SHORT COMMUNICATION

RAPID BEHAVIOURAL ADJUSTMENTS TO UNFAVOURABLE LIGHT CONDITIONS IN EUROPEAN STARLINGS (*STURNUS VULGARIS*)

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Although it is known that many birds possess ultraviolet (UV)-sensitive vision, most commercially housed poultry species, as well as species held in zoos, laboratories, or bred for show, are maintained under lighting that is deficient in UV wavelengths compared with normal daylight. UV-sensitive vision has been shown to be important in both foraging and mate-choice decisions. UV-poor conditions, in which information in this waveband is eliminated, could, therefore, present an important welfare issue. Eight European starlings were given a series of preference tests (eight hours per trial, for six days), in which they could choose to feed in one of four channels. Four experimental trials were carried out, during which the channels were covered in either UV-transmitting (UV+) or UV-blocking (UV–) filters, to determine whether birds had an initial preference for feeding in UV-rich environments and whether there was any change in their preference over time. There was an initial preference for the UV+ environment, but this preference declined very rapidly with familiarity, and was absent by the final trial. These results imply that starlings can rapidly adjust their feeding behaviour if faced with unfamiliar light environments and that any initial behavioural changes attributable to UV-deficient environments may be short-lived. However, further work is necessary to establish whether these adjustments occur across a range of species and contexts before any welfare concerns can be ruled out.

Keywords: *animal welfare, foraging behaviour, light environment, European starling, ultraviolet vision*

Introduction

Ultraviolet light has been shown to be used in various visually orientated behaviours, providing cues for both foraging and signalling (reviewed by Cuthill *et al* 2000; Bennett & Cuthill 1994). Therefore, the common practise of housing birds under incandescent or normal fluorescent lights (both of which are poor UV emitters; see review by Lewis & Morris 1998) may be sub-optimal, as such cues are not available, or are available to a much lower degree. When such cues are used to signal social status, their removal may lead to an increase in aggressive behaviour (Sherwin & Devereux 1999); for example, injurious pecking is significantly reduced in turkeys, *Meleagris gallopavo*, that are maintained under continuous UV lighting and with environmental enrichment (Lewis *et al* 2000). In addition, increased overall or re-directed pecking rates may be observed in UV-poor environments because of the loss of foraging cues, since some commonly used feeds and substrates show UV

reflectance (Huber-Eicher & Wechsler 1997; Prescott & Wathes 1999). Such effects may also be enhanced in wild-caught birds that are used to natural light environments and are subsequently kept in unnatural, UV-poor light environments.

There is some evidence that the number of pecking injuries suffered by turkey poults declines when supplementary UV light is provided (although this was as part of a further enriched environment; see Sherwin *et al* 1999). There is also evidence that turkeys prefer to spend time in UV-enriched environments, and that this preference exists whether the birds are reared with or without supplementary UV light, hence discounting a basic preference for novelty (Moinard & Sherwin 1999). Although this implies that supplementary UV light is preferable, the addition of another light source increases the overall intensity of the light as well as the proportion of different wavelengths emitted. As turkeys also prefer higher light intensities (Sherwin 1998), a preference for supplementary UV may indicate a preference for higher intensities rather than for an increase in UV wavelengths specifically. Most studies of the influence of the illuminant on avian behaviour or production have confounded manipulations of spectral composition with changes in the overall light intensity and/or light source (see eg Manser 1996), so we took care to balance quantal flux across treatments.

In this study, the effect of manipulating UV wavelengths independently of intensity was investigated over four eight-hour trials. European starlings are known to have UV-sensitive cones in their retinas (Hart *et al* 1998), and to possess UV plumage cues (Cuthill *et al* 1999) that are used in mate choice (Bennett *et al* 1997). Hence, we aimed to establish whether starlings preferred feeding in UV-rich environments and whether any initial preference varied over time. We stress that the goal of the experiment was to assess preferences for feeding in a particular light environment, not to assess the effects of the light environment on the appearance of the food. The demonstration that removal of the UV-reflectance from a coloured object affects its attractiveness as a food item to an animal with UV-sensitive vision was not an aim of this experiment. Our experiment was designed deliberately to exclude preferences resulting from the food being an unfamiliar colour, by placing the food in darkened shielded containers.

Materials and methods

We used eight wild adult starlings, maintained in captivity for a maximum of five months prior to the experiment. The birds were numbered with single numbered leg bands (A C Hughes, Middlesex, UK). Between trials, the birds were housed in one of two groups of eight starlings, in cages measuring 0.67 × 1.2 × 0.5 m. Room illumination was a combination of 1.8 m Osram 58W cool white fluorescent tubes, and 1.8 m 100W fluorescent Durotest Truelite tubes, all powered by Tridonic 240V, 71W, 35–40 kHz ballasts. The spectral emission of the Truelites tubes is designed to mimic natural daylight, giving a higher level of ultraviolet emission than standard fluorescent tubes (Bennett *et al* 1996; Bennett *et al* 1997; Hunt *et al* 1997), and the use of high-frequency ballasts provided flicker-free illumination (ie the flicker frequency was above the avian critical flicker fusion frequency; see D'Eath 1998). The birds were maintained on a 13 h L : 11 h D photoperiod, at a constant temperature of 18°C, for the duration of the experiment. Turkey starter crumbs and water were available *ad libitum*. After the experiment, all birds were released back into the wild following veterinary inspection.

The test apparatus comprised a main chamber with four choice channels leading from it (see Figure 1), illuminated by two centred Truelites suspended 1.5 m above the apparatus. When carrying out the experimental trials, filters were placed over each channel in order to

manipulate the available wavelengths. Ultraviolet wavelengths were transmitted (UV+) in two randomly chosen channels and were blocked (UV−) in the other two (for transmission spectra, see Bennett *et al* 1996). The total amount of light transmitted through these filters was similar, as the total quantal flux was approximately balanced across the avian visual range of 300–700 nm (Bennett *et al* 1997). The apparatus was constructed with aluminium, which has fairly even reflectance at all avian-visible wavelengths, to increase the horizontal radiance spectrum within each cage and provide uniform illumination conditions (see Bennett *et al* 1996; Bennett *et al* 1997; Hunt *et al* 1997).
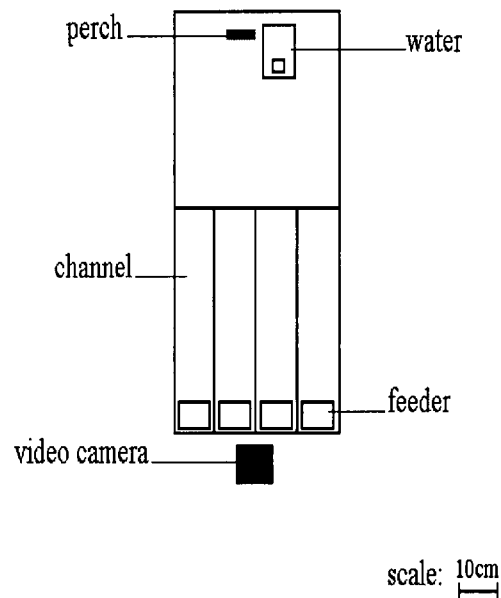

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Figure 1   **The experimental apparatus, comprising a main chamber with four channels. The channels end in matt-black-painted feeders (7 × 9 × 5 cm) containing turkey starter crumbs, and are covered with either UV+ or UV− filters during experimental trials (see text). The main chamber contains a perch and *ad libitum* water. Perches are positioned in front of each channel to encourage the birds to enter the channels (there is a 0.14 m difference in depth between the channels and the main chamber, which have depths of 0.14 m and 0.29 m, respectively).**

Each bird had six consecutive trials of eight hours duration that ran from 0900h to 1700h. Test birds were food-deprived for three hours prior to trials in order to ensure motivation to feed. During each trial, the bird was released into the main compartment and allowed to move freely within the apparatus. The first two trials were the acclimatisation period. In trial one, 36 live mealworms (*Tenebrio molitor* larvae) were scattered throughout the apparatus (seven in each channel and eight in the main compartment) to encourage the bird to explore its environment, and the number eaten was recorded. Before trial two, four covered D-cup feeders were fixed vertically to the end of each channel in a semi-random order that was not used in the experimental trials. These feeders were painted matt black using vinyl matt

emulsion paint, and the area of the feeder entrance was reduced by blocking the lower half using black painted card. This was done to minimise illumination of the food itself and thus to minimise any differences in its appearance between the UV+ and UV– environments during experimental trials (the experiment was designed to test for preferences for a particular light environment when feeding, rather than for an effect resulting from a change in the perceived colour of food). Each feeder initially contained 50 g of turkey starter crumbs. Trials three to six were experimental trials in which filters and feeders were assigned to each channel for a given trial using a Latin square design. During all trials except the first, the birds' activity was recorded using a video camera fixed 1.58 m above the apparatus.

Statistical analysis

The total time spent in each channel and the time spent feeding in each channel were determined using video analysis. One bird did not enter any of the channels on two trial days, and so was excluded from the analysis. The data were log-transformed to normalise the residuals. Total time spent within the channels was broken down into two dependent variables: time spent feeding, and time not feeding. The former comprised only the actual head-down feeding probes, rather than the duration of entire bouts, because in the small feeding channels it was difficult to objectively distinguish the inter-probe intervals from genuine breaks in feeding behaviour. The two dependent variables were initially analysed using MANOVA on MINITAB (Minitab Inc. 1998) to test for any overall preference for foraging in a certain light environment. Following this, univariate ANOVAs were used to determine which variables differed between treatments. Two-tailed tests of probability were used throughout.

Results

MANOVA revealed a significant day x filter interaction (Wilk's $\lambda = 0.458$; $F_{6,34} = 2.709$, $P = 0.029$), indicating that filter preference changed over the course of the experiment. Univariate ANOVAs indicated that this interaction was significant for both feeding and non-feeding time (feeding time: $F_{3,18} = 5.03$, $P = 0.01$; non-feeding time: $F_{3,18} = 3.28$, $P = 0.045$). These results are attributable to an initial preference for UV+ that declines over the four trials (see Figure 2). The birds show a significant preference for the UV+ channels on trial 1, which declines and is lost by trial 4.

Discussion

The results indicate an initial preference for UV-rich environments that is consistent with that shown in some previous studies (Moinard & Sherwin 1999), but starlings appear to lose this preference over a fairly short time period (under four days; see Figure 2). The preference for UV+ in trial 1 could represent either a preference for UV-rich environments *per se* or a preference for a more familiar illumination, having lived in full-spectrum lighting in the wild and having been exposed to it in the two acclimatisation trials. Indeed, it was the expectation that familiarity with UV-deficient lighting might diminish any aversion to it that led us to design an experiment in which we could track any changes in preference. This was indeed what we observed: the treatment difference ceased to be significant after trial 1, and was non-existent by trial 4. Thus, whatever the reason for the preference in trial 1, familiarity rapidly leads to indifference between UV+ and UV– conditions. This implies that unnatural and, on capture, unfamiliar UV-poor light environments may cause only short-term alterations in the behaviour of wild birds. However, although this result is reassuring from a welfare

perspective, this decline in preference may not apply in other contexts and there is the possibility that any adjustments may reverse over the longer term. These birds were tested individually, choosing from channels containing visually identical food resources (because the containers shielded the food from the illuminant). Because starlings, along with other avian species, have been shown to utilise UV-dependent cues in mate choice (reviewed by Cuthill *et al* 2000), preferences may not be lost so rapidly in contexts where social signalling is important.
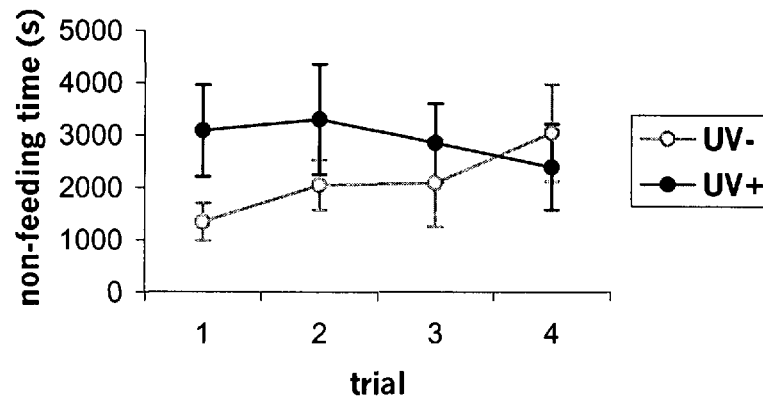
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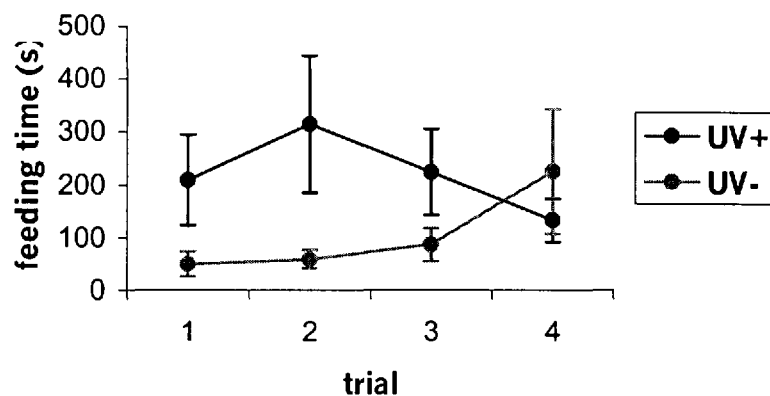
(b)

Figure 2   Interaction plots indicating the change in average time spent within each channel over the four experimental trials. The graphs show mean ± SEM for (a) feeding time and (b) time spent not feeding. The effect of filter is only significant on trial 1. (ANOVAs follow for each trial separately. Feeding time — trial 1: $F_{1,6} = 12.88$, $P = 0.012$; trial 2: $F_{1,6} = 5.83$, $P = 0.052$; trial 3: $F_{1,6} = 0.51$, $P = 0.501$; trial 4: $F_{1,6} = 2.12$, $P = 0.196$. Non-feeding time — trial 1: $F_{1,6} = 28.86$, $P = 0.002$; trial 2: $F_{1,6} = 2.06$, $P = 0.201$; trial 3: $F_{1,6} = 0.04$, $P = 0.853$; trial 4: $F_{1,6} = 0.31$, $P = 0.599$.)

Broiler chicks reared and then tested under different coloured light sources of equal intensity (white, green, blue or red) initially preferred the familiar light source, but within a week they altered their preferences depending on which rearing conditions they had experienced (Prayitno *et al* 1993). Again, this suggests that preferences alter over time and in response to previous experience. Hence, although UV preferences have been identified in various species, further work is required to determine whether they occur in different contexts and, more importantly, how persistent such preferences are. The potential welfare implications of UV-deficient light sources can then be accurately determined.

Animal welfare implications

This study suggests that although preferences for environments containing ultraviolet wavelengths exist, they may not be persistent, implying that commonly used UV-deficient light sources (incandescent and normal fluorescent lights) may not be a welfare problem. However, evidence from various avian species shows that UV-dependent cues are important in behaviours involving mate-preferences and foraging. Such evidence suggests that further work is required in order to establish whether the persistence of such preferences varies with the resources available before the need for lighting with emissions similar to natural daylight can be ruled out. Furthermore, the lack of a detectable behavioural preference does not rule out deleterious chronic effects.

Acknowledgements

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