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Colour Perception in Fighting Cattle

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ABSTRACT

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Eight adult cows of the fighting breed were studied using the discrimination conditioning method to determine the differentiation of 7 colours (violet, blue, green, yellowish green, yellow, orange and red) from grey samples equivalent in brightness. It was concluded that these animals perceived and differentiated perfectly colour stimuli with long and medium wavelength (between 550 and 700 nm), but experienced considerable difficulty in perceiving short-wavelength colours (between 400 and 500 nm). The similarities and differences of the results obtained with respect to other cattle breeds, and the possible implications of the colour vision of the fighting cattle in their behaviour during the bullfight are discussed.

INTRODUCTION

The study of visual perception of different animal species has been one of the most important fields of study for animal behaviour researchers from the pioneer experiments of von Frisch (1912) to the present time.

As far as species bred by man are concerned, the interest in such research goes beyond the legitimate desire for knowledge, which is often the main consideration in studies of non-zootechnical species, and can be used to improve normal handling practices (Dabrowska et al., 1981). This interest in zootechnical species is especially great in the case of fighting cattle. This bovine prototype is bred for particular behaviour patterns, which in turn depend to a large extent on their perceptive abilities. However, only a few studies refer to other bovines (Soffie et al., 1980; Dabrowska et al., 1981; Gilbert and Arave, 1986), while for fighting cattle there are only anatomical and histological studies (Martin, 1976; Paños, 1976), which give rise to the hypothesis that the fighting bull shows poor perception of all or some of the colours of the visible spectrum, and a lack of perception of tone shade.

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MATERIALS AND METHODS

The present study was carried out on eight adult fighting cows, between 14 and 18 months old at the beginning of the tests. The animals were separated from the wild herd when they were between 1 and 4 months old, and then kept in a free stall system. The experimental sessions were begun when the animals showed clear signs of adaptation to the new environmental situation.

The method of operant or instrumental conditioning was used. This technique uses reinforcement to maintain or modify the frequency of a given behaviour (Houpt and Wolski, 1982). The design of the experimental area is shown in Fig. 1. In the test area (C), with a sector in a circular shape, the animal had to choose between two feeding troughs on which the visual stimuli were placed.

Three different experiments were carried out. In the first, each animal was subjected to 30 tests, at the rate of 5 tests per day for 6 consecutive days, in which it had to choose between the two feeding troughs without any visual stimulus. The fodder was placed on a random basis in one of the troughs. The aim of this first phase was threefold:

(1) to accustom the animals to the handling required by the experiment and to the eating of fodder in isolation.

(2) to test how good the design was as far as eliminating all types of non-controlled stimulus (olfactory, placing, etc.) were concerned.

(3) to determine the position preferences, if any, of the subjects.

In the second stage of the experiment the ability to discriminate between two non-chromatic visual stimuli, differing in brightness or luminosity, was studied. Samples of white and black were used, with brightness values of 83 and 3, respectively, determined spectrophotometrically using the International Illumination Commission (CIE, 1931) method. The samples were square (40 cm), and were placed in a vertical position on the upper back edge of the feeding trough, right in front of the eyes of the animal while it was eating the fodder.

The animals were divided into two groups of four heifers each and one of the groups was subjected to visual discrimination tests with white as the rewarded

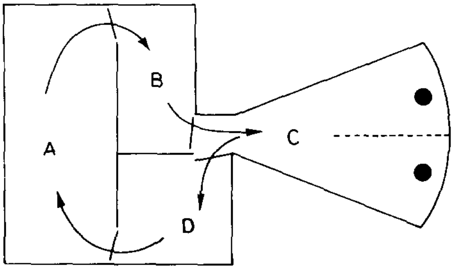

Fig. 1. Plan of experimental area used.

TABLE 1

Characteristics of the chromatic and grey stimuli

Colour	Wavelength (nm)	Brightness values	
		Colour	Grey
Violet	385	12.3	12.8
Blue	482	9.1	9.6
Green	517	13.0	13.2
Yellowish green	560	21.9	22.2
Yellow	580	62.6	62.9
Orange	610	28.0	27.4
Red	675	16.9	17.7

stimulus and black as the non-reinforced stimulus. The stimuli were reversed for the other group. The aim of this series of experiments was to provide information about their learning rates, which would permit the adequate design of the third set of tests. Eighty tests per animal (5 tests per day for 16 consecutive days) were carried out, divided into four series of 20 tests each.

In the last series of tests the animals' ability to discriminate 7 colours of the visible spectrum (violet, blue, green, yellowish green, yellow, orange and red) was studied in relation to 7 greys of equivalent luminosity. The characteristics of the colours and greys were calculated spectrophotometrically using the CIE method as shown in Table 1. A grey equivalent in luminosity or brightness corresponds to each colour.

Every animal was subjected to 80 discrimination tests for each colour and its grey equivalent in brightness at the rate of 5 per day for 16 consecutive days. After this period, the animal spent 72 h without undergoing any tests before beginning the process again with the following colour grey pair studied.

RESULTS

The results obtained in the habituation stage (Table 2) show that, in the absence of visual stimulus, the subjects' choice behaviour was at a chance level. With regard to individual preferences for the position of the trough, four animals showed very little or no preference for any particular position, while others demonstrated a clear preference for either the right hand feeding trough (3 animals), or for the one on the left (1 animal). These preferences remain unchanged for each animal throughout the 30 habituation tests.

The results of the discrimination stage showed that the percentages of correct choices increased in each of the four consecutive series, rising from nearly 50% in the first 20 tests to almost 100% in the last series (Fig. 2).

In the third stage, where each colour had to be distinguished from its equiv-

TABLE 2

Correct choices and first feeding trough right-left judgement percentages

Animal number	Correct choices (%)	First judgement (%)	
		Right	Left
1	57	60	40
2	50	100	0
3	60	53	47
4	50	100	0
5	43	93	7
6	47	70	30
7	53	60	40
8	47	3	97
Average	51	68	32

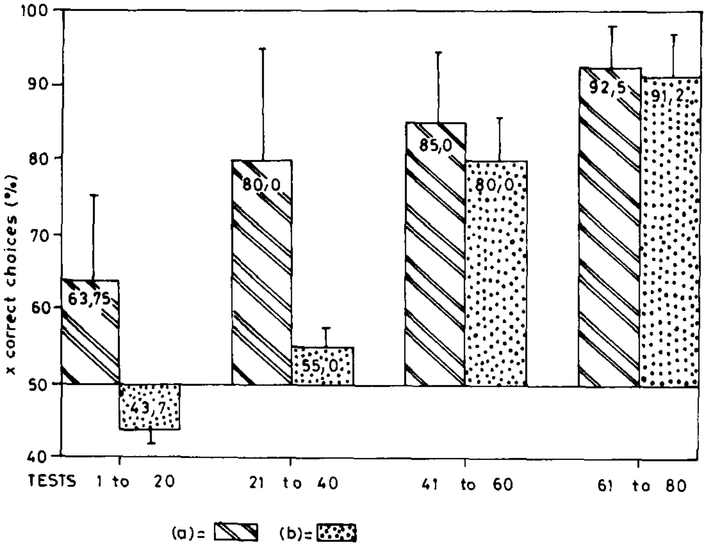

Fig. 2. Average percentage of correct choices for each group of animals in the 4 series of tests carried out (20 tests/animal/series). (a) Group of 4 animals with white as the reinforced stimulus; (b) group with black as the rewarded stimulus.

alent grey, the average frequency of correct choices and their changes throughout the series of tests are shown in Fig. 3. The overall percentage of correct choices obtained for each colour in all of the tests is shown in Fig. 4.

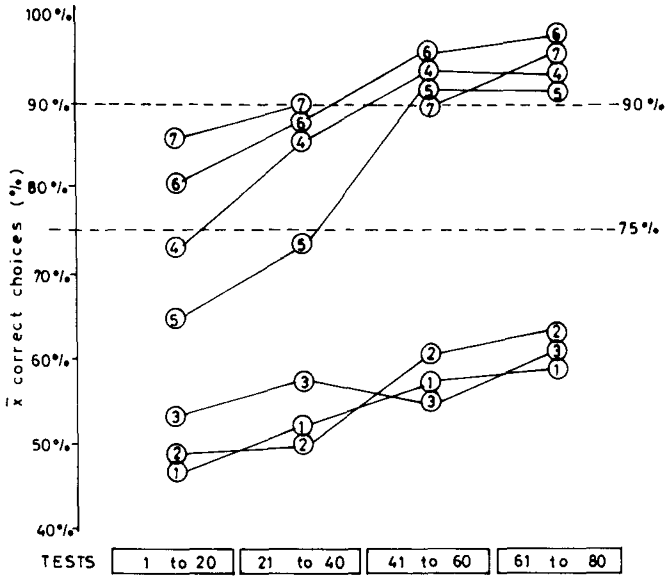

Fig. 3. Average percentage of correct choices in each series of tests for colours. (1) violet; (2) blue; (3) green; (4) yellowish green; (5) yellow; (6) orange and (7) red.

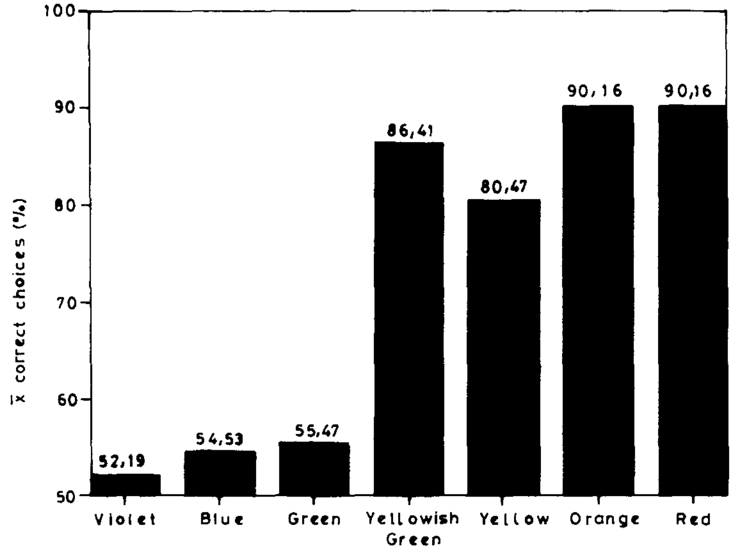

Fig. 4. Total average percentages ($n=640$ tests/colour) of correct choices for each of the colours studied.

DISCUSSION

A fundamental part of assuring the reliability of this type of test is making sure that only the key visual stimuli situated on the feeding troughs are used to guide the animal's choice. Other types of useful information must be eliminated. Thus, possible olfactory stimuli were suppressed by impregnating the trough containing the non-reinforced stimulus with the scent of the concentrate. Visual sources of information of a different nature to those being studied were controlled by filling the trough to such a level that the animal could see the reward only when its head was vertical to the trough. Finally, in order to prevent the animal from learning the positions, the visual stimuli in further tests were placed randomly, ensuring that each stimulus was found the same number of times in the different positions, in case possible preferences for either half of the experimental area distorted the data. The results shown in Table 1 indicate that the experimental arrangement met the requirements.

Taking into consideration previous studies, (Soffie et al., 1980), as well as the particular nature of the subjects and their relationships with the handlers, the use of corporal punishment and the cutting off of access to the reward in the event of a wrong choice was discarded. Thus, the animals were able to correct the first wrong judgement, but in such a way that the barrier situated between both troughs forced them to cover a greater distance. This could constitute an incentive to accelerate the learning process.

The figures given by different authors indicative of effective discrimination among visual stimuli are ~75% (Gilbert and Arave, 1986). With regard to differentiation between black and white (Fig. 2), these percentages were clearly surpassed by all the animals in our studies, in the last series of 20 tests. This finding demonstrates the capacity of the fighting breed to discriminate between visual stimuli with different levels of brightness or luminosity.

For those tests which focused on examining colour perception, it was necessary to study the animal's capacity to distinguish between one coloured sample and another grey one reasonably equivalent in brightness (Hawryshn, 1982). Therefore, in view of the average percentages of correct choice recorded in Tests 61–80 (Fig. 3), we could assume that the fighting breed is able to perceive all the colours used in this test. However, as already pointed out (Gilbert and Arave, 1986), >75% of correct choices will be necessary in order to demonstrate the possible existence of effective discrimination ability. In this case, we can conclude that the fighting breed can perceive the yellowish green, yellow, orange and red samples. The percentages of correct choices among these colours in the last series of 20 tests go far beyond the given value. The other 3 colours tested (violet, blue and green) do not reach the required level of correct choice, and indicate a question regarding these colours.

The average percentage of correct choices in all of the tests carried out (Fig. 4) may be considered as a reflection of the speed at which the animals learn to distinguish between each colour in relation to its equivalent grey. Thus, the colours which are more quickly recognized would probably be those perceived with greatest clarity. The colours most easily distinguished by the fighting breed would be as follows, in decreasing order: orange; red; yellow-green; yellow. In the same way, the difficulty in perception of non-discriminated colours would increase from green to blue, reaching its maximum level with violet.

The extreme difficulty which different breeds of cattle experience in perceiving the colour blue (or any other shorter wavelength colour), is clear from other studies (Hebel and Sambraus, 1976; Soffie et al., 1980; Dabrowska et al., 1981). However, the difficulty shown by the fighting breed in perceiving short-wavelength colours such as blue and violet is extended, and almost reaches the medium-wavelength colours. Consequently, their chromatic-vision spectrum would be different from that of other breeds. This seems to agree with histological and biochemical studies carried out on the retina of the fighting bull, which show a reduced number of cones and some of the photopigments (visual blue) closely linked to colour perception (Martin, 1976).

Although no particular agitation, restlessness, etc., were found, the possibility that the attention paid by the bull to the "muleta" (red cape) during the bullfight depends not only on movement (Stratton, 1923) but also on its colour (Dabrowska et al., 1981), must not be discarded. The fighting bull would charge with greater force against red, orange or yellow stimuli, which encourage this type of reaction (Martin, 1976), than against shades of green, blue or violet. Taking into account the above-mentioned, and presupposing that there is no difference in the physiology of vision between males and females, it can be concluded that the fighting breed perceives and differentiates perfectly those colour stimuli with long and medium wavelength (between 550 and 700 nm), but experiences considerable difficulty in perceiving short wavelength colours (between 400 and 500 nm).

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