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Species and individuals in the perceptual world of monkeys

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Abstract. When a monkey is given the choice of looking at a novel picture or a blank white screen he shows an initial preference for the picture which usually abates within about 200 seconds; if the picture is then changed for another his preference revives. The level of preference for the second picture depends on the degree to which it is perceived as 'similar' to or 'different' from the first. This technique has been used to investigate how rhesus monkeys classify pictures of animals, and in particular the extent to which they differentiate between individual animals of the same species. Two classes of animal pictures were used, namely pictures of other rhesus monkeys and pictures of domestic animals. The results indicate that inexperienced monkeys, to whom the domestic animals are unfamiliar, treat individual domestic animals of the same species as being closely similar; they treat individual monkeys, on the other hand, as being quite different from each other. Experienced monkeys, however, who have been exposed over the course of 6 months to many further pictures of animals, come to treat *all* individuals as different from each other, so that one pig, say, is now seen as being as different from another pig as is one monkey from another.

1 Preface

This paper describes experiments related to the problem of subjective bias in the classification of visual stimuli, and how this may be modified. It is concerned specifically with bias in 'perceptual acuity'—the extent to which particular features of a figure are noticed or ignored. Subjective bias of this kind is a familiar enough phenomenon, evident for instance in the proverbial failure of Englishmen to see the differences between Chinese faces or in the ability of Eskimos to differentiate thirteen kinds of snow.

I have investigated how monkeys respond to the detail in pictorial stimuli. Since the experimental method is not a familiar one, the paper begins with some background information on the use of a 'preference technique' and the way in which this technique lends itself to the study of perceptual classification.

2 Background and introduction

When monkeys are given the choice of looking at a picture or a blank white screen (matched in subjective brightness) they usually show an initial preference for the picture; this preference dies away gradually over a few hundred seconds. Figure 1 shows the typical pattern, based on results obtained from six monkeys with 92 pictures of animals. Here the preference for each picture, measured in a way to be described, has been followed for 200 s, with a 20 s break in the test after the first 100 s. As may be seen, the decline in preference is roughly exponential, with a slight, but significant, recovery after the break.

I have found that, provided the picture is novel, the preference is almost always close to 100% for the first few seconds but that the subsequent decline depends in predictable ways on the specific content of the picture. In general, the greater the amount of detail in the picture and the more meaningful it is, the longer the monkey will continue to look at it. And with meaningful pictures the preference depends on what the picture represents. Figure 2 shows the results of two separate experiments: the graphs on the left show the preferences over the first 100 s for either photographs

of country landscapes or photographs of wild animals, and those on the right show the same thing for either photographs of domestic animals the right way up or photographs of comparable animals turned upside down. The preferences are reliably higher for pictures of animals than for pictures of landscapes ($p < 0{\cdot}01$), and they are reliably higher for pictures of animals the right way up than for pictures of animals upside down ($p < 0{\cdot}02$, t tests, two-tailed). Since the stimuli which were compared in both these experiments were chosen to be more or less equally complex, the differences in response almost certainly stem from the fact that the pictures, as representations, had differing significance for the monkeys. The curves look very much like classical habituation curves, yet no theory which proposes that all the monkey is doing in looking at the picture is to build up an engram of the physical stimulus—to commit it to memory—can plausibly account for such results. No doubt the monkey is indeed learning from the picture, and when he shows a continuing preference for it he does so because it still has something new to tell him, but it only has something new to tell him while he is still prepared to heed it. In some pictures the details command attention, in others only the grosser features do so.

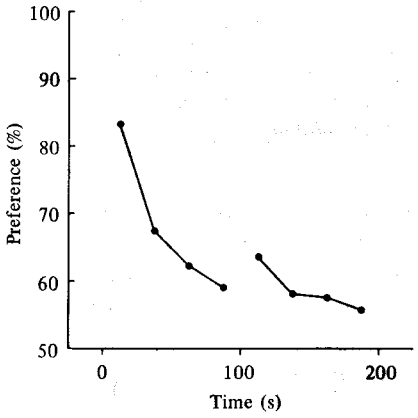

Figure 1. Mean preference as a function of time since the introduction of the picture, based on results from six monkeys presented with 92 pictures of animals. The gap corresponds to a 20 s break after the first 100 s.

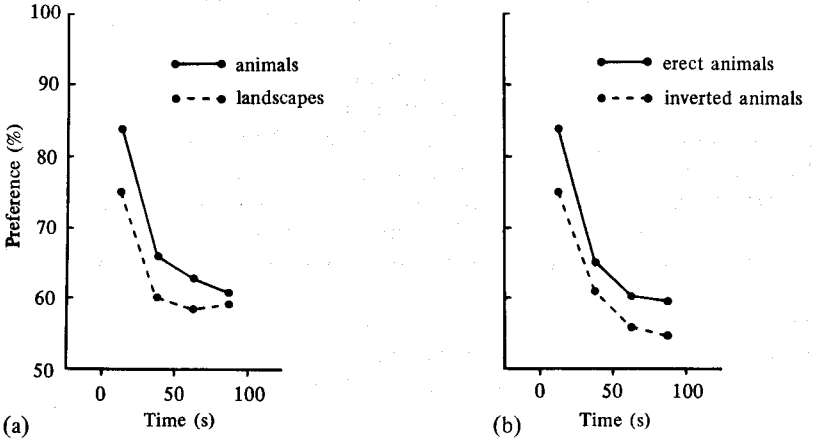

Figure 2. Mean preferences over the first 100 s, based on results from six monkeys presented with (a) 16 pictures of animals and 16 of landscapes, and (b) 6 pictures of erect and 6 of inverted animals.

Monkeys, like men, may be assumed to look at and remember the world in a way conditioned by the *categories* they use. Subjective category systems act as selective filters on experience, determining among other things the range and type of features which are regarded as important. According to the nature of the stimulus material the monkey will sometimes make one kind of distinction, sometimes another; he will attend sometimes only to a few salient features, but at others to the subtler details. Which way it goes will depend on what the material means to him in terms of past experience and present needs. It seems reasonable to suppose that monkeys generally look more closely at pictures of animals than at pictures of landscapes; the results suggest that the same holds true for pictures of erect animals as against pictures of inverted ones.

If subject matter affects the level of perceptual analysis in this way, the effect ought to show up in the response—or lack of it—to a small *change* in the picture. We might predict for instance that a monkey would be more likely to notice the difference between two pictures of similar animals than the difference between two similar landscapes. In general we might expect him to treat two pictures which are similar in form, but different in detail, either as interestingly different or as closely similar according to what they represent, and hence the sort of category system he brings to bear.

It is with such questions of perceived similarity and difference that this paper is concerned. The technique I used was one which exploits the importance of 'novelty' as a determinant of preference. Earlier work (Humphrey, 1972) showed that if a monkey is preexposed to a particular picture, his preference for the same picture in a subsequent choice test is dramatically reduced. In the present study I examined the effect of preexposure to one picture on the preference for a different one. Specifically, the monkey was given the opportunity to look at one picture until his preference for it had abated, and then in the course of the same testing session the first picture was changed for another. In this situation the preference always revives, at least transiently, when the second picture is introduced, but the strength of preference for the second picture depends on how different it is from the first. If, in an extreme case, the second picture is merely a mirror image of the first the revival of interest is very small, whereas if the two pictures are unrelated the revival of interest is high. All the evidence suggests that the extent to which the preference for the second picture is reduced by exposure to the first is monotonically related to perceived similarity between the two pictures. In other words the preference for the second picture depends (in this situation) on how much new it has to say. That, at least, has been my working assumption—though I have no *independent* measure of perceived similarity with which to validate it.

The experiments to be described were concerned with the perception of similarity and difference between pictures solely of animals. I used two classes of pictures which I guessed the monkeys might tend to categorise in rather different ways, namely pictures of domestic animals which were initially unfamiliar to the monkeys and pictures of other rhesus monkeys which, as a class, were familiar to them from the start. I expected to find that in general the monkeys would treat individual animals of the same species as being more similar to each other than individuals of different species; the main goal of the experiments was to see whether they would treat individual monkeys as being *as* similar as individual members of an unfamiliar species.

The results of the first experiment indicated that the monkeys drew much finer distinctions between individual monkeys than between, say, individual cats or individual dogs. The explanation for this finding could take several forms. It might be (i) that the monkeys were in some sense predisposed genetically to be specially

discriminative with regard to other monkeys, or (ii) that they had learned to be so as a result of differential reinforcement in a social situation, or (iii) that they had learned to be so as a result merely of visual exposure to other monkeys throughout their earlier life. In order to examine the third possibility, the experiment was repeated with the same subjects 6 months later, while in the meantime they had been exposed in the course of other experiments to a further 87 pictures of different animals. The results of this second experiment indicated that a change had come about and that the monkeys now treated individual cats and dogs as being as different from each other as individual monkeys.

3 Methods and experimental design

The method for measuring the monkeys' preferences for pictures has been described in detail in an earlier paper (Humphrey, 1972). The method, briefly, was as follows. The monkey sat in a small dark chamber (figure 3) with a screen (40 cm × 40 cm) at one end onto which could be projected either the picture or a blank white field of light of the same subjective brightness. The monkey controlled the presentation of the two stimuli by pressing a button: successive holds on the button produced the two stimuli in strict alternation. Thus, when the monkey first pressed the button he might get, say, the picture, which would stay on as long as he held the button down; when he let go the picture would go off and the next press would then produce the blank field; the next press would produce the picture again, and so on. After every 100 s of exposure to the stimuli (a cumulative total of 100 s, no matter how it was distributed) the houselights came on in the chamber and the monkey was given a rest for 20 s, during which time two peanuts were delivered to him. In all basic details the procedure was the same as that used in the earlier study.

The monkeys in this situation tended to alternate fairly rapidly between the two stimuli, averaging about 25 alternations per 100 s of exposure. Preference for the picture was measured as the ratio of the total time spent with the picture to the total time spent with both stimuli, over a defined interval.

Each experimental session had the following form. The session lasted for 500 s (5 bouts of 100 s of total exposure). The first 100 s was a period of adjustment, during which every press on the button produced the blank field with no alternative. A picture of an animal was then introduced and for the next 200 s the monkey was free to view this picture or the blank screen as he chose. After 200 s of the first picture it was replaced by a second picture and the monkey then had a further 200 s of choice. Two classes of 'stimulus change' were investigated: (i) change from an animal of one species to an animal of another, (ii) change from an animal of one species to a different individual of the same species. In addition, in the first experiment a 'no change' condition was included where the picture remained identical for the full 400 s; in the second experiment the 'no change' condition was replaced by a 'mirror-image change' condition where the second picture was simply a right-left reversal of the first.

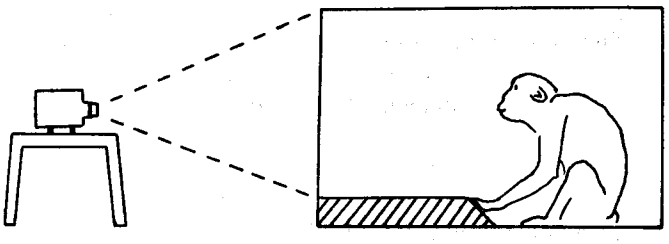

Figure 3. Testing chamber.

All the pictures were coloured photographs, showing a single animal against a relatively featureless background. Besides the pictures of rhesus monkeys there were pictures of five species of domestic animals, namely pigs, dogs, horses, sheep, and cats. While all the animals within a particular species were 'typical' (to my eyes) of that species, the different individuals were deliberately chosen to be different with regard to such features as coat colour, facial expression, bodily proportions, shape of ears, size of horns, etc. In other respects care was taken that each of two pictures used in one experimental session (whether of the same or different species) were as nearly matched as possible, being roughly equated for the animal's background, its size and position in the field, its orientation and its bodily posture (for instance, if one picture showed the animal lying down, so did the other; if one animal was full face on, so was the other).

Since one of the main objects of the study was to discover whether pictures of rhesus monkeys would be treated differently from pictures of domestic animals, the experimental series was designed so as to obtain as much data on monkey pictures as on pictures of all the other five species together. The simplest way of doing this, whilst keeping a balanced design, was to have the cases of 'across-species change' limited to a change from a monkey to one of the domestic animals or vice versa. Accordingly, in both experiments I and II the subjects were given 30 sessions, 5 within each of the following 6 categories:

Across-species change

(i) monkey → domestic animal,

(ii) domestic animal → monkey.

Within-species change

(i) monkey → monkey,

(ii) domestic animal → domestic animal of same species.

No change (experiment I) or mirror-image change (experiment II)

(i) monkey,

(ii) domestic animal.

Each of the species of domestic animal was represented once only in each appropriate type of session. Thus, altogether in the course of each experiment the subjects were exposed to 25 different monkeys and 5 different members of each species of domestic animal. The order of the different types of session and the order of presentation of the different species were randomised within the limits of the experimental design.

Before the start of experiment I four out of the six subjects were experimentally naive and had never seen pictures of either monkeys or domestic animals; the other two had been extensively tested in an earlier study, in the course of which they had been exposed, approximately one year previously, to a few animal pictures, including 6 pictures of monkeys, 2 pictures of dogs and 1 picture of a horse (see section on subjects). Experiment I was completed in 3 weeks. During the following 6 months all the subjects took part in a series of preference experiments (not reported here), during which they were exposed to 12 pictures of domestic animals, 75 pictures of wild African animals (e.g. zebras, hippos, leopards—many of which were not unlike the domestic animals), 24 pictures of landscapes, and a variety of nonrepresentational pictures. Most of these pictures were shown in the normal way, though 32 of the animals were upside down, a few were cut in half, and a few were 'composite animals' made up for instance of the head of a hippo and the tail of a giraffe. There were no monkey pictures included in the series. Experiment II was done 2 weeks after the last experiment of this series.

4 Subjects

The subjects were six young male rhesus monkeys (*Macaca mulatta*). They were kept in pairs in the home colony. Two of the subjects were, as just mentioned, veterans of earlier experiments who had already taken part in over 300 testing sessions involving a variety of visual stimuli (see Humphrey, 1972) and, more recently, a variety of auditory stimuli. The other four had not previously been tested with any visual stimuli other than those used in initial training. The training procedure for these new monkeys was the same as that described in the earlier paper, and involved exposure to blank fields of light of different brightness, followed, just prior to experiment I, by a few nonrepresentational pictures. There were no important differences in the results obtained in the present experiments from the old and the new monkeys.

5 Presentation of data and statistics

The results are presented in the form of graphs where preference for the picture is plotted as a function of time since it was introduced, averaged for all six monkeys over a number of sessions. The preference for the picture is given in terms of the percentage of time spent with the picture as opposed to the blank screen in each successive 25 s of exposure. Though the preference for each picture was followed for 200 s, several of the graphs refer only to the first 100 s during which the preferences were highest.

Where a statistic is given for the significance of the difference between two conditions, it was computed as follows. For each subject the difference between the mean preference in each condition was calculated, and a t test was run for the six subjects as a group (giving 5 degrees of freedom) to see if the differences were significantly different from zero. All statistical comparisons between conditions are based on the average preference over the first 50 s with the picture, since it was during this initial period that the differences between conditions were most marked and that the variance between subjects was least. All probabilities quoted are two-tailed.

6 Results

6.1 *Experiment I*

Figure 4 illustrates the basic phenomenon under investigation—the response to stimulus change. The right-hand graph shows the pattern of preference when there was *no* change in the picture, averaged over all the sessions of this kind; the left-hand one shows the pattern when the picture changed after 200 s, averaged over all the sessions

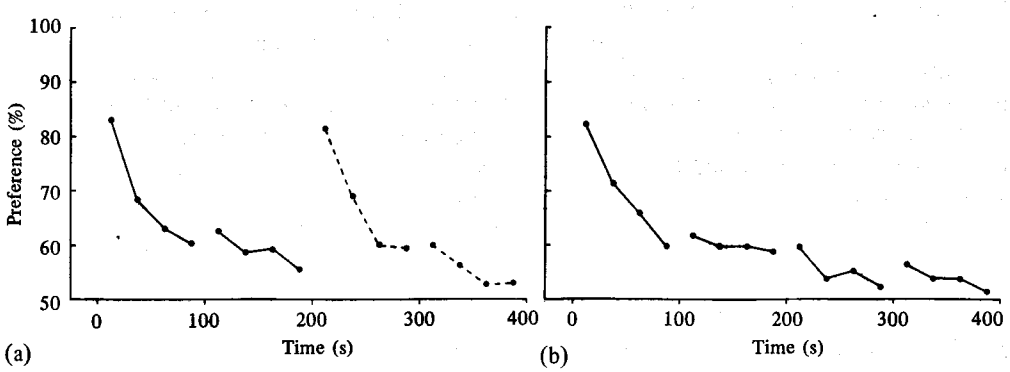

Figure 4. Experiment I. Mean preferences with (a) a new picture introduced after 200 s, and (b) the same picture throughout. Results averaged over all the sessions involving across- or within-species change (see text).

involving across—or within—species change. That in general there was renewed preference for a new picture is apparent enough. The question is: to what extent was the preference affected by the kind of preexposure?

There are three conditions to be compared: (i) the case where the picture came first in the session, not preceded by any other picture, (ii) the case where the picture came second, preceded by one of an animal of the same species, and (iii) the case where it came second, preceded by one of an animal of a different species. The data for making these comparisons are presented in figure 5 which shows the preferences during the first 100 s in each of the three conditions; the data for pictures of monkeys and those for pictures of domestic animals are shown separately.

Consider first the pictures of domestic animals. The results show no significant difference between the levels of preference for a picture which came first, preceded by no other picture, and for a picture which came second, preceded by a picture of a monkey. However, for a picture which came second, preceded by a picture of an animal of the same species, the level of preference was considerably lower than in either of the other two conditions ($p < 0{\cdot}01$ for each comparison). This may be taken to indicate that the subjects treated two domestic animals of the same species as being closely similar. Nonetheless it cannot be argued that the subjects simply did not notice the change between two animals of the same species, for even in this condition the preference for the second picture was significantly higher than at the equivalent point of the session in the 'no-change' condition for domestic animals ($p < 0{\cdot}05$).

Then consider the pictures of monkeys. Here the results were quite different, there being no significant differences between any of the three conditions. In other words the preference for a monkey picture was just as high whether it was preceded by another monkey, by a domestic animal, or by no picture at all.

When the response to pictures of monkeys is compared to that to pictures of domestic animals it turns out that there were no significant differences, except in the case of a domestic animal preceded by another of the same species. The preference in this latter case was significantly lower than the preference for monkeys in all three conditions ($p < 0{\cdot}05$ for each comparison).

Though the main effects here are in the direction that might have been predicted, some aspects of the results are rather surprising. It seems odd, for instance, that there should have been no drop at all in the preference for a monkey preceded by another monkey; it also seems curious that the preferences for monkeys should have been no higher than those for domestic animals in at least two of the conditions. These findings, which I think may be related, will be taken up in the discussion.

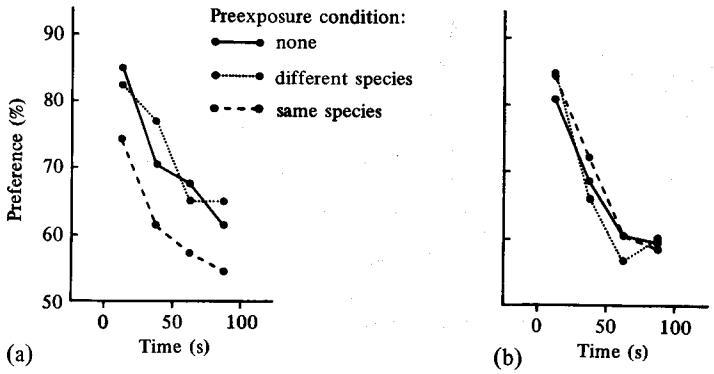

Figure 5. Experiment I. Mean preferences over the first 100 s for pictures of (a) domestic animals, and (b) monkeys, under 3 different preexposure conditions.

6.2 *Experiment II*

Between experiments I and II the subjects were exposed to a feast of additional pictures, including 87 pictures of different animals, as detailed in the section on experimental design.

Experiment II was exactly the same as experiment I except for the substitution of the 'no-change' condition by a 'mirror-image change' condition. Figure 6 shows the general pattern of performance in the same way as figure 4 for experiment I. As may be seen, the preference was considerably reduced when a picture was preceded by its mirror image (for both domestic animals and monkeys the preference was lower in this condition than in any other, $p < 0{\cdot}05$ or less).

Figure 7 shows the preferences during the first 100 s in the three conditions other than 'mirror-image change'. Comparison of figure 7 with figure 5 reveals a striking change between experiment II and experiment I: in experiment II the preference for a domestic animal was no longer reduced by preexposure to another animal of the same species. In fact, in experiment II the subjects apparently treated every picture, apart from the mirror images, as equally novel, no matter what the preexposure condition and no matter whether it was a picture of a monkey or a domestic animal—all the curves of figure 7 lie almost on top of each other.

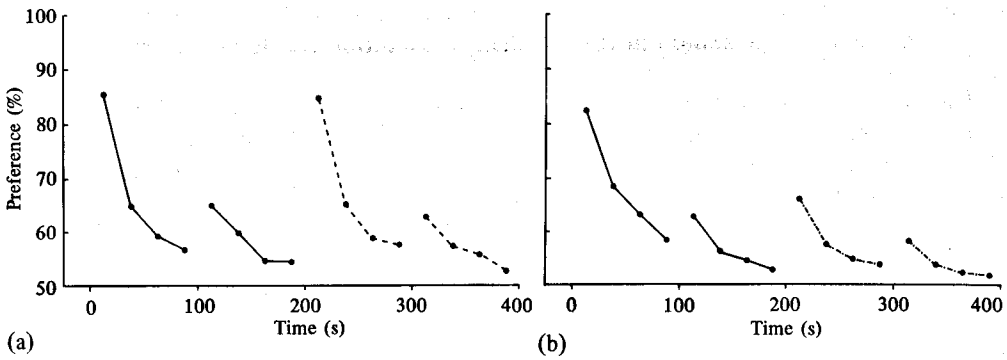

Figure 6. Experiment II. Mean preferences with (a) a new picture introduced after 200 s, and (b) a mirror image of the same picture introduced after 200 s (see text).

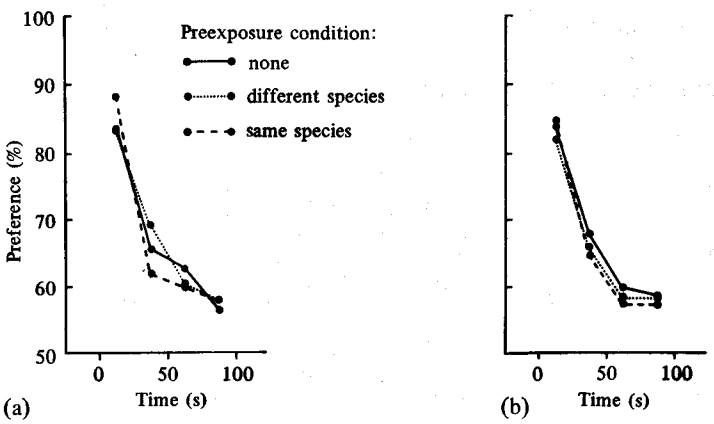

Figure 7. Experiment II. Mean preferences over the first 100 s for pictures of (a) domestic animals, and (b) monkeys, under 3 different preexposure conditions.

7 Discussion

The results indicate that initially the subjects drew fine distinctions between individual monkeys but relatively crude distinctions between individual domestic animals of the same species; six months later, however, after considerable interpolated exposure to different animals, they drew fine distinctions also between individual domestic animals.

Let me comment first on the findings in the initial stage—the results of experiment I. In line with the argument developed in the introduction I would suggest that the difference in the results for monkeys and domestic animals was a function of the different ways the subjects categorised them. With domestic animals the subjects initially attended only to the grosser 'species-specific' characteristics and ignored those features which contribute to individual differences, while with monkeys they always attended to the individual details. At this stage then the subjects classed a cat simply as 'a cat' and a dog simply as 'a dog' but they classed a monkey as, say, 'a juvenile female making an appeasement gesture'.

There are however certain problems raised by this interpretation: (i) If the subjects looked at monkeys in greater detail than domestic animals, why were the preferences for monkeys not higher than those for domestic animals in every condition? (ii) Since the subjects must have perceived the gross similarity between two monkeys, even if they also noticed the individual differences, why was there no reduction in the preference for a monkey when it was preceded by another monkey? There is a way of accounting for both these apparent anomalies, which is to suppose that, because the subjects were familiar from the start with the gross features of monkeys, the 'monkeyness' of a monkey never had any novelty value for them. In that case the preferences for monkey pictures would have been determined in every condition *only* by the individual details. On this supposition, the first problem is answered by suggesting that the subjects in fact took about as long to take in the details of any individual monkey as they did to take in the gross features of a novel species of domestic animal, and the second by suggesting that a monkey, preceded by another monkey, carried just as much new information as if it had not been so preceded.

The results of experiment II indicate that, after the intervening experience with pictures, the subjects came to treat domestic animals in the same way as they had previously treated monkeys. In other words they now made distinctions beyond the 'species level' in every case. It seems reasonable to suppose that this change came about as a specific consequence of seeing the additional pictures—the fact that the two older and more experienced subjects gave results exactly parallel to those of the four naive ones certainly suggests that the change was not a consequence simply of increasing maturity, of increasing experience in the testing apparatus, or of nonspecific exposure to visual stimuli. How, then, did the intervening experience effect this change?

Everything points to the change being an example of what Eleanor Gibson calls 'perceptual differentiation' (Gibson, 1969): "A closer correspondence between the sources of stimulation and perception is achieved ... detection of properties, patterns, and distinctive features not previously registered". But, as an example of perceptual differentiation, the present case is unusually interesting, for the differentiation was brought about by experience which was special in two ways: (i) the experience consisted merely of exposure to pictures in a series of preference tests, without the subjects being given any external inducement to 'better' their discriminative ability, (ii) the pictures the subjects were exposed to were not, for the most part, pictures of domestic animals but pictures of wild animals of Africa.

That the intervening experience proved effective, even though it involved no overt reinforcement, is perhaps not surprising. For the very fact that the subjects regularly showed *preferences* for new pictures indicates that attention to visual detail—and presumably discrimination—can be its own reward. I would suggest, indeed, that

every session with a new picture was in effect a 'practice session' through which the subjects, indulging in a sort of self-rewarding visual play, progressively improved their discriminative powers. Improvement of discrimination as a result of 'mere exposure' is known to occur in the context of 'imprinting' (see Bateson, 1973).

That the experience was effective, although it involved exposure chiefly to animal species different from those which were tested in experiment II, is more of a surprise. Admittedly the experiments do not provide unequivocal evidence as to what particular aspects of the experience were important. Besides the 75 wild animals (and landscapes and abstracts) the subjects did in fact see 12 pictures of domestic animals in the intervening period and they had, of course, already seen 25 domestic animals in the course of experiment I; the fact that some of the animals were presented in odd ways (upside down, cut in half, ...) further complicates the situation. But assuming, as seems likely, that exposure to the wild animals was an influential factor, it is important to stress that many of these animals were actually not all that different from the domestic animals: there are obvious resemblances, for instance, between a zebra and a horse, a jackal and a dog, a hippo and a pig, a cheetah and a cat ... Just how different the 'practice' material can be (or has to be?) from the test material to get evidence of perceptual differentiation remains to be seen in future experiments.

I suggested in the introduction that the finding that the subjects from the very beginning drew fine distinctions between individual monkeys might be explained in terms of visual exposure to other monkeys throughout their earlier life. The evidence of emergent differentiation in the perception of domestic animals clearly lends credence to this view. But there are of course other possibilities. Sackett (1970), for instance, has argued that monkeys have an innate predisposition to respond to the individual features of other monkeys. In man, on the other hand, the schemes of classification applied to other human beings are the product, at least in part, of social learning, backed up by the conventions of culture and language. Social factors of a lower order—differential reinforcement in a social situation—could well be responsible for the monkeys' initial classificatory bias. No doubt there may be other explanations still. Nonetheless, my findings indicate that mere exposure to other monkeys could provide a *sufficient* explanation.

In some circumstances at least, insensitivity to visual detail seems to be simply a consequence of visual inexperience. A naive subject may declare that "When you've seen one, you've seen them all", but the experienced subject is likely to make a more modest and more accurate claim: "When you've seen a hundred, you've only seen a hundred".

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