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How monkeys acquire a new way of seeing

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Abstract. In an experiment on perceptual learning, monkeys were given the opportunity to watch on television the 'private behaviour' of another monkey (which did not know it was being watched). The subjects were shown monkey X for twenty sessions in a row, followed by monkey Y for twenty sessions, followed by monkey X again for twenty sessions. The subjects' 'interest' in the stimulus monkey remained roughly level within each block of twenty sessions, but *increased* in a step-like way at the changeover from X to Y, and again from Y to X. These results are interpreted as evidence that the subjects gained little or no extra insight into the nature of private behaviour through watching the same monkey in successive sessions; the critical factor in their perceptual education was the comparison between one monkey's behaviour and another's.

1 Introduction

A short while ago there was a game in fashion: people were given the answers to unstated questions and were asked to guess what the questions might have been. For example, to the answer "Dr Livingstone I presume" the question could be "What is your full name Dr Presume?", or to the answer "9 W" the question could be "Does your name begin with a V Herr Wittgenstein?". With these and many other answer–question pairs the subject, when he hits on (or is told) the question, experiences a peculiar sense of revelation: the answer, which was previously a trite, ambiguous or senseless phrase, becomes charged with unexpected meaning.

The game can be played with visual stimuli as well as words. In its visual form it has been known to experimental psychologists for many years. Figure 1, for example, shows Porter's famous "Hidden Man" (Porter 1954). When the subject hits on (or is shown) how to look at this picture the mosaic of blotches becomes a representation of the head and shoulders of a bearded man. But why should we suppose there is a parallel between discovering *how to look* at a picture and discovering the *question* which will make sense of an answer? We do so on the following grounds.



Figure 1. The Hidden Man (after Porter 1954).

When a subject attends to a visual stimulus—or indeed any other sensory event—he looks for information, i.e. the resolution of uncertainty. But uncertainty can exist for the subject only in so far as he is alert to possible alternatives. If someone tosses a coin it will often be true that he is uncertain whether it will come down heads or tails, but it will generally not be true that he is uncertain whether the head will be facing North, South, East, or West; so the outcome 'heads or tails' conveys information, but the outcome 'facing North, South, East or West' does not. Likewise, the information a subject gets from a visual stimulus depends on whether and in what ways he is uncertain of its meaning, and hence to what questions he sees it as an answer. Ask no questions and you will get told no lies—and no truths either.

Everyone questions the world in his own way. And because no one has either the inclination or the knowledge to ask more than a restricted set of questions, everyone lives surrounded by answers to questions which they never ask. Thus someone may look at tracks in the mud and fail to see the evidence of a fox catching a hare, or he may listen to a symphony and fail to see how the movements hang together, or he may run his fingers over a text in Braille and fail to distinguish the individual letters. And so it is with 'higher' levels of perception too. Many people before Darwin must have observed the finches of the Galapagos islands without seeing them as evidence of the adaptive radiation of species, many people before Archimedes had had baths...

The problem for psychology is to know how an individual man or animal constructs his perceptual questionnaire. Babies are born, presumably, with few if any questions in their heads. The questions come with experience. What kind of experience?

In an earlier experiment (Humphrey 1974) we studied the way in which monkeys perceive photographs of domestic animals (cats, dogs, sheep, horses, and pigs). We found that initially the monkeys paid little attention to the individual characteristics of the domestic animals; when, however, these same monkeys had been exposed over a period of several months to a large number of photographs of animals of other species (wild animals of Africa) they began to see in the domestic animals details which they had previously ignored. Thus at first they would treat one cat as being nearly identical to any other cat, or one dog as being nearly identical to any other dog; but after being exposed to the 'practice' pictures they started to treat each new cat and each new dog as if it were indeed a novelty. They had begun to ask new questions; questions not simply about the animal's generic character but also about its individual features. We concluded from that experiment that mere exposure to the right kind of practice material had been sufficient to instruct the monkeys in this new way of seeing. We could not, however, specify what it was that constituted the 'right kind of practice material'. The practice pictures were *different* from the test pictures insofar as they showed animals of different species; but at the same time they were *similar* to the test pictures insofar as they showed animals rather than, say, plants. Did it matter that the practice pictures were similar to the test pictures? Did it matter that they were different?

There were good grounds for supposing that it mattered that the practice pictures were in some respects similar to the test pictures. Before the experiment began the monkeys had, after all, had a lifetime's experience of looking at things which were not in any way related to pictures of domestic animals, and yet they still remained perceptually naive about cats, dogs, etc.; why should the practice pictures have proved so influential if it were not that they bore *some* resemblance to the test pictures? But whether it mattered that the practice pictures were in other respects different from the test pictures we could not say. We simply did not have the requisite experimental control group, namely monkeys which were, for example, tested on cats, then exposed to nothing but further cats for weeks on end and then tested on cats again. It may be that that is something which we should have tried. But there is a snag in it.

If monkeys are shown cat after cat after cat they soon get hopelessly bored. The very fact that initially they see all pictures of cats as being closely similar to each other means that they have no incentive to go on looking at them—and if they do not look they clearly cannot learn.

The present paper describes a new and in some ways more informative experiment. We have studied how monkeys perceive the 'private behaviour' of another monkey. By 'private behaviour' we mean the behaviour of an isolated monkey which does not know it is being watched. When a monkey is left on its own, out of sight of others, it tends to get up to rather strange things: it may pull faces, play with its own body, do acrobatics, etc.—behaviour which would be quite unusual in a social situation. We guessed that other monkeys would be eager to be covert spectators of such a performance. But, more important, we thought that they would, if given the opportunity, grow increasingly sophisticated at seeing what was going on: they would learn to see a 'pattern' in the bizarre behaviour of the stimulus monkey, to see in it answers to questions which they would not at first have thought of asking. Further—and this is what gives this experiment an edge over the earlier one—the spectacle of a living monkey was likely to provide a continuing incentive to the subjects to go on looking even if the stimulus monkey remained the *same* monkey day after day. Thus we were in a position to ask the question which we had no means of asking in the earlier experiment: Would the experience of watching a single stimulus monkey—call it monkey X—over an extended period be sufficient to teach the subjects all there was to see in that particular monkey's behaviour? Or would the subjects gain added insight into monkey X's behaviour if they were given the opportunity to watch a different monkey—monkey Y—before returning to monkey X?

As an index of how the subjects were perceiving the stimulus monkey we measured their 'interest level', defined in terms of their preference for looking at the picture of the monkey as against looking at a blank white screen. There is good reason to think that this measure correlates directly with the subjective information content of the picture (cf Humphrey 1972, 1974).

The plan of the experiment was as follows. The subjects were given the opportunity to watch monkey X for twenty sessions in a row, then monkey Y for twenty sessions, and then monkey X once more for twenty sessions.

2 Subjects and methods

The subjects were three adolescent male rhesus monkeys, *Macaca mulatta,* imported from India a year previously (monkeys G, A, and M). The 'stimulus monkeys' were two adolescent males from the same group (monkeys R and C). All monkeys lived in pairs in the home colony, the two stimulus animals together.

When one of the stimulus monkeys was being used in the experiment it was removed from its home cage and placed on its own in a separate cage which was visually isolated from the rest of the colony. Its 'private behaviour' was monitored by a television camera which displayed the isolation cage on a screen in the subjects' testing chamber (figure 2). Before the start of the experiment the stimulus monkeys were placed in the isolation cage for several long periods so that they should become accustomed to the situation; during the course of the experiment the appropriate monkey was placed in the isolation cage about an hour in advance of the beginning of the daily testing sessions so that it should have time to settle down. The overall pattern of each monkey's behaviour seemed to our eyes to be remarkably stable both between and within sessions. The two monkeys, R and C, did not behave in quite the same way: R was on the whole more active and boisterous, C more contemplative. In our view R was slightly the more interesting of the two.

The subject in the testing chamber controlled the presentation of the television picture by pressing a button: successive presses on the button produced alternately either the picture or a blank field of the same brightness for as long as the button was pressed down (for further details see Humphrey and Keeble 1974). Each testing session lasted for 500 s, during which time the subjects typically alternated between the picture and the blank field 100–150 times. The subjects' preference for the picture was measured as the proportion of the whole session for which the picture was kept on.

Prior to the experiment the subjects had had considerable practice in the testing chamber, initially with projected photographs as stimuli and more recently with television pictures taken on-line from the BBC (the Test match, the Liberal Party Congress, etc). They had also had some practice with the closed-circuit television setup, including a few sessions with the camera pointing at an empty cage or at a cage containing *two* monkeys. They had not seen private behaviour on television; nor, of course, had they seen it in real life. Immediately before the experiment the subjects were given a complete break from testing for a week.

The subjects were tested twice each day, in the morning and afternoon. The stimulus monkey was monkey R on days 1 to 10 (stage RI), monkey C on days 11 to 20 (stage CI), and monkey R again on days 21 to 30 (stage RII).

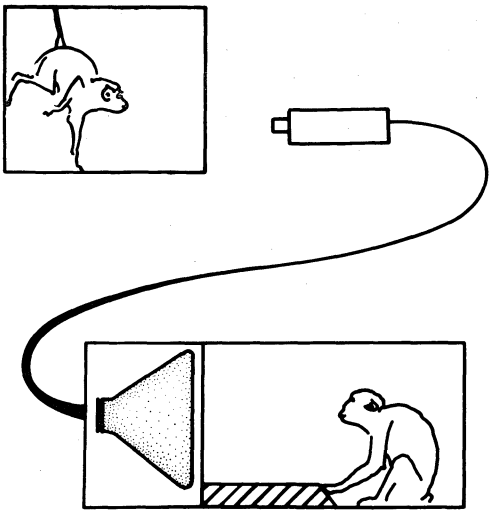


Figure 2. Schematic view of the testing situation.

3 Results

Figure 3 shows the results for the three subjects in terms of mean preference, averaged over the twenty sessions comprising each stage of the experiment. Statistical comparisons may be made between the levels of preference shown at stages RI, CI, and RII using the Wilcoxon matched-pairs test (with the results for day 1 matched to those for day 11, etc). This is done for each subject individually in table 1.

No great weight should be attached to the comparison between stages CI and RI, since it is possible that monkey C would have been, whatever the circumstances, more interesting to the subjects than monkey R. The important comparison is between stages RI and RII, i.e. the two stages which featured the same monkey; between these stages all three subjects showed a highly significant increase in preference ($p < 0{\cdot}01$ for each of them).

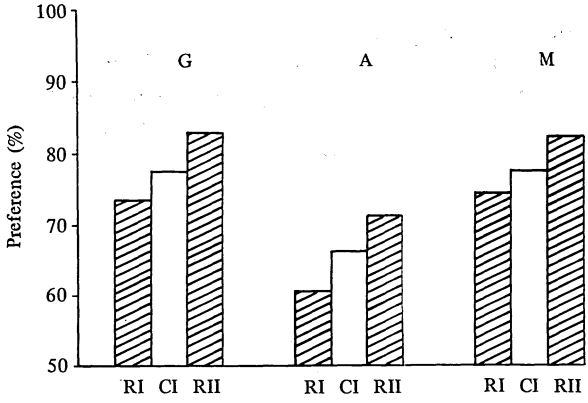


Figure 3. Mean preference levels, averaged over ten days (twenty sessions) comprising each stage of the experiment.

Table 1. Comparisons for each subject of preference levels between the different stages (Wilcoxon test, two-tailed probabilities).

Subject	Stages		
	RI to CI	CI to RII	RI to RII
G	up $p < 0{\cdot}02$	up $p < 0{\cdot}02$	up $p < 0{\cdot}01$
A	up $p < 0{\cdot}05$	up $p < 0{\cdot}01$	up $p < 0{\cdot}01$
M	up n.s.	up $p < 0{\cdot}05$	up $p < 0{\cdot}01$

What was happening? Did this increase in preference for monkey R reflect, perhaps a continuous day-to-day trend upwards over the course of the experiment? Figure 4 shows the change in preference from the first to the second half of each stage for the three subjects taken together. There was a slight downward trend during stages RI and CI, while stage RII was roughly level. By far the major effect appears to have been a 'quantal' increase in preference immediately following the changeover from R to C and again from C to R.

We interpret this pattern of results as evidence that the subjects gained little or no extra insight into the nature of private behaviour through watching the same monkey in successive sessions. The critical factor in their perceptual education was the opportunity they were afforded to compare one monkey's behaviour with another's.

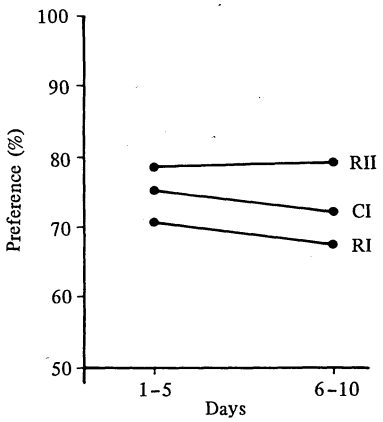


Figure 4. Changes in preference within stages RI, CI, and RII for the three subjects taken together. Note that, in real time, stage RI was followed by CI, and CI by RII.

4 Discussion

Suppose that human subjects were to be given the chance to view the private behaviour of another human being: the behaviour, let's say, of a man in his bath. Suppose, specifically, that there were to be a daily television programme which from 10.00 to 10.15 each evening showed a cabinet minister in his bath. This programme, "Bath at Ten", might feature different ministers on different days, starting perhaps with the following schedule: a week of the Chancellor of the Exchequer, followed by a week of the Home Secretary, followed by another week of the Chancellor of the Exchequer. If the results of the present experiment are anything to go by, we might predict that the audience rating for the programme would grow between the first week and the third. How, if it were so, should we account for this phenomenon?

At one level the two ministers would each present a similar spectacle: a naked man in a tub of water, washing himself. But there would almost certainly also be ways in which they were significantly different. Thus the Chancellor might be much dirtier than the Home Secretary, he might have a deeper bath, he might sit at the tap-end rather than the far end, he might use a sponge rather than a flannel, he might splash about much more, he might hum the National Anthem rather than Jerusalem... Now, a naive viewer, during the first week of seeing the Chancellor, could hardly be expected to be in any way inquisitive about such differences. Why should he notice that the Chancellor was sitting by the taps if he had never seen someone sitting the other way round? Why should he notice that the Chancellor did not wash behind his ears if he had never seen someone else who did? But when the viewer came back to seeing the Chancellor after the intervening week of the Home Secretary, he would have become alert to a whole new range of possibilities. The microstructure of the bathtime behaviour would have been brought out by the *comparative* evidence.

Comparison pervades every level of perceptual classification. We see a bath as deep—deep relative to what? We see a man as dirty—dirty relative to what? And even when perceptual judgements could, logically, have some kind of absolute meaning, it takes comparison, psychologically, to bring that meaning into prominence. No one will see a coin as 'heads' who has never seen one 'tails', no one will see a man as naked who has never seen one clothed. The Lord God was right to be suspicious of Adam when he hid himself in the Garden of Eden: "And he said, Who told thee that thou wast naked? Hast thou eaten of the tree whereof I commanded thee that thou shouldest not eat?" (*Genesis,* III, 10–11). The tree of knowledge is a branching decision tree, with *alternative* apples at the end of every branch.

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