able to manipulate both their real-life experience with the training stimuli (objects) and the test stimuli (humans). We were also able to prevent the control birds from acquiring the crucial discriminative feature by ensuring that they had no visual access to familiar objects. Simultaneously, we used a variety of objects with very different appearance during the training to facilitate the transfer of discrimination (Cook *et al.*, 1990) and controlled for similar amounts of pre-experience with every object among the experimental birds. Hence, we consider studies on captive birds to provide a promising approach to further investigate the exact impact of pre-experience on heterospecific recognition although obtained findings must be tested in the field to evaluate the ecological relevance of this capacity under natural conditions.

In conclusion, pigeons are able to recognise familiar humans on the basis of 2D-representations of facial features. In contrast to corvids, pigeons are not thought to be genetically predisposed to show high-level cognitive abilities. Nonetheless, extensive experience with heterospecifics, the ecological need to recognise individuals and to adjust their behavioural response on the basis of this may lead to comparably sophisticated cognitive capacities and represent a surprisingly flexible learning capacity. The extent of these abilities is currently unknown. Whether the birds possess "true" individual recognition of heterospecifics is unclear and investigations of cross-modal recognition would be a promising focus for further studies.

ACKNOWLEDGEMENTS

We would like to thank Hanna Specht and Katharina Kramer for their help with preparing the stimuli. This work was supported by funding from the Austrian Science Fund (FWF) (to L.H.) under contract number P19574.

REFERENCES

Aust, U. and Huber, L. (2006) Picture-object recognition in pigeons: Evidence of representational insight in a visual discrimination task using a complementary information procedure. *J. Exp. Psychol. – Anim. Behav. Process.*, **32**, 190-195.

Belguermi, A., Bovet, D., Pascal, A., Pre´vot-Julliard, A.C., Saint Jalme, M., Rat-Fischer, L. and Leboucher, G. (2011) Pigeons discriminate between human feeders. *Anim. Cogn.*, **14**, 6, 909–914.

Bogale, B.A., Aoyamab, M. and Sugitaa, S. (2011) Categorical learning between 'male' and 'female' photographic human faces in jungle crows (*Corvus macrorhynchos*). *Behav. Proc.*, **86**, 109–118.

Cook, R.G., Wright, A.A. and Kendrick, D.F. (1990) Visual categorisation by pigeons. In: Commons, M. L. and Herrnstein, R. J. (eds), *Quantitative analyses of behavior: Vol. 8. Behavioral approaches to pattern recognition and concept formation*, pp. 187-214. Hillsdale, NJ: Erlbaum.

Dittrich, L., Adam, R., Ünver, E. and Güntürkün, O. (2010) Pigeons identify individual humans but show no sign of recognizing them in photographs. *Behav. Proc.*, **83**, 82-89.

Ferrari, M.C.O., Messier, F. and Chivers, D.P. (2008) Can prey exhibit threat sensitive generalization of predator recognition? Extending the predator recognition continuum hypothesis. *Proc. R. Soc. Lond. Ser. B Biol. Sci.*, **275**, 1811–1816.

Griffin, A.S. (2004) Social learning about predators: A review and prospectus. *Learn. Behav.*, **32**, 1, 131-140.

Huber, L., Troje, N.F., Loidolt, M., Aust, U. and Grass, D. (2000) Natural categorisation through multiple feature learning in pigeons. *Q. J. Exp. Psychol. B*, **53,** 4, 341-357.

Lee, W.Y., Lee, S. I., Choe, J.C. and Jablonski, P.G. (2011) Wild birds recognise individual humans: experiments on magpies, *Pica pica*. *Anim. Cogn.*, **14**, 6, 817-825.

Levey, D.J., Londono, G.A., Ungvari-Martin, J., Hiersoux, M.R., Jankowski, J.E., Poulsen, J.R., Stracey, C.M. and Robinson, S.K. (2009) Urban mockingbirds quickly learn to identify individual humans. *Proc. Natl. Acad. Sci. USA,* **106**, 22, 8959-8962.

Marzluff, J.M., Walls, J., Cornell, H.N., Withey, J.C. and Craig, D.P. (2010) Lasting recognition of threatening people by wild American crows. *Anim. Behav.*, **79**, 699–707.

Munksgaard, L., de Passille, A.M., Rushen, J., Thodberg, K. and Jensen, M.B. (1997) Discrimination of people by dairy cows based on handling. *J. Dairy. Sci.*, **80**, 1106–1112.

Nakamura, T., Croft, D.B. and Westbrook, R.F. (2003) Domestic pigeons (*Columba livia*) discriminate between photographs of individual pigeons. *Learn. Behav.*, **31**, 307-317.

Ryan, C. M. E. and Lea, S. E. G. (1994) Images of conspecifics as categories to be discriminated by pigeons and chickens: slides, video tapes, stuffed birds and live birds. *Behav. Process.*, **33,** 155–176.

Sliwa, J., Duhamel, J.R., Pascalis, O. and Wirth, S. (2011) Spontaneous voice–face identity matching by rhesus monkeys for familiar conspecifics and humans. *Proc. Natl. Acad. Sci. USA*, **108**, 4, 1735–1740.

Slobodchikoff, C.N., Kiriazis, J., Fischer, C. and Creef, E. (1991) Semantic information distinguishing individual predators in the alarm calls of Gunnison prairie dogs. *Anim. Behav.*, **42**, 713–719.

Stephan, C., Wilkinson, A. and Huber, L. (submitted to *Anim. Cogn.*) Individual recognition in the non-social domain – Pigeons recognize individual objects that are ecologically relevant for them.

Stone, S.M. (2010) Human facial discrimination in horses: can they tell us apart? *Anim. Cogn.*, **13**, 51–61.

Taylor, A.A. and Davis, H. (1998) Individual humans as discriminative stimuli for cattle (*Bos taurus*). *Appl. Anim. Behav. Sci.*, **58**, 13–21.

Tricarico, E., Borrelli, L., Gherardi, F. and Fiorito G. (2011) I know my neighbour: individual recognition in *Octopus vulgaris*. *PLoS ONE*, **6**, 4, e18710. doi:10.1371/journal.pone.0018710.

Wascher, C.A.F., Szipl, G., Boeckle, M. and Wilkinson, A. (2012) You sound familiar – Carrion crows can differentiate between the calls of known and unknown heterospecifics. *Anim. Cogn.*, In press.

Wilkinson, A., Specht, H.L. and Huber, L. (2010) Pigeons can discriminate group mates from strangers using the concept of familiarity. *Anim. Behav.*, **80**, 109-115.