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Transfer of stimulus control from a TFT to CRT screen

Renee Caron Richards Railton*, T. Mary Foster, William Temple

University of Waikato, Hamilton, New Zealand

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ABSTRACT

The use of television and computer screens for presenting stimuli to animals is increasing as it is non-invasive and can provide precise control over stimuli. Past studies have used cathode ray tube (CRT) screens; however, there is some evidence that these give different results to non-flickering thin film transistor (TFT) screens. Hens' critical flicker fusion frequency ranges between 80 and 90 Hz – above standard CRT screens. Thus, stimuli presented on CRT screens may appear distorted to hens. This study aimed to investigate whether changing the flicker rate of CRT screens altered hens' discrimination. Hens were trained (in a conditional discrimination) to discriminate between two stimuli on a TFT (flickerless) screen, and tested with the stimuli on a CRT screen at four flicker rates (60, 75, 85, and 100 Hz). The hens' accuracy generally decreased as the refresh rate of the CRT screen decreased. These results imply that the change in flicker rate changed the appearance of the stimuli enough to affect the hens' discrimination and stimulus control is disrupted when the stimuli appear to flicker.

1. Introduction

Computer and television screens have become a common medium for presenting visual stimuli to animals in studies of animals' social processes, visual perception, social behaviour, and category and concept formation (e.g., Bradshaw and Dawkins, 1993; Clark and Stephenson, 1999; Kodric-Brown and Nicoletto, 2001; Patterson-Kane et al., 1997). Most studies assume that the animal responds to these images, both static and moving, as if the real object or animal were present. It is not always clear that this is the case. Furthermore, television and computers have been designed with the human visual system in mind, and important information may be missing for animals.

Computer and television screens have commonly been cathode ray tube (CRT) screens, but there has been a recent move to the use of thin film transistor (TFT) screens. Images on a CRT screen get refreshed at a particular rate. The individual phosphor dots used to make up the image darken between refresh scans. These refresh scans commonly occur at 50–85 Hz and consequently the images may appear to flicker for animals with a critical flicker fusion (CFF) threshold higher than this. CFF is defined as the lowest frequency that a flickering light is seen as steady or continuous (Landis and Hamwi, 1954; Brundett, 1974). If televisions and computers present images at a rate lower than the CFF of an organism, the images will not fuse and will appear to be flickering. With TFT monitors the individual pixels remain lit between scans and there is no phosphor decay and so the images are virtually flickerless. As a result, it is possible that CRT and TFT screens would give rise to different findings.

There are data with birds that support this suggestion. Some studies have reported that birds failed to respond appropriately to CRT images and/or failed to generalise any learned discrimination from CRT images to the real object (e.g., D'Eath and Dawkins, 1996; Ryan and Lea, 1994; Patterson-Kane et al., 1997; Pepperberg et al., 1998). Patterson-Kane et al. (1997) found that hens were unable to generalise their discrimination of real objects to videoed images of the same objects presented on CRT screens, and had more difficulty learning to discriminate between two sets of video images than between the real objects (except when the discrimination could be done on colour alone). This suggests that the video images were not equivalent to the real stimuli for these birds. Studies using TFT screens have had more success than have those using CRT screens. For example, female Zebra and Bengalese finches will show courting behaviour to images of conspecific males on TFT screens (Swaddle et al., 2006) and female Japanese quail increased the time they spent near a live male after having seen the same male mate with another female in a video shown on a TFT monitor (Ophir and Galef, 2003).

One possible reason for birds' limited successful discrimination of CRT screens (compared to TFT screens) could be that their critical flicker fusion (CFF) may be higher than the monitor's flicker rate. Birds have been reported to have high CFF thresholds; pigeons range between 65 and 145 Hz (Hendricks, 1966; Powell, 1967) and hens range between 69 and 105 Hz (Nuboer et al., 1992;

* Corresponding author at: The Psychology Department, University of Waikato, Private Bag 3105, Hamilton, New Zealand. Tel.: +64 7 838 4466x8863; fax: +64 7 858 5132.
E-mail address: reneer@waikato.ac.nz (R.C.R. Railton).

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Railton et al., 2009), both potentially above common CRT refresh rates.

Ikebuchi and Okanoya (1999) compared the use of TFT and CRT screens and found male Zebra and Bengalese finches emitted directed singing and showed courtship behaviour comparable to that found with live conspecific female, towards images of the same females on a TFT screen. They failed to do this when the same images were presented on a CRT screen.

If it is indeed the refresh rate of CRT screens that gives rise to the discrimination failure in previous studies, it seems reasonable to suggest that increasing the refresh rate above the CFF of the animal should lead to results similar to those found with TFT screens. Galoch and Bischof (2006) examined zebra finches' discrimination between two live video images presented on a 100 Hz CRT monitor. This is a higher refresh rate than conventional CRT screens. The birds were able to discriminate between images of a zebra finch and an empty cage, and between images of an unknown female and unknown male. This success, with the higher refresh rate, suggests that increasing the flicker rate of a CRT screen may alter birds' ability to discriminate or respond to stimuli presented on such screens.

If this were so then birds trained on a visual discrimination task with a TFT monitor should maintain the discrimination when the images are transferred to a CRT monitor with a refresh rate above the CFF of that particular bird. Alternatively, the discrimination should not be maintained if the CRT screen refresh rate was too low. In the present study this proposition was tested. Hens were trained to discriminate between three simple pairs of images (colours, geometric shapes, and line drawings) presented on a TFT screen. The same stimuli were then presented on a CRT screen with the CRT screen set at various flicker rates and the degree of discrimination was assessed.

The stimuli selected were a simple shape discrimination of a black outline on a white background, a colour discrimination, and a more complex black-on-white line drawing discrimination. These stimuli were selected as they were similar to those used in studies assessing simple discrimination in birds (e.g., Cabe, 1976; Wasserman et al., 1993; Young et al., 2001) and covered a range of simple discriminations.

2. Method

2.1. Subjects

Five Brown Shaver domestic hens served as subjects. They had been purchased from Bromley park hatchery, Tuakau, New Zealand as 1-day old chicks. They were approximately 4 years old at the beginning of the experiment and had previously served in an experiment establishing their CFF (Railton et al., 2009) but had no previous experience discriminating pictorial stimuli. The hens were individually housed in adjacent metal cages measuring 51 cm × 43 cm × 50 cm in a ventilated room that was lit on a 12L:12D cycle with two 100-W incandescent bulbs. Water was freely available, and grit and vitamins were supplied weekly. The hens were weighed daily and provided with supplementary feed (commercial laying pellets) if required to maintain them at approximately 80% of their free-feeding body weights. The hens' combs were red and fleshy and they occasionally laid eggs in their home cages. The principles of laboratory animal care were followed and all procedures were approved by the University of Waikato Animals Ethics Committee.

2.2. Apparatus

The experimental chamber (41 cm × 58 cm × 54 cm) was made of 20-mm thick particle-board painted black. Grey matting covered the floor. Two white 28v back-lit response keys (3 cm diameter) were positioned on the right hand wall of the chamber 40 cm off the floor and 30 cm apart. Each key was surrounded by a metal plate (7 cm × 14 cm). A brief feedback beep sounded when a response with a force of 0.1 N was made on either lit key.

Between the keys a section of the chamber wall (20 cm × 21.5 cm) was removed and a short (11.5 cm) open box was attached. This allowed placement of either a 15 in. TFT monitor (model 710A) or a 21 in. CRT monitor (Trinitron Multiscan) in such a way that the hens could only see the central area of the screens. Attached to the front of both the TFT and CRT monitors were 12 in. infrared screens (IR Touchscreen 12 in. USB) which detected the number and location of pecks. The infrared screens were large enough that their edges lay outside the viewing area.

Two computers were used throughout the study. The 'experimental' computer (Optiplex GXa) controlled the experimental equipment and recorded all data using Med PC (Version 4) software. The 'screen' computer (Optiplex GX110) controlled the stimuli presentation and recorded the infrared screen pecks.

The sample stimuli were 15 mm × 15 mm black cross and black circle (Shape Discrimination); a 40 mm yellow or blue square (Colour Discrimination); and a line drawing of a iron (63 mm × 28 mm) and a watering can (46 mm × 44 mm) (Line Drawing Discrimination), all set against a white background. All sets of stimuli were presented in the centre of the computer screen. The stimuli used in the Shape and Colour Discrimination were created using 'Microsoft Paint' and saved as tif images. The stimuli used in the Line Drawing Discrimination are similar to those used by Wasserman et al. (1993) and were created using Paintshop Pro and saved as jpeg images. On all trials a red square (20 mm × 20 mm) could be displayed directly below the stimulus.

Two apertures allowed access to two magazines containing wheat located on each side of the experimental chamber. When a magazine was operated, the hopper was raised and a 1-W white light bulb illuminated the magazine for a 3-s period.

2.3. Procedure

The hens had previous experience pecking lit keys. At the start of this study they were trained in the experimental chamber to peck the red square presented on the computer screen below either the cross or circle sample stimulus. When the hen pecked the red square, a feedback beep sounded, the red square and sample stimulus were turned off leaving a white screen and one magazine was operated. The circle and cross stimuli were alternated from trial to trial and the left magazine operated on a circle trial, and the right magazine operated on a cross trial. During this training, the key lights were not lit and pecks to other areas of the screen were not registered.

Once all hens were reliably and quickly pecking the red square, one of the two keys was lit on each trial. The left key was lit on a circle trial, and the right key was lit on a cross trial. A peck to the red square turned the red square off, but the cross or circle stimulus remained on screen until a peck to the lit key operated the magazine associated with that stimulus and turned the stimulus off. Again the stimulus alternated from trial to trial. The hens received three sessions with this procedure.

The required number of pecks to the red square was gradually increased to five (fixed ratio (FR5)). Each trial began with a stimulus being presented on the TFT screen (during which time the key lights were not lit). Once the hen had pecked the red square five times, the red square was turned off while the cross or circle stimuli remained on screen, and both keys were now lit. The keys remained lit until the hen pecked one, at which point the sample stimulus was turned off leaving just the white screen. A correct response (peck the right key if presented with a cross, or peck the left key if presented with a circle) resulted in the magazine being lit for 3 s during which