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Short Communication

Visual Bar Length Discrimination Threshold in the Pigeon

Ursula Schwabl and Juan D. Delius
Experimentelle Tierpsychologie, Psychologisches Institut, Ruhr-Universität, D 4630 Bochum, FRG

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Using an instrumental discrimination conditioning procedure, it is found that Pigeons can distinguish visually between bars differing in length by less than 2% (Weber fraction = 0.02). Pigeons are thus capable of a visual length discrimination performance that is superior to that of humans.

Introduction

Although visual stimuli are the most commonly used controlling cues in conditioning experiments with Pigeons (1), there is still much uncertainty about their psychophysically critical parameters. There is, for example, no estimate of the Pigeon's just discriminable length difference (4). Here we report results from an experiment that, although primarily designed to study a behavioural contrast effect variant (12), yielded some relevant measurements. According to these results, the Pigeon's length estimation capabilities must be reckoned to be at least on par with our own.

Method

Eight adult Homing Pigeons *Columba livia* of local origin were used. They were housed singly with water freely available, and with a light schedule of 12 hours of light and 12 hours of dark at about 18 °C. At the beginning of the experiment, the animals were maintained at 80% of their free-feeding weight. As they became experienced with their tasks, it was found that they performed better with a weight deficit of only 5% or less. The critical data were obtained with the animals under this latter condition. The apparatus used was a conventional sound insulated two-key Skinner box (30 × 35 × 35 cm) with forced ventilation. The keys were 24 cm above the floor and their centers were 17 cm apart. A houselight, 30 cm above the floor and between the keys, illuminated the interior of the chamber, while a shield ensured an indirect illumination of the walls (≈ 5 cd/m²). The feeder opening (6 × 8 cm) was situated on the same wall midway below the keys, 6 cm above the floor. Events were controlled by digital modular programming equipment, and responses were recorded with a printing counter.

No shaping was necessary since the subjects had previously served in an experiment where they had operantly discriminated various visual shapes. They were immediately subjected to the simultaneous, discrete trial length discrimination procedure. The stimuli were back-projected onto the keys with the aid of multichannel microprojectors. They appeared as horizontal 3 mm wide white (≈ 50 cd/m²) bars on the dark background (less than 0.1 cd/m²) of the 25 mm diameter keys. Care was taken that unintended cues, principally brightness differences (8) could not aid discrimination. This was achieved by varying the intensity of the individual stimuli over a range of 0.5 log units attenuation between the series of sessions. Neither the luminance nor the flux of the stimuli was thus consistently correlated with bar length. A faint fuzziness about the bar edges, estimated to spread over 0.05 mm could not be eliminated but it only made the length discriminations more difficult than they would be otherwise.

A trial began with a long bar and a short bar being projected on the keys. For one half of the Pigeons, the long bar was defined as the positive stimulus, for the

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other half it was the shorter bar. If the subjects pecked the positive stimulus, the stimuli extinguished and the animal was offered food for 2 s after which the next trial began, the short and long stimulus being respectively allotted to the left and right keys according to a quasi-random sequence (7). If the Pigeon pecked the incorrect stimulus, both the stimuli and the houselight extinguished for 5 s. The next trial was a correction trial where the allocation of stimuli to the keys was the same as in the preceding trial. This correction procedure only terminated once the subject had completed a correct trial. For performance evaluation purposes, only the non-correction, fair trials were considered. A session consisted of 48 fair trials. Sessions were run daily, occasionally twice daily, including weekends.

Animals began training with the shortest (10 mm) and longest (16 mm) bars available. As all the subjects reached a success performance of 90% or more, the length difference of the bars used in the next series of sessions was decreased, by approximately halving the Weber fraction. This was repeated several times so that the difference in length decreased progressively. However, the absolute length of the pairs of bars varied within the length range available. In the extreme case this meant that both bars to be discriminated in a new series of sessions were about 30% longer than those used previously. Since the animals generally showed good discriminative performance on the very first session of each new task — their mean performance never fell below 80% correct choices — we assume that they were responding mainly to the relative length differences and less to the absolute length of the stimuli.

Results

After 70 sessions, the animals entered into the experimental phase that is of interest here. They now had to discriminate a bar 13.3 mm long from another 12.8 mm long, the difference being equivalent to a Weber fraction of 0.039. Figure 1 shows the mean discriminative performance on these stimuli in successive blocks of four sessions. Four animals were limited to these stimuli through-out the six blocks. The other four subjects were additionally exposed to special test trials during blocks 2 and 5 (sessions 75 to 78 and 86 to 89). Sixteen of these trials were singly and randomly inserted among the 48 standard trials of each session. The test trials involved the presentation of a pair of stimuli whose length was 11.1 and 11.3 mm, that is, a Weber fraction of 0.018. Responses in these transfer trials yielded neither reward nor time-out but led directly to the next standard trial.

During standard blocks 1, 3, 4 and 6, the mean performance of both groups of subjects was closely similar: the percentage of correct responses increased from just above 85% to about 95% (Figure 1). During blocks 2 and 5, performance on the standard trials of the relevant group of pigeons decayed to just above 80% correct. This result can be interpreted as a behavioural contrast effect. The discrimination of the novel and more difficult test stimuli proceeded at a similar level (80% correct responses) during the first test block, although the subjects did not obtain any feedback about the correctness or incorrectness of their choices. The performance on the transfer stimuli deteriorated to just above 70% correct, presumably due to the onset of extinction during the second test block. The results remain, nonetheless, well above chance. Observations additionally showed that the Pigeons habitually examined both stimuli successively and binocularly from a distance of about 8 cm before responding (2).

Discussion

We conclude that Pigeons have no difficulty in visually discriminating bars whose length differ by Weber fractions of 0.018. The length difference, approximately 12′ when expressed as a visual angle, was only some four times greater than the visual acuity reported for Pigeons at comparable luminance levels (9).

Informal tests that we conducted with human subjects with good or corrected vision indicated that they could discriminate the same stimuli only under forced choice conditions. Ono (11) reported extensive research on line length discriminations thresholds in humans and his non-simultaneous, distal distance constant testing condition was closely similar to that employed in the present study. He found the threshold Weber fractions to vary between 0.050 and 0.034 depending on the absolute length of the stimuli and the viewing distance. Weber (13) himself had placed the human length difference threshold between 0.04 and 0.02. When the stimuli subtended about 6° visual angle as approximately did our stimuli to the Pigeons, Ono found humans to yield a fraction of 0.034. The criterion that he used to define these thresholds, however, was lower — 75% correct choices when translated to discrimination scores — than that effectively achieved by our Pigeons — 80% correct responses — when discriminating bars differing in length by a Weber fraction of 0.018.

The Pigeon's length difference threshold can therefore be assumed to be about half of that of humans. Also in this respect, the performance of the Pigeon's

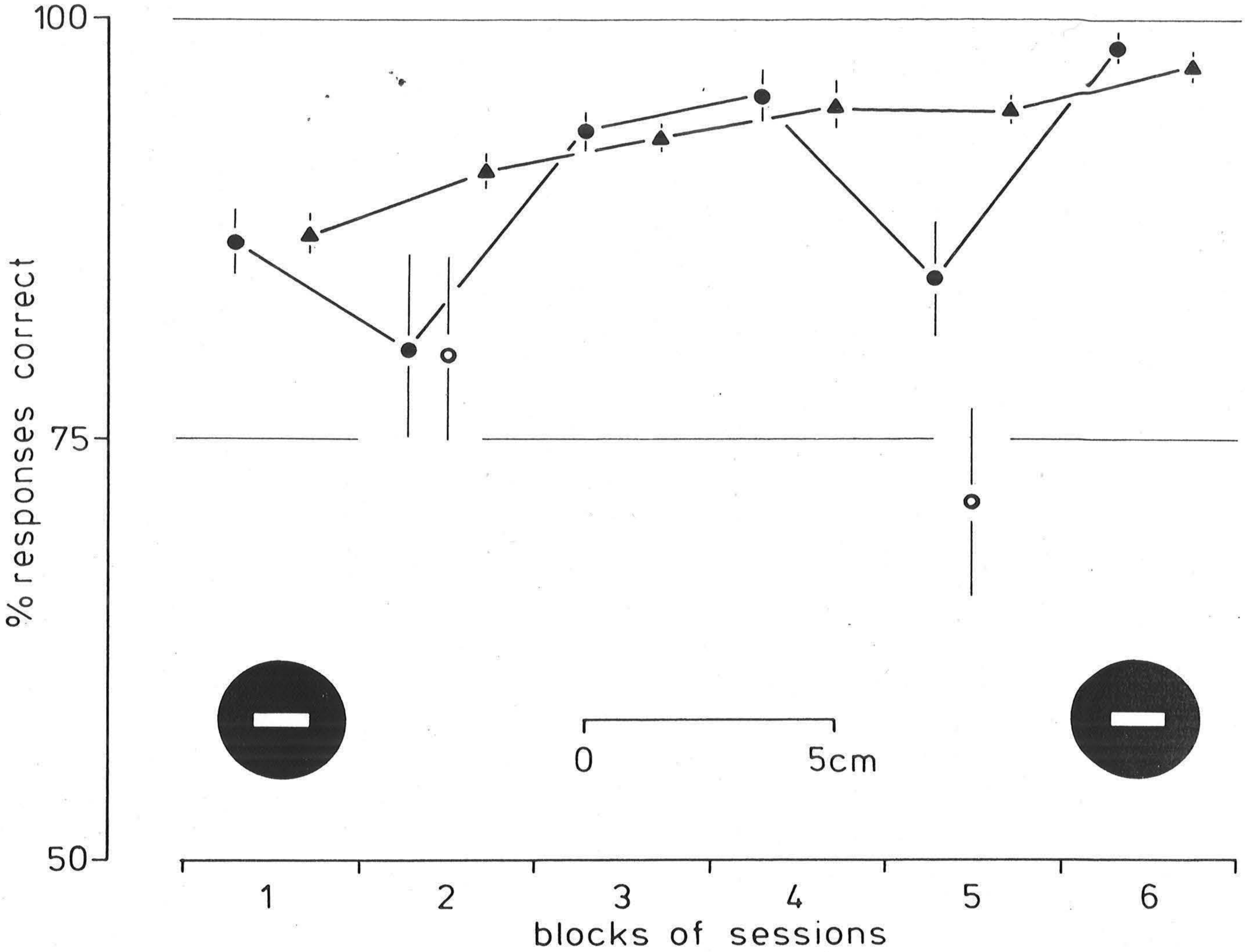

Figure 1. Mean performance with standard deviations of Pigeons on visual bar length discriminations as a function of the sequence of blocks of sessions. Two groups of four pigeons each (triangles, dots) had to discriminate between two bars 13.3 mm and 12.8 mm long. One of the groups of Pigeons also dealt with an inserted test task under extinction conditions involving bars 11.1 mm and 11.3 mm long (circles). This latter task is illustrated scaled down.

visual system is thus superior to the human one, as it is for polarization plane discrimination (3), ultraviolet sensitivity (6), hue discrimination (5) and rotational invariance (10). These results conform with popular notions about the excellence of avian sight.

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