'Interest' and 'pleasure': two determinants of a monkey's visual preferences

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Received 9 January 1973

Abstract. When given a choice between two visual stimuli (plain fields of light of different colour, photographs, cine films, etc.) monkeys show strong and consistent preferences. The strength and direction of the preferences is determined by two independent factors: the monkey's relative 'interest' in the stimuli (determined largely by their information content) and his relative 'pleasure' (determined by qualities such as colour and brightness). With an unchanging stimulus 'interest' rapidly fades but 'pleasure' (or 'unpleasure') remains stable. If the two factors are set against each other, as when a red-coloured cine film is paired with a plain white field (the pictorial content of the film being interesting, its colour unpleasant), interest over-rides pleasure in determining the observed preference. A quantitative model based on these principles predicts the behaviour in a variety of situations with great accuracy.

1 Introduction
We exploit our senses in two main ways: as sources of information about the environment and as sources of sensual or aesthetic pleasure. So, when we purposefully seek stimulation—and seek one stimulus rather than another—we may do so for two reasons: either because we find the stimulus 'informative' or 'interesting', or because we find it 'pleasant', 'agreeable', or 'beautiful'. These qualities are commonly attributed to the stimuli themselves, as when we talk of an interesting sight or a pleasant sound. Yet interestingness or pleasantness are properties wholly dependent on the *relationship* of the observer to the stimulus. "The judgement of taste", wrote Kant, "does not depend on what nature is ... but on how we look at it. If nature had produced its forms for our satisfaction ... it would be a grace done to us by nature, whereas in fact we confer one upon her" (*Critique of Judgement*, I, *58*). I suggest that, corresponding to the ways we use our senses, we should distinguish two kinds of relationship. One I call 'interest', the other 'pleasure/unpleasure'.

The relationship of 'interest' is one of active inquiry, where the observer is concerned to derive what information he can from the stimulus and discern its meaning. The relationship of 'pleasure/unpleasure' is one, less analytic and more self-centred, where the observer's concern is with the effect of the stimulus on his immediate sense of comfort and well-being. Interest or pleasure in a stimulus leads the observer to maintain his contact with it, while unpleasure leads him to reject it; interest differs from pleasure in having no negative counterpart—an uninteresting stimulus, like one which is neither pleasant nor unpleasant, evokes an indifferent response from the observer. Interest in a stimulus is maintained by complexity and novelty, and wanes if the stimulus becomes familiar; but pleasure/unpleasure may be present when the nature of the stimulus is perfectly well known. The sense of smell provides a clear example: we sniff an old bottle out of interest to discover what its contents were, but we smell a rose out of pleasure in its familiar fragrance. So, in the case of vision, sometimes we scan the evening sky out of interest in the tokens of tomorrow's weather, but at others we simply gaze with pleasure at the setting sun. I suggest the two kinds of relationship are essentially independent of each other, there being cases, say, where we take an interest in a stimulus we find unpleasant or take pleasure in a stimulus we find uninteresting.

The distinction between interest and pleasure/unpleasure, though not stated explicitly, has several times been hinted at by earlier writers. Thomas Reid in his *Essay on the Intellectual Powers of Man* wrote of the 'double province' of the senses—"to make us feel and to make us perceive". "They furnish us with a variety of sensations, some pleasant, others painful, and others indifferent; at the same time they give us a conception and an invincible belief of the existence of external objects". Closely parallel to Reid's two provinces was the dichotomy proposed by Starbuck (1921) between 'defining' and 'intimate' sensory processes, and that of Schachtel (1963) between 'allocentric' and 'autocentric' modes of perception. Aestheticians have made similar divisions, as when Roger Fry (1926) distinguished between an observer's response to what he called the 'dramatic' (storytelling) and 'plastic' (aesthetic or sensual) appeal of a painting.

Yet, while this distinction is no new idea, it has had little currency in psychological research on sensory preferences. The reason is not hard to find. For the difference between interest and pleasure/unpleasure is operationally elusive. The mere fact that a man or animal prefers one stimulus to another gives us of itself no insight as to why he does so.

This paper is about the visual preferences shown by rhesus monkeys. One of the aims of the research was to look for evidence in support of the distinction between interest and pleasure. Yet, while this was the context in which the work was done, it should be recognised that the experimental data and much of the analysis stand on their own, unprejudiced by any particular conceptual model. The background thinking has been made explicit both to provide a rationale for the experimental design and as a preamble to the subsequent interpretation. There will be those who take issue with the theorising: for them the paper provides at least some new and thought-provoking facts.

The paper has the following plan: a description of the basic method by which the preferences were measured (section 2); experiments with plain fields of light of different colour and brightness (section 3); experiments with pictures of different information content (section 4); experiments on the interaction of brightness, colour, and information content (section 5); and application of the theory to the case of preferences shown for 'focused' over 'unfocused' pictures, where an attempt is made to determine whether the monkey preferred the focused picture because he found it more interesting or simply more pleasant to look at (section 6).

2 Method and subjects

The method used throughout these experiments was essentially the same as that described in an earlier paper (Humphrey, 1971). The monkey sat in a dark chamber with a screen at one end onto which visual stimuli could be projected under the monkey's control. In any one experimental session the monkey had a choice of two stimuli. When he pressed a button, he got one of the stimuli for as long as he held the button down. When he let go, the stimulus went off, and the next press on the button produced the other stimulus. Another press and the first stimulus was restored, and so on in strict alternation. To exercise a preference the monkey had simply to hold the button down when he wanted the current stimulus, and release and press again when he wanted the other. At the end of each successive 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, the button became ineffective, and the monkey could relax for 20 s during which time 2 peanuts were delivered to him. The houselights then went off and the button became effective again. The ratio of total time spent with one stimulus to total time spent with both gave a quantitative measure of the monkey's relative preference.

The testing chamber (figure 1) was a small rectangular box, 80 cm long × 40 cm wide × 46 cm high. At the far end, covering the wall, was a ground Perspex screen, 40 cm × 40 cm, on which the alternative stimuli were projected from either of two slide or cine-projectors. The projectors ran continuously while the actual exposures were controlled by Gerbrands electronic shutters mounted in front of them. Bars across the chamber confined the monkey to a relatively small compartment at the opposite end to the screen so that he sat facing the screen, about 40 cm from it. In front of him was a sloping dashboard bearing the response button (a Grason–Stadler 'primate push button') and to the right of the button was a tray for peanuts. In the roof of the monkey's end of the chamber were two dim headlamp bulbs which served as houselights during rest periods. A television camera was mounted in front of a small lens in the wall opposite the screen so that the behaviour of the monkey could be monitored directly by the experimenter.

The course of the experiment was programmed and recorded by solid state logic modules in the next room. When the monkey entered the chamber at the beginning of a session the houselights were on and the button was inoperative. After a short while the houselights went out and the button became effective. The monkey was then free to press the button as he chose, alternating between the two stimuli and holding either as long as he wished up to a limit of 20 s, when it was automatically terminated and he had to release and press again. When he had clocked up 100 s of exposure the houselights came on for the 20 s break. The programme was then recycled for up to 10 cycles depending on the particular experiment. In the course of the experiment counts were made of the total number of alternations between the two stimuli and the total time spent with each, and these figures were printed out every 25 s. The monkey's performance was also displayed on an $X-Y$ plotter which showed from moment to moment how he divided his time between the two stimuli: the pen moved at constant speed along the X axis when one stimulus was on and at the same speed along the Y axis when the other was on, so that the overall slope indicated the preference (a slope of 45° indicating neutrality).

Two adolescent male monkeys (*Macaca mulatta*) were used as subjects. They were selected at the out-set from a group of six on the basis of their comparative tameness and the speed with which they learned how to operate the button. My excuse for using only two subjects is that their behaviour was almost identical in every situation, and those results which were statistically significant for one monkey were always significant for the other also. The similarity in the behaviour of the monkeys is discussed later on.

Outside the testing sessions the monkeys were housed in cages in the home colony, each paired with another non-experimental monkey. They were fed on a liberal diet of chow and fruit. They were unable to see other monkeys except for their cage-mate, but the cages faced a large window which looked onto a wood in which sheep and other animals were frequently in view. The monkeys were tested six days a week, usually
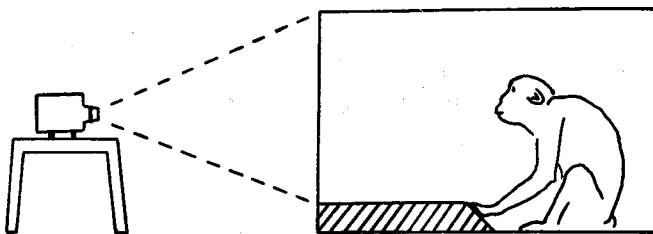

Figure 1. Testing chamber.

once in the morning and once in the afternoon. The series of experiments was lengthy, involving over 250 sessions for each monkey.

The monkeys were first trained to hold down the button in the absence of any visual stimulus for $2\frac{1}{2}$ s to obtain a peanut. They were then transferred over the course of a few sessions to the standard testing schedule; the visual stimuli during this 'training' period were plain fields of white light of different brightness. After several days practice the monkeys began to show clear preferences for the brighter stimulus. From that point on their performances settled down to a constant pattern. They usually worked with little pause and completed each bout of 100 s stimulus presentation in under 120 s. They alternated rapidly, whatever the stimuli, averaging 18 (monkey *1*) and 30 (monkey *2*) alternations per 100 s. The frequency of alternation was not in any obvious way related to the degree of preference shown. Even when the monkeys showed a very strong preference for one stimulus over the other, they seldom held the preferred stimulus on continuously for more than about 6 s.

The data to be reported consist mostly of measures of 'relative preference', defined as the percentage of time spent with one stimulus as opposed to the other over a specified time interval. Where the relative preference is greater than 50% I refer to it as 'positive', and where less than 50% as 'negative'. Many of the results are presented in graphs where preference is plotted as a function of time since the beginning of the session, averaged for both monkeys over several experimental sessions; a 25 s time interval is used when more than 30 separate observations contribute to each point, and a 50 s interval when less than 30 observations contribute. The preferences observed on repeated tests followed approximately normal distributions with homogeneous variance, and differences in preference have been assessed by parametric statistics. Significance levels are given for each monkey separately, in the order: *p* for monkey *1*, *p* for monkey *2*.

3 Experiments on colour and brightness
In the earlier study (Humphrey, 1971) it was found that the monkeys showed strong preferences related to brightness and colour. The first goal of the present experiments was to replicate and extend these findings.

The stimuli used were plain fields of light which filled the whole screen. The brightness and colour were determined by filters in the slide projectors. For the brightness study the fields were white and ranged in brightness in 5 steps from 0·2 to 2·2 log foot-lamberts. For the colour study the fields were red, orange, yellow, green, and blue (Kodak Wratten filter numbers 25, 22, 12, 58, and 38 A, respectively) and were adjusted in subjective brightness with an S.E.I. photometer to 1·2 log foot-lamberts for the human eye, which has a sensitivity curve almost identical to that of the rhesus monkey (De Valois and Jacobs, 1968). So that all measurements of preference should be directly comparable, a white field of 1·2 log foot-lamberts was used as a standard stimulus with which to pair each other stimulus.

Each testing session lasted for 1000 s of stimulus exposure (i.e. 10 bouts of 100 s). Colour and brightness tests were alternated, with the stimuli of each set in random order. Each set of stimuli was run through 3 times.

In figure 2 are shown the average preferences for each test stimulus over the full 1000 s. These results are almost exactly parallel to those obtained with different monkeys in the earlier study. The preferences for different levels of brightness were once more found to be monotonically related to brightness over the range used, and brightness levels at equal logarithmic intervals above and below the standard yielded roughly equal positive and negative preferences. The preferences for different colours were found to follow the same rank order as before, which was monotonically related

to wavelength. In the present study the standard brightness level (1·2 log foot-lamberts) was twice that used in the earlier study (0·9 log foot-lamberts); unpublished experiments from the earlier series gave similar results when the testing chamber was painted white rather than black inside, which increased the overall brightness of the stimuli still further.

From the data of figure 2 we can read off for each colour a point on the brightness preference curve at which the preference was the same as for the colour. Red, for instance, had an 'equivalent brightness' of about − 0·5 log foot-lamberts below the standard, and blue an equivalent brightness of about +0·3 log foot-lamberts above the standard. It was open to question whether, if the brightness of the white field were raised or lowered to an appropriate degree, the preferences for the colours would be neutralised. This possiblity was examined with a 'titration' method, such that when the monkey chose the coloured field the white field grew steadily brighter and when he chose the white field the white field grew steadily dimmer. The changes in brightness were accomplished by a mechanically driven optical wedge, and the rate of change was set at 0·4 log foot-lamberts per 100 s—too slow to be detected by eye over a short interval but fast enough to allow the monkey to reach an equilibrium level within 1000 s. At the start of each session the brightnesses of the coloured and white fields were matched at 1·2 log foot-lamberts as before, and the 'equivalent brightness' of the white field was measured at the end of the session. Red fields and blue fields were tested in this way, 3 times each. The average 'equivalent brightnesses' which were obtained are marked by the arrows in figure 2. These values were close to what might have been predicted, suggesting that preferences related to brightness and colour are simply commutative. It will become apparent later in this paper that not all determinants of preference interact in such a simple fashion.

The time course of the preferences for the plain fields, as recorded on the X–Y plotter, gave the impression that the preferences were more or less stable over 1000 s. As the experiments progressed, however, it became clear that the time courses should be looked at in more detail to see if there were transient 'novelty' effects or other time-dependent changes which had been missed in superficial examination. For this a new set of experiments was undertaken using a modified procedure (the same as that adopted for all subsequent experiments). Under the new schedule for the first 200 s of the testing session the monkey was given only the standard white field and no
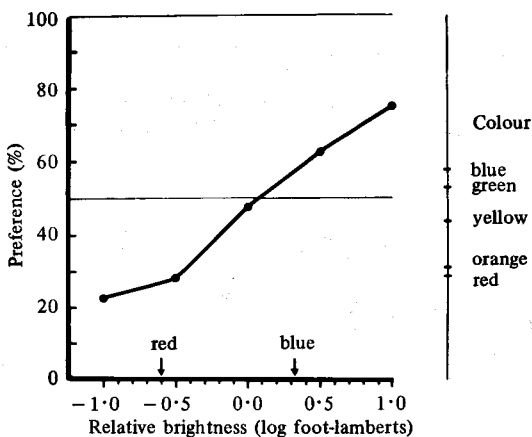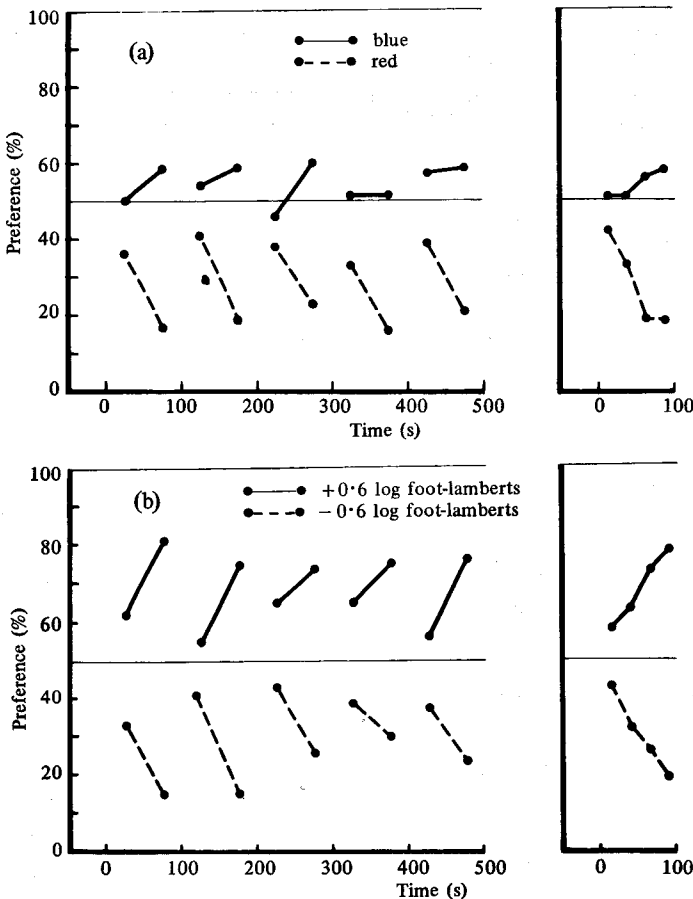

Figure 2. Mean preferences for plain fields of light of different brightness or colour, averaged for both monkeys over three 1000 s sessions. The ordinate gives relative preference for the test stimulus, calculated as the percentage of time spent with the test stimulus as opposed to the standard stimulus over the full length of the session. The arrows on the abscissa mark the experimentally-determined 'equivalent brightness' of red and blue fields.
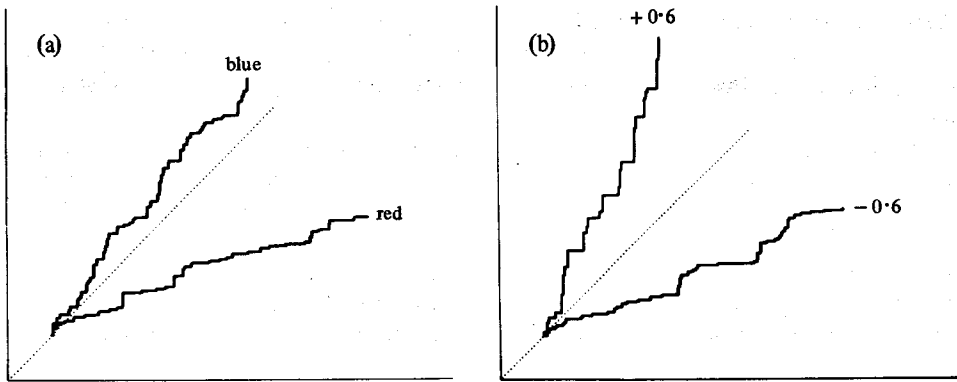
Figure 3. Sample records from tests with (a) blue and red plain fields, and (b) plain fields 0·6 log foot-lamberts brighter or dimmer than the standard. The lines show how the monkey divided his time between the test and standard stimuli: the recording pen moved vertically when the test stimulus was on and horizontally when the standard stimulus was on, so that slopes greater than 45° indicate a positive preference and slopes less than 45° a negative preference.

Figure 4. (a) Blue and red plain fields, and (b) plain fields of different brightness. Mean preferences as a function of time since the introduction of the test stimulus, averaged for both monkeys over five sessions. Points are plotted for each successive 50 s of exposure; gaps indicate the breaks between each 100 s bout. On the right are shown the pooled data from all five 100 s bouts.

choice, i.e. every press on the button produced the standard field; then, at the beginning of the third 100 s the test stimulus was introduced and from that point on, for the next 500 s, the monkey had a choice. The session was terminated after 700 s. Four test stimuli were used: red and blue fields at the same brightness as the standard, and white fields -0.6 log foot-lamberts less and $+0.6$ log foot-lamberts greater than the standard. The stimuli were tested 5 times each in random order.

Figures 3a and b show typical individual records. Figures 4a and b give the average preferences for both monkeys over the repeated tests; on the rights of these graphs are shown the pooled data for each 100 s bout. The impression one might get from the individual records that the preferences were constant over time is wrong. Although there was little change between each 100 s bout, within each bout there were marked changes—a consistent almost linear increase or decrease in preference, which was 'reset' at each break. The within-bout trends, which I call 'sensitisation' effects, were highly significant for each monkey for all except the blue fields (red: $p < 0.001, p < 0.001$; blue: $p < 0.1, p < 0.025$; white $+0.6$: $p < 0.001$, $p < 0.005$; white -0.6: $p < 0.005, p < 0.001$).

4 Experiments with pictures
At the end of the earlier study (Humphrey, 1971) the monkeys, who had previously been exposed only to plain fields of light, were tested for preferences for coloured photographs (pictures of men, monkeys, landscapes, etc.). Each photograph was paired in the testing session with a plain white field, matched in overall brightness. The monkeys showed clear preferences which were mainly negative, but there was little consistency between individuals. As it turns out, these results were misleading.

In the present study the monkeys were tested with a much longer series of pictures. The first few sessions gave results much as before, both monkeys showing maintained negative preferences, with considerable individual variation. By the fourth or fifth session, however, the pattern of response had changed and become one of initial short-lived positive preference which rapidly turned to indifference. For the rest of the series of photographs both monkeys behaved in a similar way and never again showed negative preferences; when however, later in the study, they were introduced to cine-films they began by reacting negatively once more.

Direct observation of the monkeys via the television monitor gave clear evidence that for the first few occasions on which they saw either photographs or cine-films they were frightened of them: their ears lay back, their hair stood on end, they urinated, and their posture and faces expressed great anxiety. I had the strong impression that at this stage they reacted to the pictures as real-life objects rather than mere representations. As the monkeys grew more experienced they remained excitable, but all obvious signs of fear dropped away.

The results described in the next sections refer to experiments done after the monkeys had apparently got over their fear. The findings from the initial stage are more fully treated later in the paper.

4.1 Still photographs
Thirty coloured photographs were used as test stimuli, selected on the basis of their pictorial content to fall into six classes. These classes were (with particular examples in brackets): 'men' (a portrait of the chief assistant), 'monkeys' (two infant monkeys playing), 'other animals' (a cow, a hen), 'flowers' (a clump of violets), 'foods' (a bunch of bananas), and 'abstract paintings' (Mondrian: *Composition,* 1920). I judged the different pictures to contain roughly the same amount of detail, except for the abstract paintings which on the whole had less. In none did any particular colour dominate. To measure the monkey's relative preference, each photograph was

paired with a plain white field, adjusted to match it in overall brightness. For the first 200 s of each session the monkey received only the white light, with no choice; the test stimulus was then introduced and his preference was measured over the next 500 s. The five photographs in each class were tested once each in random order across classes.

Figure 5 shows typical individual records and figure 6a shows the pooled results for all thirty photographs for both monkeys. The monkeys showed an initial very strong preference—90% over the first 25 s—but this waned within about 200 s, to level out at 50%. Superimposed on the general decline was a slight but significant recovery at the start of each 100 s bout ($p < 0.025$, $p < 0.001$).

The decline in preference from an initial high level characterised the response to all six classes of photograph. There were, however, differences in the absolute preference levels and rates of decline. Taking the first 100 s alone, the rank order of preference was 'other animals' 'monkeys' 'men' 'flowers' 'abstract paintings' 'foods'. Although there was overlap in the preferences for pictures in the different classes, if the pooled data from the first three classes are compared with those from the second three, the difference in preference over the first 100 s is highly significant for each monkey ($p < 0.001$, $p < 0.01$). We may note that the pictures in the three most preferred classes were all of animals, while those in the three least preferred were all of inanimate objects. Figure 6b shows the time course of the preferences for the two kinds of picture, 'animate' and 'inanimate', taken separately.
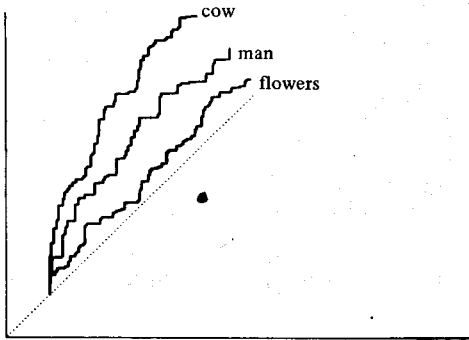

Figure 5. Sample records from tests with coloured photographs.
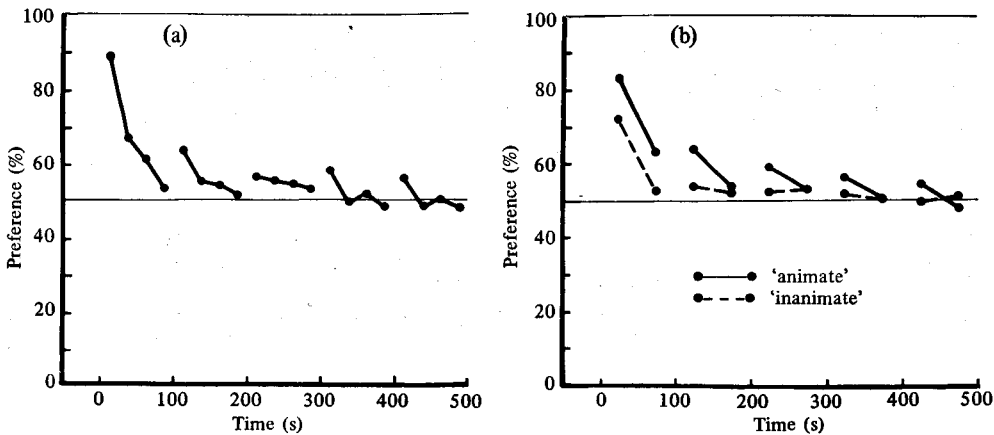

Figure 6. (a) Coloured photographs, and (b) 'animate' and 'inanimate' photographs. Mean preferences as a function of time since the introduction of the test stimulus, averaged for both monkeys over (a) thirty sessions and (b) fifteen sessions.

It seemed probable that the decline in preference with time was a matter of each of the pictures being 'novel' when it first appeared. If so, the initial preference should have been greatly reduced if the monkey was 'pre-exposed' to the picture prior to being given a choice. To prove this, the testing procedure was changed as follows. Instead of the monkey receiving the white field with no choice for the first 200 s, he was made to receive only the picture; the white field was then introduced and he was allowed to choose as before. Six new pictures were tested, one from each of the previous classes.

The results are shown in figure 7. On comparing figure 7 with figure 6a it may be seen that the initial preference was indeed reduced. The difference in preference between the 'novel' and 'pre-exposure' conditions is highly significant in the first 50 s ($p < 0.005$ for each monkey), but becomes non-significant later. Pre-exposure did not, however, abolish the initial preference altogether, and the preference is significantly above 50% over the first 100 s ($p < 0.005, p < 0.025$). We may conclude that 200 s of forced pre-exposure is nearly, but not quite, sufficient to neutralise the preference.

4.2 Cine-films

If, in the case of photographs, it was novelty that was responsible for the high initial preference and increasing familiarity which led to the decline, we should expect that the preference for a continuously changing picture would be maintained much longer. To test this, the monkeys were next presented with cine-films.

The films used were all 8 mm Walt Disney cartoons, featuring Mickey Mouse, Donald Duck, Goofy, Pluto, and a supporting cast of lions, chipmunks, ghosts, etc. Coloured and black-and-white versions were used at different stages of the experiments.

The first series of tests was done with coloured film loops rather than continuous films. The film loops were cut to a length such that the sequence repeated itself approximately every 15 s. The next series was done with continuous 'full length' ooloured films. Each film was paired with a plain white field of roughly the same overall brightness. The testing procedure was the same as that followed with photographs, except that some of the continuous films did not last long enough for the monkey to complete 500 s of choice and the session had therefore to be limited to 400 s. Thirteen different film loops and ten different continuous films were tested.
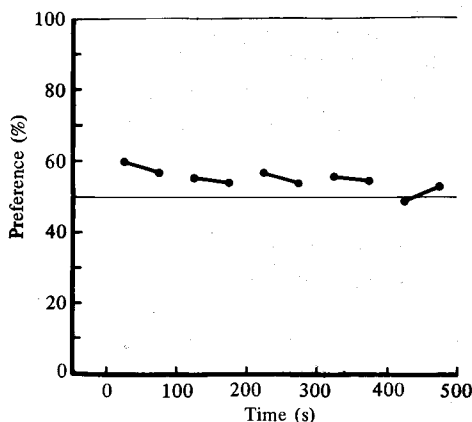
Figure 7. Effect of 'pre-exposure'. Mean preferences as a function of time since the introduction of the standard white field after 200 s of exposure to the test stimulus, averaged for both monkeys over six sessions.
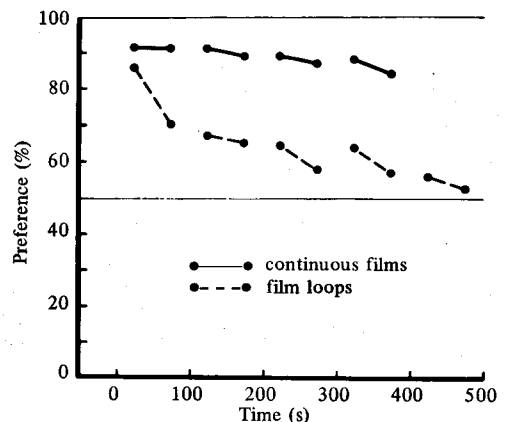
Figure 8. Film loops and continuous films. Mean preferences as a function of time since the introduction of the test stimulus, averaged for both monkeys over ten sessions.

For the first three sessions with the film loops one or both of the monkeys showed an overall negative preference, but for the next ten the preferences were positive. Sample records from the latter ten tests with film loops and from the tests with continuous films are shown in figure 9a. Figure 8 gives the average results. In the case of the film loops the preferences were higher than in the case of unchanging photographs; nonetheless, there was still a marked decline with time, down to nearly 50% by the end of 500 s. With the continuous films, however, the preferences were maintained at a very high level throughout the session.

Putting together the data from figures 8 and 6b, we may draw up a rank order of pictorial stimuli in terms of their power to maintain the monkey's preference: continuous cartoon films/cartoon film loops/still photographs.
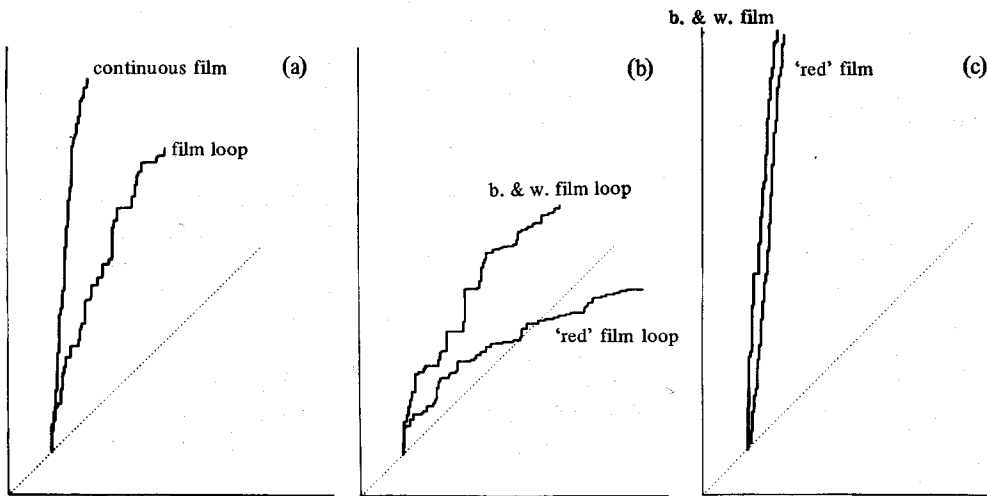

Figure 9. Sample records from tests with (a) film loops and continuous films, (b) black-and-white and 'red' film loops, and (c) black-and-white and 'red' continuous films.

## 5 Experiments on the interaction of colour, brightness, and pictorial content

The tests with plain fields of light and with pictures showed up two wholly different patterns of behaviour: in the former case, steady positive or negative preferences overlying a stable pattern of 'resetting' followed by 'sensitisation'; in the latter case, uniquely positive preferences which declined towards neutrality unless the content of the picture was continuously renewed. There would be grounds in this for postulating two separate 'dimensions' of visual stimuli which are effective in influencing a monkey's preference. If the distinction of two dimensions has any reality, we might hope to find confirmation of it by looking at their interaction.

Four sets of experiments were undertaken to examine the effects of changing the brightness or colour of black-and-white pictures. The test stimuli were 'red' photographs, 'red' film loops, 'bright' film loops, and 'red' continuous films. The 'red' stimuli consisted of black-and-white pictures projected through a red filter, and the 'bright' stimuli consisted of black-and-white pictures adjusted in brightness to be $+0.6$ log foot-lamberts brighter than the white comparison field. In order to analyse the interactions it was important to have separate information about the preferences for plain red fields, plain bright fields, and black-and-white version of the pictures. Data about the plain fields were already available, but new information was needed for the standard black-and-white pictures. So, alongside the 'red' and 'bright' pictures, tests were done with comparable standard black-and-white ones.

Six stimuli of each of the following kinds were tested: (i) 'red' and black-and-white photographs, drawn from the same content classes as before; (ii) 'red' and black-and-white film loops, all cut from one and the same film; (iii) 'bright' and standard black-and-white film loops, cut from the same film; (iv) 'red' and black-and-white continuous films, the red films being versions of the same six films as the black-and-white ones. For all the tests each stimulus was paired with a white field of appropriate brightness, and they were tested in random order according to the usual procedure.

Figures 9b and c show individual records from tests with two of the most interesting sets of stimuli, red film loops and red continuous films. Figures 10a–d give the average results for all four sets of stimuli. Each of the latter figures shows separately the data for the red or bright versions of the pictures and the standard black-and-white ones; the corresponding data for the plain fields are those shown in figures 4a and b.

The interaction between colour or brightness and pictorial content was clearly not simply additive. It would seem, in the case of the red pictures, that the positive preference for the pictorial content largely overrode the negative preference for the colour. Thus with the red continuous films the preference was hardly affected by the 'redness', and with the red film loops the 'redness' only had its full effect once the preference for the pictorial content had declined.
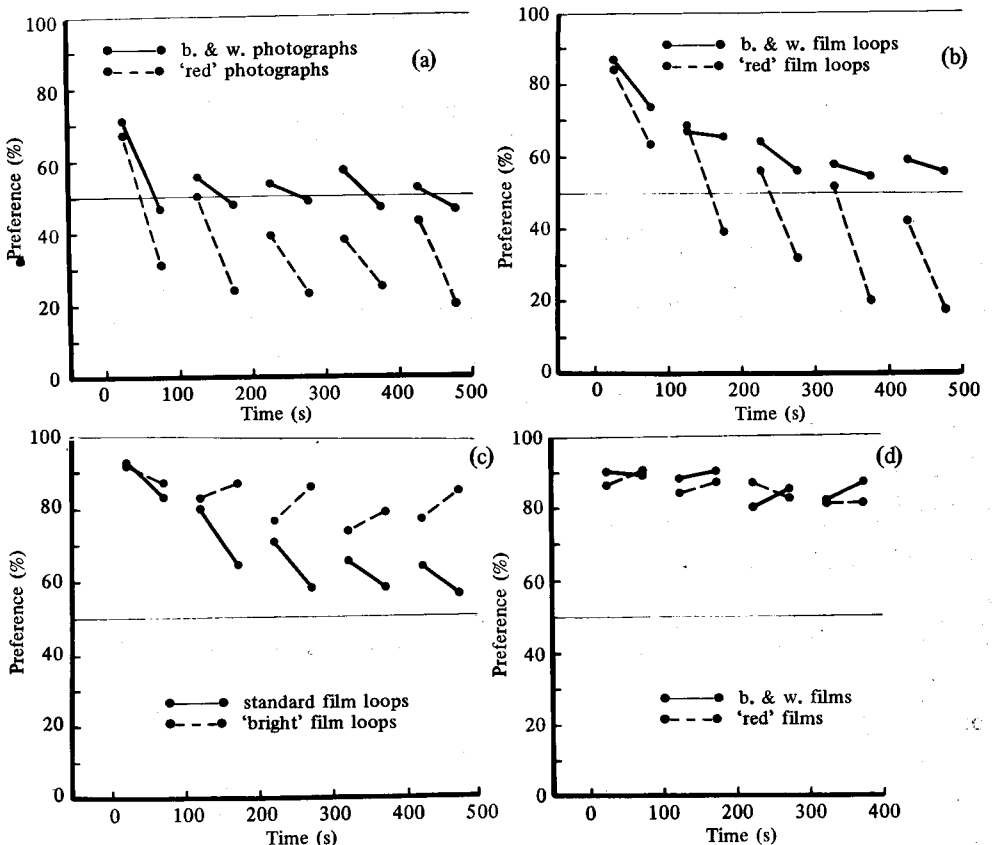
Figure 10. (a) 'Red' and black-and-white photographs, (b) 'red' and black-and-white film loops, (c) 'bright' and standard black-and-white film loops, and (d) 'red' and black-and-white continuous films. Mean preferences as a function of time since the introduction of the test stimulus, averaged for both monkeys over six sessions.

6 Analysis

I have, to this point, withheld the terms 'interest' and 'pleasure', but now propose to introduce them. I want to suggest that the monkey's preferences for the plain fields of light were determined entirely by pleasure/unpleasure, while their preferences for the unadulterated pictorial stimuli were determined entirely by interest.

The grounds for this assertion are (i) that the monkey's preferences for the plain fields showed no influence of novelty or familiarity, but were steadily positive or negative to a degree depending on the colour or brightness—in the way that we ourselves respond to stimuli which we regard as relatively pleasant or unpleasant but as in no way interesting, and (ii) that the monkey's preferences for the pictorial stimuli were strongly influenced by content and novelty but declined towards indifference when the stimuli became familiar—in the way that we ourselves respond to material we regard as potentially interesting, but as neither pleasant nor unpleasant once our interest has faded.

I would suggest, furthermore, that in the more complex case of the red or bright pictures the monkey's preferences were determined by a mixture of interest and pleasure/unpleasure. I think the rule of interaction is one which is arguably true for ourselves, that interest overrides pleasure/unpleasure in determining behavioural preference.

From these ideas a quantitative model follows which allows one to 'predict' from independently determined measures of interest and pleasure/unpleasure the preference for a stimulus which is, say, both interesting and unpleasant. The development of the model is straightforward, but a bit tedious, and the details are held over to the appendix. Briefly, the reasoning goes as follows. Certain principles are laid down, from which is derived a 'general equation' for preference. This general equation is applied to the experimental data on the assumption that certain 'limiting conditions' of interest or pleasure/unpleasure were present in the particular experiments. From this follows an equation which ought, if the model is valid, to predict how the various results tie in together. The principles and assumptions are summarised below, followed by a statement of the relevant equation.

Principles. When there is a choice between two stimuli, the monkey ranks them according to their relative interestingness and relative pleasantness.
(i) If one stimulus is more interesting than the other, the probability that the monkey will prefer it is 1.
(ii) If one stimulus is more pleasant than the other, the probability that the monkey will prefer it is 1 unless the other stimulus is more interesting.
(iii) If neither stimulus is more interesting or more pleasant, the probability that he will prefer one to the other is $\frac{1}{2}$.

Assumptions appropriate to the present experiments.
(i)   In the case of a plain field paired with either a picture or with another plain field, the probability of the former being more interesting is 0.
(ii)   In the case of a novel picture paired with a plain field, the probability of the former being more interesting when first introduced is 1.
(iii)   In the case of two stimuli of the same overall brightness and colour, the probabilities of either stimulus being more pleasant than the other are equal (except in circumstances yet to be considered, such as when one of the stimuli is 'frightening').
(iv)   In the case of two stimuli which differ both in pictorial content and in colour or brightness, the relative interestingness and the relative pleasantness of the stimuli follow the same time courses as they would do in the case of stimuli which differed along one or other dimension alone.

Equations. From these premises, without further assumptions or the introduction of arbitrary constants, the following equation may be derived:

Let pref(X/Y) stand for the observed preference for stimulus X compared to stimulus Y expressed as a percentage. Let S be the standard plain white field, and A be a plain field of different colour or brightness to the standard. Let B be a pictorial stimulus, matched in colour and brightness to the standard, and C be a composite stimulus having the same colour and brightness as A, and the same pictorial content as B. Finally, let K be any totally novel picture. Then,

$$\text{pref(C/S)} = \text{pref(A/S)} + \text{pref(B/S)} - 50 - \frac{[\text{pref(A/S)} - 50][\text{pref(B/S)} - 50]}{\text{pref(K/S)} - 50}$$

In figure 11a are shown the predicted and observed preferences for the red film loops and bright film loops, and in figure 11b those for the red photographs and red continuous films. The predicted preferences are calculated from the observed preferences for the plain fields and black-and-white versions of the pictures, as shown in figures 4a and 4b, and 10a–d; pref(K/S), based on data from several different situations,
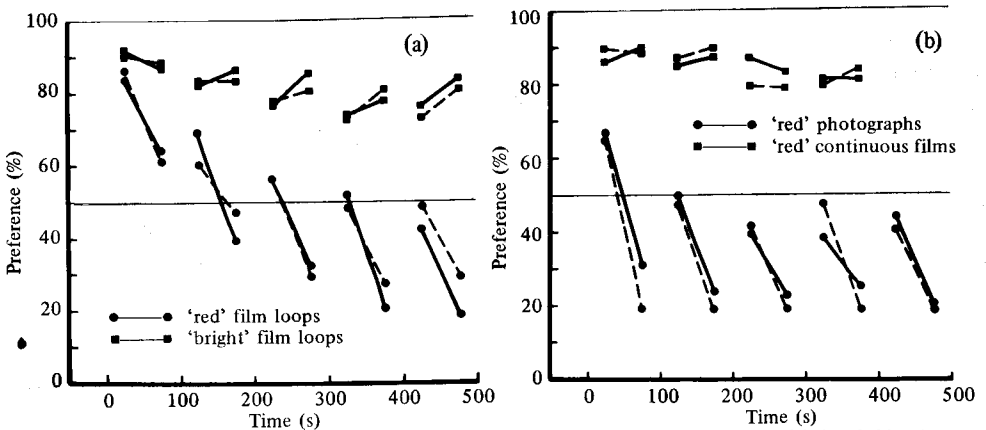

Figure 11. Observed (solid lines) and predicted (dashed lines) preferences for (a) 'red' film loops and 'bright' film loops, and (b) for 'red' photographs and 'red' continuous films.
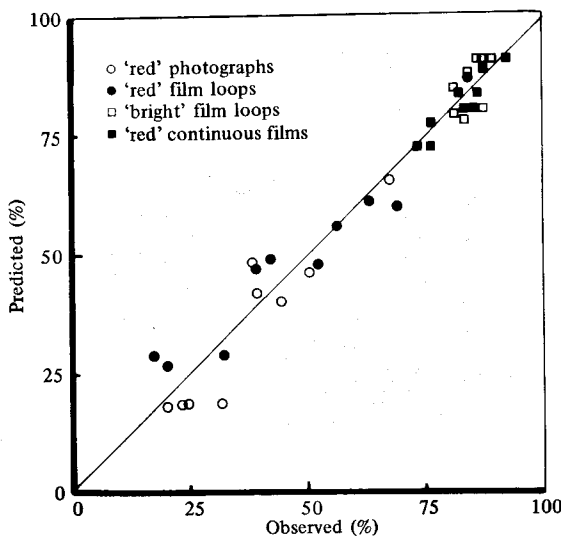

Figure 12. Observed and predicted preference for all four types of composite stimulus. Each point corresponds to a pair of points in figure 11.

is taken to be 90%. Figure 12 compares the observed with the predicted preferences over all four types of composite stimulus. The slope of the regression line is 0·98 with a standard deviation of 0·03.

The equation fits the data well and would seem on this evidence to have considerable generality. The equation was derived from a model of which the basic premise was the distinction between interest and pleasure/unpleasure. In the absence of any obvious alternative explanation, the axioms of the model get strong support from these experiments.

7 The case of 'focused' versus 'unfocused' films.

Butler and Woolpy (1963) found that monkeys would spend more time looking out of a box at a cine-film which was in focus than at one which was out of focus. I hoped that the model developed in this paper would be able to throw light on the factors responsible for this kind of preference. There were two extreme hypotheses: (i) that the monkey regarded the focused film as more informative than the unfocused one, and his preference was determined entirely by interest; or (ii) that the monkey regarded the focused film as 'easier on his eyes' or in some other way more pleasant than the unfocused one, and his preference was determined entirely by pleasure/ unpleasure. The most probable explanation was that the preference was determined by a bit of both, though my guess at the start was that interest would prove to be the more important factor.

The first series of experiments was undertaken to confirm Butler's original finding. Under the same conditions as before the monkey was given a choice of two versions of a coloured film, one focused and the other unfocused. The two versions of the film were run at the same speed on different projectors and remained in time with each other. Two different levels of de-focusing were used: for one set of stimuli the unfocused film was adjusted to be in focus at half the distance from the projector to the screen, and for the other set to be in focus at three-quarters the distance from the projector to the screen. In the former case the blurring of the picture was very noticeable, but in the latter case much less so; in neither case was the blurring sufficient to make it impossible for a human observer to see what was going on. Six pairs of films were tested for each level of de-focusing. The stimuli of each pair were matched in overall brightness, and the relative preference was tested in the usual way.
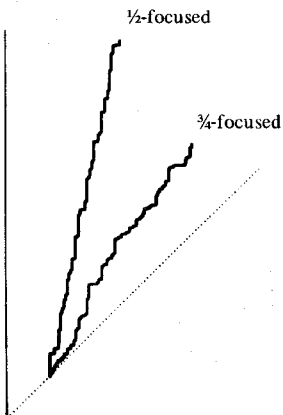

Figure 13. Sample records from tests with focused films paired with half-focused and three-quarters-focused films. The recording pen moved vertically for the focused film and horizontally for the unfocused one.

Individual records are shown in figure 13 and the average results in figure 14. With both levels of de-focusing the monkeys showed strong and stable positive preferences for the focused film. The preferences were significantly higher when the focused film was paired with the half-focused film than with the three-quarters-focused one ($p < 0·001$ for each monkey), but in the latter case they were still well above 50% ($p < 0·001$ for each monkey).

An attempt to sort out the factors responsible for these preferences was made in the following way. Tests were done in which red focused films were paired with black-and-white unfocused ones. In this case the model makes different predictions according to whether it is assumed that standard focused films were preferred to unfocused ones on the basis of interest or of pleasure/unpleasure. The detailed predictions of the model are complicated, but, briefly, they are that the effect of the redness should be less if the basis was that of interest than if it was that of pleasure/unpleasure.

In order to make quantitative predictions, additional information was needed about the preferences for black-and-white focused films versus black-and-white unfocused ones, and also for red focused films versus black-and-white focused ones. Three sets of experiments were therefore undertaken using the following pairs of stimuli: (i) red focused versus black-and-white half-focused films; (ii) black-and-white focused versus black-and-white half-focused films; and (iii) red focused versus black-and-white focused films. In all cases the two films of the pair were versions of the same film, matched in overall brightness. Ten pairs of each sort were tested.

Figure 15 shows the average results. The points on the curves are averaged over both monkeys, but here, for the first time, there was found to be a significant difference between the two monkeys: monkey *1* showed a higher preference than monkey *2* for both the black-and-white focused versus black-and-white unfocused and the red focused versus black-and-white unfocused films. On account of this the two monkeys are treated separately in the subsequent analysis.

The predictions of the model are examined in the Appendix. Two extra premises are required in addition to those outlined earlier:

Principle (iv)   Where there are two independent grounds for regarding one stimulus as more or less pleasant than another (e.g. focusing and colour), then the stimulus is more pleasant than the other if it would be so on either ground alone; except if
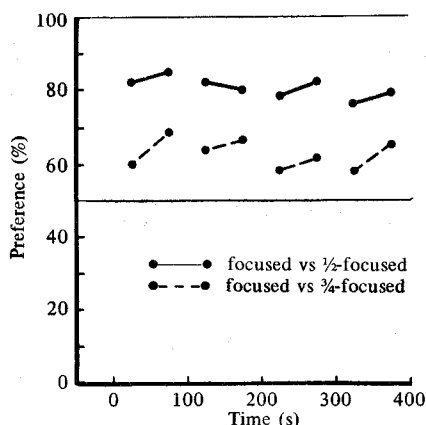

Figure 14. Focused vs unfocused films. Mean preferences for the focused film, averaged for both monkeys over six sessions.
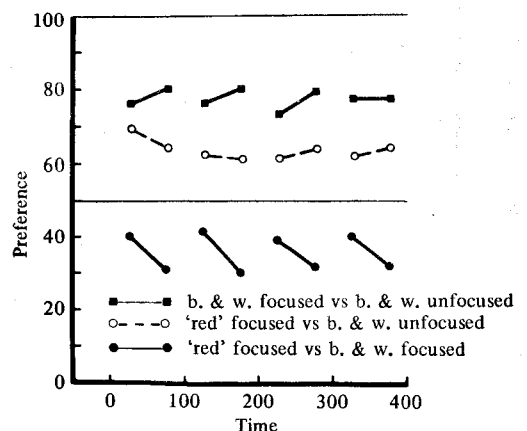
Figure 15. 'Red' focused vs black-and-white focused and unfocused films. Mean preferences, averaged for both monkeys over ten sessions.

it would be more pleasant on one ground and less pleasant on the other, in which case the two effects cancel each other and their net effect is nil.

Assumption (v).   In the case of two pictorial stimuli which are equally informative, the probabilities of either stimulus being more interesting than the other are equal.

There proves to be a measure of unresolvable ambiguity in the equations, and the predictions of the model cannot be precise.   But it is possible to set upper and lower limits to the predicted preferences, as follows.   Let S be the standard plain white field and D a plain red field.   Let E be a black-and-white focused film, F a red focused film, and G a black-and-white unfocused film.   Let K be any totally novel picture.   (All stimuli matched in overall brightness.)   Then, on the first hypothesis, that a focused film is simply more interesting than an unfocused one, we have

$$\text{pref}(F/G) \geqslant \text{pref}(E/G) + \text{pref}(D/S) - 50 - \frac{[\text{pref}(D/S) - 50][\text{pref}(E/G) - 50]}{\text{pref}(K/S) - 50},$$

$$\text{pref}(F/G) \leqslant \text{pref}(E/G).$$

But, on the second hypothesis, that a focused film is simply more pleasant than an unfocused one,

$$\text{pref}(F/G) \geqslant 50 + \tfrac{1}{2}[\text{pref}(E/G) - 50] + [\text{pref}(F/E) - 50]$$
$$- \frac{[\text{pref}(D/S) - 50][\text{pref}(E/G) - 50]}{2[\text{pref}(K/S) - 50]},$$

$$\text{pref}(F/G) \leqslant 50 + [\text{pref}(E/G) - 50] + \tfrac{1}{2}[\text{pref}(F/E) - 50]$$
$$+ \frac{[\text{pref}(D/S) - 50][\text{pref}(E/G) - 50]}{2[\text{pref}(K/S) - 50]}.$$

Figure 16 shows, separately for each monkey, the observed preferences for the red focused films versus the black-and-white unfocused ones and the predicted preferences based on the two alternative hypotheses.   For both monkeys the observed preferences lay close to the upper limit of what would have been predicted on the 'pleasure' hypothesis but well below the lower limit of what would have been predicted on the 'interest' hypothesis.
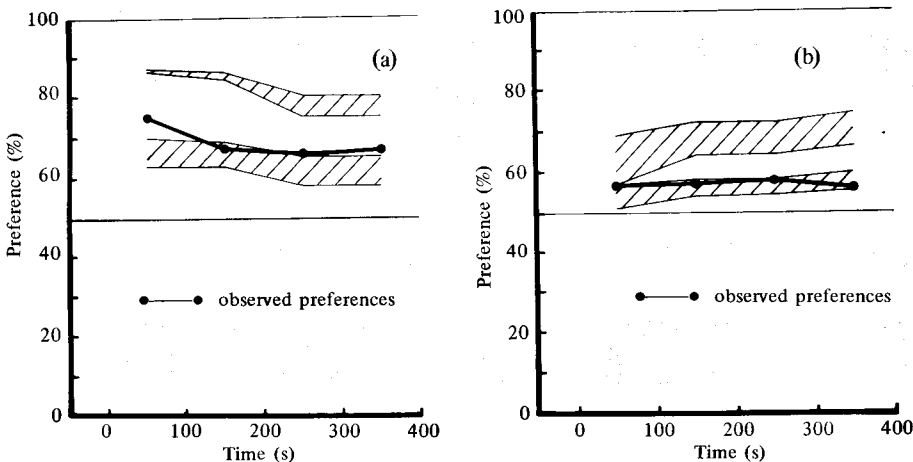
Figure 16.   Observed and predicted preferences for 'red' focused films versus black-and-white unfocused films: (a) monkey *1*, (b) monkey *2*. The 'interest' hypothesis predicts that the preferences should fall within the upper shaded area, the 'pleasure' hypothesis that they should fall within the lower shaded area.

On this evidence it seems proper to conclude that the monkeys' preference for focused over unfocused films was much more a matter of pleasure than of interest. If the degree of de-focusing had been greater than that used in these experiments, there would presumably have come a point at which this conclusion was reversed.

8 The stage of 'fear'

When the monkeys first saw photographs and moving films their preferences were negative and they showed overt signs of fear. Figure 17 shows how, in the case of the film loops, the overall preferences changed from negative to positive over the first few sessions.

At the stage when the overall preferences were negative the time course within each session showed an interesting pattern. The detailed time courses, averaged over the first three sessions, are shown in figure 18a and b for the photographs and film loops respectively. In every case, when the picture was first introduced the preference was in fact initially positive, becoming negative only with continued exposure.

It is revealing to compare the pattern of response to the pictures at the stage when they were 'frightening' with that at a later stage to the red pictures (figures 10a and b).
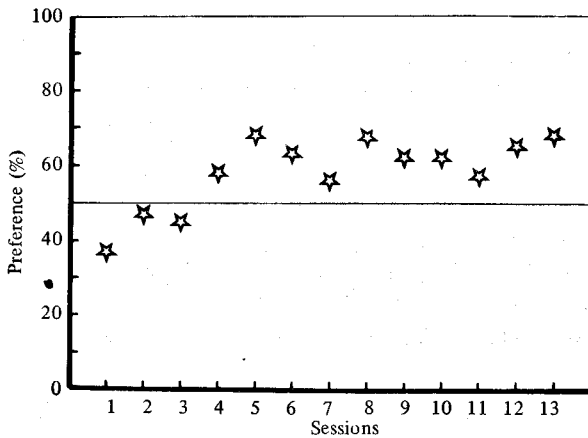

Figure 17. Changes in overall preference for coloured film loops as a function of increasing experience. Each point represents the preference measured over the full 500 s, averaged for both monkeys. Session 1 was the first occasion on which the monkeys were exposed to cine-films.
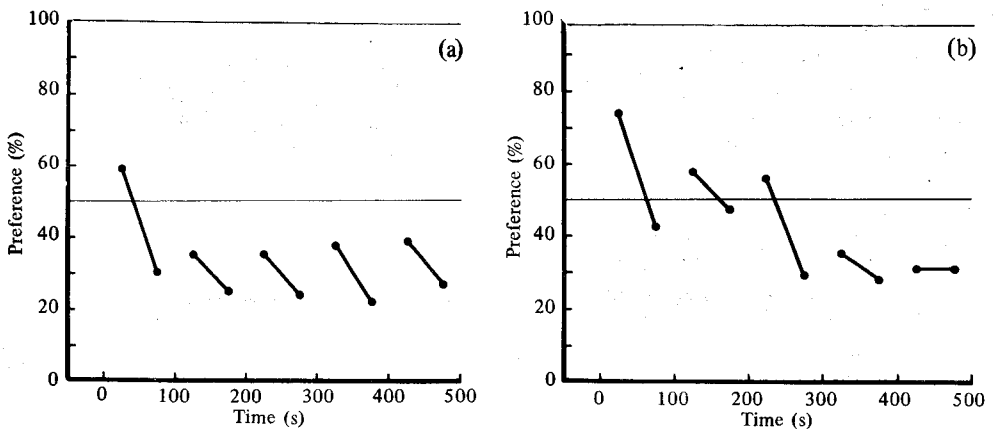

Figure 18. First three sessions with (a) coloured photographs, and (b) film loops. Mean preferences as a function of time since the introduction of the test stimulus, averaged for both monkeys over the first three sessions.

The patterns were in many ways remarkably similar; in particular the 'frightfulness', like the 'redness', only had its full effect once the novelty of the picture had declined. Though on this evidence alone the case is not a strong one, it is tempting to suppose that a frightening stimulus was unpleasant for the monkey in the same sense as a red one was, and that with the frightening pictures, as with red ones, interest initially overrode unpleasure in determining the preference. This supposition entails that if the first films the monkeys had seen had been continuous films rather than loops, they would have shown maintained positive preferences albeit in a constant state of fear.

If 'fear'—and, for that matter, 'love' or 'affection'—involves an affective relationship on the pleasure/unpleasure continuum, independent of the relationship of interest, we have the makings of a powerful new method for studying them. In the present experiments the monkeys' fear of the pictures was a transient phenomenon, but one can imagine both artifical and natural situations in which fear or affection would be much more stable. Perhaps it would be possible to discover how much a mother monkey 'loved' her baby, or how much a member of a monkey group was 'frightened' of a dominant animal by looking at their preferences for monkey films under certain experimentally imposed constraints.

9 The similarity in the behaviour of the two monkeys
One finding of the present study was unexpected, almost to the point of being bizarre: namely, that the preferences shown by the two monkeys were in most cases almost identical.

Table 1 tabulates for each monkey the overall preferences for those stimuli for which the preferences were relatively stable with time (i.e. all except the photographs and film loops). The median absolute difference between the monkeys in their preferences for these fourteen types of stimuli (ranging from plain white fields to red and unfocused cartoon films) was 2%. With those stimuli for which the preferences declined with time, the time courses were very similar for the two monkeys; figure 19

Table 1. Overall preferences for those stimuli for which the preferences were relatively stable with time.

Test	Overall preference (%)	
	Monkey *1*	Monkey *2*
Plain red vs plain white	29	28
Plain blue vs plain white	52	55
Bright plain white (+0·6) vs normal plain white	68	68
Dim plain white (−0·6) vs normal plain white	30	29
Coloured films vs plain white	86	91
Black-and-white films vs plain white	84	86
Red films vs plain white	83	86
Focused vs $\frac{1}{2}$-focused coloured films	82	79
Focused vs $\frac{3}{4}$-focused coloured films	64	62
Focused vs $\frac{1}{2}$-focused black-and-white films	83	71
Focused red vs $\frac{1}{2}$-focused black-and-white films	69	57
Red vs black-and-white films	35	36
Coloured vs black-and-white films[a]	59	59
Erect vs inverted coloured films[a]	53	55

Median absolute difference between monkeys = 2%.

[a] These tests have not been described in the text for want of space.

shows for each monkey separately the time courses of the preferences for the coloured photographs and coloured film loops. Other cases where the two monkeys showed virtually identical behaviour—e.g. the effects of 'pre-exposure', the preferences for 'animate' and 'inanimate' photographs, the existence of 'sensitisations' effects, etc. —have already been described.

The only measures on which the two monkeys differed significantly were (i) alternation frequency: monkey *1* alternated less frequently than monkey *2* ($p < 0.001$); (ii) preferences during the stage of fear: monkey *1* showed higher preferences than monkey *2* on the first three sessions with photographs and lower preferences on the first three sessions with film loops ($p < 0.001$ in each case); (iii) preferences for black-and-white or red focused versus black-and-white unfocused films: monkey *1* showed higher preferences than monkey *2* ($p < 0.001$).

The finding of such extraordinary similarity complements the finding of the earlier study where two other monkeys proved to have almost identical colour and brightness preferences (Humphrey, 1971). That different individuals should react in exactly the same way to plain fields of light is perhaps not all that surprising, but that they should do so to pictures of cows, Mickey Mouse films, etc. is very odd indeed. We should bear in mind that these complex stimuli were for the most part totally alien to the monkeys' previous experience and that the monkeys were caged separately and had little if any opportunity for 'communicating' with each other. Moreover, outside the testing sessions there were aspects of their behaviour in which they showed marked differences, and they had different personalities.
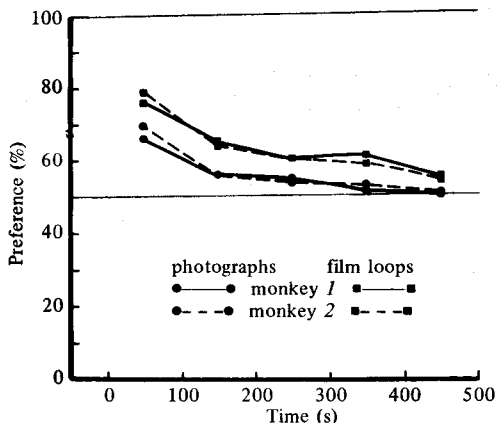

Figure 19. Comparative data for monkey *1* and monkey *2*. Mean preferences as a function of time for coloured photographs (thirty sessions) and coloured film loops (ten sessions).

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APPENDIX

1 Derivation of the 'general equation'

The axioms of the model are set out in the main text.

Consider a subject faced with a choice between two alternative stimuli, X and Y. Subject's 'relative interest in X', i_X, is defined as the probability that he regards X as more interesting than Y. Subject's 'relative pleasure in X', p_X, is defined as the probability that he regards X as more pleasant than Y. i_Y and p_Y are defined similarly. Let the probability that the subject prefers X to Y be prob(X/Y).

From principles (i)–(iii) we have that the probability that the subject prefers X to Y is equal to the probability that he finds X more interesting, plus the probability that he finds X more pleasant and does not at the same time find either stimulus more interesting, plus half the probability that he finds neither stimulus more interesting or more pleasant. On converting to symbols this gives

$$\text{prob}(X/Y) = i_X + p_X(1 - i_X - i_Y) + \tfrac{1}{2}(1 - i_X - i_Y)(1 - p_X - p_Y).$$

Similarly

$$\text{prob}(Y/X) = i_Y + p_Y(1 - i_X - i_Y) + \tfrac{1}{2}(1 - i_X - i_Y)(1 - p_X - p_Y).$$

To convert these probabilities of subjective preference into statements about observed behaviour we must introduce a conversion factor k which represents the percentage of time that the subject actually spends with the preferred stimulus when the probability that he prefers it is 1. k is bound to be less than 100% because of the constraints imposed by the testing apparatus on the behavioural expression of subjective preference. So we have that the observed preference of X over Y, pref(X/Y), is given by

$$\text{pref}(X/Y) = k\,\text{prob}(X/Y) + (100 - k)\,\text{prob}(Y/X).$$

Substituting for prob(X/Y) and prob(Y/X) and reducing we get

$$\text{pref}(X/Y) = 50 + (k - 50)(i_X - i_Y) + (k - 50)(p_X - p_Y) - (k - 50)(p_X - p_Y)(i_X + i_Y).$$

This is the 'general equation' for preference.

2 Derivation of the formula appropriate to a complex stimulus such as a 'red' or a 'bright' picture paired with the standard white field

We proceed as follows. Let the symbols A, B, C, S, and K stand for particular kinds of stimuli as defined in the main text.

Step 1. To determine k.
From assumption (ii) we have that when a totally novel picture K is paired with the standard field S then

$$i_K = 1, \qquad i_S = 0.$$

Substituting in the general equation and reducing we get

$$k = \text{pref}(K/S)$$

Step 2. To determine $(p_A - p_S)$.
From assumption (i) we have that when a plain field A is paired with the standard field S then

$$i_A = i_S = 0.$$

Substituting in the general equation and reducing we get

$$p_A - p_S = \frac{\text{pref}(A/S) - 50}{k - 50}.$$

Step 3. To deterine i_B.

From assumptions (i) and (iii) we have that when a standard picture B is paired with the standard field S then

$$i_S = 0, \qquad p_B = p_S .$$

Substituting in the general equation and reducing we get

$$i_B = \frac{\text{pref(B/S)} - 50}{k - 50} .$$

Step 4. To determine pref(C/S).

From assumptions (i) and (iv) we have that when a composite stimulus C, having the characteristics of both A and B, is paired with the standard field S then

$$i_S = 0, \qquad i_C = i_B, \qquad p_C - p_S = p_A - p_S .$$

Substituting in the general equation we get

$$\text{pref(C/S)} = 50 + (k - 50)\, i_B + (k - 50)(p_A - p_S) - (k - 50)(p_A - p_S)i_B .$$

Replacing now k, i_B, and $(p_A - p_S)$ with the values given by steps 1–3, we get

$$\text{pref(C/S)} = \text{pref(A/S)} + \text{pref(B/S)} - 50 - \frac{[\text{pref(A/S)} - 50][\text{pref(B/S)} - 50]}{\text{pref(K/S)} - 50}$$

3 Derivation of the formulae appropriate to a 'red' focused film paired with a black-and-white unfocused film, on the 'pleasure' and the 'interest' hypotheses

Let the symbols S, D, E, F, G, and K stand for particular kinds of stimuli as defined in the text.

(a) 'Pleasure' hypothesis

The hypothesis is that an unfocused film is less pleasant than a focused one, but equally interesting.

Step 1. To arrive at an equation for $(p_F - p_G)$ in terms of $(p_E - p_G)$ and $(p_D - p_S)$. An equation is needed which relates the difference in relative pleasure between a 'red' focused film and a black-and-white unfocused film, $p_F - p_G$, to the difference in relative pleasure between a black-and-white focused film and a black-and-white unfocused film, $p_E - p_G$, and to the difference in relative pleasure between a plain red field and a plain white field, $p_D - p_S$. The general form of the equation is derived as follows.

Suppose there are two independent grounds for regarding stimulus X as more or less pleasant than stimulus Y. Let the relative pleasure in X on the first grounds alone be m_X, the relative pleasure in X on the second grounds alone be n_X, and the relative pleasure in X on both grounds in combination be p_X, with m_Y, n_Y, and p_Y defined similarly. Then, from principle (iv), we have

$$p_X = (m_X - m_X n_Y) + (n_X - n_X m_Y) - (m_X - m_X n_Y)(n_X - n_X m_Y) ,$$

$$p_Y = (m_Y - m_Y n_X) + (n_Y - n_Y m_X) - (m_Y - m_Y n_X)(n_Y - n_Y m_X) .$$

So, ignoring third order terms,

$$p_X - p_Y = (m_X - m_Y) + (n_X - n_Y) - (m_X n_X - m_Y n_Y) .$$

The problem is to rewrite $(m_X n_X - m_Y n_Y)$ in terms of $(m_X - m_Y)$ and $(n_X - n_Y)$. We know from simple algebra that

$$m_X n_X - m_Y n_Y = \tfrac{1}{2}(m_X - m_Y)(n_X + n_Y) + \tfrac{1}{2}(n_X - n_Y)(m_X + m_Y) .$$

And we also know that

$$|m_X - m_Y| \leqslant m_X + m_Y \leqslant 1 \;,$$

$$|n_X - n_Y| \leqslant n_X + n_Y \leqslant 1 \;.$$

For the present purposes we need only consider the case where X is on the whole more pleasant than Y on the first grounds and less pleasant on the second grounds, so

$$m_X - m_Y > 0, \qquad n_X - n_Y < 0$$

and

$$|m_X - m_Y| = m_X - m_Y \;, \qquad |n_X - n_Y| = -(n_X - n_Y) \;.$$

Then we get

$$m_X n_X - m_Y n_Y \geqslant -\tfrac{1}{2}(m_X - m_Y)(n_X - n_Y) + \tfrac{1}{2}(n_X - n_Y) \;,$$

$$m_X n_X - m_Y n_Y \leqslant \tfrac{1}{2}(m_X - m_Y) + \tfrac{1}{2}(m_X - m_Y)(n_X - n_Y) \;,$$

which, substituted in the equation above, gives

$$p_X - p_Y \geqslant \tfrac{1}{2}(m_X - m_Y) + (n_X - n_Y) - \tfrac{1}{2}(m_X - m_Y)(n_X - n_Y)$$

$$p_X - p_Y \leqslant (m_X - m_Y) + \tfrac{1}{2}(n_X - n_Y) + \tfrac{1}{2}(m_X - m_Y)(n_X - n_Y) \;.$$

Assuming 'focusing' and 'redness' to be independent determinants of pleasure we can then write

$$p_X = p_F, \qquad p_Y = p_G; \qquad m_X = p_E, \qquad m_Y = p_G; \qquad n_X = p_D, \qquad n_Y = p_S;$$

and so arrive at a formula for $(p_F - p_G)$ which, if it does not specify it exactly, at least sets upper and lower limits.

Other steps. The further steps required to arrive at the formula given in the text for the limits of pref(F/G) follow the same lines as steps 1–4 in the previous section. The calculations are unavoidably long and complicated to set out, and for that reason will not be given in detail. The reader who wishes to work through them for himself should have no difficulty.

(b) 'Interest' hypothesis
The hypothesis is that an unfocused film is less interesting than a focused one, but equally pleasant. The steps in this case involve no new problems, but again the working is lengthy and will not be given in detail. As in the case of the 'pleasure' hypothesis, it turns out not to be possible to specify pref(F/G) exactly but only to set upper and lower limits. The reason here is that $i_F + i_G$ is not determinable from the experimental data, and we have to make use of the fact that

$$|i_F - i_G| \leqslant i_F + i_G \leqslant 1 \;.$$