

## **Domestic Chicks' Attraction to Video Images: Effects of Stimulus Movement, Brightness, Colour and Complexity**

**Colette H. Clarke and R. Bryan Jones**  
*Roslin Institute, United Kingdom*

Video images of screensavers attract domestic chicks. This study identified their attractive attributes. One focal chick in groups of three was observed for 5 min daily on 10 consecutive days from 2 days of age. Chicks spent little time in the end zones of the home box in the absence of video stimulation (Experiment 1). Videos differing in one attribute were then presented simultaneously at opposite ends of the cage. Chicks spent longer near moving than still videos (Experiment 2), bright than dull videos (Experiment 3), coloured than black-and-white videos (Experiment 4), a complex "Fish" screensaver than a simple "Square" screensaver (Experiment 5), and a more complex cartoon than the Fish screensaver (Experiment 6). Repeated exposure increased approach and preferences were strongest for complex stimuli.

Televised images are being increasingly used as tools for studying behaviour in a variety of mammalian, amphibian and avian species, including chickens (Clarke & Jones, 2000a; D'Eath, 1998). The benefits of this medium include controllability and ease of standardization. More specifically, it is already known that exposure to videos of dustbathing or feeding conspecifics induced chickens to show similar behaviours, presumably via social facilitation (Clarke & Jones, 2001; Keeling & Hurnik, 1993; McQuoid & Galef, 1993). Feeding was delayed when hens were shown a video of a threatening conspecific (D'Eath, 1998) and televised images of ground and aerial predators elicited appropriate anti-predator responses (see Evans, Macedonia, & Marler, 1993).

We have shown that chickens regulate their behaviour in response to biologically neutral video images, such as screensavers that are normally used to delay the degradation of a computer screen. We chose them to avoid potentially confounding connotations of social attraction, feeding or predation. In a series of studies we focused primarily on the Apple Macintosh "Fish" or "Flying Toaster" programmes. Previously, it was found that both individually (Jones, Larkins, & Hughes, 1996) and socially housed (Jones, Carmichael, & Williams, 1998) chicks became readily attracted

We are grateful to the Biotechnology and Biological Sciences Research Council for providing a studentship for Colette Clarke. These experiments formed part of her study for a PhD degree at the University of Edinburgh that were jointly supervised by Bryan Jones and Aubrey Manning. Bryan Jones's contribution was supported by the UK Ministry of Agriculture, Fisheries and Food (now the Department of Environment, Food and Rural Affairs). We would also like to thank Caroline McCorquodale for statistical advice. Dr. Colette Clarke is now at The Department of Environment, Food and Rural Affairs, Animal Welfare Veterinary Team, Area 501, 1A Page Street, London SW1P 4PQ, United Kingdom. Address correspondence to Bryan Jones, Welfare Biology Group, Roslin Institute (Edinburgh), Roslin, Midlothian EH25 9PS, UK. (Bryan.Jones@bbsrc.ac.uk).

to and showed progressively greater interest in such videos when they were presented at one end of their home cages for 5 min on each of 9 or 11 consecutive days. The chicks preferred their familiar screensaver to a blank, illuminated television screen in a subsequent two-choice test but they preferred a novel screensaver to their familiar one in a similar test situation (Jones et al., 1996). These findings indicate that the chicks remembered the video images and that novelty can be attractive.

Housing chickens in impoverished environments can damage poultry welfare and productivity (Jones, 1996; Jones, 2001). Environmental enrichment can help in this respect. The aims of this procedure include increasing the animals' behavioural repertoire, enabling them to cope with challenges, and, of particular importance here, helping to satisfy their need for stimulation (Burghardt, 1999; Jones, 1996; Mench, 1994; Newberry, 1995). When a video of the Fish screensaver was presented to individually caged laying hens for 10 min on each of 20 consecutive days it attracted positive interest by the third day that was then sustained for as long as 8 days (Clarke & Jones, 2000a). Interest waned gradually after the eighth presentation but was fully restored when an unfamiliar video ("Doodles") was shown on day 21 (Clarke & Jones, 2000a). Such sustained interest satisfies one of the criteria of effective environmental enrichment. Furthermore, regular exposure to a screensaver video reduced the chicks' fear responses in an unfamiliar arena (open field) even in the absence of the video image (Clarke & Jones, 2000b). We also know that other types of enrichment, such as the provision of objects, pictures, feeds and sounds, can improve poultry welfare, productivity and profitability by reducing the expression of harmful behaviours such as fear, feather pecking and cannibalism, improving growth, and decreasing trauma and injury when battery cages are depopulated (Jones, 1996; Jones, 2001; Newberry, 1995). However, the results have not always been consistent across laboratories, many so-called enrichment stimuli were ignored by the birds (Jones, Carmichael, & Rayner, 2000), and some even elicited adverse effects, such as increased aggression (Lindberg & Nicol, 1994). Clearly, it is important to establish the animals' preferences and to design enrichment devices accordingly. Here, we use video playback to assess the attractiveness of selected attributes of visual stimuli. Experiment 1 was designed to provide base line information concerning the way chicks distributed themselves in the home box in the absence of video stimulation. Subsequently selected videos were dissected into their component features and we systematically determined which of these were important in eliciting and sustaining the interest of socially housed domestic chicks. Differential attraction was tested by simultaneously presenting the chicks with two video images differing in just one feature at each end of the home cage for brief periods on each of 10 consecutive days. We focused on the stimulus attributes of movement (Experiment 2), brightness (Experiment 3), colour (Experiment

4), and complexity (Experiments 5 and 6) because these features are all thought to be influential in learning, memory, and filial attachment (Bateson & Horn, 1994; Eiserer, 1980).

## General Methods

### *Subjects*

Female ISA Brown chicks, *Gallus gallus domesticus* (a brown egg-laying strain originally derived from a Rhode Island Red x Rhode Island White cross), were obtained from a commercial supplier at 1 day of age. Because sex differences in chicks' responses to novel stimuli are occasionally reported (see Jones, 1987), only females were used in this study. Upon receipt they were randomly allocated to groups of three and housed in 18 wooden boxes measuring 110 x 38 x 48 cm (length x width x height). These rested on shelving raised 1 m off the floor and all the boxes were aligned. The 1-cm wire-mesh floor of each box was raised 2 cm off the shelving to allow the passage of excreta. Food (starter mash) and water were provided *ad libitum* in semi-circular plastic hoppers attached to wire grids suspended from the midpoints of the two long walls; food was presented on one side and water on the other in random fashion across boxes. For maintenance purposes, these hoppers could be removed, replenished and replaced remotely thus minimising the chicks' visual contact with the experimenter. The photoperiod ran from 05:00 to 19:00 and ambient temperature was maintained at approximately 30°C using overhead dull emitter heaters. To the best of our knowledge, there were no apparent extraneous visual cues in the housing room that may have affected the distribution of chicks within the home boxes. Rotation of test stimuli also minimized any potential confounding effects (see below). Immediately prior to its placement in a home box, one chick from each group was randomly selected and marked with indelible ink on the top of its head to facilitate later identification. For ease of measurement and because chicks housed in small groups tend to remain in close proximity to one another, we only recorded the responses of this focal chick in subsequent tests.

### *Apparatus*

The end walls of each home box slotted into grooves and could thus be easily removed with minimum disturbance immediately before a television monitor was moved into place at each end (see below). Any gaps between the sides of the box and the monitor were covered with cardboard in order to minimize visual contact with the experimenter, or any other extraneous stimuli, at this time. Wire-mesh grids situated directly behind the removable walls prevented the chicks from escaping while still allowing them a clear view of the monitor screens. All video images were presented to the birds using Panasonic TC-15 MIR 36-cm television monitors with a flicker rate of 50 Hz. These were connected to Panasonic Superdrive NV-SD30B video recorders. With the exception of experiments designed to probe the effects of varying that specific feature, the colour, brightness and contrast levels on the television monitors remained on the standard settings used for human vision.

### *Procedures*

Tests began when the chicks were 2 days of age. All chicks were naive at this stage, i.e. none had previous experience of videos. The focal chick in each group was observed for 5 min on each of 10 consecutive days by positioning an unobtrusive colour micro camera (Panasonic WV-KS152E) 1 m above the home box. This camera was linked to a 36 cm colour playback monitor (Phillips 14TVCR240/05 combined television monitor and video recorder). Lines drawn on an acetate sheet placed over the screen divided the home box into three parallel zones; these representations translated to the 20-cm long sections nearest the end walls that were labelled 'Close Zone 1' (CZ1) and 'Close Zone 2' (CZ2) while the central 70-cm long section was regarded as a neutral zone. Although the chick could see the videos from the central zone, its presence there was deemed to reflect neither attraction to nor avoidance of either video.

One min before the first test was carried out, all three members of a group were herded gently into a bottomless 1-cm wire mesh 'holding' cage (29 x 15 x 30 cm) and moved to the centre of the home box in order to standardize their position. This 'holding' cage was then raised to allow full access to the home box and the responses of the focal chick were recorded for 5 min. The latency to enter each of the close zones and the accumulated times spent in them were then measured. A chick was deemed to be in that zone containing the major portion of its body. If a chick failed to enter either of the close zones it received a maximum latency of 300 s. The order in which the home boxes were observed was randomized daily, as were the ends of the boxes at which the wall was first replaced (Experiment 1) or each televised stimulus was presented (Experiments 2-6). Such randomization reduced the likelihood that previously established side preferences (Jones & Carmichael, 1999) might confound the results.

### ***Data Analysis***

The latency data were omitted from further analysis because some chicks showed panic running and were considered unlikely to have made an informed choice.

Our two-choice test situation meant that the times spent in the close zones were not independent. Therefore, because the locations of CZ1 and CZ2 remained fixed whereas the ends at which the videos were rotated, scores for chicks' specific attraction (SA) to one video or the other were calculated by expressing the time spent near Video A as a percentage of the time spent near Video A + Video B in each of Experiments 2-6. In these cases, values greater than 50% indicated that chicks spent longer near Video A and vice versa. The chicks could also spend time in the central (70 cm) zone of the home box. For that reason, we also calculated general attraction (GA) towards the videos, regardless of their content, by expressing the time spent in CZ1 + CZ2 as a percentage of the total observation period. Here, because CZ1 and CZ2 only accounted for a 40-cm length (i.e. 36.36%) of the 110-cm long box, values greater or smaller than 36.36% signified that the chicks spent more or less time near the videos than would have occurred by chance. The same calculations were also performed for Experiment 1; here the ends of the box at which the wall was first replaced substituted for videos A and B.

The need for randomization rendered the data sets unbalanced across days. Therefore, a residual maximum likelihood analysis (REML) was used to examine the effects of the ends at which the wall was first replaced (Experiment 1) or the images were presented (Experiments 2-6) as well as those of repeated exposure and their interactions on SA and GA. REML is an extension of analysis of variance that allows examination of unbalanced data sets obtained from repeated measures (Genstat 5, 1997). To obtain probability values the Wald statistic provided by the analysis output is divided by the degrees of freedom (df) for the factor analysed (e.g. df for day = 9) and compared with an F-distribution for factor and for group. The Wald statistic is hereafter referred to as W. Neither the SA nor the GA data sets followed a normal distribution. They were therefore transformed to the logistic (logit) scale to better fit the assumptions of the analysis. The null hypothesis that SA and GA would not deviate from the chance values of 50% and 36.36%, respectively, was examined within days using a one-sample t-test of means in the logistic scale.

### **Experiment 1: Distribution of chicks in the absence of video stimuli**

It has been reported that chicks sometimes establish preferences for one half or other of seemingly symmetrical home cages (Jones & Carmichael, 1999). The present experiment was designed to determine how chicks distributed themselves within the home boxes in the absence of any extraneous stimulation and to thereby provide a baseline for subsequent comparisons (albeit not statistical) with the results of experiments that incorporated video exposure.

## **Method**

The animals and husbandry, test procedures, behaviours measured and statistical analyses were carried out as described in the General Methods section. The chicks were not exposed to any video stimuli in this experiment.

## **Results and Discussion**

There were no detectable effects of day ( $W(9) = 5.81$ ,  $F(9,7) = 0.64$ ,  $p > 0.1$ ) or of the end at which the cage wall was first removed / replaced ( $W(1) = 0.22$ ,  $F(1,7) = 0.21$ ,  $p > 0.1$ ) and no significant interactions ( $W(9) = 2.5$ ,  $F(9,7) = 0.34$ ,  $p > 0.1$ ) on specific attraction (SA) scores. The SA scores did not deviate significantly from the neutral value of 50% ( $t(7) > 1.39$ ,  $p > 0.1$ ) on any of the test days. Neither were there any significant effects of day ( $W(9) = 4.75$ ,  $F(9,7) = 0.52$ ,  $p > 0.1$ ), of the end at which the wall was first replaced ( $W(1) = 0.76$ ,  $F(1,7) = 0.72$ ,  $p > 0.1$ ) or their interaction ( $W(9) = 16.51$ ,  $F(9,7) = 1.84$ ,  $p > 0.1$ ) on general attraction (GA) scores. The overall GA ( $13.2 \pm 2.5\%$ , back-transformed mean  $\pm$  standard error) was significantly lower ( $t(7) = 6.06$ ,  $p < 0.001$ ) than 36.36%; this clearly demonstrates that the chicks spent more time in the central zone of the home box than in the combined close zones. Indeed, the chicks' GA scores were significantly less ( $t(7) > 2.22$ ,  $p < 0.01$ ) than expected by chance on each test day.

These findings indicated that the chicks showed no overall preference for one end or other of the home box, though this does not imply that preferences were not formed within boxes. The present results suggest that measuring the times spent in close zones during simultaneous presentation of different video images would allow meaningful assessment of their relative attractive or aversive properties. Purely numerical comparison of GA scores in Experiments 2-6 with the current baseline of 13.2% would also allow informal assessment of the attractiveness of video stimulation per se.

### **Experiment 2: Chicks' responses to moving vs. still images**

Young chicks readily approach and follow moving, conspicuous stimuli (Bolhuis, 1991). Furthermore, moving three-dimensional objects or two-dimensional patterns projected onto screens are often used as stimuli in studies of imprinting (Bolhuis, 1991). Because movement is thought to increase the attractiveness of such stimuli (Bolhuis, 1999; Ten Cate, 1989) it is conceivable that it was this feature of the screensavers that attracted the chickens in our earlier studies (Clarke & Jones, 2000a; 2000b; Jones et al., 1996, 1998). This issue was addressed here by comparing the patterns of chicks' responses to moving and static images of the Fish screensaver over 10 consecutive days.

## **Method**

A moving image of the Fish screensaver was produced by filming it from a computer monitor. The median speed was selected from the set-up options so that the depicted images took about 19 s to cross the screen. The static video was prepared by filming the same image on pause. At test, both videos were presented simultaneously at opposite ends of the home box for 5 min on each of 10 consecutive days. Standard settings for brightness, contrast and colour ensured that the images differed only in movement aspects. Procedures are described above.

Specific (SA) and general attraction (GA) scores were derived as:

$$SA = 100 [M / (M + S)] \quad \text{and} \quad GA = 100 [(M + S) / 300]$$

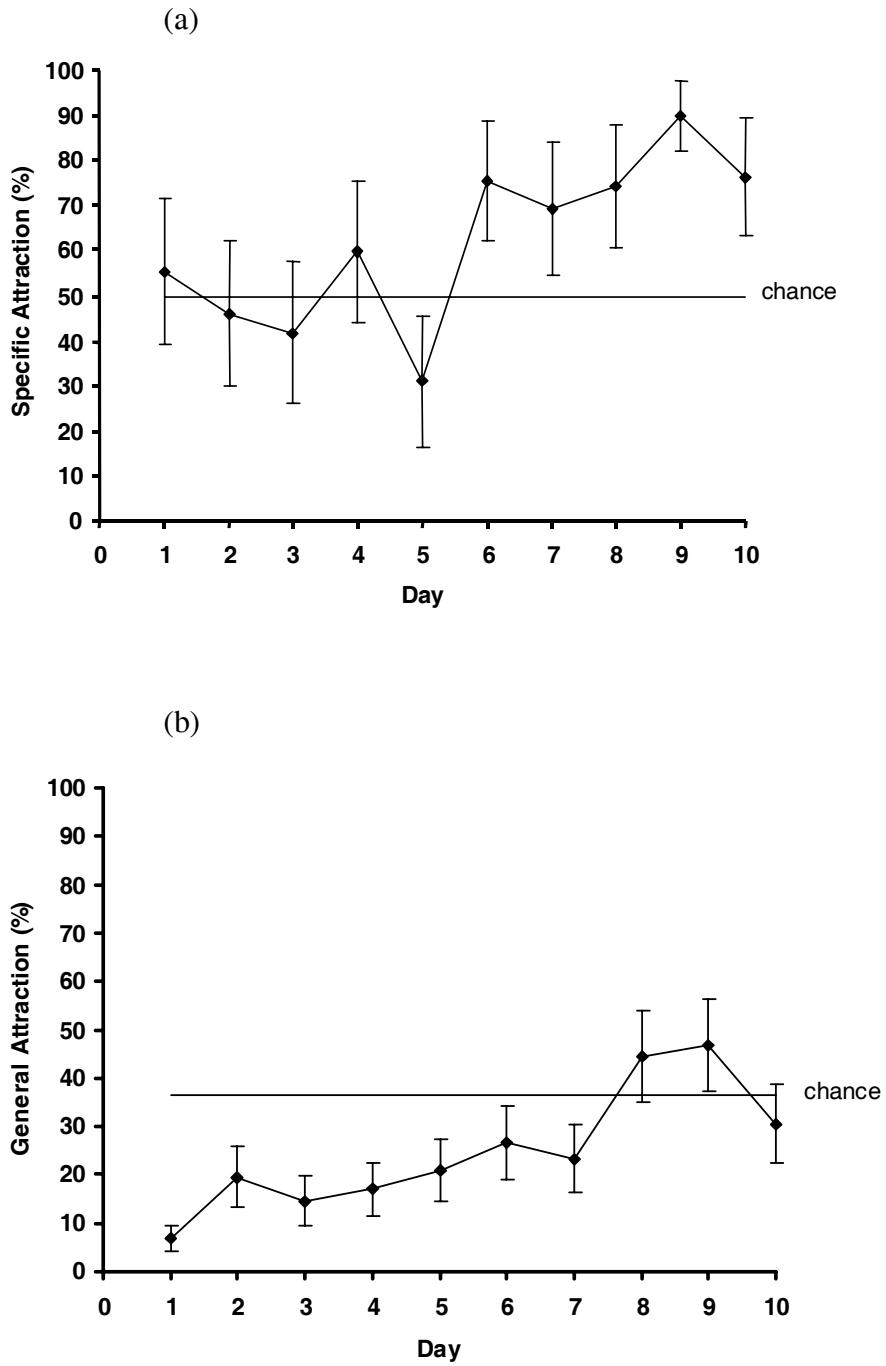
where M and S equal the time(s) spent in the close zone nearest the moving or the still image, respectively. Thus, if SA was larger or smaller than 50% it would denote more or less time, respectively, spent near the moving image. A GA score larger than 36.36% would imply that the zones close to the video images were more attractive than the central neutral area.

## **Results and Discussion**

There were no significant effects of day ( $W(9) = 9.41$ ,  $F(9,17) = 1.04$ ,  $p > 0.1$ ) or of the end of the box at which the stimuli were presented ( $W(1) = 0.32$ ,  $F(1,17) = 0.33$ ,  $p > 0.1$ ) on SA and no interaction. However, SA showed a numerical increase with repeated exposure (Figure 1a) and it was significantly greater than would have been expected by chance on day 9 ( $t(17) = 2.18$ ,  $p < 0.05$ ). Supplementary analysis revealed that the pooled mean of SA scores on days 6 to 10 ( $78.0 \pm 4.1\%$ , back-transformed mean  $\pm$  standard error) was significantly greater ( $t(4) = 6.58$ ,  $p < 0.003$ ) than that of the scores on days 1 to 5 ( $46.7 \pm 5.2\%$ ). Additionally the overall mean SA score ( $63.8 \pm 5.5\%$ ) was greater than 50% ( $t(17) = 2.36$ ,  $p < 0.05$ ). These findings indicate that the moving image was more attractive than its static counterpart.

There were no detectable effects of presenting either video at either end of the box on GA. The overall GA score ( $23.0\% \pm 4.0$ ) was less ( $t(17) = 2.90$ ,  $p < 0.01$ ) than that expected by chance (36.36%) thus showing that chicks spent more time in the central area than near the videos. GA scores increased with repeated exposure ( $W(9) = 35.32$ ,  $F(9,17) = 3.92$ ,  $p < 0.01$ ). Within-day comparisons showed that GA remained significantly below 36.36% until day 5 ( $t \leq -2.17$ ,  $p < 0.05$ ) but did not deviate from chance thereafter (Figure 1b).

The present finding that chicks were more attracted to a moving rather than a still video image of the Fish screensaver is consistent with previous observations that moving imprinting objects were preferred to static ones (Bolhuis, 1999; Ten Cate, 1989). In view of the attractive properties of flicker, the likelihood that the chicks perceived screen flicker (Clarke & Jones, 2000a; D'Eath, 1998) when the static video was presented renders the present results conservative. Clearly, the chicks perceived sufficient difference to show a preference.



**Figure 1.** Specific attraction (SA; a) and general attraction (GA; b) scores of chicks that were simultaneously presented with moving or still images of a 'Fish' screensaver video for 5 min on each of 10 consecutive days (Experiment 2).

### Experiment 3: Bright vs. dim images

A preference for projected images was positively associated with stimulus brightness in monkeys (Humphrey, 1972). The possibility that bright televised images may be particularly attractive to chicks was examined here by comparing their responses to a bright vs. dim video of the Fish (F) screensaver or to a bright vs. dim blank screen (B) when these were presented simultaneously at opposite ends of the home cage. The latter treatment was included in order to determine the chicks' responses to televised images differing in brightness alone, unlike the screensaver images that incorporated shapes, colour and movement.

#### *Method*

The groups of chicks were randomly assigned to one of two paired-test conditions, i.e. 9 groups were exposed to bright vs. dim videos whereas the others were shown blank screens. Bright and dim stimuli were prepared by switching the brightness controls of the television monitors to the highest and lowest level, respectively. Colour and contrast levels were standardised (see above). The bright and dim F and B stimuli emitted 38.4, 18.8, 15.6 and 10.6 lux, respectively; these estimations were averages of measurements made at 18 different points along the length of the home box. Procedures and analyses were similar to those described above. SA and GA scores were derived as follows:

$$SA = 100 [B / (B + D)] \quad \text{and} \quad GA = 100 [(B + D) / 300]$$

where B and D equal the times (s) spent in the close zones nearest the bright and dim stimuli, respectively.

#### *Results and Discussion*

The REML analysis revealed a significant effect of the end of the box at which the stimuli were presented; regardless of whether they were shown videos or blank screens the chicks' SA scores were higher when the bright stimulus was presented at the CZ1 rather than CZ2 end of the box ( $88.4 \pm 3.9$  and  $79.1 \pm 6.7\%$ ;  $W(1) = 5.94$ ,  $F(1,16) = 5.93$ ,  $p < 0.05$ ). Therefore, even though stimulus presentation was randomised and the box appeared symmetrical the chicks preferred one end of the box to the other. There are no obvious explanations for this finding but the chance establishment of side preferences is consistent with a previous observation (Jones & Carmichael, 1999). Despite such asymmetry, the SA score ( $79.1 \pm 6.7\%$ ) was still significantly greater ( $t(16) = 3.94$ ,  $p < 0.01$ ) than chance when the bright stimulus was presented in the least preferred end. B chicks spent longer ( $W(1) = 9.3$ ,  $F(1,16) = 9.36$ ,  $p < 0.01$ ) near the bright stimulus than did F ones ( $91.3 \pm 3.9$  and  $69.9 \pm 9.2\%$ , respectively). Both F ( $t(8) = 2.62$ ,  $p < 0.05$ ) and B ( $t(8) = 7.27$ ,  $p < 0.001$ ) chicks showed significantly greater attraction to the bright stimuli than would have been expected by chance.

There were no significant effects of day or day x test condition interaction on SA scores (Figure 2a). Within-day tests of the null hypothesis revealed that, apart from day 1, B chicks showed significantly higher SA scores than expected by chance on all test days ( $t(8) > 2.36$ ,  $p < 0.05$ ) whereas those of F chicks only deviated from chance on days 5 ( $t(8) = 3.11$ ,  $p < 0.05$ ) and 6 ( $t(8) = 2.83$ ,  $p < 0.05$ ).

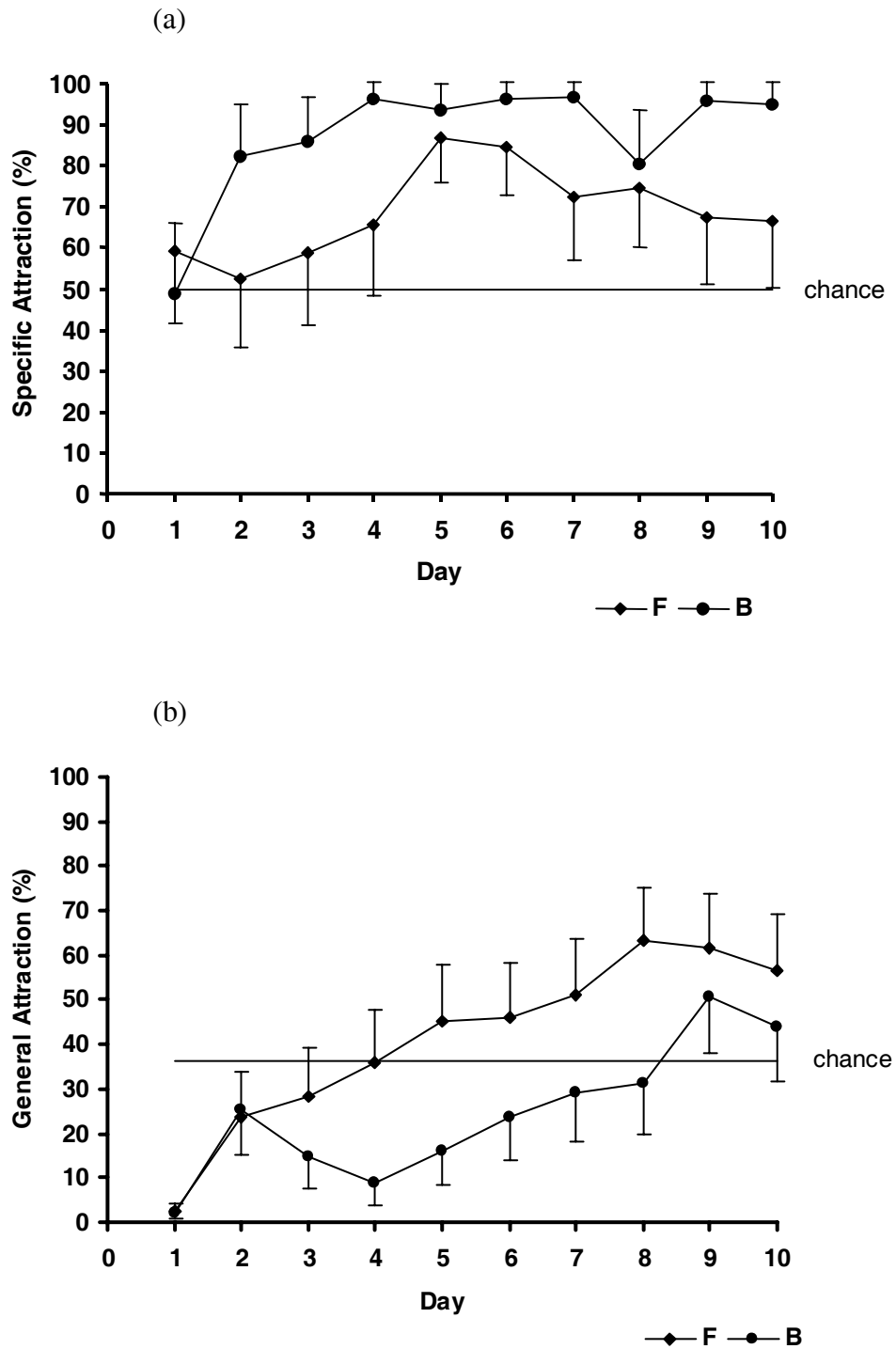
The end at which the stimuli were presented exerted no detectable effects on GA scores. Overall, chicks were numerically more attracted ( $W(1) = 4.01$ ,  $F(1,16) = 4.02$ ,  $p < 0.06$ ) to the television monitors if they displayed screensaver videos than if they were simply illuminated but blank (GA for F and B chicks =  $37.0 \pm 6.6$  and  $20.3 \pm 4.7\%$ , respectively). The overall GA score of F chicks did not deviate significantly from chance whereas that of B chicks was lower ( $t(8) = -2.80$ ,  $p < 0.05$ ). In other words, F chicks spent as long near the videos as in the neutral zone whereas B ones preferred the neutral zone. The pooled GA scores for F and B increased significantly ( $W(9) = 93.87$ ,  $F(9,16) = 10.45$ ,  $p < 0.01$ ) with repeated exposure from  $2.4 \pm 1.0\%$  on day 1 to  $50.3 \pm 9.4\%$  on day 10.

GA scores of B chicks increased with repeated exposure but, apart from day 2, were less ( $t(8) > -2.77$ ,  $p < 0.05$ ) than expected by chance until day 6 (Figure 2b); thereafter they did not deviate from chance. In F chicks GA was less than expected by chance on day 1 ( $t(8) = -7.77$ ,  $p < 0.001$ ) but from day 8 onwards it was greater than chance ( $t(8) > 2.38$ ,  $p < 0.05$ ).

Our findings suggest that chicks were more attracted to bright televised images than dim ones, regardless of whether the screens were blank or displaying screensavers. Brightness and screen flicker are positively associated (D'Eath, 1998) and flicker attracts chicks (Bateson & Rees, 1969). Thus, the preference for bright screens may have reflected this phenomenon. The stronger preference for brightness shown by chicks exposed to the blank, illuminated screens suggests that brightness acquires greater relevance in the absence of other features, such as colour, shape or movement. Indeed, increasing ambient illumination enhanced imprinting onto a static object by ducklings (Eiserer, 1980). Like earlier observations (Jones et al., 1998) the trend towards spending longer near the televised stimuli with repeated exposure was more pronounced in F than B chicks; suggesting that blank screens may not be sufficiently "interesting" to elicit strong attraction in the presence of social companions.

#### **Experiment 4: Coloured vs. black-and-white images**

Chickens have good colour vision that ranges from the infrared to ultraviolet regions of the spectrum (Rogers, 1995) and they show strong colour preferences (Bolhuis, 1991; Jones et al., 2000; Roper & Marples, 1997). However, chickens' colour preferences can vary according to the



**Figure 2.** Specific attraction (SA; a) and general attraction (GA; b) scores of chicks that were simultaneously presented with bright or dull images of a blank (B) screen and a 'Fish' (F) screensaver video for 5 min on each of 10 consecutive days (Experiment 3).

stimulus, their previous experience, and the experimental context (Jones & Carmichael, 1998; Jones et al., 2000). Firstly, for example, preferences for different types of coloured food can vary or even be reversed by modification of the rearing environment or the way in which the foods are presented (Roper & Marples, 1997). Secondly, chicks drank water sooner if it was dyed black rather than red (Roper & Marples, 1997). Thirdly, red and blue imprinting stimuli are thought to be more attractive than green, yellow or orange ones (Bolhuis, 1991) but, on the other hand, chicks and laying hens pecked much more at white or yellow strings than at red, green or blue ones (Jones & Carmichael, 1998; Jones et al., 2000).

Colour may also be an influential variable governing the birds' responses to video images, particularly since chickens discriminated between video images of differently coloured food dishes (McQuoid & Galef, 1993) or coloured cards (Patterson-Kane, Nicol, Foster, & Temple, 1997). This possibility was investigated here despite suggestions that video playback is inappropriate for determining animals' responses to different colours (see General Discussion).

### ***Method***

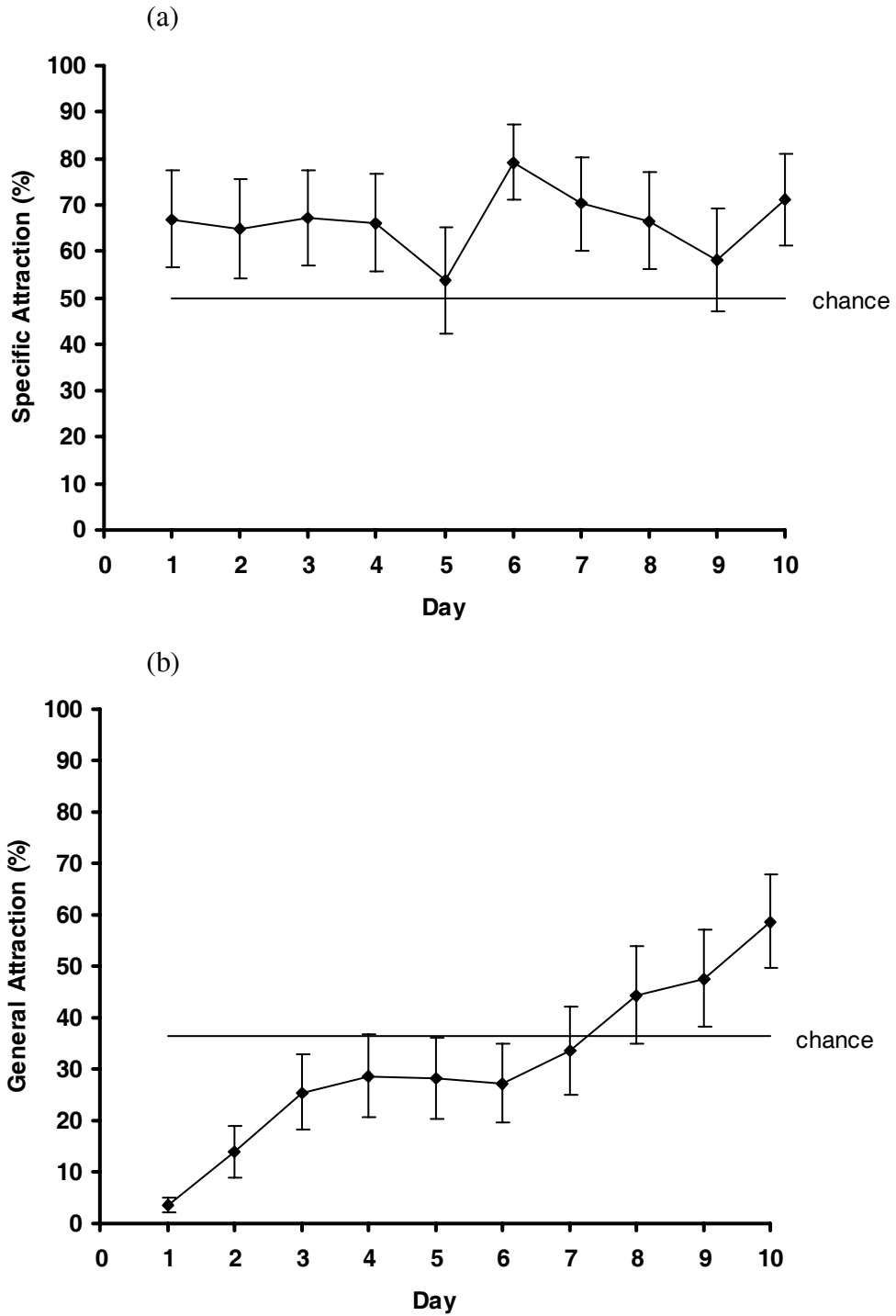
As before, two video images were presented simultaneously at opposite ends of the home box for 5 min on 10 consecutive days and the responses of one focal chick in each of 18 groups of 3 naive chicks were recorded. The coloured "Fish" screensaver video was similar to that used in our previous experiments; this was displayed on a television monitor on which the colour level was set at the standard for human vision. The black and white ("greytone") version of the F video was produced by turning the colour setting of the monitor on which it was being shown to zero. Brightness and colour remained on the standard settings on both monitors. SA and GA scores were calculated as:

$$SA = 100 [C / (C + BW)] \quad \text{and} \quad GA = 100 [(C + BW) / 300]$$

where C and BW equal the accumulated times (s) spent in the close zone nearest the coloured or the black-and-white screensaver video, respectively.

### ***Results and Discussion***

There was no significant effect of day on SA (Figure 3a). The average of the sums of daily SA scores ( $66.7 \pm 3.7 \%$ ) was greater than expected by chance ( $t(17) = 4.14, p < 0.001$ ). This result suggests that chicks found the coloured image more attractive than the black-and-white one. SA scores were higher ( $W(1) = 8.36, F(1,17) = 8.37, p < 0.05$ ) when the coloured image was presented in CZ2 rather than CZ1 ( $75.8 \pm 4.2$  and  $56.1 \pm 5.5\%$ , respectively). Thus, although we randomised the ends at which the videos were presented, the chicks had established a preference for one end of the box. SA was significantly greater than 50% ( $t(17) = 4.98, p < 0.001$ ) but only when the coloured stimulus was presented in the preferred zone. Thus, the chicks' greater attraction to the coloured than the black and white image may have been rendered conservative by their apparent preference for one end of the box.



**Figure 3.** Specific attraction (SA; a) and general attraction (GA; b) scores of chicks that were simultaneously presented with coloured or black and white images of a 'Fish' screensaver video for 5 min on each of 10 consecutive days (Experiment 4).

On the other hand, there was no effect of the end at which the stimuli were presented on the overall GA score. Neither did this score of  $27.5 \pm 5.0\%$  differ from chance (36.36 %); suggesting that the chicks spent similar times in the neutral and the close zones.

GA scores increased ( $W(9) = 74.41$ ,  $F(9,17) = 8.38$ ,  $p < 0.01$ ) with repeated exposure (Figure 3b) and were greater than chance on day 10 ( $t(17) = 2.29$ ,  $p < 0.05$ ). Therefore, the chicks became increasingly attracted to video images per se, regardless of their content.

Collectively, our results suggest that chicks were more attracted to a video image of the Fish screensaver that human beings perceive as coloured rather than as black-and-white (greytone). This finding is consistent with that of an earlier study comparing coloured vs. achromatic imprinting objects (Schaefer & Hess, 1959). However, we must temper our finding with the possibility that differential responsiveness reflected attraction towards certain levels of brightness and/or contrast as well as or rather than just colour. Future studies might benefit from measuring the colour/brightness output of the video images using a spectroradiometer (D'Eath, 1998) that can take account of the spectral sensitivity of chickens. Alternatively, chicks' preferences for coloured images could be more rigorously tested over a wide range of brightness conditions.

### **Experiment 5: Complex vs. simple images**

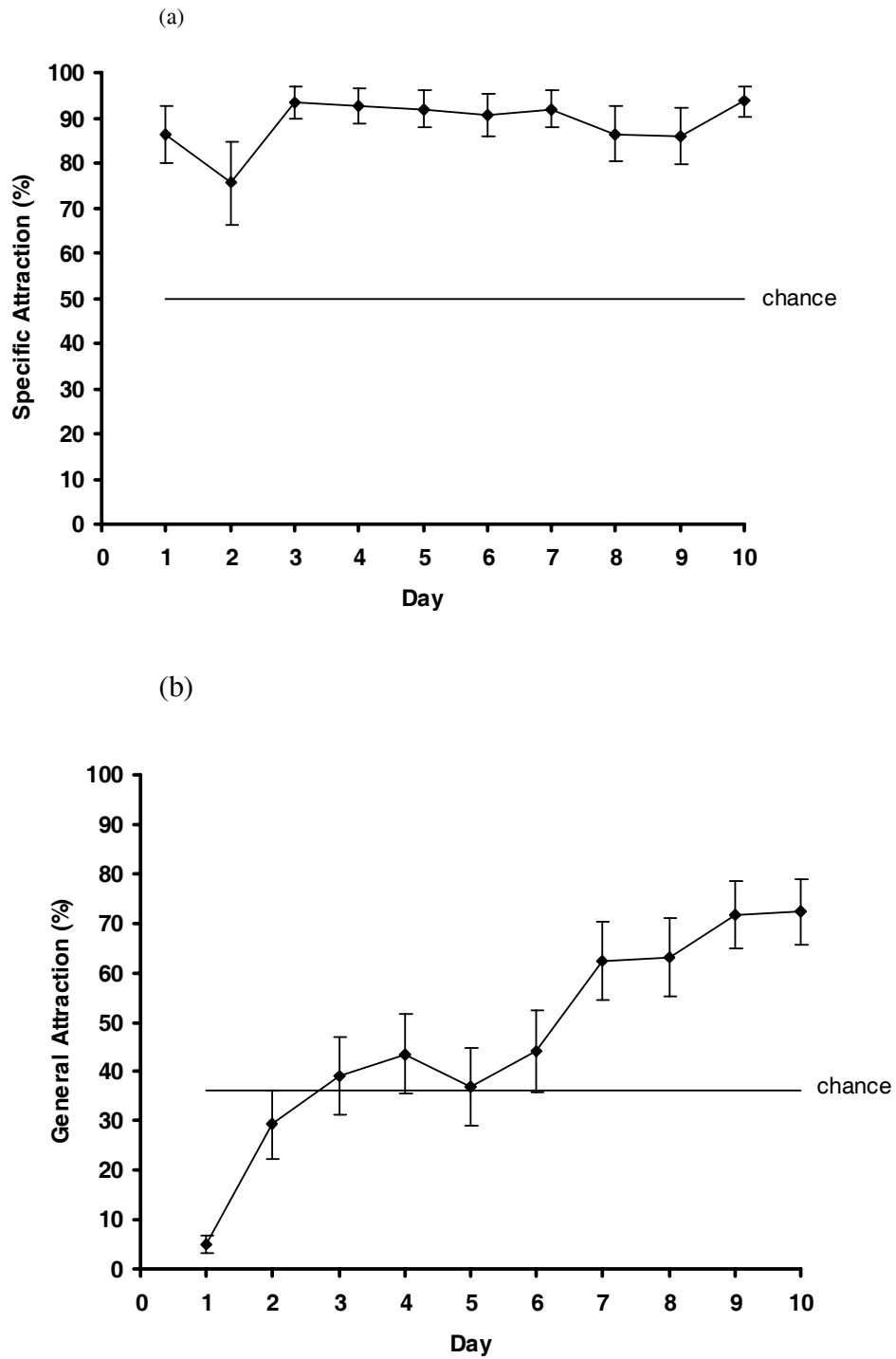
Complexity is thought to encourage animals to interact with their environment and to be positively associated with activity (Chamove, 1989). Furthermore, complex stimuli are often preferred to simple ones. For example, rhesus monkeys worked harder to view complex rather than simple projected images (Humphrey, 1972). More specifically, chicks approached cards with complex patterns more than plain or simply patterned ones (Berryman, Fullerton, & Sluckin, 1971; Dutch, 1969). Similarly, televised images of screensavers were more attractive to chicks than blank, illuminated monitors (Jones et al., 1996, 1998). We examined chicks' responses to simultaneously presented video images of simple (S, bouncing green square) and more complex (F, fish) screensavers.

#### ***Method***

Dutch (1969) defined complexity as "the number of elements constituting each stimulus". This definition was applied here; the screensavers used differed in the variety of colours and moving objects as well as in the size and the number of images on screen. The F video incorporated 12 fish (each one approximately 2.5 cm long) on screen at any one time whereas the S video depicted just one lime green, 4.5 cm square, (roughly the same size as 4 or 5 fish). The brightness of the images was measured at 18 points along the length of the home box, averages were similar for F (24 lux) and S (19 lux). SA and GA scores were calculated as:

$$SA = 100 [F / (F + S)] \quad \text{and} \quad GA = 100 [(F + S) / 300]$$

where F and S equal the accumulated time (s) spent in the close zone nearest the F or S videos, respectively.



**Figure 4.** Specific attraction (SA; a) and general attraction (GA; b) scores of chicks that were simultaneously presented with videos of a simple ‘Square’ screensaver and the more complex ‘Fish’ screensaver image for 5 min on each of 10 consecutive days (Experiment 5).

## ***Results and Discussion***

There were no significant effects of day or of the end at which the video stimuli were presented on SA scores. Overall SA ( $89.6 \pm 2.1 \%$ ) towards the F video image was greater than expected by chance ( $t(17) = 9.65$ ,  $p < 0.001$ ) and this was true for each of the test days (Figure 4a;  $t(17) > 2.21$ ,  $p < 0.05$ ). The end at which the stimuli were presented exerted no effect on GA but this score increased markedly (Figure 4b) with repeated exposure ( $W(9) = 111.88$ ,  $F(9,17) = 12.44$ ,  $p < 0.01$ ). Though GA fell below neutrality on day 1 ( $t(17) = -6.91$ ,  $p < 0.05$ ), it was significantly greater than expected by chance from day 7 onwards ( $t(17) > 3.11$ ,  $p < 0.01$ ).

Clearly, the chicks became increasingly attracted towards both the simple and complex videos with repeated exposure. However, they showed a consistent and significant preference for the complex video over the simple one. These findings are consistent with earlier reports of chicks' preferences for complexity (see Introduction to Experiment 4). We can reach no conclusions concerning the precise features of the Fish screensaver that underpinned this differential response. It may have reflected the fact that it incorporated more moving stimuli, a greater range of colours, numerous small stimuli, or a combination of all these features.

### **Experiment 6: Degrees of image complexity**

Rhesus monkeys performed an operant response to view films of Walt Disney Cartoons (Humphrey, 1972) and monkeys in zoos were attracted to televised cartoons ("Molly's Zoo", British Broadcasting Corporation, 1998). Like screensavers, we consider cartoon images to have little immediate biological relevance, particularly since our remote maintenance regime minimized the chicks' visual contact with people. However, they are generally much more complex than the Fish screensaver in that they include frequent changes of scenes, characters and backgrounds as well as substantially more movement and colour, at least to the human eye. The previous experiment showed that chicks preferred a relatively complex screensaver to a simple one incorporating only one image. The level of complexity was elevated here in that the Fish screensaver was used as the simple stimulus whereas the complex one consisted of an excerpt from an episode of "The Simpsons<sup>TM</sup>" cartoon programme.

### ***Method***

Although complexity varied considerable between the cartoon and screensaver stimuli their brightness levels were similar (28 and 24 lux, respectively). Brightness, colour and contrast settings for both display monitors were standardised. Specific (SA) and general attraction (GA) scores were derived as:

$$SA = 100 [C / (C + F)] \quad \text{and} \quad GA = 100 [(C + F) / 300]$$

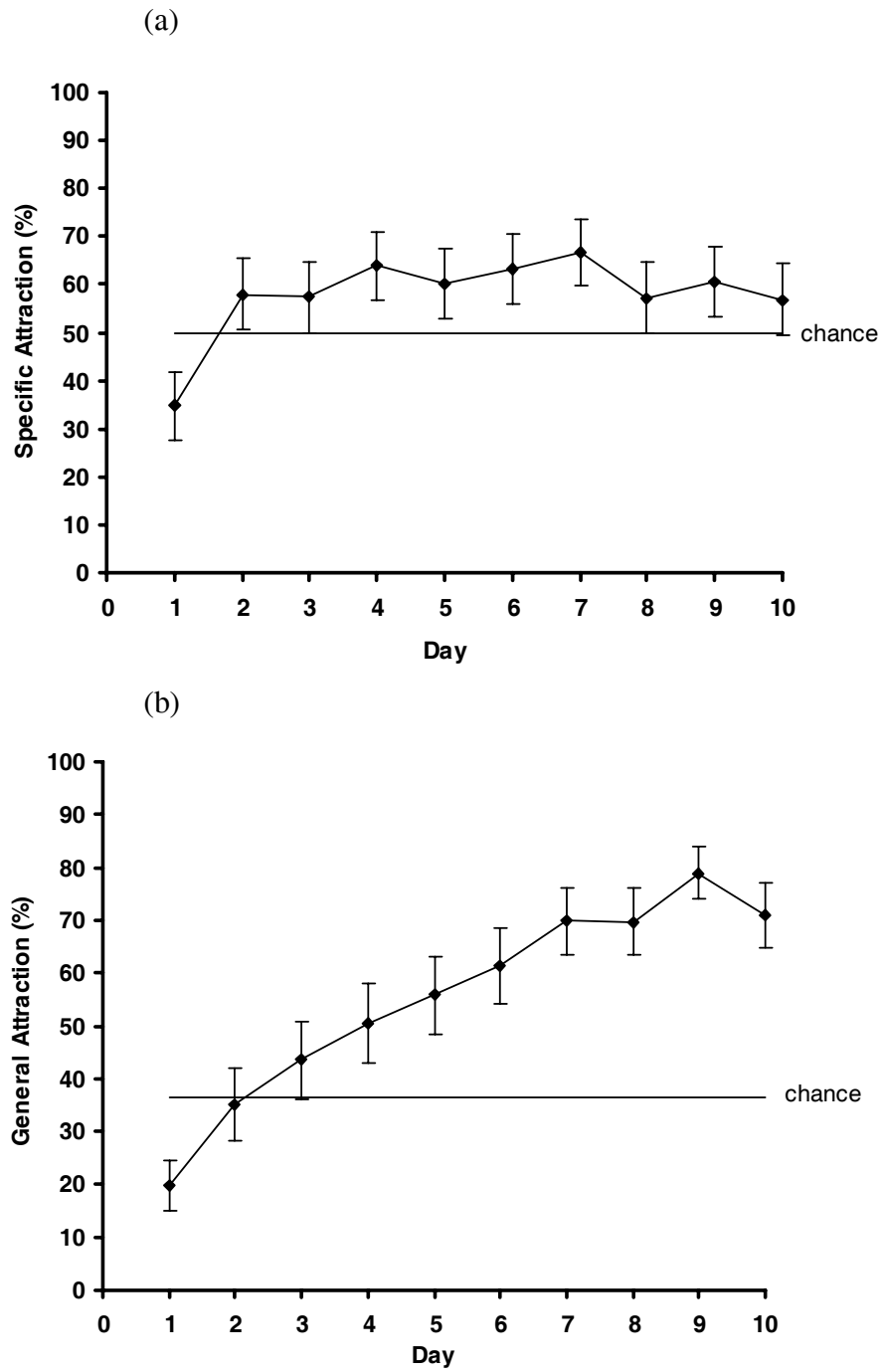
where C and F equalled the accumulated time (s) spent in the close zones nearest the C (cartoon) and the F videos, respectively.

### ***Results and Discussion***

Overall SA ( $57.9 \pm 3.0$  %) was greater than expected by chance ( $t(17) = 2.62, p < 0.02$ ), showing that the chicks spent longer near the cartoon than the screensaver. There was no significant effect of repeated exposure on SA (Figure 5a). The chicks spent more time ( $W(1) = 6.22, F(1,17) = 7.41, p < 0.05$ ) in CZ1 when the cartoon was presented at that end of the box than in CZ2 when the cartoon was presented at that end ( $63.7 \pm 3.6$  and  $52.0 \pm 3.9$  %, respectively). Though there are no obvious explanations for this preference for one end of a seemingly symmetrical cage; it is considered likely to weaken overall preference for the cartoon and thereby render our results conservative.

On the other hand, there was no effect of the end of the cage at which the stimuli were presented on GA. A significant interaction between day and end of presentation ( $W(9) = 31.11, F(9,17) = 3.43, p < 0.02$ ) likely reflects the fact that chicks spent longer in the close zones than the central area when the cartoon was presented at CZ2 on day 1 ( $0.1 \pm 8.8$  and  $8.3 \pm 3.1$  %, respectively,  $t(17) = -4.41, p < 0.001$ ) whereas GA was greater on day 4 when the cartoon was at CZ1 ( $63.3 \pm 8.5$  and  $37.6 \pm 8.6$  %, respectively,  $t(17) = -2.32, p < 0.05$ ). However, in the absence of any logical pattern of response these results were considered likely to simply reflect chance effects.

GA increased significantly ( $W(9) = 75.65, F(9,17) = 8.42, p < 0.01$ ) with repeated exposure (Figure 5b). Within-day comparisons showed that GA fell below the neutral value of 36.36 % on day 1 ( $t(17) = -2.73, p < 0.02$ ); it then increased progressively and remained significantly greater than chance from day 5 ( $t(17)$  always  $> 2.59, p < 0.02$ ). These results are consistent with those of Experiments 2-5 in that the chicks initially avoided the videos but became progressively more attracted to them with repeated exposure regardless of any preference for one stimulus over the other. Such increased attraction and the preference for more complex images are consistent with our observations in Experiment 5 and in earlier studies of chicks' responses in single-choice tests (Jones et al., 1996, 1998). We made no attempt to identify the most attractive attributes of the cartoon here. It is unlikely that the chicks associated the animated characters with human caretakers because they were fed and watered remotely and thereby had minimal visual contact with the experimenter.



**Figure 5.** Specific attraction (SA) and general attraction (GA; b) scores of chicks that were simultaneously presented with videos of the 'Fish' screensaver programme and a more complex cartoon sequence for 5 min on each of 10 consecutive days (Experiment 6).

## General Discussion

A concern over the use of video playback in studies of animal behaviour is that the subjects may not perceive images on a television screen in the same way that people do, particularly because of differences in colour perception and critical flicker-fusion frequency (D'Eath, 1998). Differences between video images and real-life objects in dimensionality, detail and distortion, and in the absence of other sensory cues or of the opportunity for interaction represent other potential weaknesses in video playback experiments. However, these concerns need not trouble us here, we simply required descriptive labels for any observed preferences.

When presented simultaneously with video images that differed in one attribute at opposite ends of the home cage for brief periods on each of 10 consecutive days, chicks spent significantly longer near moving rather than still, bright rather than dim, coloured rather than greytone, and complex rather than simple images. These findings are similar to those reported in various imprinting studies. For example, moving objects elicited greater approach than static ones (Bolhuis, 1991), motion facilitated discrimination in imprinting tests (Regolin, Tommasi, & Vallortigara, 2000), a flickering light source attracted chicks (Bateson & Reese, 1969), brightness increased imprinting (Eiserer, 1980), coloured stimuli were more attractive than achromatic ones (Schaefer & Hess, 1959), and complex patterned cards were preferred to simple ones (Berryman et al., 1971). However, to the best of our knowledge, this is the first time that the stimulus properties of movement, brightness, colour and complexity have been systematically examined in the same study.

Preference tests can be controversial and some authors have identified interpretational difficulties (Fraser & Matthews, 1997; Hughes, 1977; Mench, 1994). However, preference tests at least allow for some determination of what is attractive to the animal (Bayne, Hurst, & Dexter, 1991; Hughes, 1977) and "if the various stimuli are equally healthful (or neutral), the observer may be able to draw conclusions about those stimuli to which the animal prefers being exposed" (Bayne et al., 1991). Interestingly, the strongest preferences were seen here when chicks were asked to choose between complex vs. simple images (Experiments 5 and 6). The "complex" videos incorporated all the features that had been identified as attractive in Experiments 2-4, i.e. movement, colour and brightness. Therefore, it is tempting to speculate that the most attractive video images are likely to incorporate all of these features. However, there may be a point above which increasing the complexity of a video stimulus no longer increases its attractiveness.

During their early exposure to televised images the chicks spent most of the observation period in the central "neutral" zone of the cage. Although fear levels remain low for 2 days after hatching (Jones, 1996),

this may have reflected avoidance of the videos caused by their novel and, hence, fear-inducing properties (Jones, 1987; 1996). Alternatively, though less likely, chicks of that age may have been more interested in the food and water dishes located in the central area of the cage. The chicks spent progressively longer near the video images, regardless of their content, with repeated exposure. Furthermore, although not statistically comparable, the overall GA scores (proportional measure of the time spent near the videos) of 23, 37, 27.5, 47.3 and 57.0% calculated in Experiments 2-6, respectively, were substantially greater than the baseline score of 13.2% obtained in Experiment 1 when no videos were shown. Note too that the highest GA scores were observed in Experiments 5 and 6, i.e. when complex videos were shown. Our results suggest that video stimulation engendered greater utilisation of certain areas of the cage than might otherwise have been the case. This notion is consistent with previous reports that chicks were more likely to enter and then spend longer in an area peripheral to the home pen if it contained novel objects than if it was empty (Newberry, 1999), and that the introduction of enrichment stimuli increased usage of the previously least preferred area of the home cage (Jones & Carmichael, 1999). Collectively, these findings support the hypothesis that animals seek opportunities to explore novel stimuli (Jones, 1996; Jones, 2001; Mench, 1994). The apparent existence of such motivation is a powerful argument for the provision of environmental enrichment. We do not suggest that television sets should be incorporated into poultry houses. Rather, because video technology allows easy and rapid dissection, amplification, reduction or morphing of selected features of a visual image, this facility may represent a powerful laboratory tool for guiding the development of enrichment stimuli and for identifying ways of improving housing systems. Our findings could also have direct cross-species relevance because televised images have been used as a form of enrichment for laboratory primates (Platt & Novak, 1997) and commercially produced videos are available for pet cats.

Why should chicks show preferences for one component of a video image over another? If newly hatched chicks are exposed to a conspicuous stimulus they rapidly form a specific attachment to it (Bolhuis, 1999). Therefore, it might be argued that the chicks' attraction to the video images used here may have reflected imprinting. Indeed, van Kampen (1993) proposed that when a chick is simultaneously exposed to two objects situated 20 cm or more apart, it will imprint only to one of these and show no attachment to the other, a phenomenon referred to as overshadowing. However, the present chicks were exposed to the videos for only brief periods from 2 days of age. Furthermore, since socially reared chicks are likely to imprint onto each other (Bolhuis, 1991), their companions may have blocked (van Kampen, 1996) attachment to the videos. Therefore, the present findings may have reflected a perceptual learning process that affected

behavior gradually as a function of exposure to the stimuli rather than an imprinting phenomenon. It has been proposed that attraction to a novel compound stimulus increases when it has several features in common with a familiar one and vice versa (Bateson & Horn, 1994). Additionally, perceptual preferences may ensure that young animals direct their attention towards appropriate objects, such as conspecifics (Bolhuis, 1999). Thus, the present chicks may have preferred video stimuli that contained more of the properties shared with their siblings, e.g., movement, colour, and complexity.

We do not know if the observed preferences would have remained stable over longer exposure periods than the 10 days used here. Encouragingly though, chicks' attraction towards videos presented outside the home cage were paralleled in our study of adult hens (Clarke & Jones, 2000a).

In conclusion, the present findings support previous reports that chickens are highly responsive to video images of biologically neutral stimuli, that they remember and are readily attracted to such images, and that they can distinguish between two moderately different videos (Clarke & Jones, 2000a, 2000b; Jones et al., 1996, 1998). This, in turn, reinforces the view that video technology can be used to further investigate chickens' perception and regulation of their visual world. From a practical viewpoint, they also further support the suggestion that we should consider enriching the environment outside as well as inside the birds' cage (Jones, 1996; Newberry, 1995).

## References

- Bateson, P.P.G. & Horn, G. (1994). Imprinting and recognition memory – a neural net model. *Animal Behaviour*, **48**, 695-715.
- Bateson, P.P.G. & Reese, E.P. (1969). The reinforcing properties of conspicuous stimuli in the imprinting situation. *Animal Behaviour*, **17**, 692-699.
- Bayne, K.A.L., Hurst, J.K., & Dexter, S.L. (1991). Evaluation of the preference to and the behavioural effects of an enriched environment on male rhesus monkeys. *Laboratory Animal Science*, **42**, 38-45.
- Berryman, J.C., Fullerton, C. & Sluckin, W. (1971). Complexity and colour preferences in chicks of different ages. *Quarterly Journal of Experimental Psychology*, **23**, 255-260.
- Bolhuis, J.J. (1991). Mechanisms of avian imprinting: a review. *Quarterly Review of Biology*, **70**, 165-191.
- Bolhuis, J.J. (1999). Early learning and the development of filial preferences in the chick. *Behavioural Brain Research*, **98**, 245-252.
- Burghardt, G.M. (1999). Deprivation and enrichment in laboratory animal environments. *Journal of Applied Animal Welfare Science*, **2**, 263-266.
- Chamove, A.S. (1989). Environmental Enrichment: a review. *Animal Technology*, **40**, 155-178.
- Clarke, C.H., & Jones, R.B. (2000a). Responses of adult laying hens to abstract video images presented repeatedly outside the home cage. *Applied Animal Behaviour Science*, **67**, 97-110.
- Clarke, C.H., & Jones, R.B. (2000b). Effects of prior video stimulation on open-field behaviour in domestic chicks. *Applied Animal Behaviour Science*, **66**, 107-117.
- Clarke, C.H. & Jones, R.B. (2001). Domestic chicks' runway responses to video images of conspecifics. *Applied Animal Behaviour Science*, **70**, 285-295.
- D'Eath, R.B. (1998). Can video images imitate real stimuli in animal behaviour experiments? *Biological Reviews*, **73**, 267-292.

- Dutch, J. (1969). Visual complexity and stimulus pacing in chicks. *Quarterly Journal of Experimental Psychology*, **21**, 63-66.
- Eiserer, L.A. (1980). Development of filial attachment to static visual features of an imprinting object. *Animal Learning & Behavior*, **8**, 159-166.
- Evans, C.S., Macedonia, J.M., & Marler, P. (1993). Effects of apparent size and speed on the response of chickens, *Gallus gallus*, to computer generated simulations of aerial predators. *Animal Behaviour*, **46**, 1-11.
- Fraser, D., & Matthews, L.R. (1997). Preference and motivation testing. In M.C. Appleby & B.O. Hughes (Eds.), *Animal Welfare* (pp. 159-173). Wallingford, UK: CAB International.
- Genstat 5, Release 4.1. (1997). Lawes Agricultural Trust, IACR, Rothamsted, UK.
- Hughes, B.O. (1977). Behavioural wisdom and preference tests. *Applied Animal Ethology*, **3**, 391-392.
- Humphrey, N.K. (1972). 'Interest' and 'pleasure': two determinants of a monkey's visual preferences. *Perception*, **1**, 395-416.
- Jones, R.B. (1987). Social and environmental aspects of fear in the domestic fowl. In R. Zayan & I.J.H. Duncan (Eds.), *Cognitive Aspects of Social Behaviour in the Domestic Fowl* (pp. 82-149). Amsterdam: Elsevier.
- Jones, R.B. (1996). Fear and adaptability in poultry: insights, implications and imperatives. *World's Poultry Science Journal*, **52**, 131-174.
- Jones, R.B. (2001). Environmental enrichment for poultry welfare. In: C.M. Wathes (Ed.), *Integrated Management Systems for Livestock* (pp. 125-131). British Society for Animal Sciences. Occasional Publication 28.
- Jones, R.B. & Carmichael, N.L. (1998). Pecking at string by individually caged, adult laying hens: colour preferences and their stability. *Applied Animal Behaviour Science*, **60**, 11-23.
- Jones, R.B. & Carmichael, N.L. (1999a). Can 'environmental enrichment' affect domestic chickens' preferences for one half of an otherwise symmetrical home cage? *Animal Welfare*, **8**, 159-164.
- Jones, R.B., Carmichael, N.L. & Rayner, E. (2000). Pecking preferences and pre-dispositions in domestic chicks: implications for the development of environmental enrichment devices. *Applied Animal Behaviour Science*, **69**, 291-312.
- Jones, R.B., Carmichael, N.L., & Williams, C. (1998). Social housing and domestic chicks' responses to symbolic video images. *Applied Animal Behaviour Science*, **56**, 231-243.
- Jones, R.B., Larkins, C., & Hughes, B.O. (1996). Approach/avoidance responses of domestic chicks to familiar and unfamiliar video images of biologically neutral stimuli. *Applied Animal Behaviour Science*, **48**, 81-98.
- Keeling, L.J., & Hurmik, J.F. (1993). Chickens show socially facilitated feeding behaviour in response to a video image of a conspecific. *Applied Animal Behaviour Science*, **36**, 223-231.
- Lindberg, A.C. & Nicol, C.J. (1994). An evaluation of the effect of operant feeders on welfare of hens maintained on litter. *Applied Animal Behaviour Science*, **41**, 211-227.
- McQuoid, L.M., & Galef, B.G. (1993). Social stimuli influencing feeding behaviour of Burmese fowl: a video analysis. *Animal Behaviour*, **46**, 13-22.
- Mench, J.A. (1994). Environmental enrichment and exploration. *Laboratory Animal*, **February**, 38-41.
- Newberry, R.C. (1995). Environmental enrichment: increasing the biological relevance of captive environments. *Applied Animal Behaviour Science*, **44**, 229-243.
- Newberry, R.C. (1999). Exploratory behaviour of young domestic fowl. *Applied Animal Behaviour Science*, **63**, 311-321.
- Patterson-Kane, E., Nicol, C.J., Foster, T.M. & Temple, W. (1997). Limited perception of video images by domestic hens. *Animal Behaviour*, **53**, 951-963.
- Platt, D.M. & Novak, M.A. (1997). Video stimulation as enrichment for captive rhesus monkeys *Macaca mulatta*. *Applied Animal Behaviour Science*, **52**, 139-155.
- Regolin, L., Tommasi, L. & Vallortigara, G. (2000). Visual perception of biological motion in newly hatched chicks as revealed by an imprinting procedure. *Animal Cognition*, **3**, 53-60.
- Rogers, L.J. (1995). *The Development of Brain and Behaviour in the Chicken*. Wallingford, UK: CAB International.
- Roper, T.J. & Marples, N.M. (1997). Odour and colour as cues for taste-avoidance learning in domestic chicks. *Animal Behaviour*, **53**, 1241-1250.
- Schaefer, H.H. & Hess, E.H. (1959). Colour preferences in imprinting objects. *Zeitschrift fur Tierpsychologie*, **16**, 161-172.

Ten Cate, C. (1989). Stimulus movement, hen behaviour and filial imprinting in Japanese quail (*Coturnix coturnix japonica*). *Ethology*, **82**, 287-306.

van Kampen, H.S. (1993). Filial imprinting and associative learning: similar mechanisms? *Netherlands Journal of Zoology*, **43**, 143-154.

van Kampen, H.S. (1996). A framework for the study of filial imprinting and the development of attachment. *Psychonomic Bulletin and Review*, **3**, 3-20.

*Received March 12, 2001.*

*Revision received June 15, 2001.*

*Accepted July 27, 2001.*