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Interactive effects of unpleasant light and unpleasant sound

IN tests of colour preference, rhesus monkeys have been found to have a strong aversion to light at the red end of the spectrum". No comparable reaction to colours has been described in healthy human beings although in patients who are suffering from cerebellar or spinal disorders colours may assume a new potency. It has been claimed that in cerebellar patients who exhibit the so-called `sensori-motor induction syndrome', red light not only exacerbates the motor disorder but disrupts thought processes and leads to acute subjective distress, whereas blue-green light alleviates the symptoms". Furthermore, Halpern and Feinmesser' found that in such patients red light, besides causing discomfort in itself, increases the sensitivity to noxious auditory stimulation: in their experiments the `threshold of acoustic discomfort' was consistently lowered when the patients wore red filters in front of their eyes. So we have investigated in monkeys whether the aversion to red light is increased when the preference tests are conducted in the presence of unpleasant background noise.

The technique for measuring the monkey's reactions to red light was similar to that previously described'. The monkey sat in a small dark chamber with a screen (40 cm X 40 cm) at the far end, on to which red or white light could be projected. The red light (Kodak Wratten filter 25) and the white light were matched in subjective brightness at 1.5 log foot lamberts. The monkey controlled the presentation of the two stimuli by pressing a button. Successive presses on the button produced the red and the white light in strict alternation, either stimulus staying on for as long as the button was held down. Each test lasted for 400 s of total exposure, during which time the monkeys typically alternated between the two stimuli about 100 times. The relative preference for the red light was measured as the ratio of the time spent with the red light to the total time spent with either red or white light over a defined interval.

The effect of background noise on the colour preference was investigated by comparing the monkey's performance when the chamber was quiet with that when `white noise' was played through an overhead loudspeaker during the test. The sound pressures in the `quiet' and the `noisy' conditions were 59 db and 80 db respectively. For comparisons to be made within a single test, each test was subdivided into eight 50-s bouts, four `noisy' and four `quiet' presented alternately. Each monkey was given twenty tests, ten of which started with `noise' and ten with `quiet'.

Four young adult male monkeys *(Macaca mulatta)* served as subjects. Monkeys are not all equally reactive to white noise and these four were selected as being two who found noise extremely aversive and two who found it relatively tolerable. This assessment was made by running preliminary tests in which the monkeys were given the opportunity to choose between noise and quiet in a simple (noise+light)/(quiet+light) preference test[s]. In five tests, each lasting 400 s, monkeys 1 and 2 preferred the quiet condition 85% and 83% of the time, while monkeys 3 and 4 preferred it 65% and 68 % of the time.

The results of the main experiment are shown in Fig. 1, the two subgroups of monkeys being treated separately. For monkeys 1 and 2 the background noise increased the aversion to red light; for each of these monkeys the effect was significant beyond the 0.001 level (Wilcoxon test, based on the performance within each of the twenty tests). For monkeys 3 and 4, however, the noise had little if any influence; although each of these monkeys showed a marginally greater aversion to red light in the noisy condition, the effect was not significant. The implication is that background noise increases the aversion to red light if, and only if, the monkeys find the noise itself markedly aversive.

Although Halpern and Feinmesser studied the effect of red light on the aversion to noise, whereas we did the reverse in our experiment, there is an obvious parallel between the results of the two studies. The difference in experimental design is in fact more apparent than real, since, whichever way round the experiment is done, the most one can conclude is that a combination of red light and noise is unduly aversive. The experiments do not allow one to distinguish whether it is red light which increases the unpleasantness of noise or noise which increases the unpleasantness of red light; indeed this is probably a false antithesis, the truth being that the effects of the two stimuli mutually potentiate each other.

Leaving aside the puzzle of why red light should be aversive to either monkeys or cerebellar patients, one may speculate on the broader implications of these findings. Whether it is a general rule that unpleasant stimulation in one modality potentiates the effect of unpleasant stimulation in another remains unknown; but a rube of this sort would be given a certain plausibility by Stevens' `power law' for subjective sensation'. Stevens showed that when people are given electric shocks their subjective discomfort is an accelerating function of the magnitude of the physical stimulus (thus the discomfort resulting from a 40 V shock is more than twice that from a 20 V shock). Suppose, purely for illustrative purposes, that red light alone is equivalent to

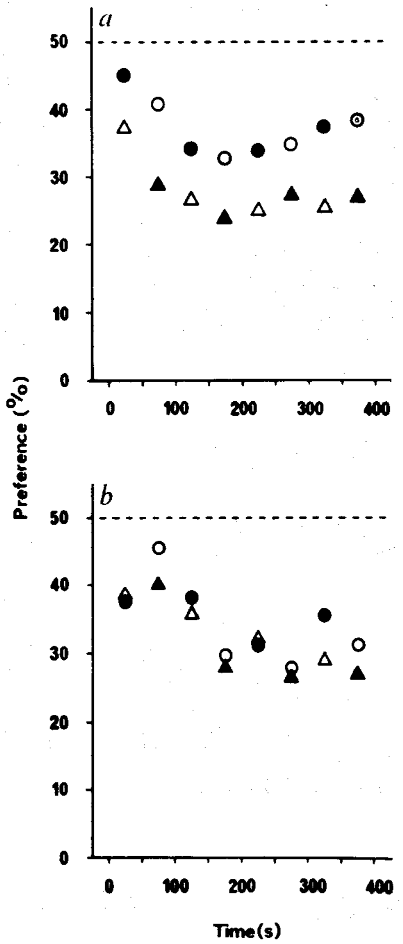

Fig. 1 Preference for red over white light in each successive 50-s period. *a*, Monkeys 1 and 2; *b*, monkeys 3 and 4. ○, ●, 'Quiet' condition; △, ▲, 'noisy' condition. ○, △, Tests which began with noise; ●, ▲, tests which began with quiet. Each point represents the mean of the two monkeys' mean scores over ten tests.

X units of shock, and noise alone is equivalent to Y units of shock, then the discomfort due to a combination of red light and noise may be expected to be greater than the sum of the discomfort caused by the component stimuli, since $(X+Y)^n > (X^n+Y^n)$, if the sensory exponent, n, is greater than one.

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