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# CARDIOVASCULAR RESPONSES DURING HABITUATION AN[D] MENTAL ACTIVITY IN ANXIOUS MEN AND WOMEN

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A sample of 80 subjects was rated on the IPAT anxiety scale and 10 subjects each selected from the categories of high and low anxiety, half male and half female. Orie[nting] and habituation to a 60 db tone were monitored by a photoplethysmograph an[d] experiment also incorporated two mental tasks. The data collected included [b] volume changes, and heart rate. Habituation of the blood volume response occ[urred] significantly faster for non-anxious subjects, and for men. Heart rate change[s] baseline showed deceleration during orienting and acceleration during the [ ] Measures of heart rate distinguished between anxious subjects during the hear[t] recovery phase.

## 1. Introduction

The study of sex differences has become an increasingly important ar[ea] psychological research (Maccoby, 1966; Garai and Scheinfeld, 1968; Ou[nsted] and Taylor, 1972), where the causes for the differences observed have [ ] frequently been attributed to social or to developmental factors, rathe[r] in terms of basic differences in neural activity. During the 1950s, the [ ] of Spence and his colleagues showed that there were significant differen[ces in] the rate and amount of conditioning between men and women, and be[tween] subjects rated as high or low on an anxiety scale. Spence and Farber ([ ] reported that women produced more eyeblink conditioned responses than men with the personality factor of anxiety controlled. Many experi[ments] on human conditioning are open to the criticism that the somatic ne[rvous] system may interact with autonomic processes. To avoid this proble[m] experiment was designed to investigate habituation of an autonomic resp[onse].

Although conditioning and habituation probably involve different n[ ] mechanisms (Horn and Hinde, 1970), nevertheless habituation is defin[ed] the waning of a UCR—the orienting response (Sokolov, 1963). Hence processes involve CNS-generated inhibition or excitation acting upon [ ] distal systems. If the speed and amount of neural reactivity is a ge[ ]

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BV returned to baseline, white noise was presented over the earphones and was signalled by the experimenter. This was heard for 2 min and then the first tone sounded. It was not expected by the subject. Twenty, 1 sec, 1000 Hz tones were presented at random intervals (13–70 sec) for 15 min unless the subject had clearly habituated before that time.

Following the habituation trials the subject was asked to relax and then was given two short tasks. The first was a word association test to the letter B. The second was a numerical test in which the subject had to make rapid serial subtractions of 17 from 393. The subject was led to believe that the results on these tests were some measure of ability. The numerical task was paced by a metronome and lasted 1 min. The verbal test lasted 3 min. The decision to use two tests was taken on the basis that some people are more productive verbally than numerically.

## 3. Results

### *3.1. Scoring*

All habituation data were based only on BV changes as d.c. recording makes PV analysis very difficult. Two analyses of habituation scores were carried out. The time to habituate was calculated as the time, in minutes, to the first series of three no-responses in a row. The second measure was based on the number of responses appearing in the record. All responses, including those which occurred after a three no-response sequence were counted. Only when a subject had clearly habituated (e.g. continuous no-responding) was the experiment stopped.

Table 1.
Mean scores and analysis of variance for habituation criteria.

| | Men | | Women | |
|---|---|---|---|---|
| Measures | High anxiety | Low anxiety | High anxiety | Low anxiety |
| Time to three no-responses (min) | 13.50 | 7.66 | 15.00 | 10.35 |
| Number of positive responses | 16.20 | 5.80 | 16.80 | 12.00 |
| SV | | *df* | *MS* | *VS* |
| Sex | | 1 | | |
| 3 No-responses | | | 51.79 | 7.07* |
| Response total | | | 45.00 | 3.60 |
| Anxiety | | 1 | | |
| 3 no-responses | | | 176.65 | 24.23† |
| Response total | | | 259.00 | 20.77† |
| Sex × anxiety | | 1 | | |
| 3 no-responses | | | 1 | 1 |
| Response total | | | 51.4 | 4.12 |
| Within cell error | | 16 | | |

*$p \leq 0.025$; †$p \leq 0.001$.

A response was quantified as a deviation from baseline of more than 5 mm deflection of the pen (peak to peak) in the direction of constriction (BV diminution) and occurring not later than 3 sec after the stimulus. A 5 mm criterion is well within the range of all subject's responses.

Heart rate scores were compiled as deviations from basal heart rate which was measured over the last 3 min of the relaxation phase. Heart rate was measured as a percentage change over minutes one and two during the first orienting response, at the end of habituation, and during each stress task. Heart rate was quantified as beat/min for each 30 sec epoch.

### 3.2. *Habituation trials*

The scores were compiled as described above and the mean scores are illustrated in table 1. An analysis of variance showed that there is a significant effect for anxiety ($p < 0.001$) and for sex ($p < 0.025$) with the latter result only occurring when using the three no-response criterion. There was no significant interaction.

### 3.3. *Mental tasks*

BV changes during the tasks were somewhat idiosyncratic and bore no relationship to the categories investigated. Both dilatation and constriction in BV were observed, with some subjects demonstrating lability between the two. Because of this it was impossible to analyse these changes during the tasks. This contrasted sharply with observed BV constriction in all subjects ($p < 0.005$, Wilcoxon) during instructions from the experimenter preceding the tasks. This suggests that BV may be specifically responsive during attention to an external stimulus, but not specific with respect to internally demanding tasks.

### 3.4. *Heart rate*

No apparatus was available for a beat-to-beat analysis and so all calculations were carried out as beat/min. However, tonic heart rate incorporates phasic responses, and when the stimulus is at 60 db, deceleration should be the predominant response (Graham and Clifton, 1966). A Wilcoxon test showed that deceleration occurred across all categories during orienting, but reached only a value of significance of $p < 0.10$. No effect of sex or anxiety was found ($F(1, 16) = <1, <1$). Heart rate at the end of habituation was near or below baseline for most subjects but was elevated for some anxious subjects. However, there was no significant effect for anxiety or for sex ($F(1, 16) = 2.59, <1$).

During the letter and number tasks HR acceleration occurred for every subject to both tasks ($p < 0.005$, Wilcoxon). The percentage increase in HR to the most stressful task for each subject, as measured by the greatest heart rate increase, showed no significant effect of anxiety or sex ($F(1, 16) = 1.2, <1$).

Table 2.
Results of analysis of variance for HR stress recovery.

| SV | *df* | MS | VR |
|---|---|---|---|
| Sex | 1 | 3 | 0.075 |
| Anxiety | 1 | 192 | 4.80* |
| Sex × anxiety | 1 | 65 | 1.62 |
| Within cell error | 16 | 40 | |

*$p < 0.05$.

Heart rate recovery during stress (table 2) was measured for the letter task as the percentage change over baseline during the mean of minute one, minus the percentage change over baseline of minutes one and two combined. A low score on this measure indicates little recovery. The effects were significant for anxiety ($p < 0.05$) but not for sex. No analysis was carried out on the number task as it lasted only 1 min.

## 4. Discussion

The effects of sex and anxiety observed by Spence and Farber (1953) durin conditioning have also been demonstrated during habituation. Anxiety ha the most consistent effect on habituation rate, while sex, although significan did not produce a significant interaction. However, it can be seen by the mea scores in table 1 that no anxious female subject reached the three no-respons criterion during the 15 min period, whereas a few of the anxious males did so Had the experiment been extended for a longer period of time it is possibl that female subjects may have continued to fail to meet the criterion. It is als important to bear in mind that subjects were chosen from extreme ends of th anxiety continuum. Studies on habituation or conditioning which investigat subjects normally distributed on any personality dimension, will obviousl continue to show the sex effect in the absence of any effect of personality.

The results also suggest that blood volume changes provide a useful inde for a habituation paradigm, as well as being an extremely simple technique t employ. The lessening of blood volume changes in magnitude over trial parallels the findings of Raskin et al. (1969) who observed that forehea blood volume diminished with stimulus repetition while pulse volume did no Magnitude estimation using blood volume is also considerably simpler t calculate than that for pulse volume, where in some subjects the response ca diminish to 1 mm or less.

The physiological mechanism of finger pulse volume has received conside able experimentation (Abramson, 1964) but that of blood volume has no It is known that digital blood flow changes are largely under the control the sympathetic nervous system (Hertzman, 1959; Ruch and Patton, 196 and there is no doubt that the correlation between GSR latency and B latency is high (author's unpublished data), but the blood volume chang which were observed during internal processing or concentration are not consistent between subjects, and the mechanism influencing these changes during the tasks is difficult to determine. The observed variability could be due to the interaction of autonomic systems. The sympathetic system is dominant in determining the tone of the arterioles and anastamoses (Ruch and Patton, 1966) but it remains to be determined whether blood volume variability can arise from changes in venous volume, or perhaps by blood pressure changes triggered from the vasomotor centre or the hypothalamus.

The current study showed that a pattern of responding resulting from a gross sympathetic discharge which has been presumed to produce blood volume vasoconstriction and heart rate acceleration did not occur during orienting or the mental tasks. This confirms similar findings by Lacey and Lacey (1970) who observed a division in responding depending upon the types of attention involved. However, the reason for the observed 'fractionation' is due to an incorrect assessment of the influence of the sympathetic system on heart rate.

At present all evidence on heart rate during orienting and startle shows that heart rate is under the control of the vagus (Obrist, Wood and Perez-Reyes, 1965; Baust and Bohnert, 1969; Eckberg, Fletcher and Braunwald, 1972). Therefore any change in heart rate to any stimulus presentation is almost entirely due to the parasympathetic system and is outside the so-called 'sympathetic arousal' response. The findings of Eckberg et al. (1972) indicate that sympathetic effects on heart rate only occur during sustained high metabolic output, such as during exercise. As there is no sympathetic arousal effect on the heart, there is no rationale for employing beat-to-beat analyses where the stimulus employed is of a moderate intensity. The phasic deceleration which generally occurs to a 60 db tone will be incorporated in the tonic measure. A subsequent beat/sec breakdown of the data revealed that subjects reacted to the stimulus over the early beats with either no change in rate or a slight deceleration.

Heart rate increases during concentration or 'mental stress' are due to vagal inhibition, whereas the labile shifts in blood flow suggest an interaction of systems and could be partly attributable to changes in systolic blood pressure. Evidence in support of this suggestion comes from a study using pharmacological blocking agents on dogs (Obrist, Howard, Lawler, Sutterer, Smithson and Martin, 1972) which showed that during aversive conditioning the sympathetic system had little effect on the observed heart rate increase, but a large effect on the contractile properties of the heart and systolic blood pressure. Further evidence comparing physiological responses to both aversive stimuli and 'stressful' mental activity needs to be accumulated to evaluate this comparison.

Pribram (1967, 1971) offers a hypothesis that two major types of inhibition are reciprocally involved in a habituation paradigm. The first (lateral) affecting the intensity of the initial response, and the second (self), the time course of response diminution. Interpretation of the findings of this study in terms of two types of inhibition may prove more enlightening than adopting the theory that individuals will vary in the speed at which they generate central inhibition (Eysenck, 1967). As no significant differences were found in either heart rate deceleration during orienting, or acceleration during concentration between anxious and non-anxious subjects, it seems possible to eliminate lateral inhibition as distinguishing individuals with differing levels of anxiety. It is more appropriate to suggest that anxiety affects self inhibition, as in two situations: habituation, and heart rate recovery time during mental tasks, anxious subjects respond for *longer* than non-anxious subjects.

Likewise, females took longer to habituate than males, but did not produce any differences in initial heart rate responses, again suggesting that the temporal factors of inhibition are involved, rather than intensity factors. However, the speed at which heart rate returned to baseline during mental processing did not distinguish between the sexes. A recent experiment by the author (unpublished) showed that females hear tones as louder than males across the frequency range, as well as being less tolerant of a repeating auditory stimulus. It remains to be determined whether hearing a tone as subjectively louder causes a delay in habituation (with no observable effect on heart rate) or whether the delay is due to the effect of repetition *per se*, and whether the sex difference is only observed in the auditory mode.

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