Learning and Motivation 49 (2015) 14–22

Contents lists available at ScienceDirect

Learning and Motivation

journal homepage: www.elsevier.com/locate/l&m

Analysis of the role of stimulus comparison in discrimination learning in Pigeons

Esther Mondragón[a,b,c], Geoffrey Hall[a,d,e,*]

[a] University of York, UK
[b] Centre for Computational and Animal Learning Research, St. Albans, UK
[c] Systems and Control Research Centre, School of Mathematics, Computer Science and Engineering, City University, London, UK
[d] University of New South Wales, Australia
[e] Plymouth University, UK

A R T I C L E I N F O

Article history:
Received 24 October 2014
Received in revised form 6 January 2015
Accepted 8 January 2015
Available online 13 February 2015

Keywords:
Discrimination
Comparison
Relational learning
Perceptual learning
Pigeons

A B S T R A C T

In Experiment 1, pigeons were trained on a conditional discrimination in which presentations of a color and of a shape signaled that one response would be reinforced, and presentations of a different color and a different shape signaled that another response would be reinforced. For Group C (comparison), both colors were presented in some sessions and both shapes in others; for Group NC (no comparison), some sessions involved presentations of one color and one shape, other sessions of the other color and shape. The discrimination was acquired more readily by Group NC than by Group C and this difference between the groups was maintained in a further task (Experiment 2) involving a successive go/no-go discrimination in which pecking at one of the colors and one of the shapes was reinforced, response to the other color and shape being nonreinforced. Analysis of the details of the birds' performance supported an explanation in terms of responses governed by the absolute properties of the stimuli. In contrast to what has been found for human subjects, there was no support for the notion that the opportunity to compare similar stimuli (available to Group C in Experiment 1) engages a perceptual learning process that enhances their discriminability.

According to some accounts of perceptual learning (e.g., Gibson, 1969), exposure to similar stimuli, when it is arranged in such a way as to permit comparison between them, will enhance the discriminability of the stimuli, increasing the perceptual effectiveness of features that distinguish between them and reducing the effectiveness of features that they hold in common. Demonstrations of the importance of comparison are provided by studies of perceptual learning in humans. For example, Mundy, Honey, and Dwyer (2007) (see also Mundy, Honey, & Dwyer, 2009) tested their participants on a categorization task involving two very similar visual stimuli. Performance was enhanced by giving prior exposure in which the stimuli were presented simultaneously (side by side), allowing the opportunity for comparison. Successive presentations, with the stimuli presented in an intermixed fashion during preexposure, were less beneficial. Some degree of comparison (between the stimulus being presented and the trace of the preceding stimulus) could still occur when the events are presented

* Corresponding author at: Department of Psychology, University of York, York YO10 5DD, UK.
E-mail address: geoffrey.hall@york.ac.uk (G. Hall).

http://dx.doi.org/10.1016/j.lmot.2015.01.003

successively; it is significant, therefore, that inserting a distractor between presentations of the test stimuli has been found to attenuate the positive effect of this form of exposure (Dwyer, Mundy, & Honey, 2011).

These results contrast with those obtained from studies with nonhuman animals. Although there are many experiments (usually using rats as subjects and flavors as the stimuli, e.g., Bennett & Mackintosh, 1999; Blair & Hall, 2003; Mondragón & Hall, 2002; Symonds & Hall, 1995; but also with auditory stimuli and appetitive procedures, e.g., Mondragón & Murphy, 2010) showing that preexposure in which the stimuli are presented in alternation is particularly helpful in facilitating subsequent discrimination, we may doubt that this arises because such exposure promotes comparison of the stimuli. In these experiments the interval between preexposure trials was long and reducing it, a procedure that might be expected to facilitate comparison, has uniformly been found to convey no special advantage (and sometimes to be disadvantageous) (e.g., Alonso & Hall, 1999; Bennett & Mackintosh, 1999; Rodriguez, Blair, & Hall, 2008). In a recent review, Mitchell and Hall (2014) concluded that a difference in the ability to benefit from the opportunity to compare the stimuli might constitute an important distinction between the perceptual learning effects seen in animals and those seen in humans.

This conclusion may seem to face a challenge from the results of studies conducted in the 1950s, and designed to test Spence's (1936) account of discrimination learning. These (e.g., Bitterman, Calvin, & Elam, 1953; Bitterman, Tyler, & Elam, 1955; MacCaslin, 1954; North & Jeeves, 1956) generally found that rats learn a simultaneous discrimination task more readily than a successive discrimination involving the same stimuli. These results do not, however, require the conclusion that the simultaneous task is easier because it allows the possibility of comparing the stimuli, as the two types of discrimination that were used differed in other ways. In the simultaneous task the rat could learn simply to approach black (say) and to avoid white; in the successive version it had to learn to go to the left (say) when faced with two black cues, and to the right when faced with two white cues. The latter task could be more difficult because it requires the use of a configural or conditional cue involving two stimulus dimensions (brightness and position). There is, however, one early study (Saldanha & Bitterman, 1951) that avoids this issue by using a different design, and that produces evidence suggestive of a role for stimulus comparison.

In the procedure used by Saldanha and Bitterman (1951), the rats were trained on two simultaneous discriminations concurrently. In their Experiment 2, one group (to be referred to as Group C for comparison) received some trials on which choice lay between two gray cards differing in brightness, and other trials on which the choice was between black and white stripes that differed in width. A second group (Group NC, for noncomparison) received trials in which the positive gray was presented along with the nonrewarded stripe-width, intermixed with trials in which the positive stripe-width was presented along with the nonrewarded gray. Group C thus got the chance to compare each pair of similar stimuli, whereas Group NC did not. Saldanha and Bitterman found that Group C learned the discriminations much more readily than Group NC and concluded that the opportunity for comparison promoted discrimination learning. This result is consistent with the proposal that a perceptual learning process can go on alongside the associative changes that are necessary for accurate performance on a discrimination task – that the opportunity for comparison available to animals in Group C makes them better able to perceive the distinctive features of the wide and narrow stripes (say) and thus allows them to form the associations between these features and reward (or nonreward) that permit correct choice.

The aim of the work reported here was to attempt to replicate the essence of the effect reported by Saldanha and Bitterman (1951) (using pigeons as the experimental subjects), and to analyze its source. We modified the original experimental design to take account of certain complications noted by Wills and Mackintosh (1999). In an experiment with pigeons, modeled on that of Saldanha and Bitterman, Wills and Mackintosh found that the comparison condition was helpful only for some stimuli (specifically for rectangles that differed in luminance and not for stars differing in the number of vertices). Furthermore, the difference in performance between these two discriminations (luminances and stars) was not sustained when the pigeons were given a test in which the stimuli were presented individually rather than simultaneously. Wills and Mackintosh concluded that their results were best explained in terms of the operation of a low-level sensory process that, at least for some stimulus dimensions (and luminance is an obvious candidate), allows the contrast between similar stimuli to enhance the perceived difference between them. Such an enhancement would not involve a learning process and thus would not operate in a subsequent test in which the stimuli were presented individually. Standard interpretations of perceptual learning, on the other hand, envisage a process that has long-lasting, even permanent, effects and thus predicts positive transfer to other discriminations involving the same stimuli.

The first experiment to be described here used a modified version of the Saldanha and Bitterman (1951) design that was intended to rule out an explanation in terms of sensory contrast effects. The subjects were pigeons required to learn discriminations involving a pair of colors (R and G; red and green) and a pair of shapes (+ and ×; a white plus or cross on a black background). For all subjects the stimuli were presented one at a time, thus precluding the operation of simultaneous contrast effects. All subjects experienced just two of the stimuli in any given training session, but the two groups differed in the pairings that were arranged. For Group C some sessions contained presentations of R and G and other sessions presentations of + and ×; that is, both members of each pair of similar stimuli occurred in the same session. For Group NC the members of each pair occurred in different sessions; that is, they received, for example, presentations of R and + on some sessions and presentations of G and × on the other sessions. The arrangement adopted for Group C may be less effective in promoting the operation of a comparison process than one in which the two similar stimuli are presented simultaneously, but, as we have noted for the human case, intermixed presentations, although not as effective as simultaneous presentation, still produce positive transfer to a subsequent discrimination. It may reasonably be assumed that any comparison process will be more likely to operate in Group C, when the difficult-to-discriminate stimuli are presented a few seconds apart, than