EXPERIMENTS ON COLOUR SENSE IN BIRDS.

BY

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FOLLOWING a report by Dr. Zuckermann to the Zoological Society, in March, 1932, that he had discovered an awareness of colour in a young baboon, an interesting abnormality, *The Times* printed a number of letters from correspondents who asserted that their favourite cat, dog or horse could readily distinguish at least one colour.

The point that all the writers seemed to miss was that animals, while they may be colour-blind, as is generally understood, are not tone-blind. And that it was, most probably, the tone of the garment which the pet animal recognized, not its colour.

That this might be the case was brought out, unconsciously, by several of the statements, particularly one of a dog, which could distinguish between a " rather light green " dress and a " dark grey " dress, and another of a dog which mistook " King's College " colours—purple and white—for " Third Trinity " colours—dark blue and white—and yet could readily distinguish between these and other College colours. In the first case the tone of light green is so *different* from the tone of dark grey that there is nothing remarkable in the dog's ability to distinguish between them. While in the other case the tone of purple being the *same* as dark blue, only a sense of colour would enable the dog to recognize each and as it could not there is proof of its colour-blindness.

As there is a wide misconception as to the meaning of " tone " it may not be amiss to say that " tone " is something quite different from " colour " : " colour " being the " hue ", e.g., red or pink, green or lavender ; while " tone " is the strength of the " hue ", e.g., the degree of its darkness or lightness. Two blues, for example, may be identical in " colour " but different in " tone ", i.e., one may be light, the other dark ; two colours may be totally different in " hue ", green and orange for instance, but identical in " tone ", i.e., their strength may be the same.

Some time ago I made certain observations on the " colour " and " tone " sense of birds by experiment on the Ringed Plover (*Charadrius h. hiaticula*), *cf. British Birds*, Vol. XXV., pp. 34-44. Experiments for the same purpose I have made on the Nuthatch (*Sitta europæa affinis*), the Great Tit (*Parus major newtoni*) and the Blue Tit (*Parus cæruleus obscurus*), particulars of which are now given.

For Test I. I prepared a set of pea-nut pods by painting each a different colour. The colours used were white, light blue, orange, green, red, dark blue and purple. One was left its natural colour and all were spread out on the ground.

The Nuthatch came at once and walked about among them looking at them dubiously, then, seizing the orange pod, wedged it in a crevice close at hand and proceeded to dig out one of the kernels. He then came back and after touching the white pod with his beak, flew off. Returning, he took the other kernel out of the orange pod, carrying it away.

The coloured pods proved somewhat disconcerting to other birds, the Marsh-Tits and Chaffinches leaping into the air several inches startled, as though by something strange. House-Sparrows looked at them with suspicion. Hedge-Sparrows seemed quite oblivious of their presence.

The Nuthatch appeared again and carried off the green pod, then, coming back, walked round inspecting the pods but touching none. Up to this time he had taken the orange pod, similar in colour and tone to the real thing, had taken the green, different in colour but similar in tone, but, and this is strange, had ignored the real pod.

As he now stayed away a long time, and thinking the position of the pods on the ground might be a disturbing factor, I fixed them in holes of appropriate size drilled in a section of a tree trunk.

The bird returned, broke into the natural nut, then carried it off. Coming back he attacked the purple pod, the white, the red and next the dark blue, which he partly broke open, then carried off. When he came back he broke into the light blue pod and extracted the kernel.

The female Nuthatch now arrived and took the remaining kernel from the light blue pod. Her mate returned, attacked the purple pod, then attended to the red. The female stood shivering her wings and opening her beak until he had extracted a kernel from the purple pod to which he had returned. She then tackled the red pod and carried off the kernel. White was the only pod left and this, in ten minutes, was removed, shell and all.

For Test II. I repeated the first test by fixing a second set of pods in the tree trunk, having added pods painted black and pink.

In two minutes the male Nuthatch attacked the white pod, left it, returned, resumed his attack on the white, transferred himself to the orange pod from which he extracted a kernel, carrying it off. Coming back he went again to the orange

pod, got out the other kernel and left. He came back and breaking open the green, got the kernel and flew. Next he resumed work on the white pod from which he took the kernel. Back again, he carried off the natural pod. Returning he tapped the dark blue pod, the black, the light blue, the pink, the purple, then the dark blue again, following it with the pink pod from which he extracted the kernel. He came back, attacked the dark blue, went, came again, had another try at the dark blue but left it. The female now came and had a go at the dark blue pod, then tried the light blue from which she took a kernel. The male returning, attacked the dark blue pod, left it, tapped the black, left that and went back to the dark blue from which he got a nut. After eating this he went to the light blue pod and took the other nut. Again he tapped the black, next attacked the purple pod, opening it, then returned to the black, getting a kernel. On his return he resumed operations on the black pod and found the other nut. The female came and walked all over the stump but did not touch any of the pods. When he returned he tapped the pink pod, then pecked the red which, shortly, he left. Coming back he again tapped the pink pod, then pecked hard several times at and broke open the red pod, carrying off the nut, then, returning to the red, took the other kernel. After this he got the other nut from the purple pod and finally, on his return, extracted the last kernel from the pink.

As some Great Tits had been showing an interest in the proceedings I allowed them, in Test III., a free hand. For this experiment the pods were painted and laid out in a line on the ground in the following order: ultramarine blue, orange, prussian blue, black, red, green, pink, light blue, natural pod, purple, white. Single pods were used this time by reason of the two kernels in the double pods complicating matters.

A Great Tit was the first to arrive, he carried off the white pod. The Nuthatch came, walked along the row of pods and seeing the natural pod took it. The pink pod was now taken by the Great Tit and on his return he selected the prussian blue. When the Nuthatch came back he attacked the orange pod but, leaving it, decided to carry away the green one. The Great Tit, coming back, pecked the red pod, then flew off. He returned shortly and after trying several times to pick up the red pod gave it up and went over to the orange pod, which he removed. The purple pod was now carried off by the Nuthatch. Red again attracted the Tit, but again he left it to attend to the black pod which he removed. On his

return ultramarine blue was the pod he selected and this, after pecking it several times, he carried away. Once more he returned to the red pod and this time he removed it. Light blue was the only pod left and this, when he came back, he removed quickly.

As it was felt that the rattle of the kernel in the pod, which could be felt and heard when the pod was touched, might help the birds to recognize the coloured pods as containing something edible, the next two tests were made with extracted kernels.

Two sets of kernels were painted with the same colours as the last (pod) experiment. To each set was added an imitation kernel made of carbolic soap, which is almost exactly the same colour and tone as the real nut, and another, also of carbolic soap, painted green.

In the first of the kernel tests, Test IV., the kernels were laid out on the ground in a row in the same order as before, the soap kernel being placed between prussian blue and black and the green-painted soap kernel separating light blue and the natural nut.

Blue Tits had not been able to cope with the pods but the much smaller kernels permitted them to join in.

The unpainted natural kernel was at once taken by a Blue Tit. A Great Tit removed the red and on his return carried off the uncoloured soap kernel, evidently satisfied as to its authenticity. On his coming back he took the prussian blue nut and on his next return he carried off the pink one. He followed this by flying off with the white kernel. Returning, he touched the ultramarine nut, walked to the black which he pecked, touched the light blue, then carried off the orange. Purple was the next colour he selected, and on coming back first pecked the ultramarine blue kernel, then the black, next the lilac and then the green, after which he flew without taking any. Nuthatch now came; he picked up the ultramarine blue kernel, dropped it, picked up the black, dropped that, returned to the ultramarine blue, lifted it, then walking along the line picked up the light blue kernel but flew without taking any. The Great Tit now removed the light blue nut. Returning, he touched the green, then the lilac, then the black; after going to ultramarine blue and pecking that he returned to the black kernel which he also pecked, then flew off with the lilac kernel. Green the Great Tit took next and on his return he carried off the ultramarine blue nut and after that the black. The green-painted soap which had been ignored was now removed.

The second set of painted kernels for Test V. was arranged

in two concentric circles with the green-painted soap in the centre.

As before, a Blue Tit took the natural unpainted kernel without any hesitation from the inner ring; to get it he had to pass several others. He returned and pecked the green nut, picked up the unpainted soap kernel, dropped it and took the white kernel, all these being in the outer circle. Coming back, the Blue Tit bit a piece out of the soap, wiped his beak on the ground and flew off. The Great Tit now came, pecked the soap nut, then took the pink kernel, both being in the outer circle. Returning, he carried off the purple nut from the outer circle. The Blue Tit arriving pecked the green soap in the centre of the circles, then the uncoloured soap and the black kernel, both these being in the outer circle. The Great Tit now carried off the light blue kernel from the outer circle. The Blue Tit, on coming back, pecked the ultramarine blue and the soap kernel and carried off the lilac kernel from the inner circle. The Great Tit now picked up the green soap but dropped it and flew. The Nuthatch coming picked up the prussian blue kernel, the green soap and the green nut, dropping each in turn. Now the Blue Tit took the green kernel. He returned and took the ultramarine blue after which the Great Tit carried off the red kernel. On returning he picked up the prussian blue, dropped it, took the orange nut and, on coming back, removed the uncoloured soap. Whether he ate this dainty I could not see, but, returning, he took the prussian blue and afterwards the black kernel. The green soap was not in favour but was removed some time after by the Great Tit.

The next tests were of a different nature. Having ascertained the complementary colour of the hue of the natural pea-nut pods I painted half a dozen pods with this colour, which is almost a Cambridge blue. This was done in order to obtain the greatest possible contrast to the colour of the natural pods, the tone being the same. For Test VI. these painted pods were arranged in a circle on the ground alternately with six natural pods to give the birds an equal choice of coloured or natural pods.

The Nuthatch came first and took a natural pod. The Great Tit coming next also removed a natural pod. On his return he pecked one natural pod and took away another. The Nuthatch now came and having looked at the array went without taking any. The Great Tit, coming back, pecked first a blue pod, next a natural one, then flew off with a blue pod. Following this the Great Tit pecked a blue pod,

then a natural, then took another natural pod. Returning, he pecked a natural, next another natural, then a blue one, flying off without taking any. Coming back, he first pecked a blue pod, then carried off a natural one. The Nuthatch now came and took the remaining natural pod.

Five blue pods were thus left. To these I added five natural pods and for Test VII. placed them in a ring as before, alternately.

This time the Great Tit took a natural pod, followed by the Nuthatch, which did the same. The Great Tit now pecked two natural pods, taking none, after which the Nuthatch paid three successive visits, removing a natural pod each time.

A similar experiment, Test VIII., was now made with this difference. Six pods were again coloured with the complementary hue but, instead of making it the same in tone as the natural nuts as in the last test, the colour was mixed to the extreme opposite tone, i.e., dark, thus giving the greatest possible difference of tone as well as colour. The pods were placed in a ring alternating with six natural pods.

The Nuthatch pecked one natural and took another natural pod. The Great Tit touched a natural pod and removed another natural one. Returning, he took another natural. The next time he came back he pecked a natural but carried off a blue pod. After that he removed a natural pod. Following which the Nuthatch paid two visits, taking each time, without hesitation, a natural pod.

I had now five of the light blue pods and five of the dark blue left over from these tests. My last experiment, Test IX., with peanut pods was made by arranging these two tones of blue alternately in a circle.

A Great Tit came and took a light blue pod. On his return he took another light blue. Next time he came he picked up a dark blue nut, but dropping it, carried off a light blue. The Nuthatch now arrived, walked two-thirds round the circle looking at the pods, but did not touch any. After absenting himself for a while he returned, touched the nearest dark blue, walked half round the circle, then flew. The Great Tit now came, pecked at each of the light blue pods, then a dark blue, and departed without one. Returning, he at once took a light blue pod. The next time he came he pecked a light blue, then carried off a dark blue pod. Again returning, he took a dark blue, came back and removed the last of the light blue pods and followed this by fetching a dark blue. The Nuthatch now came and took a dark blue, and the last pod, a dark blue, was fetched by the Great Tit.

Hazel-nuts, being part of the normal food of Nuthatches, I took a number and painted them for Test X. as follows: white, yellow, light blue, green, red, ultramarine blue, prussian blue, purple and black. These were spread out on the ground. The Nuthatch, after touching several with his beak and seeming to have satisfied himself that they were all right, quickly carried them off in this order: black, purple, red, green, ultramarine blue, yellow, light blue, white, prussian blue.

The shapes of pods and nuts were, of course, quite familiar to the birds and may be presumed to have decided them that the baits, though strangely coloured, were yet their familiar food. Test XI. was tried relative to the shapes. A monstrous hazel-nut was constructed by sticking together half hazel-nut shells till the mass was larger than an egg. Again, three natural peanut pods were glued together into a bundle.

The Nuthatch at once seized the monster nut and carried it a distance of several yards and there left it. The bundle of pods he pecked several times, then abandoned it.

Again, thinking the rattle of the kernel in the shell might be an aid to identification I opened, Test XII., two pea-nut pods, and after extracting the kernels filled the space tightly with bread and neatly closed the pods. They were now the same weight as in the natural pod but there was no rattle. Taking a hazel-nut I halved it and, substituting carbolic soap for the kernel, joined the halves again. I imitated a pea-nut kernel in carbolic soap of the same colour as the natural kernel.

The Nuthatch immediately broke open and ate the bread from one of the pods, then started to break open the other, but carried it off to eat in private. One tap at the doctored hazel-nut was enough to tell him that the contents were uneatable. How this did so I could not tell as he did not crack or pierce the shell. The imitation soap kernel he treated with contempt.

In Tests I. and II. the Nuthatch took, first of all, pods which were similar in tone to the natural pods, i.e., the light colours, and his first preference was, in both tests, for the orange-coloured pod, which was the nearest of them all to nature. This he followed with green, natural, pink, white and light blue. A curious contradiction was the choice of dark blue in each test among the light colours. In Test III. he again began with the light colours. In Tests VI., VII. and VIII. he ignored the coloured pods, though they were the same

in tone as the natural ones, and took the latter each time. In Text IX., being restricted in choice to a light colour and a dark, he, with one hesitation, always took the light colour.

It is not clear from this that the Nuthatch could distinguish between a natural pod and coloured pods of the same tone as the natural one. But it seems certain that the pods coloured with dark tones were not so attractive as the light ones. Also it was evident that colours having a preponderance of yellow, and in this resembling the natural pod, received early attention.

In the hazel-nut experiment, Test X., the same thing happened: the Nuthatch began by taking colours which were dark in tone and also having a preponderance of red, both of which are characteristic of the natural hazel-nut. Here again it may be noticed that he took a dark blue in the midst of the light colours.

On the evidence one may say, I think, that the Nuthatch was influenced rather more by the tone of the colour than by the colour itself, though the kind of colour also had weight; that is to say his preference was for warm colours rather than cold hues.

It was interesting to observe that in the extracted kernel experiments, Tests IV. and V., the Nuthatch was frankly puzzled, as shown by his examination of the kernels and his decision not to eat any of them. He was familiar with edible nuts disguised in various colours and colours of different tones, so that it could not have been those features which deterred him. Can it be that the shape, unfamiliar to him in nature, prevented him?

No method can be traced in the order of choice of the Tits, for, with the exception of the Blue Tit which took the natural kernel first in each of the Tests IV. and V., they carried off the kernels (and the pods in Test III.) without reference to their tones or colours, to which they seemed indifferent. I would suggest that the explanation lies in the omnivorousness of the Tit family.

In Tests VI., VII. and VIII. with complementary colour, the Great Tit, with two exceptions, took the natural nut in preference to those coloured with the complementary hue.

In Test IX. he took the pods, with one exception, which, though painted with the complementary colour, were the same in tone to the natural pods, clearly showing that it had a perception of tones.

Finally, smell could not have helped the birds, for the paint used was ground in fish oil, the smell of which was far from resembling the odour of the natural pods or kernels, while the carbolic soap imitations were quite distinctive.