Effects of differential relevance of external stimuli on heart rate under food deprivation*

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Ss were deprived of food for 24 h, after which heart rate (HR) was recorded with food placed before the Ss and also after they had eaten it. It was predicted, according to Malmö's interaction hypothesis, that HR in both situations would be higher than at a control level but that the increase after food ingestion would be greater than that found in the presence of visual cues. The results did not wholly support these predictions. Only after eating were significant HR increases found. Possible reasons for the discrepancies between findings in this area were discussed.

The relationship between the organic drive states and the autonomic nervous system has received much attention. Malmö's (1962) "interaction hypothesis" suggests that the environmental context is crucial in determining whether or not increases in the level of autonomic activation will be found under deprivation conditions. Activation level depends upon an internal state of motivation and an external situation that is relevant—that is, related in some way to primary reinforcement.

This general position has been supported by a number of studies on animals under food or water deprivation, employing HR as a measure of activation. Several kinds of relevant stimulation have been used: consummatory behavior itself (Eisman, 1966; Jolley, 1970a); the operant situation (Belanger & Feldman, 1962); and prior association of the test environment with primary reinforcement (Goldstein, Stern, & Rothenberg, 1966). Jolley (1968) has also shown that nonrelevant stimuli (changes in illumination level not previously associated with feeding) are not effective in promoting HR increases after food deprivation. All of these experiments demonstrate that deprivation has no effect on HR in the absence of food- or water-related stimuli. Employing human Ss, Buckhout & Grace (1966) showed that HR after 24-h food deprivation increased significantly in a situation where anticipation of eating was accompanied by the sight of food but not when these stimuli were absent. These findings give further support to the interaction hypothesis.

The interaction hypothesis further suggests that stimuli differ in the degree of relevance that they possess,

which in turn affects the amount by which activation is raised under a given level of deprivation. Thus, if the stimuli involved include those of consummatory behavior itself (i.e., the presence of food in the mouth, mastication, and peristalsis), then the greatest effect on HR will be produced, since such stimuli are, by definition, the most relevant of all. Any other relevant stimuli will have a relatively smaller, though still significant, effect on HR. It is this aspect of the interaction hypothesis that is the main concern of the present study. Ducharme (1966) found that the HR of rats under a given level of water deprivation was higher in a Skinner box, where water was actually ingested, than it was in the presence of stimuli—handling and the attachment of recording leads—that heralded placement in the Skinner box and the receipt of primary reinforcement. In turn, this latter level was higher than that in a control group of equally deprived rats, where the same stimuli had no cue function. No comparable study has been carried out with human Ss.

It is hypothesized therefore that, under a given level of food deprivation, a situation involving knowledge that deprivation is about to end, plus the sight of food, will raise HR above a control level. However, the introduction of the more relevant stimuli involved in eating itself will produce a further significant increase in HR. The following experiment attempts to test these predictions.

SUBJECTS

Ss were a group of 10 undergraduate students (6 male and 4 female). All were naive regarding the aims of the study but had had previous experience of the recording apparatus.

APPARATUS

Heart rate recording was carried out in an electrically screened room. Ss sat comfortably in a dental chair while a stainless steel electrode was fastened to the inner surface of each forearm.

The signal was fed, via a cardiometer, to a Honeywell U.V. Visicorder.

PROCEDURE

Heart rate recordings were taken over 2 consecutive days, according to the following procedure:

Day 1

Base Level (BL) Situation

Ss drank ½ liter of milk before reporting to the laboratory. They then sat quietly for 30 min outside the experimental room before sitting in the chair. After electrode placement, a further 30 min elapsed before recording commenced. Ss were instructed to be as relaxed as possible. Five minutes of continuous HR recordings were taken. Ss were then instructed to report for further recordings 24 h later and to eat nothing in the interim. They could drink water as required. They were also told that after the following day's recording session the experiment was to terminate.

Day 2

Visual Cues (VC) Situation

After the 1-h period of adaptation to the laboratory and recording apparatus, a piece of bread and butter measuring approximately 4 x 4 x 1½ cm was placed on a table in front of the Ss. They were told that they could eat it after a few minutes. Five minutes of HR was then recorded.

Consummatory Behavior (CB) Situation

Ss then ate the food, which was placed in their mouths by the E. They were told to eat slowly. After this, HR was recorded again for a final 5-min period. The experiment was then terminated.

RESULTS AND DISCUSSION

Heart rate was sampled by taking a reading at the end of every 60 sec during each 5-min recording period.

Figure 1 shows the comparison between pre- and postdeprivation mean HR levels. Using a *t* test for correlated samples (two-tailed), no significant increase in HR was found over BL rates in the VC situation ($t = .806$, $df = 9$, $p > .05$). However, in the CB situation, a highly significant rise was found ($t = 5.075$, $df = 9$, $p < .001$). This change seems to be the result of an interaction between the state of deprivation and the stimuli of the CB situation. If deprivation alone had produced the increase, a similar change would have been found in the VC situation. In any case, as already noted, much evidence exists to suggest that deprivation *per se* has no effect on HR. The possibility remains that the increase could have been due solely to the activity of eating—independently of the internal state of motivation. However, data published elsewhere (Jolley, 1970b)

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Fig. 1. Comparison of pre- and postdeprivation mean HR. BL—base level condition (predeprivation); VC—visual cues condition (postdeprivation); CB—consummatory behavior condition (postdeprivation).

on similar consummatory activity, indicate that such stimulation has little effect on HR in satiated Ss.

The lack of significant change in the VC situation is unexpected and at odds with the findings of Buckhout & Grace (1966) in a situation of comparable relevance. In the present study, stimulation became appropriate (in instigating HR increases) only at a higher level of relevance, i.e., with the introduction of consummatory

stimuli. However, the specific visual cues of the two experiments were rather different—chocolate bars and a glass of milk (Buckhout & Grace, 1966), as opposed to a small piece of bread and butter in the present study. It seems likely that the degree of palatability of the food employed is an additional important factor here. When palatability is relatively low (present study), a higher level of relevance is required to render stimuli appropriate. The converse also appears to be true (Buckhout & Grace, 1966). Individual food preferences will be of importance in determining precise levels of palatability. Thus, relevance seems to be an essential but not necessarily sufficient criterion of appropriate stimulation under short-term deprivation. Even consummatory stimuli may not be appropriate if palatability is extremely low. Clearly, further research is needed here. Under more intense conditions of hunger, of course, the functional relationships between these variables are likely to be very different. It might be that under protracted food deprivation, relevance and palatability of stimuli need be only minimal to be appropriate. Investigations are planned to look at such hypotheses.

Although the predictions derived from the interaction hypothesis are not all upheld in this study, the findings do not automatically undermine Malmo's (1962) position. It may well be that all appropriate stimuli are relevant—the evidence certainly points in that direction (Jolley, 1968). It is the converse which

is not supported by the present results. This suggests a degree of complexity in the deprivation/HR relationship not apparent in Malmo's writings. In an experiment using stimuli which are appropriate at varying levels of relevance, the hypothesis that differential relevance will promote differential HR change could still be put to the test. Such an experiment still remains to be carried out.

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