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THE PSYCHOPHYSIOLOGY OF THE
DEFENCE REACTION

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

by

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This thesis describes original research carried out by
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Douglas Carroll
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PREFACE

Some of the findings of this study were presented at the annual conference of the Australian Psychological Society, Melbourne, Victoria, August, 1971. Other portions have been published by or are in submission with the following journals:


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## LIST OF ABBREVIATIONS

The following abbreviations have been used in this thesis.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BV</td>
<td>Blood volume</td>
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<td>BVP</td>
<td>Blood volume pulse</td>
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<td>CS</td>
<td>Conditioned stimulus</td>
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<tr>
<td>DR</td>
<td>Defence reaction (also referred to by other workers as the defence response or reflex, and the defensive reaction, response or reflex)</td>
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<td>EEG</td>
<td>Electroencephalograph</td>
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<tr>
<td>E-I</td>
<td>Extraversion - introversion</td>
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<tr>
<td>EMG</td>
<td>Electromyograph</td>
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<tr>
<td>N</td>
<td>Neuroticism</td>
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<td>MMPI</td>
<td>Minnesota multiphasic personality inventory</td>
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<td>OR</td>
<td>Orienting reaction (also referred to by other workers as the orienting response or reflex, and the orientation reaction, response or reflex)</td>
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<td>PSI</td>
<td>Perceived stress index</td>
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<td>RF</td>
<td>Reticular formation</td>
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<td>R-S</td>
<td>Repression-sensitization</td>
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<td>RT</td>
<td>Reaction time</td>
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<tr>
<td>S</td>
<td>Subject</td>
</tr>
<tr>
<td>SCL</td>
<td>Skin conductance level</td>
</tr>
<tr>
<td>SCR</td>
<td>Skin conductance response (also referred to by other workers as the galvanic skin response)</td>
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<tr>
<td>UCS</td>
<td>Unconditioned stimulus</td>
</tr>
</tbody>
</table>
This thesis is concerned with the Soviet formulation of physiological arousal reactions as ORs and DRs. The proposed association of the OR with the heightening of perceptual sensitivity and the DR with the attenuation of sensitivity renders this formulation of theoretical importance. The reported occurrence of directionally distinct forehead vasomotor responding in the two reactions holds considerable empirical interest.

The initial experiment reported in Chapter 2 explored the generality of the Soviet formulation, i.e., whether physiological responses to complex, affective visual stimuli could be characterized as ORs and DRs. Forehead BVP was recorded as an index of forehead vasomotor responding. Changes in other physiological parameters, as a result of such stimulation, were also monitored. Whereas unpleasant homicide slides elicited extensive forehead constriction, indicative of the DR, mainly vasodilation, indicative of the OR, was observed with pleasant and interesting visual stimuli. The unpleasant stimuli also tended to elicit the most persistently large SCRs.

The effects of signal value on the nature of the response to such affective stimulation was then explored in Chapter 3. With the imposition of a "memory set" the differences noted in Chapter 2 were no longer observed.

Chapter 4 explored flexor and extensor EMG responses to such stimuli, to test a related hypothesis that linked dominant flexor EMG activity with unpleasant stimulation and dominant extensor EMG activity with pleasant visual stimulation. Whereas the unpleasant homicide slides tended to elicit the most emphatic flexor EMG activity, extensor EMG responding did not differentiate slide conditions.

Chapter 5 explored individual differences in forehead BVP response to the unpleasant homicide slides. The extent of the forehead BVP constriction response showed little or no relationship to self-
report of distress and defensive style as defined by position on the R-S perceptual-personality dimension. However, R-S scale score did influence self-report of affective experience. Ss showing little forehead BVP constriction tended to look relatively longer at the homicide pictures than Ss showing extensive forehead BVP constriction.

At the onset of the present thesis there were few accounts of Western experiments that monitored forehead vasomotor change. However, several such experiments have now been reported. The finding of some of these experiments, that forehead vasomotor responding, is an insensitive parameter, presents problems for the Soviet formulation. Consequently in Chapter 6 forehead vasomotor responding to moderate and intense simple auditory stimuli was re-examined. Both forehead BVP and BV were monitored as indices of forehead vasomotor change. The results were generally in line with the earlier Soviet findings of differential forehead vasomotor responding to moderate and intense stimulation.

A central assumption of the Soviet schema is that the OR and DR are associated respectively with increases and decreases in perceptual sensitivity. Chapter 7 reports an experiment which explored the relationship of forehead vasomotor responding and performance in a simple reaction time task. The results demonstrated an association between the presence of the DR and relatively slower reaction times, and the OR and relatively faster reaction times.

The findings of the present study suggest that forehead vasomotor measurement represents a useful addition to those more commonly employed psychophysiological variables, particularly in the study of phenomena that pass under the general heading of "stress". Further, doubt is cast on the classical "arousal" or "activation theory" view of autonomic function, that regards autonomic change as reflecting only "intensive" and not "directional" aspects of behaviour.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>iii</td>
</tr>
<tr>
<td>PREFACE</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS</td>
<td>v</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>vi</td>
</tr>
<tr>
<td><strong>CHAPTER 1 INTRODUCTION</strong></td>
<td>1</td>
</tr>
<tr>
<td>1.1 Orienting and defence reactions</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Orienting and defence reactions and affective experience</td>
<td>7</td>
</tr>
<tr>
<td>1.3 Defence reaction to vicariously unpleasant stimuli</td>
<td>9</td>
</tr>
<tr>
<td>1.4 Relevant psycho-physiological parameters</td>
<td>12</td>
</tr>
<tr>
<td>1.5 Signal value and physiological response</td>
<td>18</td>
</tr>
<tr>
<td><strong>CHAPTER 2 ORIENTING AND DEFENCE REACTIONS TO AFFECTIVE VISUAL STIMULI</strong></td>
<td>22</td>
</tr>
<tr>
<td>2.1 Statement of aim of initial experiment.</td>
<td>22</td>
</tr>
<tr>
<td>2.2 Experimental method</td>
<td>22</td>
</tr>
<tr>
<td>2.2.1 Subjects</td>
<td>22</td>
</tr>
<tr>
<td>2.2.2 Stimuli</td>
<td>23</td>
</tr>
<tr>
<td>2.2.3 Design</td>
<td>25</td>
</tr>
<tr>
<td>2.2.4 Apparatus and the measurement of dependent variables</td>
<td>26</td>
</tr>
<tr>
<td>2.2.4.1 Forehead blood volume pulse</td>
<td>26</td>
</tr>
<tr>
<td>2.2.4.2 Skin conductance level and skin conductance response</td>
<td>30</td>
</tr>
<tr>
<td>2.2.4.3 Eye-blinking</td>
<td>31</td>
</tr>
<tr>
<td>2.2.4.4 Self-report measures</td>
<td>32</td>
</tr>
<tr>
<td>2.2.5 Procedure</td>
<td>34</td>
</tr>
<tr>
<td>2.3 Results</td>
<td>35</td>
</tr>
<tr>
<td>2.3.1 Forehead blood volume pulse</td>
<td>35</td>
</tr>
<tr>
<td>2.3.2 Skin conductance level and skin conductance response</td>
<td>40</td>
</tr>
<tr>
<td>Chapter 3</td>
<td>SIGNAL VALUE AND PHYSIOLOGICAL RESPONSE TO AFFECTIVE VISUAL STIMULI</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>3.1</td>
<td>Introduction</td>
</tr>
<tr>
<td>3.2</td>
<td>Method</td>
</tr>
<tr>
<td>3.3</td>
<td>Results</td>
</tr>
<tr>
<td>3.3.1</td>
<td>Forehead blood volume pulse</td>
</tr>
<tr>
<td>3.3.2</td>
<td>Skin conductance response</td>
</tr>
<tr>
<td>3.3.3</td>
<td>Self-report measures</td>
</tr>
<tr>
<td>3.4</td>
<td>Discussion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 4</th>
<th>THE STARTLE PATTERN AND THE DEFENCE REACTION: ELECTROMYOGRAPHIC RESPONSE TO AFFECTIVE VISUAL STIMULI</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Introduction</td>
</tr>
<tr>
<td>4.2</td>
<td>Method</td>
</tr>
<tr>
<td>4.3</td>
<td>Results and Discussion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 5</th>
<th>INDIVIDUAL DIFFERENCES IN THE EXTENT OF THE DEFENCE REACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Introduction</td>
</tr>
<tr>
<td>5.2</td>
<td>Self-report and individual differences in forehead BVP response</td>
</tr>
<tr>
<td>5.2.1</td>
<td>Introduction</td>
</tr>
<tr>
<td>5.2.2</td>
<td>Method</td>
</tr>
<tr>
<td>5.2.3</td>
<td>Results</td>
</tr>
<tr>
<td>5.2.4</td>
<td>Discussion</td>
</tr>
<tr>
<td>5.3</td>
<td>Repression-sensitization and individual differences in forehead BVP response</td>
</tr>
<tr>
<td>5.3.1</td>
<td>Introduction</td>
</tr>
<tr>
<td>5.3.2</td>
<td>Method</td>
</tr>
</tbody>
</table>
5.3.3 Results
5.3.4 Discussion
5.3.5 Repression-sensitization and self-report of affective experience
5.3.6 Repression-sensitization and the verbal elaboration of experience: A side issue

5.4 Looking time and individual differences in forehead BVP
5.4.1 Introduction
5.4.2 Method
5.4.3 Results
5.4.4 Discussion
5.4.5 Looking time and repression-sensitization
5.4.6 Looking time and signal value

5.5 Concluding remarks

CHAPTER 6 FOREHEAD VASOMOTOR RESPONSE TO MODERATE AND INTENSE AUDITORY STIMULATION: A RECONSIDERATION

6.1 Introduction
6.1.1 Integration of recent studies
6.1.2 Forehead vasomotor measurement
6.1.3 Studies employing BVP measurement
6.1.4 Studies employing BV measurement
6.1.5 Aim of present experiment

6.2 Method
6.2.1 Subjects
6.2.2 Design
6.2.3 Stimulus presentation and calibration of stimulus intensity
6.2.4 Forehead blood volume pulse and blood volume measurement
6.2.5 Procedure
6.3 Results
6.3.1 Forehead blood volume pulse
6.3.2 Forehead blood volume

6.4 Discussion
6.4.1 Forehead blood volume pulse
6.4.2 Forehead blood volume
6.4.3 Comparison of BVP and BV response measures
6.4.4 Blood volume, blood volume pulse and sensitivity regulation

CHAPTER 7 ORIENTING AND DEFENCE REACTIONS: THEIR ROLE IN SENSITIVITY REGULATION AND PERFORMANCE:

7.1 Introduction
7.1.1 The role of ORs and DRs in stimulus reception
7.1.2 The role of ORs and DRs in learning and performance
7.1.3 Stimulus intensity and performance
7.1.4 ORs and DRs and performance on a simple reaction time task

7.2 Method
7.2.1 Subjects
7.2.2 Design
7.2.3 Apparatus and dependent variable measurement
7.2.4 Procedure

7.3 Results
7.3.1 Reaction time
7.3.2 Forehead vasmotor responding
    7.3.2.1 Forehead blood volume pulse
    7.3.2.2 Forehead blood volume
    7.3.2.3 Forehead blood volume and blood volume pulse changes prior to the visual RT stimulus in the no tone control trials
CHAPTER 8  CONCLUDING REMARKS

8.1  Summary of results  200

8.2  Implications of the present results  202

8.3  Parallel responding in the forehead and cerebral vasculature  205

8.4  Sokolov's model of the OR  206

APPENDIX I  SELF-REPORT MEASURES  214

I.1  Jacob-Munz Perceived Stress Index  214

I.1.1  Items and median intensity values  214

I.1.2  Instructions for prestimulation rating  214

I.1.3  Instructions for ratings after stimulus block presentation  215

I.2  Davitz list of words  215

I.2.1  Items comprising list  215

I.2.2  Instructions for completion of Davitz list  216

APPENDIX II  PERSONALITY INVENTORY  217

II.1  Repression-sensitization scale  217

II.1.1  Items in scale and scoring procedure  217

II.1.2  Instructions for scale administration  222

REFERENCES  223
CHAPTER 1

INTRODUCTION

1.1 Orienting and defence reactions

One of the most exciting developments in psychophysiology over the past decade has been the analysis and classification of physiological reactions in terms of their influence on an organism's sensitivity to environmental stimulation. The major outcome of researches so directed has been the elucidation of what has come to be called the orienting reaction (OR).

The reaction received its first systematic articulation by Pavlov (1927), who referred to it as the "investigatory" or "what-is-it," reaction and described it as follows:

"It is this reflex which brings about the immediate response in man and animals to the slightest changes in the world around them, so that they immediately orientate their appropriate receptor organ in accordance with the perceptible quality in the agent bringing about the change, making a full investigation of it" (Pavlov, 1927, p. 12).

Since that early description the OR has received the consistent and unfailing attention of Soviet psychophysicists (cf. Cole & Maltzman, 1968). Its investigation in Western laboratories received major impetus from the extensive work of Sokolov (1960, 1963a, 1963b) and subsequent comprehensive accounts of this and related Soviet work (e.g. Lynn, 1966). Sokolov's (1960, 1963a, 1963b) conception of the OR is similar to that of Pavlov i.e., it is a non-specific reaction to stimulus change and novelty which according to Sokolov (1963a), promotes "the most favourable conditions for stimulus reception (p. 285)". In the service of such favourable conditions the organism, according to Sokolov, musters a repertoire of central and peripheral physiological responses. Lynn (1966)
expressed it succinctly:

"Apart from the simple turning towards the source of the novel stimulus, it has become evident that the orientation reaction involves a large number of physiological changes. The purpose of these changes, in general terms, is to make the animal more sensitive to incoming stimuli so that it is better equipped to discern what is happening, and to mobilize the body for whatever action may be necessary" (Lynn, 1966, p. 2).

Thus the measurable physiological components of the OR would seem to serve two inter-related functions. Firstly, they serve to heighten perceptual sensitivity and thereby facilitate an organism's informational interaction with its environment. Secondly, the physiological changes represent an organism's preparedness toward anticipated muscular activity. Although Sokolov (1963a) almost exclusively stressed the former function and other workers have placed emphasis on the latter (e.g. Ruttkay - Nedecky, 1967) it would seem that the physiological components of the OR encompass both functions (Lynn, 1966).

Experimental evidence of the association of physiological components of the OR with changes in perceptual sensitivity was presented by Sokolov (1963a). Several studies were cited in which an OR elicited by a tone resulted in an increase in the sensitivity to visual stimuli. Visual threshold determinations were made by eliciting verbal reports from subjects, or by recording occipital electroencephalographic (EEG) changes and the skin conductance response (SCR), or, more usually, both. After it had been established that an individual did not respond, behaviourally and physiologically (as evidenced by alpha rhythm desynchronisation or an SCR), to a particular light intensity, a tone (73db intensity), which evoked an OR, was introduced. The presence of the OR was again gauged by alpha blocking and the SCR. In the presence of the OR the subliminal
light was experienced as liminal, as evidenced by both behavioural and physiological response measures. The intimate connection between the physiological components of the OR and changes in sensitivity was further demonstrated by repeatedly presenting the tone. With repetition of the tone, the OR to it gradually extinguished. OR extinction was associated with a rise in the visual threshold to its previous level such that the same light intensity no longer evoked a response.

The role of peripheral physiological responses in the preparation for motor action has been recognised by psychophysiologists for some time (e.g. Cannon, 1936; Darrow, 1936). As Darrow stated:

"Many of the physiological changes in organisms are primarily preparatory and facilitative. They are preparatory in the sense that they occur in anticipation of activity that has yet to come," (Darrow, 1936).

However, Sokolov (1963a) maintains that although involved in the preparation for muscular activity the significance of the physiological constituents of the OR is not restricted to this role.

"The orientation reaction does not, however, end with the tuning of the peripheral muscular apparatus." (Sokolov, 1963a, p. 80).

Vinogradova and Sokolov (1957) and Sokolov (1963a) differentiated between the OR and another unconditioned reflex, the defence reaction (DR). Whereas the OR operates to heighten perceptual sensitivity and promote an organism's commerce with its environment the DR apparently functions to produce decreased perceptual sensitivity and limit the effects of environmental stimulation. Sokolov distinguished between the two reactions as follows:

"... they differ in their ultimate object, this being the establishment of contact in the case of the latter (OR), and the breaking away from, or limitation of the activity of the stimulus in the case of the former (DR)." (Sokolov, 1963a, p. 14).
Whereas the OR occurs to stimuli of moderate intensity, the DR is summoned to attenuate the effects of intense or noxious stimulation.

According to Vinogradova and Sokolov (1957) differentiation of the two reactions can be made by observation of the forehead vascular response. Vinogradova and Sokolov (1957) observed that the occurrence of the OR was accompanied by vasodilation of the blood vessels of the forehead. Forehead vasodilation to a wide array of stimuli was also noted by Hertzman and Dillon (1939). Royer (1965) reported results in keeping with these. He, too concluded from his observations on cutaneous vascular reactions to auditory stimuli (pure tones of moderate intensity) that "the vasomotor component of the orienting reflex is dilatative in the skin of the forehead".

Evaluation of the record of vasomotor responding in these studies apparently involved little more than visual inspection. A recent study by Hord and Ackerland (1968) suggests that the forehead vasomotor component of the OR might be more complex. They recorded forehead responding in sleeping subjects to moderately intense auditory stimuli (30db above auditory threshold) using a detailed beat-by-beat analysis of the forehead pulses. The results of such an analysis indicated that the forehead vasomotor component of the OR involves a polyphasic response, an initial constriction phase preceding the previously reported dilation. Hord and Ackerland suggest two possible reasons for the discrepancy between their observation of a biphasic response and earlier reports of a monophasic OR component. Firstly, they suggest that the form of the OR may differ for sleeping and waking subjects. Unfortunately they offer no particular reasons for expecting such differences in response. Secondly, they suggest that the failure of earlier workers to use parametric descriptive techniques may have led to an oversimplification of the response.
"Sokolov's report of vasodilation in the forehead during orienting is due to the use of a less precise measure of the response. An important point which we wish to make is that the secondary dilative component of the forehead response is sometimes of high amplitude - and it would be easy to misconstrue the complex wave as only vasodilation if beat-by-beat averaging techniques were not applied to responses obtained during a state of nonhabituation". (Hord & Ackerland, 1968).

As Hord and Ackerland indicate, however, the dilative phase is by far the most emphatic in terms of amplitude change and in this sense would appear primary.

In contrast to their observations on forehead vascular responding to moderately intense stimuli, Vinogradova and Sokolov (1957) found that forehead vasoconstriction accompanied the presentation of intense tones or unpleasant electric shocks, thus making physiological differentiation of the two reactions possible.

Vinogradova and Sokolov (1957) and Sokolov (1963a) contend that these differences in the forehead vascular component of the two reactions reflect the operation of a basic mechanism of influence with regard to the tuning of perceptual sensitivity. These workers argue coherently, on the basis of their observations on forehead blood flow and the parallel observations of other Soviet investigators on cerebral blood flow, that a direct correspondence exists between forehead and cerebral circulatory changes.

"The reactions of the blood vessels of the surface of the head are similar in character to the vascular reactions of the brain and are essentially different from the reactions of the blood vessels of the limbs". (Vinogradova & Sokolov, 1957).

Hertzman and Dillon (1939) arrived at a similar conclusion.

"The similarity in the direction and character of the vascular changes in the forehead skin with those known to occur in the cerebral circulation suggests the possibility of using forehead skin plethysmographs as indicators of the cerebral circulation". (Hertzman & Dillon, 1939).
The forehead vasodilation observed in the OR, then, presumably reflects an increase in blood flow in the brain, the constriction observed with intense stimulation being indicative of a decrease in cerebral flow. As blood flow within the brain and related oxygen transport are apparently operative in the regulation of perceptual sensitivity (Sokolov, 1963a; Lynn, 1966), forehead vasodilation should reflect an increase in perceptual sensitivity and constriction a decrease in sensitivity.

Thus the directionally opposite forehead vasomotor changes which characterize the two reactions also reflect a major mechanism for their postulated differential influence on perceptual sensitivity.

The OR has attracted considerable interest in Western laboratories. A proliferation of research has appeared in recent years endeavouring to confirm and extend the innovative investigations of Sokolov (e.g., Lovibond, 1969; Maltzman, 1967; Maltzman & Mandell, 1968; Maltzman & Raskin, 1965; Unger, 1964; Zimny & Miller, 1966; Zimny & Schwabe, 1965). In comparison, the DR has received little or no attention in the West, although it has been prominent in numerous Soviet researches, and the different forehead vascular components of the OR and DR observed many times (e.g., Luria & Vinogradova, 1959; Sokolov, 1963a; Vinogradova, 1965; Vinogradova, 1963). Forehead vasomotor responding has rarely been employed as a dependent variable in Western psychophysiological research in spite of the fact that the consistent Soviet finding of differential forehead vasomotor responding with moderate and intense simple physical stimuli commends it as a measure of major empirical interest. The contention of Vinogradova and Sokolov (1957) and Sokolov (1963a) that these differences in forehead vasomotor responding reflect the operation of a mechanism involved in the tuning of perceptual sensitivity suggests that such measurement is also of considerable theoretical importance. The most prominent
Western view of the role of physiological processes in behaviour is that they are all indices of the "activation" or "arousal level" of the organism, i.e., the degree to which an organism is mobilizing its resources for action. The influential writings of Duffy (1962) and Malmo (1959) depict a unidimensional continuum of arousal from coma to high excitement, and contend that physiological processes reflect the intensive rather than the directional aspects of behaviour. The observation that moderate and intense stimuli evoke directionally opposite behaviour in the forehead vasomotor response channel, and the assertion that such differential responding is associated with the differential regulation of sensitivity (i.e., a directional aspect of behaviour), present major difficulties for "activation" or "arousal level" theory.

1.2 Orienting and defence reactions and affective experience.

Early attempts to attach specific physiological labels to different emotional states were generally unsuccessful. Sternbach (1966) points out, however, that although the results of such studies, and the pioneering work of Cannon (1936) and Selye (1946) tends to discourage the search for different patterns of physiological responses in different emotions the conviction persists that physiological responses must differ for different affective experiences. Some experiments (e.g., Ax, 1953; Schachter, 1957) have observed some physiological differentiation between "fear" and "anger" but results have been generally difficult to interpret, emerging patterns being overshadowed by extensive inter-subject differences.

It is possible that the Soviet dichotomy of physiological arousal patterns into ORs and DRs might relate to qualitatively different affective states. Grossman (1967, p. 624) makes the point that many of our emotional states are accompanied by responses which can be characterized as ORs. Further, Lynn (1966) points out that whereas
the occurrence of the OR is accompanied "by a reasonable rise in excite-
ment and interest (p. 9)" the DR is accompanied by a degree of unpleasant affect. A similar point has been made by Sokolov (1963a, 1965).

"The emergence of the reaction of comple-
mentary constriction (DR) coincides with the
emergence of unpleasant sensations." (Sokolov,
1965).

The assertions of these workers strongly suggest that one should look
to the forehead vasomotor response for physiological differentiation of affective states, or at least a differentiation of what are commonly referred to as positive and negative affective states. Grossman (1967) proposed that:

"Vascular responses can be monitored
crudely by inspection. Blanching in any part
of the body is an indication of vasoconstriction;

Consideration of common figures of speech suggests that facial or forehead "blanching" and "flushing" are associated with quite different affective states. Charles Darwin included such blanching in his descrip-
tion of the expression of fear, postulating the following mechanism for its occurrence:

"This paleness of the surface, however,
is probably in large part, or exclusively, due
to the vasomotor centre being affected in such
a manner as to cause the contraction of the
small arteries of the skin". (Darwin, 1955,
p. 290).

Thus the application of the concepts of ORs and DRs to affective experience, and the measurement of forehead vascular changes in stimulus situations contrived to elicit positive and negative affects would seem a worthwhile pursuit. Sternbach (1966) expressed enthus-
iasm for such an approach:

"Such concepts as need to enhance stimulus input, or the need to decrease perceived stimulus intensity may be more useful in understanding autonomic response patterns than the traditional approach of studying the consequence of "stress", or trying to discover the physiological definitions of emotions". (Sternbach, 1966, p. 90).
1.3 Defence reaction to vicariously unpleasant stimuli.

In spite of the interpretative implications of ORs and DRs, and their proposed roles in the regulation of perceptual sensitivity, for all manner of behavioural events, empirical investigation has focussed almost exclusively on responses to simple physical stimuli. As Maltzman and Mandell (1965) state, specifically with regard to OR investigations:

"The OR can no longer be conceived as a simple reflex induced by stimulus change in spite of the fact that most studies in the West directed toward the examination of the OR have confined themselves to the simplest stimulus variations" (Maltzman & Mandell, 1968).

The application of the OR/DR framework to the wider arena of affective experience demands an investigation of whether such responses occur in a broader stimulus context i.e. whether responses elicited by more complex stimuli can be interpreted in terms of the Soviet schema. A question of particular importance is whether a response primarily suggestive of the DR will be elicited by vicariously unpleasant stimuli i.e. stimuli whose unpleasantness arises from the operation of some sort of identification process by the subject (cf. Lazarus, 1966) or from the prior contingencies established between the stimuli and directly unpleasant stimuli such as electric shocks or intense auditory stimuli.

The results of the few studies employing more complex stimuli have for the most part been encouraging, Luria and Vinogradova (1959) observed DRs to words conditioned to unpleasant electric shocks. Not only was the forehead vasoconstriction of the DR apparent with the reinforced word but also with words with a close semantic link to the reinforced word. For example, when the key reinforced word was "skripka" (violin) such words as "skripach" (violinist), "smychok" (bow), "struna" (string) and "mandolina" (mandolin), also elicited a DR. A
still wider group of words, with apparently a looser semantic link with the key word, such as "klarnet" (clarinet), "baraban" (drum), and "koncert" (concert) elicited an OR, indicated by a forehead vasodilation response. ORs were also observed for acoustically related words such as "skrepka" (paper-clip). Unrelated words such as "shkaf" (cupboard) and "sapog" (boat) evoked no change in vascular behaviour. Apart from their interesting implications for the study of the dynamics of the semantic system, Luria and Vinogradova's findings adequately demonstrate that the DR can be produced in conditioned form and can thus presumably occur to stimuli whose unpleasantness is of a more vicarious nature. Several other Soviet studies report that the forehead vasomotor component of the DR can be reproduced in conditioned form (e.g., Sokolov, 1963a; Vinogradova, 1965, 1968). These studies, however, still employed simple physical stimuli (tones) as conditioned stimuli.

Brotsky (1969) attempted part replication of Luria and Vinogradova's study, but was unsuccessful and did not apparently observe the development of the vasoconstrictive DR. According to Brotsky the forehead vasomotor response "fails to provide an adequate index for reliably differentiating ORs from DRs or an adequate index for assessing semantic conditioning or generalization". Brotsky used a 1 sec. burst of white noise as the unconditioned stimulus. However, the background noise level was rather loud (60 db) and this may have subjectively reduced the intensity of the superimposed 100 db noise, thus decreasing the probability of eliciting the DR. Further the conditioning procedure appears unusual. The conditioned stimulus-unconditioned stimulus interval was 10 secs., while the interval between successive trials appeared to be 10 - 15 secs. Finally; Brotsky's admission that "scoring of the polygraph records presented considerable difficulty" casts doubt on the quality of the records of
vascular response obtained.

Maltzman, Kantor and Laugdon (1966) reported results in line with the findings of Luria and Vinogradova (1959). Maltzman et al. observed significantly greater forehead vasoconstriction with "high" than "low" arousal words and concluded "that the former evoked conditioned DRs". The "high" and "low" arousal lists used in this study were those devised by Walker and Tarte (1963). The "low" arousal list consisted of words which on a priori grounds seemed "emotionally innocuous", whereas the "high" arousal list was made up of words assumed to be "emotion-producing".

In contrast to these investigations employing verbal stimuli (words) with affective contingencies, there appears a marked paucity of direct information on the nature of the forehead vascular response to complex visual stimuli and whether the physiological responses manifest to affective visual stimulation can be characterized as ORs and DRs.

Davis (1957) did investigate physiological responses to a wide array of affective visual stimuli (pictures of nudes, cartoons, and a picture of a starving man), but was mainly interested in the common pattern manifest to visual stimuli in general, and thus his analysis did not thoroughly explore differences in the patterns of physiological responding associated with differences in stimulus content, save to note that such differences occurred. Davis monitored facial vascular changes (recorded from the chin) to his visual stimuli. Vasoconstriction was the most common response noted. However, as Hertzman (1959) pointed out, the mechanisms of circulatory regulation differ from one skin area to another. Thus it is difficult to assess the bearing of results obtained from chin sites on those from forehead sites.

The examination of physiological responses to visual stimuli, chosen on the basis of their positive and negative affective impact, would seem to provide an excellent opportunity to evaluate the assertion
that the conception of functionally and physiologically distinct ORs
and DRs (at least with regard to their postulated role in the regulation
of perceptual sensitivity) might provide a useful model within which to
describe affective experience. Lazarus, Speisman, Mordkoff and Davison
(1962) explained why visual stimuli, as a means of eliciting affective
reaction, should be preferred to the employment of the sort of deception
manoeuvres used by Ax (1953) and Schachter (1957). The major advantage
of pictorial material is that it is extremely versatile and can be
easily manipulated by the experimenter. All manner of events can be
portrayed, and a variety of experiences evoked quite readily. A single
individual can be exposed successively to any number and sort of
portrayed situation.

An explicit question might now be formulated:

Would visual stimuli experienced as pleasant and/or
interesting elicit physiological responses that
characterize the OR, while the presentation of
visual stimuli which evoke feelings of distress
and uneasiness would be associated with physiol-
ogical behaviour more in line with the DR?

1.4 Relevant psycho-physiological parameters.

Any research attempting to elucidate the physiological
parameters involved in the expression of positive and negative affect
must decide what parameters from the vast catalogue to focus on. A
firm adherence to a dichotomous notion of arousal, involving reactions
which serve to increase or decrease an organism's sensitivity to
stimulation, obviously limits the area of search to those responses
likely to differentiate ORs and DRs. It is clear that the most con-
sistent and successful differentiation of the two reactions has been
achieved by observation of the cutaneous vascular changes in the forehead
(Sokolov, 1963a; Lynn, 1966). However, the status of many other physiological variables with respect to OR/DR differentiation is not so clear.

Lynn (1966) points out that many of the physiological changes present in the OR will be similarly present with the DR, since a common purpose of both is to mobilize the organism for action. Vinogradova and Sokolov (1957) and Sokolov (1960, 1963a) reported vasoconstriction in the periphery (hand) with both moderate and intense stimulation, although the peripheral vasoconstriction was more emphatic and persistent with intense stimulation. This peripheral vasoconstriction obeys what Sokolov (1963a) refers to as the "Law of Intensity" i.e. no directional change in response is apparent at higher intensities of stimulation. Intensification only results in a more emphatic and persistent reaction of the sort established by lower intensity stimulation.

Maltzman, Kantor and Inagdon (1966) point out that the status of the skin conductance response (SCR) with respect to ORs and DRs is unclear i.e. whether it is a unique measure of the OR or a nonspecific response that occurs, like peripheral vasoconstriction to both. These authors suggest, however, that the SCR is primarily a measure of the OR. Sokolov (1963a) was also far from explicit concerning the role of the SCR in the OR and DR. From his writings it is possible to infer that the SCR appears as a component of both reactions (cf. Sokolov, 1963a, p. 64). Its appearance as part of the DR is illustrated by Sokolov's (1963a) observation that thermal stimuli elicit no SCR "as long as the heat gives rise to no unpleasant sensation (p. 59)". Unpleasant sensation from thermal stimulation is, according to Sokolov, accompanied by a marked SCR. Lynn (1966) has also indicated that the SCR occurs as a component of both OR and DR. Mordkoff (1967) was more specific and suggested that although palmar SCR could be associated with both the OR and DR, he
found it particularly responsive to unpleasant stimulation, such as the anticipation of an aversive electric shock. This particular susceptibility of the SCR to unpleasant stimulation is supported by the recent findings of Kaiser and Roessler (1970). These workers observed that larger and more persistent SCRs were obtained with an unpleasant, distressing movie than with a benign control film. Davis, Buckwald and Frankman (1955) present evidence that persistently greater amplitude SCRs are elicited by intense than by moderate auditory stimuli. Fenz and McCabe (1970), although interested mainly in the physiological response differences between retarded and normal children, provide clear information concerning the effects of stimulus intensity on SCR responding. The largest and most persistent SCRs, they observed, were exhibited to 100 db tones, 70 db tones eliciting less in the way of SCR responding and 30 db tones eliciting hardly any SCRs. Sokolov (1963a) drew the following conclusion from his observations on the effects of stimulus intensity on the SCR:

"Intensification of the galvanic skin reaction (SCR) to liminal stimuli gives place to its weakening in response to stimuli of medium intensity. Intensification is again observed in the high intensity range where the "Law of Intensity" enters into the picture". (Sokolov, 1963a, p. 62).

It would appear from these findings that the SCR behaves in a similar way to the peripheral vasomotor response; the main difference between the SCR occurring as part of the OR and DR lies in its increased amplitude and persistence in the case of the latter. The recording of either peripheral vasomotor changes or SCRs would seem worthwhile, even though the predicted differences in the response to pleasant and unpleasant visual stimuli would only be differences of degree. There are two obvious advantages of preferring to monitor SCR. Firstly, it is much easier to score than vasomotor response. Secondly, and more importantly, the recording of SCR with most preamplifier systems also
yields valuable information concerning change in basal skin conductance level (SCL). The extensive work of Lazarus and his coworkers (e.g., Lazarus, Speisman, Mordkoff & Davison, 1962; Lazarus, 1966) employing movies as a means of eliciting distress has repeatedly shown SCL to be extremely susceptible to such unpleasant visual stimuli. Unpleasant movies were found to produce a marked rise in SCL, while little change or a decrease in SCL was observed with a benign control movie. Similar observations have been made recently by Roessler and Collins (1970).

The inclusion of eye-blinking as a dependent variable when investigating physiological responses to visual stimulation is suggested by Sokolov's (1963a) assertion that "the blink reflex can be considered as a special defense reflex for the eye (p. 71)". This response would seem especially appropriate in the light of the resemblance noted by Lynn (1966) between the DR as described by Sokolov (1963a) and the startle pattern of Landis and Hunt (1939). Landis and Hunt induced startle reactions by firing a revolver behind the subject. The subject's reaction pattern was recorded photographically. A prominent feature of the startle pattern is pronounced blinking of the eyes. This, in fact, appears to be the most commonly manifested element of the pattern (Landis & Hunt, 1939).

The tentative suggestions of Graham and Clifton (1966) that cardiac deceleration appears to be a component of the OR, while acceleration occurs as part of the DR strongly favours the inclusion of heart rate as a dependent variable. However, heart rate has been found to relate to all manner of experimental manipulations in addition to the intensity or pleasantness-unpleasantness of the stimulus employed. The Laceys (Lacey, 1950; Lacey, Kagan, Lacey & Moss, 1963) report that directional heart rate responding depends primarily on the sort of task employed. Tasks which demand attention to the external world (e.g., attention to a visual display, or a story) are associated with cardiac
deceleration. Attention directed away from the external world (e.g., in mental arithmetic problems) is accompanied by cardiac acceleration. The work of Obrist and Webb (Obrist, 1967; Obrist & Webb, 1967; Obrist, Webb & Sutterer, 1969; Webb & Obrist, 1967) indicating that cardiac deceleration accompanies the preparation for a motor response, as, for example, in the preparatory interval before a reaction time response, would seem to echo the involvement of cardiac deceleration in environmentally-directed attentional behaviour. In these Obrist studies, at least those using human subjects, an attempt was made to keep respiration constant throughout the experiment, thus removing from the observed cardiac effect any variance in heart rate due to respiration changes. Obrist (1967) related two methods employed in such control. In one method subjects were trained to breathe in concert to a light. When the light was on, the subject inspired; when the light was off the subject expired. The second method, nicknamed "the passionate breather" had subjects breathe in the rhythm of an auditory signal adjusted to mimic perfectly any one subject's resting respiratory pattern. Lacey et al. (1963) suggest that tasks eliciting pleasant or positive affect can be regarded as tasks which promote environmentally-directed attentional behaviour and thus should elicit cardiac deceleration. Stimuli eliciting unpleasant affect, they suggest, are special instances of situations where attention needs to be directed away from the external stimulus world and thus are associated with cardiac acceleration. Beebe-Center (1932) cites a series of studies which found heart rate decrease with pleasant stimulation and heart rate acceleration with unpleasant stimulation. These considerations seem to indicate some commonality between the stimulus properties which result in the appearance of the OR and DR with those properties invoked by Lacey as contributing to directional heart rate responding. However, the affair is further complicated by the findings of Campos and Johnson (Campos & Johnson, 1966,
1967; Johnson & Campos, 1967). These workers report that the major variable of import concerning the directional heart rate response is not the direction of the subject's attention as dictated by the constraints of the task, but whether the task requires the subject to engage in later verbalisation or not. A prerequisite for later verbalisation results in cardiac acceleration accompanying the task. Deceleration accompanies tasks where no later verbalisation is required. Campos and Johnson (1967) observed that heart rate was more responsive to verbalisation requirements than to the content of visual stimuli. Both cartoons and slides of gruesome road accident victims ordinarily elicited heart rate deceleration, whereas when presentation was preceded by instructions for later detailed verbalisation concerning the slides, presentation was accompanied by heart rate acceleration.

The question of heart rate response in the present context becomes even more difficult when one considers the conclusion of Craig (1968) and Craig and Wood (1969) that the vicarious experience of unpleasant stimulation is associated with cardiac deceleration. Acceleration accompanies unpleasant stimulation of a more direct nature. These reports were based on the observation of cardiac response to the cold-pressor test and observation of a contemporary experiencing the test. The conclusions of Craig concerning directionally opposite heart rate responding to direct and vicarious adverse stimulation is in marked contrast to the findings of Lazarus and his coworkers (e.g. Lazarus, 1966) that the vicarious experience of adverse stimulation (via a movie depicting painful events) was associated with cardiac acceleration. Alfert (1966), actually, compared the cardiac response associated with the vicarious distress involved in the response to such a movie with the cardiac response to a directly adversive stimulus (threat of shock). Heart rate acceleration occurred with both direct and vicarious experience. However, even here, discrepancies exist.
Recently, Roessler and Collins (1970) failed to confirm Lazarus' often reported finding of significant heart rate acceleration to the key incidents in an industrial accident movie.

The varieties of reported influence on the heart rate response, aside from stimulus pleasantness-unpleasantness, suggest that heart rate measurement in the present context would be of considerable empirical interest, particularly in the light of the discrepancies noted in response to unpleasant visual stimulation. Whereas Campos and Johnson (1967) observed cardiac deceleration to road accident slides, Lazarus and his co-workers (e.g., Lazarus & Opton, 1966) have repeatedly found cardiac acceleration to, for example, the critical incidents, in a workshop accident movie.

In order to provide a post hoc check of the experienced affective impact of the visual stimuli some sort of verbal description of affective experience should be obtained. The administration of a simple "mood" or "affect" checklist would seem an efficient means of obtaining such a description. Further, the inclusion of such a self-report measure would allow the investigation of another major issue which pervades the literature on affective experience (cf. Lazarus, 1967; Trumbull & Appley, 1967), i.e. the question of the agreement between verbal and physiological aspects of affective reaction. A more thorough consideration of this topic, and the relationship of individual differences in physiological response to other behavioural and personality factors, is given in Chapter 5.

1.5 Signal value and physiological response.

The employment of a self-report measure may, if not approached with caution, present a major impediment to the appearance of the physiological responses which characterize the DR.

According to Sokolov (1963a) any manipulation which increases
the signal value or signal significance of the prevailing stimulus array will decrease the probability of obtaining a DR and increase the probability of obtaining an OR.

"The acquisition by a stimulus of signal significance results in a fall of the threshold for the orientation and an increase of the threshold for the defense reaction". (Sokolov, 1963a, p. 177).

Signal value conferment appears to encompass an array of manipulations which alters the significance of a stimulus such that a more detailed discrimination of stimulus properties is necessitated to permit the selection of a response (Berlyne, Craw, Salapatek & Lewis, 1963). The commonest means used to confer signal value or significance on a stimulus would appear to be making that stimulus a conditioned stimulus (Sokolov, 1963a). In man verbal instructions, which impose some additional or alternative interpretation on the stimulus act in a similar way (Sokolov, 1963a; Maltzman & Mandell, 1968).

Several sources of evidence exist to show that the investment of signal value increases the magnitude, stability and resistance to habituation of the OR (Sokolov, 1963a; Sokolov, 1965; Maltzman & Mandell, 1968; Germana & Chernault, 1969). Recently Kohlenberg (1970), for example, reported that instructions to ignore one of a set of stimuli enhanced the OR to that stimulus.

Sokolov also presents evidence that signal value investment in intense or unpleasant stimuli decreases the likelihood of obtaining a DR and increases the likelihood of an OR appearing in such circumstances. Sokolov (1963a) has observed that as soon as an intense stimulus "by virtue of verbal instruction, acquires signal significance, it gives rise to the orientation, instead of the defense reaction, that is, vasoconstriction in the hand and cephalic vasodilation, instead of concomitant vasoconstriction at both sites (p. 167)". If discrimination of unpleasant stimuli is called for, such stimuli will similarly
give rise to ORs and not DRs; the more difficult the discrimination the
greater this tendency for DRs to be replaced by ORs. A requirement for
extensive classification or detailed reporting concerning stimulus effects
apparently act in the same way. Sokolov (1963a) has observed that "the
request for classification of stimuli acts in the same way as the forma-
tion of a conditioned reflex, namely it restores the orientation
reaction (p. 175)". The more extensive the classification the greater
this restoration effect. It would appear that stimulus classification
or report superimposes some additional interpretation on the task,
demanding a closer and more detailed discrimination of stimulus propert-
ies. Such a discrimination would seem to require the operation of a
reactive system geared to the increase of perceptual sensitivity i.e.
an OR. Berlyne et al. (1963) observed that the imposition of a recog-
nition "set" was an ideal means of conferring signal value on visual
stimuli. It seems likely that the request for detailed classification
or report similarly compels the subject to examine stimulus properties
more closely so that comprehensive recall can be effected.

These considerations suggest two precautionary measures to
minimize task signal value in the present context. Firstly, the self-
report index employed should demand only gross, general, "impression-
istic" ratings of experience which can be made easily by the subject and
do not alter the essential nature of the task by requiring detailed
recall of slide content. Secondly it would seem essential to state
formally to the subject what the essential nature of the task is, i.e.
subjects should be told that the task is purely one of looking at the
stimuli and that no recall of the presented visual material would be
required. Orne (1952) has pointed out that, if not given precise
expectancies of what is demanded of them in a psychological experimert,
individuals will manufacture their own hypotheses about the task and
presumably assign their own signal value to the stimuli. Maltzman and
Mandell (1968) make a similar point. They suggest that a disposition to orient "may be engendered by self-generated instructions as well as by instructions from others". Sokolov (1963) also states that signal value investment is not solely the result of a particular instruction but that "in the case of man the term signal stimulus should also be applied to stimuli to which activity is directed by implication (p. 163)".

1.6 Summary.

The Soviet dichotomy of arousal reactions into ORs and DRs, and the differential physiological (particularly forehead vasomotor) responding with these reactions, holds considerable empirical interest. The association of these reactions with reports of different affective experience suggests that such a formulation might provide a particularly useful framework within which to investigate affective reactions. Since Soviet research in the area has focussed almost entirely on reactions to simple physical stimuli, the use of more complex visual stimuli as a means of evoking particular affective reactions, should yield an indication of the generality of the Soviet findings. Consequently Chapter 2 reports on investigation of physiological responding (particularly forehead vasomotor responding) to complex affective visual stimuli.
CHAPTER 2

ORIENTING AND DEFENCE REACTIONS TO AFFECTIVE VISUAL STIMULI.

2.1 Statement of aim of the initial experiment.

The experiment described in this chapter was primarily undertaken to examine physiological responses to affective visual stimulation. The hypothesis was entertained that visual stimuli experienced as pleasant or interesting would elicit physiological responses which characterize ORs. The presentation of visual stimuli which evoke feelings of distress and uneasiness, on the other hand, were expected to elicit physiological responses more in line with the DR, as described, for example, by Sokolov (1963a) and Lynn (1966).

The liberation of such a dichotomous arousal model and OR/DR measurement from paradigms employing simple physical stimuli should not only yield valuable information on the generality of the model (i.e., whether a conception of physiological responses in terms of their influence on perceptual sensitivity has any basis in more complex affective stimulus situations), but also an estimation of the model's worth in the description of affective experience.

Consequently, the physiological responses and subjective ratings of affective experience of 24 subjects were monitored during the presentation of 4 blocks of slides, selected for their affective impact.

2.2 Experimental Method.

2.2.1 Subjects.

Subjects (Ss) were 12 male and 12 female undergraduates enrolled in an introductory psychology course at the Australian National University. They were paid A$2 for their participation in the experiment which lasted approximately 2 hours.
2.2.2 Stimuli.

The rationale for using complex visual stimuli was given in the preceding chapter. Most of the previous studies measuring physiological response to visual stimuli have employed either slides (e.g. Davis, 1957) or movies (e.g. Lazarus & Opton, 1966) to elicit affective reaction. Although the dramatic impact of movies would appear to be greater than that of slides, the greater stimulus control and versatility offered by slides does much to commend their use in the present context. The heterogeneous nature of the situations portrayed even in the most carefully chosen and edited movies presents several difficulties for result interpretation. With regard to reported affective experience, Lazarus, Speisman, Mordkoff and Davison (1962) make the following point:

"It is difficult to say...what aspects of his experience during the entire 17 minutes of the subincision film he is recalling or responding to". (Lazarus et al., 1962).

The choice of slides to portray the sorts of situations and effect the sorts of reactions wanted presents a much simpler problem. Their discreteness permits the easy application of rating procedures to determine a description of which pictures are most likely to elicit the affect desired.

Consequently a large population of slides, portraying a wide array of situations, was obtained from various sources; from the Melbourne Police Department, various photographic magazines, anthologies of cartoons etc.

The final aim was to secure 4 blocks of slides with 6 slides in each block - one block which provoked feelings of distress, one which elicited feelings that could be characterized as positive affect, and two blocks which were generally neutral with regard to any "pleasantness-unpleasantness" affective dimension. One of these neutral blocks should contain slides experienced as interesting, the
other slides experienced as boring. The inclusion of stimuli differing along some dimension of "interest" was primarily suggested by the work of Berlyne (Berlyne, 1961; Berlyne, Craw, Salapatek & Lewis, 1963) who observed that complex and incongruous visual stimuli (slides), which could generally be described as interesting (cf. Day, 1967 who observed that ratings of interest increased with increasing complexity) elicited more in the way of ORs than less interesting, simpler visual patterns.

This large population of slides was reduced to 60, on the basis of intuition. Final slide selection was made on the basis of ratings on two 7-point scales; one of "pleasantness" (1 = very unpleasant, 7 = very pleasant), the other of "interest" (1 = very interesting, 7 = very boring). Twenty psychology undergraduates (10 male and 10 female) were each paid A$1 to rate these remaining 60 slides on the two 7-point rating scales. It was stressed that the "pleasantness-unpleasantness" dimension referred to the feelings elicited by the slides i.e. whether the affect experienced during presentation of a particular slide was pleasant or unpleasant. The dimension, it was explained, did not refer to an aesthetic judgement but an affective one. A mean rating for each slide on the two scales was then computed. Inspection of these ratings enabled the experimenter to assemble the 4 stimulus blocks. Each block contained 6 slides. For the sake of brevity and consistency of representation the 4 blocks were labelled:

1. Unpleasant block
2. Pleasant block
3. Interesting block
4. Boring block.

Table 2.1 indicates the mean ratings for each block on the two scales. The unpleasant block was composed of gruesome pictures of homicide victims. The pleasant block contained mainly cartoons, the interesting block mainly pictures with some conceptual incongruity (impossible
TABLE 2.1

Mean rating for each of the 4 stimulus blocks on the two 7-point scales.

<table>
<thead>
<tr>
<th>Stimulus Block</th>
<th>Unpleasant-Pleasant</th>
<th>Interesting-Boring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unpleasant</td>
<td>1.82</td>
<td>2.62</td>
</tr>
<tr>
<td>Pleasant</td>
<td>5.33</td>
<td>2.52</td>
</tr>
<tr>
<td>Interesting</td>
<td>4.30</td>
<td>2.45</td>
</tr>
<tr>
<td>Boring</td>
<td>4.04</td>
<td>5.29</td>
</tr>
</tbody>
</table>

figures), while the boring block consisted of pictures of simple geometric shapes.

2.2.3 Design.

The design of the present experiment was similar to that of Campos and Johnson (1967), in that the slides were shown in blocks. Further, all Ss saw all 4 slide blocks.

Each slide within a block was shown for 20 seconds, making the total presentation time for a block 2 minutes. The inter block interval was generally about 2 minutes, but varied slightly with the time taken by Ss to return to their preblock physiological state or as near that state as possible. The maximum interblock interval was 3 minutes.

As there were 4 blocks of slides this meant 24 possible orders of block presentation. The interesting-boring block interaction was considered of minor consequence and thus the orders were reduced to 12. Within the 12 orders each block appeared 3 times in each presentation position. The order of slides within each block remained constant throughout the experiment. One male and one female S saw each of the
2.2.4 Apparatus and the measurement of dependent variables.

A Grass model 7 polygraph was used to record forehead blood volume pulse (BVP), palmar skin conductance level (SCL) and skin conductance response (SCR), and eyeblinking. Heart-rate was also recorded. However, the failure of the tachograph to trigger consistently, its generally erratic behaviour and the subsequent lack of trust the present author placed in the outcomes of the analyses it performed crushed the hope of obtaining reliable heart rate data on which to evaluate cardiac reaction in the present stimulus situation.

Flexor and extensor electromyographic (EMG) activity was also recorded. It was thought, however, that clarity of presentation would be best served by discussion of the rationale for and outcome of EMG measurement later, in a separate chapter. Consequently Chapter 4 is given over to consideration of EMG responses to affective visual stimulation.

2.2.4.1 Forehead blood volume pulse.

A photoplethysmographic transducer was used to measure forehead BVP. For a discussion of alternative methods of measuring peripheral circulatory changes the reader is referred to Abramson (1967). The transducer was used because of its convenience. As Abramson stated:

"The photoelectric plethysmograph lends itself to prolonged observation in vascular sites where other types of instruments could be used only with difficulty, or not at all". (Abramson, 1967).

The forehead is such a site.

A comprehensive account of photoplethysmograph operation is given by Weinman and Manoach (1962) and Weinman (1967). The photoplethysmographic transducer consists of two distinct parts; a light source and a photodetector for receiving the light signals and
converting them into electrical signals. An Albrecht Alba Type 10 (6 volt, 50 milliamp) ultra miniature incandescent light was used as the light source. Weinman (1967) pointed out that "the detector should have a high sensitivity because light fluctuations caused by the BVP are small (p. 191)." A Phillips ORP 12 photoconductive cell was used as the detector. The photoconductive cell appears to be the most apt for the task. As Weinman (1967) stated the photoconductive cell "is both small and highly sensitive, properties vital for a photoplethysmographic detector (p. 192)."

The rationale behind photoplethysmographic operation is relatively simple. A definite relationship exists between blood flow through tissue and the amount of light the tissue transmits or reflects, given by the equation more blood equals less light i.e. the amount of light reflected or transmitted is inversely proportional to the amount of blood present in the given area of tissue.

The forehead transducer used in the present work is the "reflecting" sort i.e. light source and photodetector lie side by side. Its structure differs from the "transmitting" sort of plethysmograph, where the light source and detector are opposite each other and the tissue in between. This "transmitting" sort of device is used to gauge circulatory changes in the fingers, toes and ears, and is more readily available commercially. The basic equation, that the amount of light reaching the detector is inversely proportional to the amount of blood present in the tissue, applies to both modes of operation (Weinman, 1967).

In the present device both light source and photoconductive cell were embedded in a block of black phenolic plastic. The plastic was concave to fit neatly and with the minimum of pressure onto the forehead. A fine band of soft elastic round the head held the transducer in place.
Hertzman (1938) lists the basic sources of error in monitoring circulatory changes using the photoplethysmograph. He states:

"The most important source of error and the most difficult to control is movement of the skin with respect to the plethysmograph". (Hertzman, 1938).

In the forehead, movement of the underlying muscles shift the position of the skin with respect to the plethysmograph. In the present study, in addition to the band of elastic, zinc oxide tape was used to secure the transducer to the surface of the forehead, and thus reduce movement artifacts. Ss were instructed to move as little as possible.

Another source of error results from the device resting too firmly against the skin so that interference with the normal circulation of the blood in the underlying tissue results. Care was taken, when attaching the plethysmograph, to ensure that it fitted snugly but without undue pressure.

Interruption of the contact between the plethysmograph and the skin also results in erroneous measurements, changing the amplitude of the BVP. The zinc oxide tape and the elastic band maintained the device in steady contact with the forehead skin.

Finally, changes in the ambient light within the experimental room can greatly influence results. A dark head-band was used to shield the plethysmograph from such ambient light changes.

The plethysmograph was placed on the right side of the forehead, above the right eye brow, just medial to the temporal artery. Figure 2,1 illustrates photoplethysmograph position. This position was similar to that used by the Soviet workers. As Vinogradova stated:

"What we, for short, call the 'plethysmograph of the vessels of the head' is the record of the reactions of the capillaries and small vessels in the epidermis of the forehead in the area limited by the art. temporalis superficialis and the art. frontalis". (Vinogradova, 1965).
FIGURE 2.1 Position of photoplethysmograph on forehead.
Signals from the transducer were fed into the PC input of a Grass 7P8B preamplifier, modified for the 6 volt lamp. A time constant of 0.5 sec., recommended by Grass, was used.

2.2.4.2 Skin conductance level and skin conductance response.

For a comprehensive treatment of the rationale behind and the measurement of SCL and SCRs the reader is referred to Venables and Martin (1967). An entertaining history of such electrodermal measurement is given by Neuman and Blanton (1970).

Venables and Martin (1967) point out that it is generally believed that the eccrine sweat glands are responsible for changes in SCL and SCR. However, it would appear that skin conductance changes do not depend primarily upon the emergence of sweat, but on pre-secretory changes in the permeability of the sweat gland cell membrane, and the consequent flow of ions across the membrane.

The use of the terms "SCL" and "SCR" is suggested by Venables and Martin (1967) to alleviate the confusion that has arisen in the literature from the array of terms used to describe electrodermal measurement. SCL refers to the changes in basal conductance level. Such changes are slow and gradual and not to be confused with the SCR which describes a sudden increase in skin conductance. SCRs are more likely to follow specific stimuli (with a latency of approximately 1.5 to 3.5 sec.) and have a characteristic waveform which is superimposed on the basal level (Venables & Martin, 1967).

For recording palmar SCL and SCRs a Grass 7P1A preamplifier was used and set in the P.G.R. input position. With such a setting a constant current of 50 uamps/cm² is passed through the applied electrodes. To obtain the recommended current density (Venables & Martin, 1967) rather large electrodes had to be used. An Ag/AgCl disc electrode, 3.2 cm. diameter, was placed on the palm of each hand. One advantage of using such large electrodes is that it minimizes the
effects of electrolyte seepage which are relative to effective electrode areas (Venables & Martin, 1967). Nikkoh Kirokushi electrode paste was used with all electrode attachments.

Prior to electrode attachment Ss were asked to wash their hands thoroughly. The electrodes were then attached to the middle of the palms, zinc oxide tape being used to secure electrode position. As with the forehead photoplethysmograph, care was taken to avoid undue pressure on the palmar skin as a result of electrode placement. Venables and Martin (1967) point out that, "Mechanical pressure on the electrodes is to be avoided since this can introduce artifact . . ." (p. 69).

2.2.4.3 Eye-blinking.

For a comprehensive account of electro-oculography (EOG) the reader is referred to Shackel (1967). According to Shackel the measurement of eye-blinking is a "particularly simple" application of EOG method. Blinks are clearly distinguishable from other eye movements, being characterized by a rapid rise and fall of potential, (recorded in a vertical plane). Blink duration is normally 0.2 sec. to 0.4 sec. (Shackel, 1967).

Eye-blinks were recorded from the left eye using 0.9 cm. diameter Ag/AgCl disc electrodes. One electrode was placed just above the eye and one just below the eye. As with the SCL/SCR electrodes Nikkoh Kirokushi electrode paste was used. Small strips of zinc oxide tape held the electrodes in place. The electrodes were connected to a Grass 7P5A preamplifier. A time constant of 0.1 sec. was used.

Prior to electrode attachment the relevant skin areas were thoroughly bathed with ethanol and scrubbed lightly with a tooth brush.
2.2.4.4 **Self-report measures.**

Two self-report measures were used. The first, the Jacob-Munz Perceived Stress Index (PSI) (1968), is a checklist of 15 "feeling" phrases. Appendix 1 presents information about the phrases which comprise the list, the value attached to each, and the exact instructions given to Ss concerning their affective descriptions on the list. The PSI was preferred over more extensive and well-tried scales because of its convenience, brevity, and the generality of the rating demanded. Jacob and Munz (1968) state that "the PSI is an index which is simple and fast to administer and score, and can be administered repeatedly to the same subject." Such factors, it was thought, would not cause a significant rise in the signal value of the stimuli, but would still yield a comprehensive indication of subjective affect. Sokolov (1963a) has pointed out that the more complex the stimulus differentiation and classification procedures, the greater the signal value conferred on stimuli. Jacob and Munz (1968) demonstrated the validity of the scale in a contrived stressful examination setting. Jacob and Munz state that, "construct validity has been demonstrated... suggesting that the instrument is measuring affective change."

S was made familiar with the phrases on the checklist in the pre-experimental period by checking off the phrase which best described the way he "normally" felt. The exact instructions for this procedure are again given in Appendix 1. Four copies of the checklist were placed on a clipboard in front of the S and he was asked to check off the phrase which best described the way he felt during the preceding block of slides as a whole. This he had to do immediately after the block had been presented.

Although the PSI should provide some immediate description of affective experience to the different slides, without, it has been argued, adding significantly to the signal value of the task, it was
thought valuable to obtain a more thorough and comprehensive description and classification of the affective impact of the slides; particularly if, later on, one wished to consider the influence of dynamic personality factors on affective experience (see Chapter 5).

It is patently obvious, from the previous considerations, that extreme caution would have to be exercised in obtaining such a comprehensive description that one did not alter the nature of the task by compelling detailed recall of the slides and the sorts of discrimination behaviours on which such a detailed recall would depend.

To gain a more comprehensive insight into the different affective states experienced during slide presentation, 50 were administered the 50 "feeling" labels described and classified by Davitz (1969). The use of the Davitz list would permit not only an indication of what affective states accompanied slide presentation, but also a format for classifying these states.

Davitz (1969) attempted the awesome task of classifying 50 common emotional labels i.e. providing a dictionary of emotional meaning. As Davitz states:

"... I set out to compile a dictionary of common emotional terms that might be of some use in clarifying communication about emotional phenomena, not by legislating definitions but by describing the commonalities of meaning shared by members of a given language community... The general strategy of this research, therefore, was to ask people to describe verbally their experiences of a number of emotional states - designated by a particular label such as Anger, Love, Sadness - to identify those aspects of reported experiences agreed upon by a specified portion of the sample". (Davitz, 1969, p. 3).

Cluster analysis of these derived definitions (i.e. these common reported experiences) revealed that emotions might be broadly classified as: Positive (amusement, cheerfulness etc.); Negative: Type 1 (apathy, boredom etc.) and Negative: Type 2 (anxiety, dislike etc.).
The Davitz list was administered after all the slides had been presented and the S had to tick off those items which best described the way he felt during the presentation of each individual slide. To aid in this extensive rating procedure 8 in. x 10 in. photographs of the slides were given as recall cues. S was informed prior to stimulus presentation that if the experimenter required any post-experimental ratings that photographs would be given to help in any such ratings, as the present task was not a memory task. All S had to do, it was emphasised, was to look at the slides. This manoeuvre, it was presumed, would contribute to a lowered task signal value.

The exact instructions for the administration of this checklist, and the items which comprised it, are given in Appendix 1. Suffice to indicate that S was instructed to tick off as many or as few items as he felt adequately described his experience during the presentation of each slide.

2.2.5 Procedure.

The S was seated in a comfortable armchair in a sound-attenuated, temperature controlled (temperature was set at 70°F.), room. S was then made familiar with phrases composing the PSI and asked to check off the one which best described the way he "normally felt". It was then impressed upon S that this was not a memory task, and that, if any post-experimental rating was required, 8 in. x 10 in. photographs of the slides would be given to aid such ratings. These instructions, were designed to minimize task signal value.

After the electrodes and transducer were attached, the experimenter retired to the adjoining room, and spent 10 minutes calibrating the recording apparatus and allowing S to relax. The S was then instructed (via intercon.) to relax (possibly a redundant command) and informed that the first slide would appear in about 2 minutes. He was previously requested to move as little as possible
during slide presentation. Slide presentation was by a Kodak Carousel S projector. Image size was approximately 2 ft. x 3 ft. The projector screen was positioned approximately 8 ft. from the S.

At the end of the first block of slides, the S was asked to make his rating on the PSI. This always took less than 30 seconds. He was then told to relax and that the next slide would appear in about 1.5 minutes. This procedure was repeated until stimulus presentation was completed. S was visible to the experimenter, throughout the stimulus presentation period, through a viewing window.

The electrodes were then removed and S asked to describe his feelings during each individual slide using the larger Davitz (1969) list of words. As promised 8 in. x 10 in. photographs were provided for this more rigorous rating procedure.

2.3 Results.
2.3.1 Forehead blood volume pulse.

Inspection of the polygraph records led to the eviction of three Ss from the experimental pool. These were substituted by three new Ss, who were assigned to the block presentation orders of the Ss they replaced. The reason for the removal of the original Ss was the difficulty encountered interpreting their BVP record. These Ss showed hyper-reactive records, the plethysmogram being in a state of continuous change, quite independent of external stimulus presentation.

Unger (1964) presents some good examples of such hyper-reactive Ss with respect to the finger blood vessels. Unger appears to have lost about twenty percent of his Ss because of hyper-reactivity. However, Hertzman and Dillon (1939) point out that these spontaneous waves are "more frequently seen in the fingers than other areas". The reason for such hyper-reactive spontaneous wave activity is not clear. Hertzman and Dillon (1939) propose that the majority of the waves "possibly represent overshooting in vasomotor regulation". They also
point out that waves in the head skin and the ear occasionally seem to bear a definite relationship to respiration.

Two examples of recordings obtained from different Ss are shown in Figures 2.2 and 2.3. Figure 2.2 illustrates persistent forehead vasoconstriction shown to the unpleasant stimuli. Figure 2.3 represents moderate dilation shown to the pleasant stimuli.

A beat-by-beat analysis of forehead BVP was undertaken. The individual amplitude values (peak to trough) were averaged in successive 5 sec. intervals for all the 20 sec. stimulus presentation periods. These respective 5 sec. interval values were meaned over each stimulus block. Thus for each stimulus block 4 values were obtained; the first value indicating the mean BVP during the first 5 secs. of presentation of the 6 slides in the block; the second indicating the mean BVP during the second 5 secs.; and so on. These block means were then expressed as deviations (in millivolts) from the mean amplitude of the 10 pulses immediately preceding the onset of the particular stimulus block. Deviations below the preblock baseline amplitude were considered as indicating vasoconstriction. Deviations above the baseline were regarded as vasodilatory changes. These BVP deviations are plotted in Figure 2.4.

A two factor (repeated measures on both factors) analysis of variance performed on the averaged BVP values revealed that the effect of stimulus block on BVP was significant \( (F = 39.10, df = 3/69, p < .001) \) and that the effect of successive 5 sec. intervals on BVP was significant \( (F = 48.84, df = 3/69, p < .001) \). The interaction of stimulus block and 5 sec. interval was also significant \( (F = 2.79, df = 9/207, p < .005) \).

Similar analyses of variance on separate pairs of stimulus blocks revealed significant differences between BVP for the unpleasant block and the pleasant block \( (F = 26.34, df = 1/23, p < .001) \), the
FIGURE 2.2  Forehead BVP response to the unpleasant homicide slides: marked BVP constriction is evidenced. (The numbers denote slide onset).
Chart speed = 2.5 mm/sec.
FIGURE 2.3. Forehead BVP response to the pleasant slides: moderate BVP dilation is evidenced. (The numbers denote slide onset). Chart speed = 2.5 mm/sec.
FIGURE 2.4 Average forehead BVP of each of the four 5 sec. intervals of the slide presentation period measured for each stimulus block.
interesting block ($F = 28.75, df = 1/23, p < .001$) and the boring block
($F = 16.50, df = 1/23, p < .001$). BVP recorded for the pleasant block
differed significantly from that elicited by the interesting slides
($F = 9.14, df = 1/23, p < .01$) and the boring slides ($F = 19.02,
df = 1/23, p < .001$). No differences were observed between the inter-
esting and the boring blocks. Significant interactions between
stimulus block and successive 5 sec. interval was observed for the
following analyses of variance: unpleasant vs. pleasant ($F = 24.14,$
df = 3/69, $p < .001$), unpleasant vs. interesting ($F = 22.82, df = 3/69,
p < .001$), unpleasant vs. boring ($F = 5.03, df = 3/69, p < .005$). All
analyses revealed significant differences between BVP for successive
5 sec. intervals of the stimulus presentation period.  

2.3.2 Skin conductance level and skin conductance response.

SCL was sampled every 10 seconds during each stimulus block
and the mean SCL for each block expressed as a deviation (in umhos)
from the immediate pre block level. Analysis of variance of skin con-
ductance measures revealed a significant difference among stimulus
blocks ($F = 4.75, df = 3/69, p < .01$). Individual t-tests indicated
that SCL was significantly higher in the unpleasant slide condition
than in the interesting condition ($t = 3.28, df = 23, p < .01$).

1. In order to control for the chance effects arising from multiple
comparisons, differences resulting from such comparisons were
considered statistically significant only when $p < .01$. Since
6 contrasts were the most common number tested this control
conforms closely with the Bonferroni method, in which the
critical $\alpha$ level is adjusted to $\alpha/r$, where $r$ is the number
of comparisons or contrasts. For a discussion of the methods
commonly employed with multiple comparisons the reader is
referred to Aitken (1971).
Differences between the unpleasant and boring ($t = 2.69$, $df = 23$, $p < .02$) and the unpleasant and pleasant ($t = 2.07$, $df = 23$, $p < .05$) conditions approached significance. No differences were observed between the pleasant and interesting blocks, the pleasant and boring blocks, and the interesting and boring blocks. All $t$-tests were two-tailed.

The magnitude of the SCR to each stimulus was calculated as the difference between the SCL just prior to the onset of each stimulus and the level attained immediately following stimulus onset. Only SCRs with a latency of less than 5 sec, from stimulus onset were included. The mean SCR magnitude for each stimulus was computed and these values are plotted in Figure 2.5.

The analytical strategy employed with the SCR data was similar to that used for the BVP data i.e. an overall analysis of variance followed by 6 separate analyses of variance between block pairs.

The overall analysis of variance revealed a significant effect of stimulus position on SCR ($F = 24.26$, $df = 5/115$, $p < .001$). The effect of stimulus block on SCR closely approached significance ($F = 2.56$, $df = 3/69$, $p < .07$). This value was thought encouraging enough to continue the analytical programme.

Further analyses between stimulus block pairs indicated a strong tendency for the unpleasant stimuli to elicit SCRs of greater magnitude than either the interesting ($F = 4.51$, $df = 1/23$, $p < .05$) or the boring stimuli ($F = 6.64$, $df = 1/23$, $p < .025$). There was a less marked tendency for the unpleasant stimuli to elicit larger SCRs than the pleasant stimuli ($F = 3.38$, $df = 1/23$, $p < .10$). None of the other comparisons yielded noteworthy differences. All comparisons revealed significant stimulus position effects on SCR. No comparison revealed a significant effect of stimulus position - stimulus block interaction.
FIGURE 2.5  Mean SCR to each stimulus.
Inspection of the SCR data indicated that there existed a reasonably large order effect. SCR magnitude appears to be strongly influenced by the order of presentation of the stimulus blocks, the first block to be shown eliciting relatively large SCRs irrespective of the nature of the slides. Figure 2.6 illustrates this order effect on SCR. Analysis of variance confirmed this suspicion of a significant block order effect on the SCR data ($F = 6.84$, $df = 3/69$, $p < .001$). The interaction between order and stimulus position in the block was not significant. It would appear that the effect of stimulus block on SCR is subsidiary to and partially obscured by this large effect of block order.

2.3.3 Eye-blinking.

Blink rate (number of blinks/min.) was measured for each stimulus block. Statistical analysis, again in the shape of analysis of variance (this time one factor, repeated measures design), revealed a significant effect of stimulus block on blink rate ($F = 3.16$, $df = 3/69$, $p < .05$). Further analyses showed there to be a strong tendency for the boring slides to elicit a faster blink rate than the pleasant ($t = 2.16$, $df = 23$, $p < .05$) and interesting slides ($t = 2.21$, $df = 23$, $p < .05$). No noteworthy difference was found between the blink rate in the boring condition and the rate in the unpleasant condition. There was a slight tendency for the unpleasant slides to elicit a faster rate of blinking than the pleasant slides ($t = 1.78$, $df = 23$, $p < .10$).

For the preblock relaxation periods blink rate was obtained by counting the number of blinks in the 20 sec. period immediately prior to the start of each block. Values for these 4 relaxation periods were summed and the total expressed in terms of blinks/min. Eye-blinks were significantly denser in the prestimulus relaxation periods than in the stimulus period ($t = 3.73$, $df = 23$, $p < .01$). In
FIGURE 2.6 SCR order effect. Mean SCRs plotted according to block order.
this last statistic the relaxation periods' blink rate was compared to
the mean of the 4 stimulus block blink rates. All t-tests were again
two-tailed.

Table 2.2 presents the mean blink rate for each stimulus
block and the prestimulus relaxation "period", since the relative order-
ing of blink rates might not be apparent to the reader from the statis-
tical treatment above.

**TABLE 2.2**
Mean blink rate for each stimulus block and for
the averaged relaxation period.

<table>
<thead>
<tr>
<th>Stimulus Block</th>
<th>Mean blink rate in blinks/min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unpleasant Block</td>
<td>12.9</td>
</tr>
<tr>
<td>Pleasant Block</td>
<td>11.0</td>
</tr>
<tr>
<td>Interesting Block</td>
<td>11.0</td>
</tr>
<tr>
<td>Boring Block</td>
<td>14.4</td>
</tr>
<tr>
<td>Relaxation Period</td>
<td>17.4</td>
</tr>
</tbody>
</table>

2.3.4 Self-report measures.

The mean intensity score (with standard deviations) on the
PSI for each slide block is shown in Table 2.3. The "feeling" phrase
nearest approximating to these scores is also represented. Analysis
of variance (one factor, repeated measures design) revealed a signif-
icant effect of stimulus block on intensity scores on the PSI ($F = 40.88,
df = 3/69, p < .001$). Scores for the unpleasant block differed signif-
icantly from those for the pleasant block ($t = 10.35, df = 23, p < .001$),
for the interesting block ($t = 8.21, df = 23, p < .001$) and for the
Pleasant slide block scores differed significantly from those obtained for the boring block \( (t = 3.65, \text{df} = 23, P < 0.01) \). There was also a tendency for the pleasant block to elicit different rating intensity scores from the interesting block \( (t = 2.72, \text{df} = 23, P < 0.02) \). No difference was observed between scores obtained for the boring and interesting stimulus blocks. All t-tests were again two-tailed.

The total number of checks on the Davitz (1969) list to each of the 50 "feeling" words was obtained for each stimulus block. The distributions of such checks are expressed in the profile form in Figures 2.7, 2.8, 2.9, and 2.10. Representation of the results of this check-list is thus much more qualitative. Even so, affective expression on the Davitz list does allow for a more extensive description of the sorts of feelings generated by or associated with the experience of a particular stimulus block. It also facilitates classification of the sorts of affect reported.

<table>
<thead>
<tr>
<th>Stimulus Block</th>
<th>Unpleasant</th>
<th>Pleasant</th>
<th>Interesting</th>
<th>Boring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Stress Intensity Score</td>
<td>7.58</td>
<td>4.23</td>
<td>5.11</td>
<td>5.22</td>
</tr>
<tr>
<td>S.D.</td>
<td>0.86</td>
<td>1.36</td>
<td>1.39</td>
<td>0.96</td>
</tr>
<tr>
<td>Nearest Label</td>
<td>&quot;uneasy&quot;</td>
<td>&quot;at ease&quot;</td>
<td>&quot;alright&quot;</td>
<td>&quot;alright&quot;</td>
</tr>
</tbody>
</table>

### Table 2.3

Mean stress intensity scores and standard deviation (S.D.) for each stimulus block on the Jacob-Munz Perceived Stress Index.
FIGURE 2.7  Distribution of checks on the Davitz list: unpleasant stimulus block.
FIGURE 2.8 Distribution of checks on the Davitz list: pleasant stimulus block.
FIGURE 2.9 Distribution of checks on the Davitz list: interesting stimulus block.
FIGURE 2.10 Distribution of checks on the Davitz list: boring stimulus block.
Inspection of the profiles revealed that reported affective experiences were substantially different for the 4 different slide blocks. The unpleasant stimulus block (see Figure 2.7) elicited in almost equal frequency, descriptors classified as Negative: Type 1 (depression, pity, remorse and sadness) and descriptors classified as Negative: Type 2 (anxiety, dislike, disgust and nervousness). Affective experience during the presentation of the pleasant stimuli (see Figure 2.8), on the other hand, was described solely in terms of Positive labels (amusement, cheerfulness, delight and enjoyment). The boring stimuli (see Figure 2.10) elicited Negative: Type 1 labels (apathy and boredom), while experience during the interesting stimulus block appeared to elicit elements of description common to both the pleasant and the boring stimuli (see Figure 2.9). Positive labels (admiration, amusement and enjoyment) and Negative Type 1 labels (e.g. apathy) were used to describe emotional commerce with the interesting stimuli.

2.4 Discussion.

The results of the present study indicate that while pleasant and interesting complex visual stimuli (and to a lesser degree boring stimuli) elicit physiological responses characteristic of ORs, unpleasant visual stimuli, whose presentation is associated with reported feelings of distress and uneasiness, evoke physiological behaviour more in line with the DR. Whereas persistent forehead vasoconstriction accompanied the presentation of the homicide pictures, with the pleasant, interesting and boring slides the response was mainly dilative.

These findings strongly suggest that the Soviet formulation of arousal reactions as ORs and DRs (Sokolov, 1963a), modelled exclusively on responses to simple physical stimuli, has some bearing on responses to more complex stimuli, and might provide a useful model with which to describe affective experience. It would appear that
reported negative affect is associated with physiological behaviour postulated to attenuate perceptual sensitivity, while reported positive affect is correlated with responses which have been associated with responses which have been associated with heightened perceptual sensitivity. At any rate, the forehead vasomotor response would seem to be a valuable physiological tool for the differentiation of affective reaction.

The forehead BVP response to complex visual stimuli of this sort, however, does appear more complex than that to simple physical stimuli described by Vinogradova and Sokolov (1957) and Sokolov (1963a). Initial vasoconstriction was noted in the present experiment with all sorts of slides. Although it is possible that the different modality employed and the greater complexity of the stimuli used might account for the more complex vasomotor response pattern obtained in the present experiment than that reported by the Soviet workers, evidence exists that the latter may have oversimplified the situation by the use of non-parametric descriptive techniques, i.e. by not employing a beat-by-beat analysis of the pulses. This point has been made by Hord and Ackerland (1968) (cited in Chapter 1). These workers using moderate tones (30 db above auditory threshold), presented while Ss were asleep also observed biphasic changes in forehead vasomotor activity. They, too, observed initial vasoconstriction and suggest that Sokolov's report of monophasic dilation as the forehead vasomotor component of the OR stemmed from the use of a less precise measure of the response. Recently, Keefe and Johnson (1970) observed a similar biphasic forehead BVP response in waking Ss to moderate auditory stimuli (65 db). Again a beat-by-beat analysis had been undertaken by these workers. The employment of beat-by-beat analytical techniques, then, point to the forehead BVP component of the OR being a biphasic reaction, consisting of an initial constriction preceding the usually more emphatic dilation phase.
The present observation of differential stimulus effects on forehead vasomotor responding is at odds with the recent findings of Raskin, Kotses and Bever (1969b). They observed constriction of forehead BVP to both moderate and intense auditory stimuli. No difference in the extent of this constriction was noted with different intensities of auditory stimulation. Their moderate stimuli, however, were of 80 dB intensity, and thus apparently within the range of DR operation. As Sokolov states:

"A sound of moderate intensity (60 db) evokes reciprocal reactions in the head and hand (OR), and a strong stimulus (80 and 100 db) results in complementary constriction (DR)." (Sokolov, 1965).

Of greater relevance to the present results, however, are the more recent findings of Hare, Wood, Britain and Shadman (1970), who observed similar forehead BVP responding to pictures of homicide victims, nude females and everyday household objects. A biphasic response pattern (constriction followed by dilation) was observed with all three sorts of slides. The differentiation of forehead BVP response with different sorts of affective visual stimuli found in the present experiment is significantly at odds with these findings of Hare et al. (1970).

However, several differences exist between the two studies which may have contributed to the discrepancy.

The first is experimental design. In the first study of this thesis a dependent S design was used i.e., each S was exposed to all stimulus conditions and subsequently estimation of treatment effects was based on within - S variance. In the Hare et al. (1970) study each S saw only one stimulus type. It has become apparent that several factors influence the nature and magnitude of peripheral physiological responses, other than the usual experimental stimuli of interest. For example, the "Law of Initial Values" (Kilder, 1957; Hord, Johnson
& Lubin, 1964) postulates that the magnitude of the physiological change to a stimulus is related to the prestimulus initial level of the particular physiological parameter. The universal observation of gross individual differences in initial basal physiological levels points to the appropriateness of within-\$S$ comparisons. Further, the pioneering work of the Laceys (1956, 1958) on response stereotypy indicates that individuals differ consistently in the efficacy of their responding within a particular physiological channel. Such individual differences in responsiveness have been shown to influence the nature and magnitude of the OR (O'Gorman, personal communication). One would expect the nature of the DR to be similarly affected.

To summarize, then, in peripheral physiological measurement, because of the massive between-\$S$ variance, a dependent \$S$ design, which computes an estimate of treatment effects based solely on within-\$S$ variance, makes for a more efficacious estimate of treatment effects for a given cost, than designs in which \$S$ is associated with only one treatment condition. However, Hare, Wood, Britain and Frazelle (1970), while exploring male-female response differences, employed a dependent \$S$ design, yet their results essentially paralleled those of their earlier study.

Transducer placement could have been another source of variance. Hare et al. (1970) are not explicit about the exact location of their forehead transducer. Recently Varni, Doerr and Frankem (1971) reported bilateral differences in vasomotor responding. Their measurements were made from the second digit of each hand but it is conceivable that similar bilateral or positional differences do exist with forehead measurement. Forehead positional differences have been noted by Cook (personal communication) who observed "regular" behaviour only in the temporal area.

Another probable major difference between the two studies
involves the notion of signal value (the relevance of this concept was discussed in Chapter 1). In the present experiment a formal attempt was made to minimize the signal value invested in the task by stressing that the task was purely one of looking at the slides. Careful and formal instruction was given to ensure that Ss in no way interpreted or inferred comprehensive recall of the slides as part of their experimental task. Hare et al. (1970) apparently did not give such explicit instructions. As cited earlier, Orne (1962) pointed out the implications of not giving Ss precise expectancies of what is required of them in a psychological experiment. According to Orne, if such expectancies are not given, Ss will manufacture their own hypotheses about the task and presumably convey their own signal value on the stimuli. Maltzman and Mandell (1968) echo this point. They suggest that the disposition to orient "may be engendered by self-generated instructions as well as by instructions from others". Sokolov (1963a) also observed that signal value could be conferred on stimuli by implication as well as by direct instruction.

It is possible, then, that the two studies were not equivalent with regard to the signal value invested in the stimuli. Such an inference suggests that an investigation of the effects of increased task signal value on forehead vasomotor responding in the present context would provide information relevant to the discrepancy in the results of the two experiments. The results of such an investigation are reported in Chapter 3.

Offering support to the present results are the recent findings of Maltzman, Smith, Kantor and Mandell (1971). They observed the forehead vasomotor responses of Ss at the beginning and again at the end of the academic quarter. For half the Ss, graduate students, the second session immediately preceded what was regarded as a "rather stressful" oral examination. For the other half of the Ss,
undergraduates, the second session was merely a repeat of the first. Higher amplitude BVP (Maltzman et al., refer to this measure as pulse width) was recorded for the undergraduates in the second session. The graduates showed significantly smaller BVP amplitude in the second stressful session. Maltzman et al., conclude:

"What we call pulse width, an empirical measure, seems to be highly sensitive to changes in the relative state of fear or defensiveness of S in that it increases and decreases under conditions which observers would ordinarily call more or less fearful". (Maltzman, Smith, Kantor & Mandell, 1971).

Consideration of Figure 2.5 and the statistical treatment of the SCR data indicate that the most persistently large SCRs occur with the unpleasant stimuli. Such a conclusion would be similar to that reached by Hare et al. (1970) from their data. They, too, inferred that the most persistent SCRs occurred to the unpleasant homicide pictures. The present observation is also in line with the findings of Kaiser and Roessler (1970), cited earlier, with an unpleasant, distressing movie. Larger and more persistent SCRs were found in response to the distressing movie than to a benign control film.

The SCR data of the present study suggests that the SCR occurs as a component of both the OR and the DR, the main difference being the extent and persistence of the response. However, the observation of such a large order effect with SCR (i.e., by far the largest responses occurred with the first block presented, irrespective of the nature of the stimuli composing the block) indicates that SCR is particularly responsive to novelty. It is interesting to note that the relationship of response magnitude to block presentation order is similar to the relationship observed between response magnitude and slide order within a block. Just as the largest response occurs with the first slide in the block, so the largest response occurs to the first block presented. Similarly, just as the last slide in a block elicits
a relatively large SCR, so the last block elicits relatively high SCRs (see Figures 2.5 and 2.6). This block order effect does provide some support for the suggestion of Maltzman, Kantor and Langdon (1966) that the SCR is primarily a response to stimulus change and novelty. However, SCR does apparently obey the "Law of Intensity" (Sokolov, 1963a, p. 63), the greater the intensity of the stimuli the greater the magnitude of the SCR elicited. It would appear from the present experiment that both these factors influence the magnitude of the SCR.

The observed changes in SCL during stimulus presentation are consistent with the SCR data. The most pronounced increases in SCL tended to occur with the unpleasant stimuli. Although not observed in the Hare et al. (1970) study, such a finding parallels the observations of Lazarus and his co-workers (cited earlier) that an unpleasant, threatening movie elicited larger increases in SCL than an innocuous control.

The SCR and SCL data, when considered independently of the other measures, do not exclusively point to the presence of a DR with the unpleasant stimuli. As stated earlier the SCR is also a commonly observed component of the OR. Persistently large SCRs may indicate the presence of a stable OR. In addition, Sokolov (1963a) has noted the existence of a tonic OR which is represented by a relatively persistent increase in basal SCL. The SCR and SCL data must be considered in the light of the BVP results. The Maltzman et al. (1971) study has some bearing on this. Not only did the BVP of their graduate students show more constriction at the second session, but SCR habituation to auditory stimuli was slower than in the first session. Undergraduates showed a similar relationship between tonic BVP and SCR habituation of tones, slower habituation being observed in the first session. The relationship between SCR habituation and BVP amplitude found by Maltzman et al. (1971) is similar to that observed in the present
The use of visual stimuli in the present experiment prompted the inclusion of eye-blinking as a dependent variable. Sokolov (1963a), as mentioned earlier, regarded eye-blinking as a specialised defense mechanism for the eye. Further, Lynn (1966) suggested a parallel between the DR and the startle pattern, a prominent feature of which is blinking. However, blink rate increments occur for reasons other than startle. Poulton and Gregory (1952), for example, found that the less complex a visual task the greater the blink rate elicited. Thus the finding that the boring slides (consisting mainly of simple geometric shapes) tended to elicit a higher rate of blinking than the pleasant and interesting slides came as no surprise. The lack of significant difference between the blink rate for the boring and the unpleasant stimuli and the tendency for the unpleasant stimuli to elicit a higher rate of blinking than the pleasant stimuli give a modicum of support to the notion that the unpleasant slides were producing a degree of startle.

In conclusion, then, it would not appear unreasonable to conceive of affective reaction in terms of ORs and DRs. Both self-report measures employed in the present study indicated that the different blocks of visual stimuli elicited different affective experiences, experiential differences being most marked with the pleasant and unpleasant stimuli. These different reported affective experiences were associated with different physiological response patterns, particularly in the patterning of the forehead vaso-motor responses. Such a conclusion must be qualified, however, pending an empirically justifiable explanation of the discrepancy between the present results and those of Hare et al. (1970) employing a similar paradigm.
CHAPTER 3

SIGNAL VALUE AND PHYSIOLOGICAL RESPONSE TO AFFECTIVE VISUAL STIMULI.

3.1 Introduction.

The results described in the previous chapter suggest that the Soviet dichotomy of arousal reactions into ORs and DRs might be readily applied to the reactions to affective visual stimuli. They demonstrate particularly the occurrence of the DR to vicariously unpleasant stimuli; stimuli which acquire their unpleasant or threatening quality through some sort of empathy or identification process (cf. Lazarus & Opton, 1966).

In this, the results are at odds with the recent findings of Hare, Wood, Britain and Shadman (1970). In the preceding chapter several differences between the two experiments, which may have contributed to this discrepancy, were cited: experimental design, transducer placement, and differences in the signal significance of the visual stimuli. The dramatic effects of alterations in the signal value invested in stimuli on physiological responding (e.g. Sokolov, 1963a; Maltzman & Mandell, 1968) would appear to suggest the last of these as most fruitful. Thus in an attempt to resolve the discrepancy in results between the previous investigation and that of Hare et al. (1970) a further experiment was conducted to gauge the effects of signal value differences on physiological responding to affective visual stimulation. The hypothesis was entertained that the forehead BVP responding associated with stimulus presentation in a situation manipulated to increase the signal value of the stimuli, would bear a closer resemblance to the behaviour noted by Hare et al. (1970) i.e. all stimulus blocks would, in such circumstances elicit patterns of forehead BVP responding suggestive of ORs.

The present investigation, then, compares the behaviour of
the male group of Ss in the previous experiment with a group of 12 male Ss exposed to the stimuli in conditions designed to maximize the signal value invested in them.

3.2 Method.

The 12 new Ss were from the same population as the previous 24 Ss. They were again paid A$2 for their participation in the experiment. The pretext for Ss participation differed for the two groups. Ss in the original experiment volunteered to take part in an experiment which involved "the measurement of physiological responses to a series of pictures". The 12 new Ss were recruited for "an experiment investigating physiological correlates of memory". Both groups were observed at the beginning of the summer vacation and contact was made by telephone.

The stimuli were the same as those used in the previous experiment. The design was identical. Twelve orders of stimulus block presentation were used as before, such that one "signal" and one "non-signal" (original) S saw each of the 12 orders.¹

Measurements were made as before, but for convenience and ease of data handling, the number of dependent variables was reduced. Only forehead BVP and SCRs were recorded from the "signal" Ss. The same two self-report measures were used.

The procedure with regard to the "non-signal" group of Ss is described in the previous chapter. It is probably enough to reiterate that during the pre-experimental period it was impressed

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¹ For the sake of economy of expression, the 12 Ss from the original experiment shall be referred to as the "non-signal" Ss, the Ss in the maximized signal value condition, i.e. the new Ss, as the "signal" Ss or group.
upon Ss that the task was not a memory task, and that all they were required to do was to look at the slides. They were told that the PSI involved only a gross, general description of their feelings and that for any further rating 8 in. x 10 in. photographs of the slides would be provided as an aid. Although some affective classification of the stimuli was called for, it was assumed that the means of seeking such a classification and the extent of the classification required, coupled with the explicit instructions about the nature of the task would not result in an appreciable rise in the signal value or significance of the task.

Ss in the 'signal' group were treated quite differently. They were told that the experimental task involved remembering the slides; that the post-experimental report would require complete recall of all 24 slides. They were not informed of the 8 in. x 10 in. photographs.

Memory instructions were chosen as a means of conferring signal significance on the stimuli, primarily because this technique was the easiest to implement. The author had previously been associated by the subject population with work on verbal memory. The interest in pictorial memory here would not have seemed incongruous to the S and it was considered that such a deception should work. Further, it was thought that this contrived predisposition to remember the slides probably closely paralleled the self-generated orientation toward the task of Ss who have received no explicit instructions to the contrary. Campos and Johnson (1967) observed that instructions for later recall and detailed verbalisation did influence physiological response to pictorial material. Further, Berlyne, Craw, Salapatek and Lewis (1963) observed that the

imposition of a recognition "set" was an ideal means of conveying signal value onto visual stimuli.

Electrode and transducer attachment procedures, instrument calibration, and stimulus presentation for the "signal" group were identical to the procedures described previously for the "non-signal" group. When stimulus presentation was complete the "signal" Ss were informed of the deception and completed the Davitz (1969) checklist of "feeling" words using the 8 in. x 10 in. photographs.

3.3 Results.

3.3.1 Forehead blood volume pulse.

A beat-by-beat analysis of BVP was undertaken as before. For each stimulus block 4 values were obtained in the same way as in the first experiment; the first value indicating the mean BVP amplitude during the first 5 secs. of presentation of the 6 slides in the block; the second indicating the mean BVP during the second 5 secs; and so on. These block means were expressed, as before, as deviations (in millivolts) from the mean amplitude of the 10 pulses prior to stimulus block onset.

These BVP changes for both "signal" and "non-signal" groups are presented in Figure 3.1.

Analysis of variance (three factor, mixed design) revealed a significant effect of group ("signal" - "non-signal") on BVP ($F = 5.90$, $df = 1/22$, $p < .05$). The effects of stimulus block ($F = 8.90$, $df = 3/66$, $p < .001$) and 5 sec. interval ($F = 63.73$, $df = 3/66$, $p < .001$) on BVP were also significant. The analysis also revealed an interaction effect of group ("signal" - "non-signal") and stimulus block ($F = 3.44$, $df = 3/66$, $p < .05$). The stimulus block - 5 sec. interval interaction effect on BVP was also significant ($F = 14.21$, $df = 9/198$, $p < .001$).

Inspection of Figure 3.1 reveals that the results obtained for the 12 male Ss were much the same as those for the full 24 Ss.
Analysis of variance within the present "non-signal" group confirmed this. Stimulus block exerted a significant effect on BVP ($F = 10.16, df = 3/33, p < .001$). The 5 sec. interval effect on BVP was also highly significant ($F = 31.80, df = 3/33, p < .001$), as was the interaction between these two factors ($F = 11.54, df = 9/99, p < .001$). A similar analysis of variance of the "signal" group BVP data revealed no main effect of stimulus block. Five sec. interval again significantly influenced BVP ($F = 57.45, df = 3/33, p < .001$). The interaction between stimulus block and 5 sec. interval effects was not significant.

Further inspection of Figure 3.1 shows that the major effect of imposing signal significance on the task manifested itself with the pleasant and unpleasant stimuli. Further statistical analysis confirmed this impression. Comparisons, undertaken to check the effect of maximizing signal value on BVP behaviour for each stimulus block, revealed no effect of change in signal value on BVP for the interesting and the boring slides. For the pleasant stimulus block there was a significant effect on BVP of signal value change ($F = 7.85, df = 1/22, p < .05$). This analysis also demonstrated a significant interaction effect between "signal" - "non-signal" groups and 5 sec. interval ($F = 3.33, df = 3/66, p < .05$). Although no main effect of signal value change was revealed for the unpleasant stimulus block, a significant interaction between group and 5 sec. interval was found ($F = 4.90, df = 3/66, p < .005$).

3.3.2 Skin conductance response.

The magnitude of the SCR to each stimulus was calculated, as in the previous experiment, as the difference between the SCL just prior to the onset of each stimulus and the maximum level attained immediately following stimulus onset. Only SCRs with a latency of
FIGURE 3.1 Average forehead BVP for each of the four 5 sec. intervals of slide presentation meaned for each stimulus block.
less than 5 secs. from stimulus onset were included. The mean SCR magnitude for each stimulus for both the 'signal' and 'non-signal' group is represented in Figure 3.2.

Analysis of variance (again three-factor, mixed design) revealed no significant difference between 'signal' and 'non-signal' groups with respect to their effect on SCR. Stimulus block (F = 3.57, df = 3/66, p < .025) and stimulus position (one through six) (F = 25.33, df = 5/110, p < .001) both had a significant effect on SCR behaviour. None of the interactions were significant.

The unavoidable use of an independent design and the employment of between-S variance in the computation of treatment effects, coupled with the awareness of gross individual differences in the amplitude of SCRs, necessitated the use of some SCR data transformation. Several transformation strategies exist for SCR. In a recent, detailed consideration of the topic Lykken and Venables (1971) suggested that, when making between-Ss comparisons, 'SCRs should be corrected for individual differences in the range of SCR specifically, rather than for differences in range of tonic SC'. They provide the following formula for such a SCR range correction:

\[
\Delta \Phi_{ix} = \frac{SCR_{ix}}{SCR_{i(max)}}
\]  

(3.1)

where \(\Delta \Phi_{ix}\) is the SCR score corrected for individual differences in the range of SCR; \(SCR_{ix}\) is the SCR of the \(i\)th S under experimental condition \(x\); \(SCR_{i(max)}\) is the maximum SCR elicited by the \(i\)th S in the experimental session.

This would appear to be a simple, yet effective procedure, since the application of such a transformation to the data reported by Lykken and Venables resulted in consistently and substantially increased F ratios over the values obtained for the SCR/SC range correction.
FIGURE 3.2  Mean SCR for each slide, for both signal and nonsignal conditions.
These authors' conclusion that this SCR/SCR\text{max} transformation "is the appropriate unit in which to express the SCR for comparing individuals" was echoed by Ax (1971) in the editorial of the same issue of *Psychophysiology*.

Applied to the present results, the maximum SCR was noted for each subject and the SCR data corrected for range of SCR using formula 3.1. The mean transformed SCR magnitude for each stimulus for both "signal" and "non-signal" groups is presented in Figure 3.3. Analysis of variance on the transformed data revealed no main effect of signal value change on SCR. Stimulus block ($F = 3.66, df = 3/66, p < .025$) and stimulus position ($F = 60.31, df = 5/110, p < .001$) effects were again significant. However, after transformation, the group-stimulus block interaction was observed to have a significant effect on SCR ($F = 4.73, df = 3/66, p < .005$).

Further analyses of variance were performed to discover just what contributed to this interaction effect.

Firstly, SCR behaviour in the "signal" and "non-signal"

---

3. A problem arises through the use of the Lykken and Venable's (1971) range correction and the expression of SCRs as ratios here. It is possible that SCR max could be affected by treatment; if a subject is in a treatment group which has a large effect on SC then his SCR max score could well be larger than if he is in a group with less effect on SC. That is, the denominator as well as the numerator in the ratio scores may be affected by treatment. This could result in an underestimation of subsequent SCRs in some treatment groups. This standardisation might have been better achieved by employing some external stimulus (e.g. loud tone) to gauge SCR max.
experiment i.e., a tendency for the unpleasant stimuli to elicit persistently larger SCRs than the other stimulus blocks. In the present analyses the main effects of stimulus block were observed for the unpleasant-interesting block comparison ($F = 10.00$, $df = 1/11$, $p < .01$) and the unpleasant-boring block comparison ($F = 9.73$, $df = 1/11$, $p < .01$). No other comparisons revealed significant effects of stimulus block on SCR. All analyses revealed significant effects of stimulus position. There were no interaction effects. As with the multiple comparisons reported in Chapter 2, statistical significance demanded $p < .01$.

A similar analytical strategy was employed with the transformed SCR data for the "signal" group. An overall analysis of variance again revealed an effect of stimulus block ($F = 4.27$, $df = 3/33$, $p < .025$) and stimulus position ($F = 41.08$, $df = 5/55$, $p < .001$). There was again no interaction effect. Analyses of variance on successive pairs of stimulus blocks indicated that the unpleasant block no longer held its unique position. A main effect of stimulus block on SCR was found for the pleasant-interesting comparison ($F = 10.63$, $df = 1/11$, $p < .01$). There was also a tendency for the pleasant stimulus block to elicit greater magnitude SCRs than the boring stimulus block ($F = 6.15$, $df = 1/11$, $p < .05$). SCRs elicited by the unpleasant block tended to be larger than those elicited by the boring block ($F = 5.37$, $df = 1/11$, $p < .05$). All analyses again revealed significant stimulus position effects and there were no significant interaction effects.

3.3.3 Self-report measures.

The mean intensity score (with standard deviations) on the PSI for each slide block in both "signal" and "non-signal" groups is shown in Table 3.1. The "feeling" label nearest approximating to these scores is also represented. Table 3.1 reveals the same array
FIGURE 3.3 Range corrected SCR data. Mean SCR for each slide for both signal and nonsignal groups.
of PSI scores for the "signal" and "non-signal" groups. The striking similarity of the PSI scores in the two experimental groups seemed to make statistical comparison redundant. Statistical analyses performed within each group revealed the same influences of stimulus block on PSI as reported for the original 24 Ss in the previous chapter.

The number of checks to each word on the longer Davitz list for both "signal" and "non-signal" groups are represented in Figures 3.4, 3.5, 3.6, 3.7. Figure 3.4 presents the profiles for the unpleasant stimuli, and Figure 3.5, the profiles for the pleasant stimuli. Profiles for the interesting and boring stimuli are shown in Figures 3.6 and 3.7 respectively. Inspection of these profiles again revealed that signal value investment in the stimuli had little or no influence on reported affective experience. Spearman's rho was computed to compare the distribution of checks of the "signal" and "non-signal" groups with respect to each of the 4 stimulus blocks. As expected, high correlation values were observed. These rho values and derived t values are presented in Table 3.1.

TABLE 3.1

Correlation of the checks made by the "signal" and "non-signal" groups for each of the 4 stimulus blocks (Spearman's rho and derived t values).

<table>
<thead>
<tr>
<th>Stimulus Block</th>
<th>ϕ</th>
<th>t</th>
<th>df</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unpleasant</td>
<td>0.69</td>
<td>6.69</td>
<td>48</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Pleasant</td>
<td>0.56</td>
<td>4.65</td>
<td>48</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Interesting</td>
<td>0.68</td>
<td>6.46</td>
<td>48</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Boring</td>
<td>0.73</td>
<td>7.45</td>
<td>48</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>
FIGURE 3.4 Distribution of checks made on the Davitz list by both "signal" and "non-signal" conditions. 
Ss: unpleasant stimulus block.
FIGURE 3.5 Distribution of checks made on the Davitz list by both "signal" and "non-signal" conditions.

Ss: pleasant stimulus block.

Non-signal

Signal

Total no. of checks

surprise
solemnity
shame
serenity
sadness
resentment
remorse
relief
pride
pity
passion
panic
nervousness
love
jealousy
irritation
inspiration
impatience
hope
hate
happiness
guilt
grief
gratitude
gratitude
contentment
courage
cheerfulness
boredom
awe
apathy
anger
amusement
affection
admiration
FIGURE 3.6 Distribution of checks made on the Davitz list by both "signal" and "non-signal"
Ss: interesting stimulus block.
FIGURE 3.7  Distribution of checks made on the Davitz list by both "signal" and "non-signal" Ss: boring stimulus block.
3.4 Discussion.

The results of the present study indicate that forehead BVP is sensitive to changes in signal value. This finding is in line with the earlier observations of Sokolov (1963a). The pattern of responses obtained for the 12 "non-signal" Ss is similar to those observed previously for the full 24 Ss. The patterns of BVP responses observed for the "signal" group, on the other hand, closely resemble those found recently by Hare, Wood, Britain and Shadman (1970). This strongly suggests that the discrepancy between the findings of Hare et al. (1970) and the initial experiment reported in Chapter 2 was due mainly to the existence of differences in signal value investment in the two studies.

It is possible, though, that difference in signal value is not the only factor which might have contributed to the discrepancy between the two studies. As noted earlier, the initial study of Hare et al. (1970) used an independent-S design i.e. each S saw only one type of slide. The experiment previously reported in Chapter 2, on the other hand, employed a design in which each S was exposed to all slide blocks. Later work by Hare, Wood, Britain and Frazelle (1971), however, did employ a dependent-S design. Although the results of this investigation generally paralleled those of the original Hare et al. (1970) study a few noteworthy differences exist. The innovation of a dependent-S design resulted in a strong tendency for their slides of simple objects to elicit the smallest BVP changes, a finding similar to that for the boring stimulus block in the present author's initial study. The original Hare et al. (1970) investigation employed only male Ss. The inclusion of females in their second published report demonstrated an effect of S sample on the nature of the BVP response. Hare et al. (1971) observed that female Ss manifested the most extensive forehead BVP constriction response to the unpleasant homicide pictures. Only for this group of slides was the initial
constriction phase not superceded by a later dilative phase. However, the overall effect of sex of $S$ on BVP response was not significant.

As Hare et al. pointed out:

"In spite of these apparent differences, however, there was a great deal of inter- and intra-subject variability with the result that the changes across beats were not significantly related to the sex of the $S$". (Hare et al. 1971).

Thus although proposed signal value differences appear to go a long way to resolving the differences in results between the experiment reported in Chapter 2 and the Hare et al. (1970) study, other factors probably contributed something to the discrepancy.

In the present research the major effect of signal value change on forehead BVP was observed with the pleasant and unpleasant stimuli. The different pattern of BVP responding observed with the unpleasant homicide slides, as a result of signal value investment, is consistent with the predictions of Sokolov (1963a). However, the observation that less vasodilation, reflecting a decreased OR, was manifest to the pleasant stimuli in the signal condition is a curious result on the basis of expectancies derived from Sokolov's scheme of things. A more emphatic OR would be expected as a result of increased signal value.

4. The finding that the acquisition of signal significance by the pleasant slides results in an attenuated OR is at odds with the analogous case for simple physical stimuli. When simple stimuli are given signal significance the OR is intensified rather than reduced (Sokolov, 1963a). It is possible that the response to the signal pleasant slide is principally an OR, whereas the response to the non-signal slide involves more than an OR.
situation, "short-circuiting" the affective or emotive qualities of the prevailing stimuli. Such a notion appears to be borne out by the BVP changes observed with the innovation of the memory set in the present study.

The general pattern of forehead BVP for the "signal" group in the present experiment was again found to be biphasic. As cited earlier, biphasic BVP response patterns have been noted elsewhere as part of the OR (Hord & Ackerland, 1968; Keefe & Johnson, 1970) and seem to result from more stringent methods of pulse analysis.

The effect of signal value change on SCR was much less obvious. No main effect of change in signal value on SCR, even after data transformation, was noted in the present study, a result at odds with the recent findings of Cohen and Johnson (1971). These authors noted that SCR was the only variable that they employed which was highly sensitive to signal value investment; signal value investment, they observed, did not influence the forehead BVP response. Germana and Chernault (1969) also noted a main effect of signal value on SCR, a result in keeping with the findings of Sokolov (1963a) on the SCR and signal value. It is, however, quite probable that the actual means employed of conferring signal value on stimuli and the precise nature of the response demanded of Ss are critical determinants of the particular effects of signal value on physiological responding. The responses demanded of Ss in the Cohen and Johnson (1971), Germana and Chernault (1969), and Sokolov (1963a) studies were well defined motor responses. In the present study the response demanded was not a well-defined, discrete, behavioural act such as finger-movement or button-pressing. Of relevance to the present results are the findings of Campos and Johnson (1967), who noted that instruction for later verbalisation about complex visual stimuli influenced heart rate but not SCL. However, Berlyne, Craw, Salapatek and Lewis (1963), although
employing SCR incidence as the index of SCR behaviour and not an amplitude measure, observed a significant effect of the innovation of a recognition "set" on the SCR manifest to visual stimuli.

The signal value-stimulus block interaction effect that was observed in the present experiment demonstrated that signal value investment did exert some influence on SCR. The interaction seemed to result from the acquired similarity of the pleasant and unpleasant stimuli in their effects on SCR in the "signal" group. In the "non-signal" group the unpleasant stimuli appeared unique in their efficacy at eliciting persistently large SCRs. The convergence in the SCR pattern with the pleasant and unpleasant stimuli as a result of signal value change parallels the convergence noted for these blocks with the BVP response parameter.

Neither self-report measure appeared to be influenced by changes in signal value. The general insensitivity of self-report measures has been noted often (e.g. Mordkoff, 1964; Weinstein, Averill, Opton & Lazarus, 1968). Self-report measures seem especially insensitive to subtle changes in experimental instructions or set, even when such devices produce a marked effect on autonomic variables. For example, Speisman, Lazarus, Mordkoff and Davison (1964) manipulated sound tracks accompanying their stressful movie. Ss viewed the movie in one of 4 conditions. One condition used a denial soundtrack i.e. a track which denied the harmful features of the events portrayed in the film. A second track encouraged an intellectualised, anthropological appraisal of the film. A third track emphasised the horror of the situation. The fourth condition was the silent version of the film. Although the sound tracks significantly influenced autonomic response (heart rate and SCL) to the movie, no effect of such manoeuvres was apparent on the Nowlis Adjective Check List of mood (Nowlis & Nowlis, 1956) or on a 5-point rating scale of tension. Lazarus and Alfert
(1964) repeated the experiment presenting the narrative prior to the film and not as a soundtrack. Similar dramatic effects on the autonomic variables were noted. Again, however, there was little in the way of self-report differences between the different treatment groups.

To summarize, then, the results of the present investigation add weight to the conclusion reached in Chapter 2, which implicated ORs and DRs in the reaction to complex affective stimulation, and advocated the application of forehead vasomotor response measurement to the investigation of affective experience. At this point one might speculate further that the conception of arousal reactions in terms of sensitivity enhancement and attenuation and the use of the forehead vasomotor response might make for more success in the investigation of individual differences in physiological reaction to affective stimuli and the relationship of such reaction to psychological parameters (e.g. personality orientation, self-report description of affect). The history of such research is noteworthy for its failure to establish enduring relationships between physiological and psychological parameters (cf. Stem & Plapp, 1969). Consequently Chapter 5 deals with the exploration of individual differences in the extent of forehead vasomotor responding.
CHAPTER 4
THE STARTLE PATTERN AND THE DEFENCE REACTION: ELECTROMYOGRAPHIC RESPONSES TO AFFECTIVE VISUAL STIMULI.

4.1 Introduction.

As mentioned earlier, Lynn (1966) has suggested that a parallel may be drawn between the startle pattern of Landis and Hunt (1939) and the DR described by Sokolov (1963a):

"The defensive reaction appears to correspond in part to what is called in Western literature the startle reaction . . . ." (Lynn, 1966, p. 8).

The startle pattern is characterised by a pronounced eyeblink response. This, in fact, appears to be the most commonly manifest element of the pattern (Landis & Hunt, 1939). The observation of a relatively high rate of blinking to the present unpleasant visual stimuli (see Chapter 2) suggests that such stimuli elicited a degree of startle.

Another prominent feature of the startle pattern is a general increment in flexor muscle activity. Muscle activity has received comparatively little attention from psychophysiologicalists. Recently, Davis (1971) expressed this point:

"Skeletal muscles have been less studied by psychophysiologicalists than almost any other response system accessible to measurement".

He goes on to lament:

"There are only a handful of reports of covert muscle behaviour in Psychophysiology. Indeed muscle tension was included in a list of "minor measures" by Brown (1966), apparently less important for the study of behaviour than the composition of urine". (Davis, 1971).

The important role of muscle activity and proprioceptive discharge in behaviour, especially affective behaviour has been remarked upon by Geisler (e.g. Geisler, 1964).
"Obviously the emotions lead not only to autonomic but also to somatic discharges. They induce manifold changes in tonic and phasic activity of the striated muscles".

According to Gellhorn different affective experiences are likely to be associated with different patterns of muscle activity.

"It is not unlikely . . . that not only the facial expressions but also the patterns of activity of skeletal muscles are different in different emotional states". (Gellhorn, 1964).

Beebe-Centre (1932), reviewing the early literature on the association of movement and muscle activity to affective or "hedonic" tone, drew the following conclusion:

"As far as available data are concerned, then we must conclude that there is indeed for voluntary movements, and probably also for involuntary ones, a relation between hedonic tone and type of response such that pleasantness is accompanied by excess of extension, unpleasantness by excess of flexion". (Beebe-Centre, 1932, p. 341).

Recently, Tarantino (1965, 1970) proposed a similar relationship. He hypothesised that unpleasant affect is associated with dominant flexor muscle activity. Pleasant affect, on the other hand, involves dominant extensor muscle activity. Tarantino derived support for such a notion from the work of Gellhorn (1964) which suggested that different patterns of muscular activity were associated with different affective states, and from the earlier studies of Sherrington (1906), who found basically that there was dominance of extensor muscle activity with weak stimuli and dominance of flexor innervation with intense stimulation. Tarantino summarizes his position as follows:

"A formulation is offered which states that organisms will make expansive approach responses to stimuli slightly or moderately deviant from the adaptation level and that such responses involve innervation of extensor muscles and are associated with positive effect. Conversely, stimuli strongly deviant from the adaptation level will evoke restrictive withdrawal responses which involve innervation of flexor muscles and are associated with negative affect". (Tarantino, 1970).
Leaving aside the concept of adaptation level it is evident that the function Tarantino ascribed to these expansive responses, involving dominant extensor muscle activity, exactly parallels the function ascribed to the OR by Sokolov (1963a). This expansive response manner, according to Tarantino, "enables animals and people to approach and experience the objects of stimulation around them . . . " and " . . enables them to acquire knowledge of the environment". The restrictive, withdrawal responses, involving predominantly flexor muscle activity, on the other hand, serve to "remove the organism from threatening or possibly injurious situations", a function similar to that credited to the DR by Sokolov (1963a).

The results, described in Chapter 2, indicated that the different slide blocks employed were associated with different affective experiences and that these affective experiences were associated with distinctive physiological response patterns. More specifically, these results, for the pleasant and unpleasant stimuli, illustrated the association of reported positive affect with the appearance of a marked OR, and the correspondence between negative affect and the appearance of responses assumed to be part of a physiological DR.

To provide direct evidence on the relationship between the OR and DR and muscle activity, flexor and extensor electromyographic (EMG) responses, then, were recorded during the initial experiment to test the following hypothesis:

1. That reported unpleasant affect is accompanied by dominant flexor EMG activity, whereas pleasant affect is associated with dominant extensor EMG activity. This hypothesis might be expressed alternatively as follows: that dominant flexor EMG activity is the somatic component of the DR, while dominant extensor EMG activity is associated with the appearance of the autonomic indices of the OR.
b. That the startle pattern of Western literature and the DR of Soviet workers are synonymous, and both are accompanied by a relatively large increase in flexor EMG activity.

4.2 Method.

Since the EMG recordings were made during the initial experiment (fully described in Chapter 2) it should be necessary to describe only that procedure which relates specifically to the measurement of EMG activity.

A comprehensive account of EMG methodology is given by Lippold (1967). In the present study EMG activity was recorded from the biceps (flexor) and triceps (extensor) muscles of the non-dominant (non-writing) arm. Prior to electrode placement, the skin in the general area of measurement was thoroughly rubbed with ethanol to dissolve accumulated grease. Extending and flexing exercises were undertaken by S to allow the experimenter to locate the appropriate muscles. Although there were minor variations in electrode location for different Ss, the usual electrode placements are shown in Figures 4.1 and 4.2. Figure 4.1 illustrates the placement for measurement of biceps activity, and Figure 4.2 the location of triceps leads. Ag/AgCl electrodes, 0.9 cm. in diameter, were used. Nikkoh Kirokushi electrode paste was employed in electrode application, and zinc oxide tape used to secure the electrodes. The electrodes were connected to a Grass 7P3A preamplifier and integrator with an integrator time constant of 2 sec.

During the 10 minute period set aside for calibration of the recording apparatus and for allowing S to relax, S was instructed to repeat the flexing and extending exercises to allow appropriate sensitivity settings. Pen baselines were set with the S relaxing. Amplifier sensitivity was usually set at 50 μV/cm. Integrator sensitivity was set such that full flexion or extension resulted in
maximal pen deflection.

4.3 Results and Discussion.

EMG activity was measured every 2 sec. during stimulus presentation and every 2 sec. for the 30 sec. immediately prior to the onset of each stimulus block. The average EMG activity for each block was expressed as the deviation from the mean pre-block amplitude. The units, then, were millimeters of deviation.

Analysis of variance showed no effect of stimulus block on extensor EMG activity. However, stimulus block significantly influenced flexor muscle activity, ($F = 3.78, df = 3/69, p < .01$). Individual t-tests indicated that this effect was due to a relatively large increase in flexor muscle activity for the unpleasant stimuli. Significant differences were revealed between flexor activity during the unpleasant and interesting stimuli ($t = 4.17, df = 23, p < .001$) and between the unpleasant and the boring stimuli ($t = 3.32, df = 23, p < .01$). Differences between flexor activity during the unpleasant and the pleasant stimuli approached significance ($t = 1.95, df = 23, p < .07$). No significant differences were observed between the pleasant and interesting stimuli, the pleasant and boring stimuli, and the interesting and boring stimuli. All t-tests were two-tailed.

This relatively large increment in flexor muscle activity lends support to Tarantino's (1970) assertion of an association between flexor muscle activity and the experience of unpleasant affect (for the self-report results the reader is referred to Chapter 2). This result is also in accord with the earlier observations on the EMG changes which constitute the startle pattern (Landis & Hunt, 1939; Jones & Kennedy, 1951) and lends support to hypothesis b, that the startle pattern and the DR are synonymous, or at least share several common components.
anterior fold of axilla

A and B are biceps' electrode locations

FIGURE 4.1 Electrode placement for biceps.
FIGURE 4.2  Electrode placement for triceps.
Tarantino’s proposition that positive affect is associated with dominant use of extensor muscles was not observed to be the case. However, it is patterns of response such as relaxation (expansive responses in Tarantino’s terminology) which involve the use of extensor muscles. It is possible, in the present study, that the pre-stimulation situation represented near maximum relaxation and thus little further relaxation, i.e. extensor muscle activity would be expected. The observed changes in extensor muscle activity were, in fact, less pronounced than those in flexor muscle activity.

There is, however, evidence that the EMG response to unpleasant and intense stimulation involves large increments in extensor as well as flexor muscle activity, and that extensor changes to such stimuli are greater than those to moderate or pleasant stimuli. Davis and his co-workers (e.g. Davis, 1948; Davis, Buchwald & Frankman, 1955), for example, observed that the extensor muscle, digitorum communalis, manifested greater activity increments to intense than to moderate stimuli. Such findings cast further doubt on Tarantino’s hypothesis of a relationship between positive affect and dominant extensor muscle activity.

Although Landis and Hunt (1939) tended to view the appearance of extensor responses, as part of the startle pattern, as the exception and always regarded the flexor response as primary, the results of Davis (cited above) demonstrate the considerable involvement of extensor muscles in the response pattern observed to intense auditory stimuli. Further, Jones and Kennedy (1951) found that the extensor muscle employed in the present study, i.e. the triceps, showed large EMG responses to intense auditory stimuli. Their results, however, were the cumulative representation of numerous stimulus trials, many with apparently quite low intensity stimulation. Thus it is difficult to assess just how parallel in response the two antagonistic
muscles are. In the present experiment a few Ss did manifest extensor muscle activity exactly parallel to that in the flexor muscle during the unpleasant stimuli (see Figure 4.3).

In conclusion, it should be emphasised that of all the muscles of the body, the activity of one flexor and one extensor muscle was sampled in this experiment. Thus caution should be exercised in the interpretation of results. It would be foolish to generalise too readily to all flexors and extensors. Despite the modest nature of the present investigation, the differential patterns of biceps activity observed with different affective stimuli would seem to recommend a more comprehensive treatment of the topic, in which activity is integrated from several flexor and extensor sites. Another line of argument could be developed with regard to the nature of EMG responses in the present and analogous situations. Peripheral vasoconstriction appears to represent a redistribution of blood from the periphery to the skeletal muscles (e.g. Cannon, 1936; Abramson & Ferris, 1940), in preparation for anticipated muscular activity (Ruttkay-Nedecky, 1967).

It should be remembered that intent to move, or anticipation of movement itself, even when there is no overt movement, produces a pronounced muscle discharge from the appropriate muscles (cf. Jacobson, 1932, 1951). The magnitude of peripheral vasoconstriction, then, should presumably reflect the extent of activity in the skeletal muscles benefiting from such redistribution of blood.

Peripheral vasoconstriction, although occurring as a component of both the OR and DR (Vinogradova & Sokolov, 1957; Sokolov, 1963a) obeys the "law of intensity" (Sokolov, 1963a, p. 49), i.e. vasoconstriction increases with the extent and magnitude of the OR, the effect with the DR being more emphatic than that for the OR. Although the present author was unable to obtain data on peripheral vasoconstrictor responding, the observations of the Soviet workers on the vasomotor component
of the OR has been replicated (Unger, 1961). Further, Hare, Wood, Britain and Frazelle (1971), presenting homicide slides, slides of nude females, and slides of simple objects found that the ordering of magnitude of digital vasomotor response, for female Ss at least, consisted of the largest vasoconstriction response occurring to the homicide slides and the least response occurring to the simple objects. With regard to the initial data reported in Chapter 2, other physiological parameters indicated that the unpleasant homicide pictures elicited a DR, the largest OR occurring to the pleasant stimuli and the least response to the interesting and boring stimuli. This suggests an ordering of peripheral vasomotor response magnitude similar to that found by Hare et al. (1971). Ignoring for a moment any suggested differences in relative flexor and extensor activity in ORs and DRs, it seems plausible that the total, integrated EMG activity would parallel such hypothetical peripheral vascular changes. It might be expected, then, that integrated EMG activity would be greatest for the unpleasant stimuli in the present experiment. The pleasant stimuli, which elicited the most marked ORs, should run second. The smallest effect should occur to the interesting and boring stimuli.

To test the empirical validity of such an ordering of activity, triceps and biceps EMG changes were summated for each S. The mean change for each stimulus block is shown in Table 4.1. Analysis of variance on the summated data revealed a significant effect of stimulus block ($F = 4.56, df = 3/60, p < .01$). Individual $t$-tests revealed significant differences in EMG activity between the unpleasant and the interesting ($t = 3.85, df = 23, p < .001$) and the unpleasant and the boring stimulus blocks ($t = 3.46, df = 23, p < .01$). None of the other comparisons revealed significant stimulus block differences.

These results, then, provide some evidence for the predicted ordering of EMG response to the visual stimuli and lend some support
FIGURE 4.3 Example of flexor and extensor EMG response to the unpleasant stimuli.
Chart speed = 2.5 mm/sec.
TABLE 4.1

Summated EMG activity. Mean response in millimeters of pen deflection.

<table>
<thead>
<tr>
<th>Stimulus Block</th>
<th>Mean Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unpleasant</td>
<td>+2.67</td>
</tr>
<tr>
<td>Pleasant</td>
<td>+1.37</td>
</tr>
<tr>
<td>Interesting</td>
<td>-0.12</td>
</tr>
<tr>
<td>Boring</td>
<td>-0.65</td>
</tr>
</tbody>
</table>

A positive sign indicates a net incremental response.
A negative sign indicates a net decremental response.

to the notion that integrated EMG activity parallels the peripheral vasoconstriction behaviour, described by the Soviet workers. This latter conclusion must, of course, be qualified by the absence of data on digital vasomotor responding in the present paradigm. However, the present EMG results are encouraging enough to warrant a more comprehensive investigation of the relationship of EMG activity to peripheral vasomotor responding. Although outside the scope of the present thesis such a study should provide valuable information on how autonomic and somatic response systems are integrated.
5.1 Introduction.

Previous observations of individual patterns of forehead BVP responding to the various visual stimuli revealed noteworthy differences in the extent of the vasomotor response displayed by different individuals. Although the overall pattern of response to the unpleasant stimuli differed from those observed to the other stimulus blocks, there appeared substantial individual differences in the extent of vasoconstriction elicited by these unpleasant pictures. The present chapter deals with attempts to relate these individual differences in the extent of BVP vasoconstriction to various psychological parameters. As concern is primarily with individual differences in the extent of the DR, analysis, for the main part, will be restricted to the unpleasant stimuli. Although it is possible to criticize as chauvinistic, this concentration on responses elicited by unpleasant stimuli, the present author is not the sole agent of such selective attention. The majority of workers within this area have restricted their search to paradigms employing unpleasant or distressing stimuli. As Lacey pointed out:

"Enormously popular manipulations are used in the vast majority of studies of arousal: aversive physical stimuli, intellectually demanding tasks, convenient perceptual motor tasks, affects of "fight or flight", and "anxiety-producing" stimuli. We do not often use non aversive stimuli, "pleasant affects", . . . .". (Lacey, 1967, p. 21).

The psychological and behavioural parameters of interest with respect to their relationship to the extent of DR occurrence were:

1. self-report of affect i.e. the intensity of distress, elicited by the slides, as reported on the Perceived Stress Index (PSI)
(2) the Repression-sensitization perceptual-personality dimension (Byrne, 1961). As revealed by a subscale of the Minnesota Multiphasic Personality Inventory (MMPI), this dimension identifies individuals differing in the way they deal with unpleasant and threatening stimulation. Whereas individuals at the repressor end of the dimension tend to deal with threatening stimuli by denial and avoidance, those toward the sensitizer end tend to approach and confront such stimuli.

(3) free looking time i.e. the time S spends looking at the slides of his own volition. In the looking time paradigm S controls the duration of stimulus exposure. Looking time has been employed frequently as a measure of visual exploratory behaviour, and as such considered part of the same phenomenon as the physiological OR.

The reasons for selecting these variables and specific hypotheses concerning their interaction with the OR and DR will be considered at length in later sections of this chapter.

One general point is probably worth making now. Although an enormous amount of time and energy has been expended exploring the interaction of psychological and physiological variables, such work has revealed very few enduring relationships. Stern and Plapp preface a recent review of such efforts by the following lament:

"Before delving too deeply into this murky area, we would like to state that although the search for invariant relationships between physiological and psychological parameters is a quest for gold, unfortunately, to date, the principal product has been chalcopyrite, or fool's gold". (Stern & Plapp, 1969, p. 227).

Several reasons have been cited for this, generally acknowledged,
poverty of consistent and invariant relationships between psychological and physiological parameters. The most common assertion is that researchers fail to consider a vast array of secondary, but influential variables, present in the usual laboratory set-up, which interact with the primary psychological and/or physiological variables of interest and cloud the appearance of any relationship between them. O'Gorman recently arrived at such a conclusion:

"In conclusion, I would submit that until studies of relationship between personality characteristics and physiological processes take into account the possibility of interactions between the basic measures of interest and extraneous variables, ... research of this kind will continue to show a poor return on investment". (O'Gorman, 1971).

A similar point has been made by Mordkoff (1964) concerning the frequently reported lack of relationship between physiological and self-report aspects of response to unpleasant and distressing stimuli. Mordkoff asserted that dynamic influences on self-report of distress could account for such discrepancies:

"The lack of agreement between verbal and physiological or behavioral response to stress can be traced further to other factors, dynamic rather than purely statistical or physiological. Verbal report is particularly susceptible, among other things, to the operation of defensive distortion on the part of the S". (Mordkoff, 1964).

While acknowledging that verbal reports of affect are undoubtedly subject to dynamic influences, it is suggested that, particularly when dealing with unpleasant or distressing stimuli, that much of the acknowledged lack of success in relating psychology to peripheral physiology might be due to an unfortunate choice of physiological variables i.e. those variables which do not adequately distinguish ORs from DRs. SCL has been the most widely used variable and may be entirely inappropriate. As mentioned earlier SCL increases occur not only as part of the DR, but also in association with a stable OR. The
absolute difference in physiological response may conceivably be slight, but affective experience as evidenced by self-report would be far from equivalent in the OR and DR.

The employment of forehead vascular changes as the dependent physiological variable and thus providing a more adequate differentiation of ORs and DRs (Sokolov, 1963a), will presumably remove any impediment to invariant psychological-physiological relationships associated with the employment of physiological measures likely to confuse the two reactions.

5.2 Self-report and individual differences in forehead BVP response.

5.2.1 Introduction.

Attempts at relating individual differences in autonomic response to unpleasant stimuli to reported affective experience, as gauged by scores on some checklist or other, have invariably proved unsuccessful. Weinstein, Averill, Opton and Lazarus (1961) asserted that the study of emotion could offer no greater puzzle than the almost universally observed discrepancy between self-report and autonomic aspects of reaction to distressing stimuli. Mordkoff articulated this dilemma as follows:

"One of the most perplexing findings concerning the relationship among these various dimensions of response to stress has been the lack of agreement among them. Verbal reports of little or no affective arousal are not uncommon in the presence of high autonomic activity in response to a presumably stressful stimulus". (Mordkoff, 1964).

It is difficult to know where to attach the blame. Should the accusing finger be pointed at autonomic indices (which themselves show little intercorrelation (Lacey, 1959)) or at unsophisticated self-report measures or both?

Self-report is usually chosen from the "line-up" by most witnesses. As mentioned, self-report measures seem to be susceptible
to numerous extraneous influences, such as the demand characteristic of the experiment (cf. Lazarus, 1967, p. 158) and particularly what Mordkoff (1964) describes as "defensive distortion on the part of the S". Weinstein et al. (1968) performed an experiment to systematically check the extent of the influence of defensive distortion on the discrepancy between self-report and autonomic response. They reported that defensive style accounted for only 10% of the discrepancy. Further, taking into account this effect of defensive style, the adjusted correlations were apparently no different from the original correlations. As Weinstein et al. state:

"In order to test the practical applicability of this, part correlations were calculated between autonomic and self-report indices of stress, with the influence of defensive style "removed" from the latter. The resulting part correlations were not appreciably greater than the original uncorrected correlations". (Weinstein et al. 1968).

Another reason often cited for the discrepancy between self-report and autonomic descriptions of affective response is that one is comparing a continuous evaluation of response (autonomic measure) with a single discrete response (self-report). Lazarus et al. made such a point with regard to the distressing movie paradigm:

"All of the foregoing argues that it is poor logic to use a single poststimulus index of a stimulus which occurs in continuous fashion and the impact of which is bound to fluctuate. Rather, future efforts should be made to derive measures of continuous psychological response such as have been evolved for measurement in the psychophysical area. It is likely that if such approaches are worked out, more coherence will be found among the various response dimensions, and considerably more information will be derived about the state and functioning of the integrated person in the stressor condition". (Lazarus et al. 1962).

Mordkoff echoed this point:

"The measurement of psychological response only once at the end of the film has several serious limitations". (Mordkoff, 1964).
These evocations suggest at least two major criticisms of customary self-report employment: that self-report is a single, usually "forced-choice", representation of what is a continuous and multidimensional experience; and that there is usually some temporal latency between the experiences per se and the required verbal description of them. However, these criticisms would seem much more pertinent to the movie situation than the present paradigm employing homicide slides. The movie generally employed by the Lazarus group lasted 17 minutes compared with the 2 minutes total presentation time for the unpleasant slide block. Experience to report latency was undoubtedly greater in the former paradigm. (This conclusion is apposite only to the PSI rating in the present studies). Further, a continuous film almost certainly presented a much wider range of affective content than a block of six discrete and relatively homogeneous slides. The problem presented by the employment of a film was adequately stated by Lazarus et al.:

"It is difficult to say, therefore, what aspects of his experience during the entire 17 minutes of the Subincision film he is recalling or responding to". (Lazarus et al. 1962).

However, it must be admitted that checks on the Davitz list in the first experiment in the present thesis (see Chapter 2) indicated a wide array of affective experiences evoked by the unpleasant stimuli. The restriction of such experiences to a single check on the PSI does present problems. However, the interpolation of more complex self-report demands might have irredeemable effects on the nature of physiological responding to unpleasant stimuli. The effects of such a manoeuvre on the occurrence of the DR were discussed in Chapter 1 and Chapter 3. Thus the employment of more complex and detailed rating procedures should be pursued with extreme caution.

Few authors consider that the legacy of a concept of unidimensional arousal (cf. Lacey, 1967) and the corresponding choice of
physiological measures might contribute to the discrepancy of indices. It is hypothesised that the choice of a dichotomous model of arousal (Sokolov, 1963a) and the employment of a physiological measure which more adequately discriminates ORs and DRs will contribute to the reduction of the variance between physiological and psychological affective reactions.

The major hypothesis, then, which prompts the present investigation, is that the individual differences in forehead BVP response will be associated with different affective experience, as evidenced by self-report. Ss who demonstrate marked DRs, as indicated by extensive vasoconstriction, should report more in the way of experienced distress than Ss who manifest vasodilation or minimal constriction.

5.2.2 Method.

Data from the original 24 Ss was employed in this study. However, another 24 Ss were added to the experimental pool. Treatment of these newcomers was generally similar to that for the original 24 Ss. (It is assumed that the general procedure can be taken as read). However, a few situational and procedural differences demand mention.

The original 24 Ss were paid A$2 for their participation in the experiment. The new Ss, on the other hand, received 2 hours credit toward a 5 hour course requirement. Although both groups were introductory psychology students, the original 24 Ss were engaged at the end of the academic session (after examinations) whereas the second group was recruited at the beginning of their course. The inclusion of this second S sample, then, should provide a good test of the reliability of the forehead BVP response pattern revealed in the original study, and whether such a pattern is susceptible to factors such as the temporal setting of the experiment within the academic session.

The use of forehead BVP as the sole autonomic variable with the second S sample also differentiated the two groups, as did the use
of the PSI as the sole self-report measure. However, experimental instructions concerning post-experimental rating and the availability of the 8 in. x 10 in. photographs were identical for both groups. These were the only noteworthy procedural differences.

5.2.3 Results.

Three Ss had to be eliminated from the second sample, due to vasomotor hyper-reactivity which obscured any stimulus effects. Unfortunately time did not allow the substitution of new Ss for those removed. Thus, the analysis was performed on 45 Ss.

Statistical analysis focussed on the forehead BVP response to the unpleasant stimuli. The previous representation of BVP response pattern was discarded in favour of a description that focussed on the behaviour of the first 10 pulses following stimulus onset of each slide. There were two main reasons for the adoption of this new strategy. Firstly, pilot work indicated that in the "looking-time" paradigm (section 4 of this chapter) very few Ss spent as much as 20 seconds looking at each of the unpleasant slides. Restriction of analysis to the first 10 pulses should permit a more standardised comparison between BVP response obtained, and any relationships derived, in the present paradigm and the "looking-time" experiment. Secondly, this representation of the forehead BVP response would promote an even closer comparison between the present results and those of Hare et al. (1970, 1971).

A beat-by-beat analysis, then, was performed on the first 10 pulses exhibited to each of the unpleasant slides. The amplitude of each of these beats was expressed as a deviation from the mean amplitude of the 10 pulses prior to the onset of the unpleasant stimulus block. As before, deviations below the pre-block baseline were regarded as evidence of vasoconstriction, deviations above the pre-block baseline as indicating vasodilation. Deviations were averaged across the 6 slides.
These averaged forehead BVP changes were then averaged across all 45 Ss. This mean pattern for the first 10 ordinal pulses is portrayed in Figure 5.1. Persistent vasoconstriction was revealed, being most emphatic between the second and the fourth ordinal beats.  

Pearsonian correlations were then computed between the grand mean BVP response of each S and intensity score on the PSI (see Chapter 1 and Appendix 1). The observed correlation was practically zero ($r = -0.08$, $df = 43$). As maximum constriction appeared within the first five represented pulses a similar correlation was computed between PSI score and the grand mean BVP amplitude of the first 5 pulses only. The computed statistic was again almost zero ($r = -0.05$). Little correlation was again observed between PSI scores and mean BVP amplitude of the second 5 pulses (i.e., ordinal pulses 6 through 10) ($r = -0.10$). The only correlation of any magnitude was observed between the grand mean BVP amplitude of the first 5 pulses and the mean amplitude of the second 5 pulses ($r = .68$, $df = 43$, $p < .001$). This result is not unexpected and implies merely that the amplitude of successive groups of 5 pulses is not independent.

Since self-report is apparently so susceptible to dynamic factors, such as a S's particular threshold for reporting distress, it was decided to represent a S's PSI score as a deviation from his description of his normal, everyday, affective disposition and re-evaluate the

1. As the two pulses associated with stimulus onset were not scored this probably means that maximum constriction occurred between the fourth and sixth pulse following stimulus onset. Hare et al. (1971) appear to have observed maximum constriction at a similar latency from stimulus onset.

2. As correlations were computed between intensity of distress scores and BVP deviations, where more extensive vasoconstriction was indicated by larger negative values, a negative correlation was to be expected.
FIGURE 5.1 Mean forehead BVP response for the unpleasant block (45 Ss).
Further, as BVP was expressed as a deviation from prestimulation level, it seemed logical to represent self-report the same way. However, correlations computed using the transformed self-report data were no more encouraging ($r$ for mean of 10 pulses $= -.10$; $r$ for mean of 1st 5 pulses $= -.10$; $r$ for mean of 2nd 5 pulses $= -.11$).

A check was made of the reliability of the forehead BVP pattern shown by the original 24 Ss to the unpleasant stimuli. Accordingly their pattern was compared to that observed for the new S sample. Figure 5.2 presents the mean forehead BVP amplitude (for the first 10 ordinal pulses averaged across the six unpleasant slides) of the original 24 Ss and the 21 newcomers. Analysis of variance revealed no difference between the two groups in BVP responding. Inspection of Figure 5.2 suggests that any difference between the two S groups in BVP responding might be located within the first 5 ordinal pulses. However, statistical analysis revealed no difference between the first 24 Ss and the 21 new Ss in BVP behaviour for the first 5 pulses. This result provides strong confirmation of the reliability of the forehead BVP pattern to the unpleasant stimuli observed in the initial investigation (see Chapter 2).

5.2.4 Discussion.

The results were disappointing for the major hypothesis that individual differences in the extent of the DR, as evidenced by the extent of BVP constriction, would be reflected in the intensity of reported distress.

Methodological flaws could explain this lack of success. The use of such a restrictive device as the PSI obviously limits the Ss' descriptions of affective experience. In fact with the exception of 5 Ss, three points on the scale (fearful, distressed, uneasy) accounted for all the checks made to the unpleasant stimulus block. Considering this limited area of description apparently open to Ss, the expectation of a high correlation between self-report and extent of DR was perhaps
FIGURE 5.2 Mean forehead BVP response to the unpleasant stimuli for both the original sample and the new sample.
a little optimistic. Further, it is probable that with such restricted affective communication available Ss relied heavily on the "demand characteristics" of the experiment, and checked the label that seemed to be the appropriate or acceptable reaction, without, indeed, experiencing the appropriate disturbance.

Although one can endlessly invoke methodological shortcomings to rationalise the observed discrepancy between indicators of affective experience, an alternative and attractively parsimonious interpretation suggests itself. Such an interpretation demands that verbal and physiological evocations of affective reaction stem from two distinct and far from perfectly coupled systems. A formulation of this sort was offered by Lacey (1967). According to such a representation, the search for exact correspondence between the measured outputs of the two systems would reveal little more than the naivety of the experimenter. High agreement between these two complex systems should not be expected. As Lazarus stated:

"We should not really expect high agreement among indicators, since each type of indicator reflects a specific kind of transaction between the individual and the situation", (Lazarus, 1966, p. 390).

5.3 Repression-sensitization and individual differences in forehead BVP response.

5.3.1 Introduction.

In their review of recent work on personality correlates of psychophysiological parameters Stern and Plapp (1969) noted the increasing emphasis being placed on those aspects of personality related to perceptual processes.

"In recent years interest has declined in compiling inventories of personality traits and investigating these with pencil and paper check lists. At the same time, interest in identifying more circumscribed, yet critical areas or dimensions of personality functioning has increased. Such efforts have led to the exploration of a number of perceptual-personality dimensions (Stern & Plapp, 1969, p. 226)."
The repression-sensitization continuum is representative of such dimensions.

Byrne (1961) proposed that repressors and sensitizers as identified by the repression-sensitization (R-S) scale (Byrne, 1961; Byrne, Barry & Nelson, 1963) differ in the way they deal with threatening stimuli. Individuals at the repressor end of the dimension tend to cope with threatening or unpleasant stimulation by denial and avoidance, whereas those toward the sensitizer pole implement approach and confrontation in such commerce.

Stern & Plapp (1969) suggested that it is possible to relate the perceptual-personality dimension of repression-sensitization to the operation of the OR as described by Sokolov (1960). Their formulation appeals particularly to the role Sokolov (1960, 1963a) ascribed to the cerebral cortex in initiating or dampening the OR. According to Sokolov the cortex acts as a stimulus analyser and can exert either excitatory or inhibitory control over the reticular centres immediately responsible for OR emergence. When an incoming stimulus fails to match the prevailing neural representation of the external world embodied in the cortex, excitatory impulses are relayed to the reticular activating system and an OR initiated. The development of a match between the real and the represented stimulus world results in the emission of cortical inhibitory impulses, which, when they impinge on the lower reticular centres, dampen or block OR appearance. Stern and Plapp (1969) suggest that the transmission of cortical excitatory impulses, and consequent OR establishment, provides a possible neural analogue of the sensitization process. Such a proposition has a certain intuitive validity: the major stated function of the OR (Sokolov, 1963a) is facilitation of an organism's informational interaction with the stimulus world. Sensitization, as a mode of operation, has a similar stated aim (Byrne, 1961) i.e., the promotion of stimulus contact and reception. Stern and
Plapp further speculate that the descent of cortical inhibitory impulses, and subsequent OR blocking, on the other hand, provides a suitable analogue of repression. However, according to Sokolov, such descending inhibitory impulses and OR disappearance usually mark the process of stimulus habituation. It seems unlikely that repression and habituation are, in any way, parallel or analogous processes. A much more probable basis for the repression process would appear to stem from DR operation. The ultimate object of the DR, according to Sokolov (1963a), lies in "the breaking away from, or limitation of the activity of the stimulus (p. 14)". A similar goal of stimulus avoidance has been accredited to the repression process (Byrne, 1961).

While acknowledging the inherent dangers in construing such personality dynamics in terms of physiological functioning, the simple formulation is offered that repression involves the implementation of the DR, while sensitization necessitates the operation of the OR. Repressors, then, whose usual mode of coping with unpleasant stimuli or events is repression and avoidance would be expected to implement DRs in the service of such aims. Sensitizers, on the other hand, would be expected to employ ORs to realize their goal of stimulus confrontation and approach.

The above formulation, admittedly, begs the question of the role of cortical and subcortical structures in DR initiation. Such a question must await later discussion (see Chapter 8). Some sort of cortical inhibitory influence might be postulated but the general mechanism of its operation would not be expected to parallel that for the habituation process.

The notion that repressors might be more inclined to manifest DRs to unpleasant or distressing stimuli than sensitizers receives a modicum of empirical support from the findings of Lazarus and Alfert (1964). These workers observed that Ss classified as repressors revealed
much higher levels of basal skin conductance than sensitizers when exposed to an unpleasant film. Hare (1966) also reported that repressors showed more autonomic disturbance than sensitizers in a distressing situation. In the Hare study Ss were administered an electric shock each time a clock hand, that they were instructed to watch, reached the 30 sec. mark. Repressors were found to have a higher level of basal skin conductance, a greater degree of nonspecific electrodermal activity, and a greater magnitude of anticipatory electrodermal responses than sensitizers in such a situation.

It is hypothesised, then, that Ss towards the repressor end of the R-S continuum would exhibit more extensive DRs, as indicated by more extensive forehead BVP constriction, to the present unpleasant homicide pictures, than Ss characterized as sensitizers.

5.3.2 Method.

Ss were the 45 employed in the self-report study (Chapter 5.2). Description of the whole experimental paradigm is probably redundant as the general procedure has been described elsewhere (Chapter 2 and Section 2.2 of the present chapter). On completion of slide presentation Ss were administered the revised version of the R-S scale (Byrne, Barry & Nelson, 1963) (see Appendix II), with the instructions to answer all the questions on the scale, if possible. It was decided to remove from the analytical pool Ss who omitted to answer 5 or more items. Fortunately, no evictions were necessary.

5.3.3 Results.

Calculation of the grand mean BVP response for each S has described already (Chapter 5.2.3). Computation, as reported, was based on the behaviour of the first 10 ordinal pulses recorded for each of the unpleasant stimuli. These BVP values were correlated with scores recorded on the R-S scale.
R-S scale score was found to correlate very poorly with BVP score ($r = 0.06$). Independent consideration of the means of the first and second 5 pulses also revealed discouragingly low correlation values ($r = 0.04, r = 0.08$ respectively).

5.3.4 Discussion.

The results offer little support for the formulation that repressors predominantly implement DRs in their interaction with unpleasant stimuli, whereas sensitizers employ the OR as the favoured response in such situations.

This failure to find a significant relationship between R-S scale score and autonomic response contrasts markedly with the previous successes of Lazarus and Alfert (1964) and Hare (1966). Both of these studies reported that, in the face of unpleasant stimulation, repressors generally manifested more in the way of autonomic disturbance than sensitizers. However, Weinstein, Averill, Opton and Lazarus (1968), on reanalysing the data of six previous experiments conducted by the Lazarus group, failed to substantiate the initial findings of Lazarus and Alfert that repressors showed significantly higher skin conductance levels than sensitizers, when exposed to an unpleasant and distressing movie.

"In the original publication of one of the experiments reanalyzed here (Lazarus & Alfert, 1964), it was reported that repressors showed significantly higher levels of skin conductance than sensitizers. This finding was not supported by the other experiments contributing to this analysis. The reason for this failure to replicate initial findings is not certain, but it seems plausible that repression and sensitization are equally valid styles of coping with threat, and that success (or failure) of the individual in coping with threat may occur with either defensive style". (Weinstein, et al. 1968).

From this point of view, there would seem no necessary reason to expect repressors and sensitizers to be associated with more or less autonomic reaction.

Weinstein et al, went on to report that the major influence
of defensive style on affective reaction was observed with self-report.

"However, the data show that it is self-report and not physiological reaction, that is related to the set of personality scales". (Weinstein, et al. 1968).

The observation that the R-S dimension exerts its primary influence on verbal processes and self-report of distress has previous empirical backing (e.g. Byrne & Sheffield, 1965; Lomont, 1965). Further, Lefcourt (1966) proposed that the R-S scale scores "depict subjects' evaluations and private interpretations of emotionality". According to Lefcourt, sensitizers, when confronted with conventional emotionally arousing stimuli, prefer to describe themselves as emotionally responsive. The opposite is true of repressors. The results of Weinstein et al. would be consistent with such an interpretation:

"This result is consistent with an interpretation of the scales in terms of pervasive styles of coping with stress, but it is equally consistent with interpretations of the scales in terms of attitudes towards emotionality (Lefcourt, 1966) or self-representation". (Weinstein, et al. 1968).

Accepting Lefcourt's proposal that the R-S scale represents a dimension relating primarily to differential tendencies to verbally elaborate affective experience, one would not expect repressors and sensitizers to exhibit differential autonomic responding.

5.3.5 Repression-sensitization and self-report of affective experience.

The above considerations suggest that the influence of the perceptual personality dimension of repression-sensitization on affective experience will be primarily exhibited in the verbal description of such experience. The subsequent correlation, computed between R-S scale score and intensity of self-reported distress (on the PSI) to the unpleasant stimuli nevertheless failed to reach significance (r = 0.16). However, as mentioned earlier, the range of descriptors chosen by Ss, from the PSI, to express their affective experience during the presentation of the unpleasant stimulus block, was noticeably narrow. This
restricted range of report suggested that self-report of affect to these stimuli was markedly bound to other dynamic factors. It seems probable that Ss might have readily inferred, from the stimulus content of the unpleasant pictures, what was, in their estimation, the acceptable response, and checked this irrespective of their own particular experience. Self-report of everyday disposition, which displayed a much wider range of affective description, was found to correlate significantly with R-S scale score ($r = 0.49$, $df = 43$, $p < .01$). Ss toward the sensitizer end of the continuum, then, reported their everyday experience or disposition to be generally more stressful than repressors, or Ss toward the repression end of the dimension. Correlation coefficients were computed between R-S scale score and PSI report for the other stimulus blocks. Little correlation was found between R-S score and self-report for the pleasant stimulus block ($r = 0.18$). Again, however, a very narrow range of "feeling" labels accounted for Ss' reported affective experience with these stimuli. As with the unpleasant stimulus block, it seems probable that stimulus content, irrespective of affective experience, readily suggested an appropriate checklist label. For the affectively neutral stimuli (i.e., interesting and boring stimuli), however, where stimulus content would not immediately suggest an affective or "feeling" label, correlations between R-S score and self-report approached significance ($r = 0.25$, $df = 43$, $p < .10$ for both the boring and the interesting stimulus blocks). These correlation values again indicate a tendency for sensitizers to report more in the way of upset or distress. The present observations indicate that the R-S continuum does indeed exert some influence on verbal or self-report aspects of affective experience. This contrasts markedly with its lack of effect on OR/DR predominance.
5.3.6 Repression-sensitization and the verbal elaboration of experience:

A side issue.

From his observations on Ss' interpretations of the function of the R-S scale Lefcourt concluded that:

"Repressors may, therefore, be viewed as interpreting the admission of emotionality as a sign of abnormality, while sensitizers view such admissions as revealing honesty with one's self, and a lack of fear of self-disclosure". (Lefcourt, 1966).

Since repressors were generally found to view emotional expression as an indication of abnormality Lefcourt proposed that their use of emotional descriptors would be limited. Sensitizers, on the other hand, who usually perceive emotional expression more positively would be expected to articulate themselves in emotional terms more frequently than repressors. Thus, given the opportunity sensitizers should show a greater propensity to verbally elaborate their experience in affective terms than repressors. Repressors and sensitizers, then, should not only differ, as observed previously, in their verbal report of affect on a forced-choice checklist, but also in the extent of their affective verbal elaboration in a free response situation i.e. a situation in which Ss are free to employ as many descriptors as they think necessary to describe their experience.

Lefcourt (1966) found empirical support for such a notion. He observed that repressors used significantly less affect-ideational terms than sensitizers in describing Thematic Apperception Test (TAT) figures. Byrne (1961), however, found no relationship between R-S score and the percentage of affective words used to describe TAT pictures.

The relationship between the extent of affective verbal elaboration of reaction to the present visual stimuli would be expected to yield information relevant to Lefcourt's notion that the R-S continuum is mainly concerned with individuals' tendencies to depict themselves
as emotional. Consequently, the relationship between scores on the R-S scale and the number of "feeling" labels, on the Davitz (1969) list, employed by Ss to describe their reactions to the 4 blocks of slides, was investigated.

Data from the original 24 Ss was employed to gauge the pertinent relationship. Slide presentation procedure and the administration of the Davitz list and the R-S scale has been described previously elsewhere (Chapter 2 and section 3.2 of present chapter). It is probably enough to reiterate the temporal sequence of procedural events. The Davitz list was administered immediately after the completion of slide presentation. S was instructed to tick off as many words as he felt adequately described his experience during the presentation of each slide. To aid in his self-report, S was given 8 in. x 10 in. photographs of the slides. However, he was explicitly instructed to use these only as recall cues and that what was required was his description of his reaction to the slides. On completion of the checklist the revised version of the R-S scale was administered.

Verbal elaboration as indicated by the total number of checks on the checklist was computed for each S. These values correlated significantly with scores on the R-S scale ($r = 0.41$, $df = 22$, $p < .05$), revealing that Ss toward the repression end of the dimension ticked off fewer words to describe their reactions than sensitizers.

The results of separate correlations between the number of checks for each stimulus block and scores on the R-S scale are represented in Table 5.1. Significant correlations were obtained for the boring stimulus block and for the unpleasant stimulus block. t-tests of difference between these correlation coefficients were computed (McNemar, 1969). The correlation between the words checked for the boring block and R-S score was significantly greater than that correlation for the pleasant stimulus block ($t = 2.22$, $df = 21$, $p < .05$). The difference
Correlations between R-S score and the number of items checked on the checklist for each stimulus block.

<table>
<thead>
<tr>
<th>Stimulus Block</th>
<th>( r )</th>
<th>df</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unpleasant</td>
<td>0.41</td>
<td>22</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Pleasant</td>
<td>0.11</td>
<td>22</td>
<td>ns</td>
</tr>
<tr>
<td>Interesting</td>
<td>0.32</td>
<td>22</td>
<td>ns</td>
</tr>
<tr>
<td>Boring</td>
<td>0.55</td>
<td>22</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

between the correlation obtained with the pleasant block and that obtained with the unpleasant block of slides approached significance (\( t = 1.98, \text{ df} = 21, p < .10 \)). None of the other differences between the correlation coefficients were significant. All \( t \)-tests were two-tailed.

The results of this investigation indicate that, taking the number of words checked on a "feeling" or mood checklist as an index of affective verbal elaboration, sensitizers elaborate their reaction to visual stimuli more than repressors. This finding parallels the observation of Lefcourt (1966), that sensitizers use more emotional terms when describing TAT figures. It is also in line with the recent observation of Axtell and Cole (1971). These workers noted that repressors talked significantly less when asked to describe themselves in affective terms than did sensitizers.

The present observations, for the most part, parallel the previously noted effect of the R-S continuum on reported affect on the PSI scale. Sensitizers appear, not only to favour the more emotional terms on a forced-choice checklist, but also, when given the opportunity,
TABLE 5.1

Correlations between R-S score and the number of items checked on the checklist for each stimulus block.

<table>
<thead>
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<th>r</th>
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<th>p</th>
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<td>Unpleasant</td>
<td>0.41</td>
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The present observations, for the most part, parallel the previously noted effect of the R-S continuum on reported affect on the PSI scale. Sensitizers appear, not only to favour the more emotional terms on a forced-choice checklist, but also, when given the opportunity,
employ more in the way of affective descriptors than repressors. It seems reasonable to postulate, as Lefcourt (1966) did, that repressors and sensitizers differ primarily in the degree to which they prefer to present themselves as emotionally responsive.

In the present study the finding, that the highest correlation between verbal elaboration and R-S score occurs with the boring stimuli, suggests that where there is more scope for affective elaboration, because the checklist response is less stimulus bound (i.e., there is no ready made pigeon hole for experimental description), repressors and sensitizers will exhibit differential propensities for elaboration. Such a result parallels the previous finding that sensitizers preferred a more emotionally intense description of their everyday experience on the PSI. There was also, as the reader may recall, a tendency for sensitizers to favour a more emotionally intense account of their experience to the boring slides on the PSI.

The correlations, computed for the separate stimulus blocks, also indicate that the differential elaborative tendencies of repressors and sensitizers exhibit themselves when the stimuli are unpleasant and threatening. Such a finding is consistent with the results of earlier experiments (Byrne & Sheffield, 1965; Lomont, 1965; Weinstein, Averill, Opton & Lazarus, 1968).

It appears, then, that sensitizers will more freely elaborate their experience than repressors when confronted with threatening stimuli or stimuli which do not immediately suggest an emotional label and to which reactions are difficult to describe in affective terms.

An explanation of these present findings, other than the exhibition of differential preferences for emotional depiction, is suggested by Clark and Neuringer's (1971) observation that repressors and sensitizers differ in general verbal abilities. Repressors, evidently, exhibit the greater verbal aptitude. Perhaps, then, repressors
find it possible to describe their affective experience with greater verbal economy.

In conclusion, however, it does appear that the R-S continuum has its major influence on the verbal expression of affect.

5.4 Looking time and individual differences in forehead BVP.

5.4.1 Introduction.

The duration of visual attention or looking time, i.e. the time Ss spend, of their own volition, inspecting stimuli, has been frequently employed as an index of visual exploratory behaviour (Berlyne, 1958; Berlyne & Lawrence, 1964; Leckart, 1966, 1967; Leckart & Bakan, 1965; Day, 1966). A consistent finding, as Day (1966) has pointed out is that "looking time is directly related to the informational content of the stimulus display". It appears that differences in what Berlyne (1960, 1966) called the "collative" properties of stimuli (such properties as novelty, complexity and incongruity) are mainly responsible for the vicissitudes in the times Ss spend looking at different stimuli. Several studies have shown, for example, that Ss manifest longer looking times to more complex figures and photographs (Berlyne, 1963; Berlyne & Lawrence, 1964; Leckart, 1966; Leckart & Bakan, 1965). Increased novelty of visual stimulation has also been found to increase the duration of visual attention (Berlyne, 1958; Cantor & Cantor, 1965; Leckart, 1966).

The appearance and extent of the OR demonstrates a remarkably similar relationship to stimulus informational content. The "collative" properties of stimuli that attract such visual exploratory behaviour are those which have also been reported to evoke ORs (Berlyne, 1961; Berlyne, Craw, Salapatek, & Lewis, 1963; Sokolov, 1960, 1963a; Lynn, 1966). Sokolov's (1960, 1963a) model of OR genesis postulated that OR will appear when the incoming stimulus fails to match an organism's expectation as dictated by the prevailing neuronal representation of
the stimulus world. Charlesworth (1966) suggested that this sort of discrepancy between expectancy and actuality best accounted for the elicitation and maintenance of visual exploratory behaviour.

Such commonalities provoked Berlyne (1960, 1966) to suggest a correspondence between the physiological changes that constitute the OR and such behavioural manifestations of exploration as observing or looking behaviour.

"The grounds for connecting exploratory responses with rises in arousal are twofold. First, a great deal of experimental work (largely, but not entirely, carried out in the U.S.S.R.) has shown at least some forms of exploratory behaviour to be accompanied by pervasive psycho-physiological changes, including several recognized indices of increased arousal. This work has led to a broadening of Pavlov's notion of an "orientational reflex" or orientation reaction. Pavlov used this term to denote the immediately visible bodily movements through which an animal focuses its sense organs on an unusual source of stimulation. It is now clear that these are accompanied by a whole network of processes, most of them not detectable without special amplifying and recording equipment, which seem to represent a mobilization of the animal's capacity to absorb information through its sense organs, process the information through its central nervous system, and act promptly and energetically.

Secondly, evidence is accumulating that the collative properties by which exploratory behaviour is so profoundly influenced are capable of increasing arousal". (Berlyne, 1966).

Berlyne, here, argues cogently that the physiological OR and such behaviours as visual inspection are manifestations of the same process, prompted by the same stimulus properties, and directed toward the same aim. Day (1968) made a similar point:

"The linear increase in looking time with increasing complexity points to the conclusion that looking behaviour, at least in an experimental situation is a measure of exploration and may be a response to an increased level of arousal, possibly induced by collative variability". (Day, 1968).

As Berlyne (1966) admitted, the fundamental role of the OR in exploratory behaviour has been recognized by Soviet workers for some
time. Cole and Maltzman (1968) wrote of Sokolov's viewpoint as follows:

"E. N. Sokolov . . . assumes that instrumental search or investigatory responses are basically the same as the physiological components of the OR". (Cole & Maltzman, 1968, p. 35).

A simple formulation, then, might be preferred. Since the physiological changes that constitute the DR and looking behaviour both represent aspects of visual exploration, the extent of each should covary. Longer looking times should be accompanied by more extensive and higher amplitude ORs. The findings of Lewis, Kagan, Campbell and Kalafat (1966) provide empirical support for such a notion. They observed that the time spent fixating a visual array (flashing light pattern) was directly related to the extent of cardiac deceleration.

Since the DR represents an interruption of the OR and exploratory interaction, the following prediction seems apposite with regard to behaviour elicited by the unpleasant homicide pictures. It is hypothesised that longer looking times will be associated with less extensive DRs, and more extensive ORs. Relatively shorter looking times should accompany more emphatic DRs. A definite relationship, then, should exist between the extent of forehead BVP constriction and the time spent looking at the homicide pictures.

5.4.2 Method.

Subjects (Ss) were 24 students enrolled in an introductory psychology course i.e. Ss were drawn from the same population as before. They volunteered to take part in an experiment "measuring physiological response to visual stimuli" and their participation was part of a course requirement.

The stimuli were those described previously. As before, they

3. Graham and Clifton (1966), after a careful review of the literature, proposed cardiac deceleration as the cardiac component of the OR.
were arranged in blocks. Between each block was a blank slide. All Ss saw all 4 slide blocks. Block order was randomised but slide order within each block was constant throughout the experiment. The slides were projected by a Kodak Carousel S projector onto a screen about 8 ft. from S. Image size was approximately 2 ft. x 3 ft.

S was seated in a comfortable armchair in a sound attenuated, temperature controlled room. Photo-transducer attachment has been described elsewhere (Chapter 2), as has the procedure for recording forehead BVP (again Chapter 2). This was the only physiological measure taken.

Numerous studies (e.g. Brown & Farha, 1966; Day, 1968; Leckart, Gehres & Thornton, 1970) have found looking time to be contingent upon the exact nature of the experimental instructions. Asking Ss to observe a stimulus "for as long as you find the stimulus pleasing" typically yields different looking times from instructions which urge Ss to "look as long as you like" (Brown & Farha, 1966; Day, 1968). Thus it was essential in the present study that instructions were standard for all Ss. Further, Leckart, Gehres and Thornton (1970) concluded from their study that:

"... a more appropriate situation to investigate looking time would (1) utilize sham GSR instructions to reduce S's uncertainty concerning the experiment's purpose, and (2) arrange for E's absence while S is viewing the stimuli". (Leckart et al. 1970).

Leckart et al. suggested that failure to meet these conditions could result in Ss looking less than they "normally" would, because they felt uncertain as to what their looking time might reveal about themselves.

Physiological measurement and the employment of an experimental set-up such that the recording equipment and E were located in a different room to S ensured that such overriding inhibitory effects would be limited in the present experiment.

S was asked to "look at each slide for as long as you want".
This instruction was similar to the "neutral" instructional sets used by Brown and Farha (1966) and Day (1968). Slides were changed by depressing a foot-pedal. Formal instruction was given to S on the operation of the foot-pedal. S was advised to "depress the foot-pedal when you wish to go on to the next slide". It was impressed upon S that he would not be required to remember the stimuli or asked anything about them later. In the present study S's were not required to check their "feelings" on the PSI.

After instrument calibration S was informed that he could start stimulus presentation. The appearance of the blank slide at the end of presentation of the first stimulus block acted as a cue for S to relax until given further instruction. After 1 minute of relaxation, S was asked to recommence stimulus presentation. The procedure was repeated until S had viewed all 24 slides. The seeming cumbersome procedure of interpolating 1 minute relaxation periods between stimulus blocks provided for the essential computation of forehead BVP responding during a preblock relaxation period for each stimulus block.

Looking time, measured as the interval between successive foot-pedal depressions, was recorded to the nearest .01 second on an electronic digital timer. The timer was housed beside the polygraph and was thus not visible to S.

5.4.3 Results.

Analysis again focussed on response to the unpleasant stimuli. Examples of forehead BVP response to the first unpleasant stimulus are shown in Figure 5.3. BVP analysis was restricted to the first 10 pulses following the stimulus onset of each slide in the unpleasant block. Even limiting analysis to these initial 10 pulses, and employing procedural variations designed to counter excessively short looking times, one S still had to be evicted from the analytical pool for failing to observe
the unpleasant slides long enough to allow analysis. No evictions due to vasomotor hyper-reactivity were necessary. Analysis, then, was performed on 23 Ss.

A beat-by-beat analysis of forehead BVP was undertaken, as before, on the first 10 pulses exhibited to each of the unpleasant slides. The amplitude of each of these beats was expressed as a deviation from the mean amplitude of the 10 pulses prior to unpleasant block onset. Deviations below the preblock level were regarded as indicating constriction; deviations above as evidence of dilation. Deviations were averaged across all 6 slides. This average pattern was then meaned across all 23 Ss. The mean pattern of BVP responding for these first 10 ordinal pulses is shown in Figure 5.4.

Looking time was recorded for each stimulus. For each S the average looking time for the six stimuli in each block was computed. In order to increase homogeneity of variance these averaged values were treated to logarithmic transformation. The log values were then meaned across all 23 Ss. These computed mean values are presented in Table 5.2.

Analysis of variance revealed an effect of stimulus block on log. looking time ($F = 4.78$, $df = 3/69$, $p < .005$). $t$-tests were then computed to compare log. average looking time values for the stimuli in separate pairs of stimulus blocks. The $t$ values, shown in Table 5.3, revealed systematic differences in looking times between stimulus blocks. Ss looked longest at the interesting stimuli, while the shortest looking times were exhibited to the boring ones. There was a strong tendency for pleasant stimuli to be looked at longer than the unpleasant ones.

Correlational analysis focussed on the unpleasant stimulus block. A Pearsonian correlation coefficient computed between log. average looking time and mean forehead BVP for the stimuli in the unpleasant block was low ($r = -0.02$). Computing coefficients, as before, for the mean of the first 5 ordinal pulses, and the mean of the second 5 pulses, and
FIGURE 5.3  Examples of forehead BVP response to the first unpleasant slide in the looking paradigm. (Slide onset is denoted by the number 1). Chart speed = 2.5 mm/sec.
FIGURE 5.4 Mean forehead BVP responses for the unpleasant block (looking time paradigm).
log. average looking time also revealed little in the way of correlation ($r = -0.10$, for the first 5 pulses; $r = 0.12$, for the second 5 pulses).

The correlation between mean BVP amplitude of the first 5 ordinal pulses and the second 5 ordinal pulses was predictably good ($r = 0.71$, $df = 21$, $p < .001$).

**TABLE 5.2**

Mean log looking time for the 6 slides in each of the 4 stimulus blocks.

<table>
<thead>
<tr>
<th>Stimulus Block</th>
<th>Log Looking Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unpleasant</td>
<td>1.22</td>
</tr>
<tr>
<td>Pleasant</td>
<td>1.34</td>
</tr>
<tr>
<td>Interesting</td>
<td>1.55</td>
</tr>
<tr>
<td>Boring</td>
<td>1.08</td>
</tr>
</tbody>
</table>

**TABLE 5.3**

$t$-values obtained from comparison of differences of log average looking times of stimulus block pairs.

<table>
<thead>
<tr>
<th>Stimulus Block</th>
<th>Pleasant</th>
<th>Interesting</th>
<th>Boring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unpleasant</td>
<td>2.58*</td>
<td>5.33***</td>
<td>2.82**</td>
</tr>
<tr>
<td>Pleasant</td>
<td></td>
<td>6.25***</td>
<td>9.18***</td>
</tr>
<tr>
<td>Interesting</td>
<td></td>
<td></td>
<td>13.19***</td>
</tr>
</tbody>
</table>

* $p < .05$ two-tailed test  
** $p < .01$ two-tailed test  
*** $p < .001$ two-tailed test.
Because of the extensive individual differences in looking time behaviour, it was considered that, for correlation purposes anyway, expression of looking time to the unpleasant stimuli as a proportion of the time spent looking at all the stimuli may be a more valid means of representing looking time behaviour. Consequently for each S the average looking time for the unpleasant stimuli was expressed as a proportion of the average time spent looking at all 24 slides. Correlations thus computed revealed a better, but again not significant, relationship between looking time and forehead BVP ($r = 0.26$). However, there was a strong tendency for the proportion of time spent looking at the unpleasant stimuli to be related to the mean forehead BVP of the first 5 ordinal pulses ($r = 0.38$, df = 21, $p < .07$). The coefficient obtained for the mean of second 5 ordinal pulses was not significant ($r = 0.12$).

5.4.4 Discussion.

The present results provide at least some support for the prediction that shorter looking times are associated with more emphatic DRs, as revealed by greater forehead BVP constriction, whereas longer looking times are associated with BVP responding more suggestive of ORs. What relationship existed, however, appeared only in analysis employing the first 5 pulses.

Nevertheless, this finding is encouraging considering the previous lack of success in establishing any direct relationship between looking time and physiological reaction. With the exception of the study conducted by Lewis, Kagan, Campbell and Kalafat (1966) most attempts have fallen short of the mark (e.g., Haywood, 1962; Berlyne & Lawrence, 1964). Berlyne and Lawrence's (1964) study is probably the most comprehensive and its lack of success therefore requires closer inspection. Contrary to their hypothesis, Berlyne and Lawrence observed
no relationship between the time spent looking at visual patterns and the extent of the OR. SCR was employed, for the most part, as the preferred index of the OR. The study however appears to have a methodological weakness, in that looking time and SCR were measured in successive phases of the experiment and not simultaneously. Berlyne and Lawrence first measured physiological response to the stimuli, presented for a fixed 0.2 seconds period. Electrodes were subsequently removed and looking time measured to the same stimuli. Thus, during the looking time phase was seeing the stimuli for the second time. Dramatic variations in looking time behaviour might be expected because of this pre-exposure. Further, the choice of an extremely short presentation time in the initial phase of the experiment was probably unfortunate. As Berlyne, Craw, Salapatek and Lewis (1963) admitted in a contemporary article:

"The material was, however, exposed for .2 sec. at a time, and this may well have been too short for Ss to distinguish the attributes of the various patterns". (Berlyne et al. 1963).

The present design where physiological response and looking time were monitored concurrently in one session would seem preferable.

The variation in looking time noted with the stimuli in different stimulus blocks was as expected. The finding that the pleasant stimuli induced more prolonged observation than the unpleasant stimuli came as no surprise. Several studies have shown that increases in positive affect are associated with increases in looking time (e.g. Bullock, 1959; Day, 1966). The present result is also consistent with the contention that the DR operates to restrict visual exploratory behaviour.

The finding that the interesting slides ("impossible" graphics of Escher and other pictures with perceptual incongruity) were looked at longest and that the boring slides (pictures of simple geometric shapes)
were looked at for the least time is consistent with the common observation that Ss look longer at more complex stimuli (Berlyne, 1953; Berlyne & Lawrence, 1964; Leckart, 1966; Leckart & Bakan, 1965). Since the boring stimulus block has been shown (see Chapter 2) to elicit physiological behaviour, such as frequent eyeblinking and relatively little in the way of SCR or BVP responding, indicative of OR habituation, it could be inferred that disruption of the OR through habituation, as well as through replacement by the DR, operates to the detriment of visual exploration.

5.4.5 Looking time and repression-sensitization.

An attempt was made to gauge the affect of those dynamic factors, found to influence self-report of affective experience, on looking time. It was suggested previously (Chapter 5.3.4, 5.3.5, 5.3.6) that position on the repression-sensitization (R-S) dimension primarily predicted whether an individual preferred to represent himself as emotionally responsive. Such an interpretation contended that the influence of the R-S scale would be primarily with verbal aspects of emotional expression. One would have no reason to expect repressors and sensitizers to consistently demonstrate differences in physiological responding.

The influence of the R-S dimension on looking time thus seemed a logical inquiry. The notion was entertained that, if repressors and sensitizers were found to exhibit different propensities for looking at visual stimuli, particularly at the unpleasant visual stimuli, would removal of this dynamic influence improve the correlation between looking time and physiological responding.

Consequently the revised version of the R-S scale (Byrne, Barry & Nelson, 1963) was administered to the Ss who participated in the looking time experiment.
R-S scale score was correlated with the log average looking time for all 24 slides ($r = 0.00$). Pearsonian correlations were then computed between R-S scale score and log average looking time of the stimuli in each stimulus block. The computed coefficients are presented in Table 5.4. None of the correlations differed significantly from zero, but $t$-tests for differences between correlation coefficients (McNemar, 1969) revealed a significant difference between the correlation coefficient for the unpleasant stimulus block and the coefficient for the pleasant stimuli ($t = 2.10$, df = 21, $p < .05$).

Previous studies attempting to relate individual differences in looking time to various personality measures have generally been unsuccessful (e.g., Day, 1966; Leckart & Wagner, 1967). Where relationships have been observed they appear dependent on the exact nature of the stimulus material (Bakan & Leckart, 1966; Leckart, Keeling & Bakan, 1966). The present results similarly indicate that the relationship between looking time and R-S score is slight and dependent on the nature of the stimulus material. The R-S dimension exerts a differential influence on the looking time exhibited to the unpleasant and pleasant stimuli.

The present observation that this tendency (of repressors to look longer than sensitizers) is greater for the unpleasant stimuli than for the pleasant stimuli is contrary to expectation derived from observation of the verbal behaviour of the two groups. It seems that repressors and sensitizers consistently exhibit the dynamic tendencies ascribed to them only with regard to verbal aspects of affective behaviour.

The low correlation obtained between R-S scale score and looking time for the unpleasant stimuli does not offer much support for the contention that the control of such dynamic influences on looking time might improve the correlation between looking time and forehead BVP response. Employing the proportional representation of looking time
TABLE 5.4

Correlations between R-S scale score and log average looking time for the stimuli in each stimulus block.

<table>
<thead>
<tr>
<th>Stimulus Block</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unpleasant</td>
<td>-0.12</td>
</tr>
<tr>
<td>Pleasant</td>
<td>0.16</td>
</tr>
<tr>
<td>Interesting</td>
<td>0.10</td>
</tr>
<tr>
<td>Boring</td>
<td>0.11</td>
</tr>
</tbody>
</table>

to the unpleasant stimuli, used previously, the correlation between looking time and R-S scale score was recalculated ($r = -0.33$). A partial correlation (Ferguson, 1966) was then computed between looking time and forehead BVP response for the unpleasant stimuli, with the effects of the R-S dimension removed. This procedure yielded a partial correlation coefficient ($r = 0.38$) exactly equal to the original coefficient obtained prior to the elimination of R-S effects.

5.4.6 Looking time and signal value.

The nature of the looking time paradigm requires Ss to make a reasonably well-defined discrete motor response to the visual stimuli i.e. to depress a foot-pedal. The endowment of the stimuli with such behavioural response associations makes them signal stimuli (Sokolov, 1963a; Germana & Chernault, 1969). They become, as Berlyne, Craw, Salapatek and Lewis (1963) state, "stimuli whose properties must be discriminated so that an overt response can be selected". According to Sokolov (1963a) conferring signal value on stimuli increases the threshold for the DR and decreases the threshold for the OR. Unpleasant visual
stimuli, then, endowed with behavioural associations would be less likely to elicit DRs and more likely to elicit physiological responding suggestive of the OR. Stated simply, one would expect less forehead BVP vasoconstriction manifest to the unpleasant stimuli in the looking time paradigm than in a situation where the stimuli did not have such clearly defined behavioural associations.

Accordingly, a comparison was undertaken of the forehead BVP behaviour of the 45 Ss previously employed in the "self-report" study with that exhibited by the "looking time" Ss. The mean BVP patterns of these two groups for the first 10 ordinal pulses averaged across the 6 slides in the unpleasant block, are shown in Figures 5.2 and 5.4. These 10 average pulse values were collapsed and a grand mean forehead BVP amplitude value obtained for each S. A simple t-test was then computed for the difference between these mean values for each group. The extent of BVP constriction manifest by the "self-report" Ss was found to differ significantly from that exhibited by Ss in the looking time paradigm \( (t = 2.42, \text{df} = 66, p < .02) \).

Less forehead BVP constriction was exhibited to the unpleasant stimuli, then, when the experimental procedure endowed them with a prerequisite for a behavioural response. In this the present result parallels that reported in Chapter 3, and stresses the susceptibility of the forehead BVP response to changes in signal value. Irrespective of whether signal significance is conferred on the stimuli by memory instructions or by procedural manoeuvres that demand a more discrete motor response to the stimuli, forehead BVP responding undergoes significant changes.

5.5 Concluding Remarks.

Although several interesting positive findings emerged from this investigation of individual differences in forehead vasomotor response the outcome of the main correlations of particular interest
was generally disappointing. It might be well to summarize the probable reasons for this lack of success and discuss what innovations might yield more in the way of positive findings.

Dynamic influences on self-report appear to be one reason for the lack of relationship observed between self-report of distress and vasomotor responding. Apart from the influence of the R-S scale, many other such factors affecting self-report undoubtedly contribute to this lack of agreement; for example, social desirability (Bergs & Martin, 1961) and dispositional anxiety (Erikson & Davids, 1955; Gordon, 1959).

The descriptive restrictions of the PSI, which offers an extremely limited choice of affective labels would seem another reason for the lack of correlation. However, the use of a more extensive scale for affective classification would, as argued previously, have drastic effects on vasomotor responding, replacing the DR with responding more in line with the OR.

The low correlation of individual differences in the forehead vasomotor response to unpleasant visual stimuli and position on the R-S perceptual-personality dimension could have stemmed from the inappropriateness of the latter, which seems to relate primarily to verbal aspects of affective behaviour.

The employment of some of the other perceptual-personality dimensions cited by Stern and Plapp (1969) may have led to more success. The augmenter-reducer dimension (Petrie, 1967) may be particularly relevant. Petrie (1967) hypothesised two types of individuals who modulate their sensory input differently - the augmenter who tends to increase and the reducer who tends to decrease the perceived intensity of the stimuli. This sensory modulation was originally inferred by Petrie from performance on a kinaesthetic figural after-effect task; augmenters overestimate the size of a wooden measuring block while reducers underestimate it. Petrie reports evidence that a sample of individuals thus
dichotomised show consistent differences in their tolerance of intense stimulation (physical injury, pain apprehension, intense heat and auditory stimulation), reducers showing the greater tolerance. With sensory deprivation or isolation, augmenters show the greatest tolerance. This tendency to reduce as a means of coping with intense or unpleasant stimulation has obvious implications for the present study; reducers should show the least physiological disruption to unpleasant visual stimuli, as evidenced by less in the way of forehead vasoconstriction. A relationship between augmenting-reducing tendencies and averaged evoked response (AER) has been established by, for example, Buchsbaum and Silverman (1968), and Silverman, Buchsbaum and Henkin (1969). These workers reported that reducers, selected by their performance on the Petrie kinaesthetic task, showed AERs which decreased in amplitude as the intensity of the stimulus (light flashes) was raised above a moderate level.

It is possible, then, that the use of the augmenter-reducer dimension, with a demonstrated physiological associate, might have made for more success in the present context.

Also of some interest for the present individual differences in DR are the Eysenck (Eysenck & Eysenck, 1964) dimensions of introversion-extraversion (E-I) and neuroticism (N). Eysenck (1957) initially identified the E-I dimension with the balance of central inhibition-excitation processes critical to Pavlov's typology of individual differences (cf. Gray, 1964). According to Eysenck extraverts are characterized by an imbalance of inhibition, introverts by excitation. Rozhdestvenskaya (1963) obtained evidence to suggest that such neural imbalance was associated with the persistence of OR emergence i.e. with the rate of OR habituation. Ss with a postulated excitatory imbalance habituated slowly, those with an inhibition imbalance habituated quickly. However, more recently Eysenck (1966) has associated his E-I dimension
with another neo-Pavlovian dimension - the strength-sensitivity of the excitatory process (cf. Teplov, 1956). Eysenck contended that the personality associated with a "weak" nervous system appears to resemble the introvert, the "strong" nervous system personality type, the extravert. This linkage of E-I with the strength/sensitivity of the nervous system has received some empirical support. Smith (1967), Haslam (1966), and Siddle, Morrish, White and Mangan (1969) report introverts to have lower sensory thresholds (auditory, pain and visual respectively) than extraverts. However, Rozhdestvenskaya, Nebylitsin, Borasova and ErmoIaeva-Tomina (1960) reported no relationship between strength-sensitivity as evidenced by sensory threshold measurement and the magnitude or persistence of the OR.

Recent empirical investigations in Western laboratories of the relationship of E-I and N to OR amplitude and habituation have revealed inter-relationships of an exceedingly complex nature. Mangan and O'Gorman (1969) observed OR initial amplitude to be related primarily to neuroticism and to a lesser degree extraversion. They concluded that OR habituation rate related primarily to extraversion, to a lesser degree neuroticism. Their results for habituation rate indicate a complex interaction of E-I and N on the persistence of the SCR component of the OR. Low N extraverts and high N introverts habituated SCR at a significantly faster rate than low N introverts. A similar interaction has been reported recently by Sadler, Mefferd, and Houck (1971). Both of these studies employed stimuli of moderate intensity. In an earlier study however, (Martin, 1960), which employed an intense auditory stimulus (100 db) more likely to elicit a DR than an OR, these relationships were not found. It is possible, as Mangan and O'Gorman infer, that such relationships for E-I and N may hold only for physiological responding to moderate or weak stimuli.

An indication that it would be premature to dismiss any
possibility of relationship between individual differences in forehead vasomotor responding and the Eysenck dimensions, particularly the E-I dimension, stems from the work of Petrie (1967). Petrie recorded contrast in the perceptual reactions of extraverts and introverts parallel to those found for reducers and augmenters.

"Those tolerating clinical pain best also showed higher 'extraversion' scores. On the other hand those showing most tolerance for isolation had the lower 'extraversion' scores". (Petrie, 1967, p. 34).

A further reason for linking these dimensions is their similar influence on perceptual after-effects. Eysenck (1955) showed that susceptibility to "figural after-effect" was positively related to extraversion. As cited earlier, Petrie (1967) employed performance on a kinaesthetic after-effect task to distinguish augmenters and reducers, and observed that the performance on this task was also related to scores on the E-I scale. This identification of the reducer with the extravert and the augmenter with the introvert, would recommend the E-I scale as a worthwhile dimension with which to survey individual differences in the physiological DR reaction to affective visual stimulation.

Finally, Roessler and his coworkers (Roessler, Alexander & Greenfield, 1963; Roessler, Burch & Childers, 1966; Pfachler & Roessler, 1965; McCollum, Burch & Roessler, 1966; Pfaehler & Roessler, 1965; McCollum, Burch & Roessler, 1966) have reported ego-strength (measured on the Barron Es Scale of the MMPI, 1965) to be significantly related to reponsiveness in a wide array of physiological channels (e.g. skin conductance, finger vasomotor changes, muscle potential and blood glucose). High ego strength Ss have been found to be more responsive than low ego strength Ss. In a recent experiment (Roessler & Collins, 1970) employing a distressing movie, high ego strength Ss were found to be more responsive (SCL) than low ego strength Ss to the distressing movie. Further, while the high ego-strength group showed significantly higher SCL during the distressing movie than during a bland
control film, the SCL of the low Es group was lower during most of the stressor film than during the bland control film. The comprehensiveness of the influence of the Barron Es scale across such a wide array of physiological parameters alone would recommend its employment in the present investigation of individual differences in forehead BVP response. The results obtained by Roessler and Collins (1970) with unpleasant visual stimulation would reinforce this. It is possible, then, that the present choice of a personality dimension with which to investigate individual differences in DR extent was an unfortunate one, and that the use of other dimensions cited might yield a better return on investment.

A final possibility is that individual variation in forehead BVP response pattern cannot be explained in terms of psychological variability alone. A large portion of the difference between Ss in forehead vasomotor response may be attributable to physiological differences which are unrelated to any psychological parameters. Such a point has been made recently by Lykken and Venables (1971) with regard to SCR and SCL values. It seems certain that individual structural, physiological and biochemical factors delimit the nature of the forehead BVP response. It may be that expression of the BVP response involving some sort of range correction analogous to that proposed by Lykken and Venables (1971) for SCR would increase the correlation of forehead vasomotor response variability and variability on relevant psychological parameters.
CHAPTER 6

FOREHEAD VASOMOTOR RESPONSE TO MODERATE AND INTENSE AUDITORY STIMULATION: A RECONSIDERATION.

6.1 Introduction.

6.1.1 Integration of recent studies.

In the opening chapter of this thesis the author lamented the apparent lack of impact that the Soviet findings concerning the differential forehead vasomotor component of the OR and DR has had on Western psychophysiology. There were virtually no accounts of studies employing forehead vascular measurement as a dependent variable. Since the commencement of the present study, several such studies have been reported, and the present discussion will attempt to integrate these investigations and assess their bearing on the earlier Soviet findings and on the formulation of functionally and empirically distinct ORs and DRs.

6.1.2 Forehead vasomotor measurement.

The experiments previously reported in this thesis have employed forehead BVP as the index of forehead vascular change. However, the use of the photoplethysmograph technique (and other mechanical plethysmographic devices) yields two possible indices of vasomotor change, BVP and blood volume (BV). As Weinman (1967) states:

"In photoplethysmography one is concerned with two events: with the BVP and with changes in BV level". (Weinman, 1967).

BVP was used in the present study for a number of reasons. Firstly, Sokolov does not state explicitly whether he employed BVP or BV as the critical measure. Failure to describe the exact details of experimental methodology seems to be a short-coming of many Soviet research reports. As Cole and Maltzman (1968) point out:

"Next is the related problem of the manner in which the research is reported. Neither in their reports of individual experiments nor in
their general review articles do Soviet researchers provide the detailed information about procedures and results which are the backbone of Western scientific communication". (Cole & Maltzman, 1968, p. xi).

Cole and Maltzman indicate that confusion arises because such communications are aimed primarily at Soviet colleagues, who are familiar with the precise experimental arrangement, rather than the Western reader.

Vinogradova and Sokolov's (1957) discussion of the methodology of their original experiment leads one to suspect that they were, in fact, employing BVP as the dependent variable. They refer exclusively to finger and forehead "volume pulse" measurement. The assumption that the Soviet workers were employing a similar index of forehead vasomotor responding was the first major reason for the employment of BVP as a dependent variable in the present study.

However, some recent Western studies, attempting to replicate the Soviet research have measured BV changes as representative of Soviet methodology. Close re-inspection of reproductions of Soviet plethysmograms (e.g. Sokolov, 1963a) would seem to bear out this interpretation that Sokolov and his colleagues employed changes in forehead BV as the index of forehead vascular change.

The second reason for the preferred employment of forehead BVP measurement in the present study arises from the interpretation of BVP and BV recordings in terms of vascular reaction and blood flow. BV records alterations in the total volume of blood in the area under study (Hertzman & Dillon, 1940; Abramson, 1967; Burton, 1954). Total volume reflects primarily the content of blood in the capillary and venous beds. However, it is the arterioles that control the flow, and as Burton (1954) points out the volume of blood there is relatively small. BVP, on the other hand, appears to represent the difference between arterial inflow and venous outflow during a single cardiac cycle (e.g. Abramson, 1967). According to Hertzman (1938) and Hertzman & Dillon (1940) the amplitude
of the volume pulse is, therefore, a measure of arterial inflow. As Hertzman (1938) states:

"... the magnitude of the volume pulse will be most dependent on the pulsatile excursions in arterial flow into the area and so will be a measure of the arterial supply". (Hertzman, 1938).

Since cutaneous arterial inflow depends upon the tone of the small arteries and arterioles, it is therefore a measure of arteriolar tone, i.e. precapillary constriction. A similar point has been made by Weinman (1967) in answer to his own question "what is the actual physiological event recorded by the photodetector?". Weinman identifies the BVP with Wiggers' (1952) term "pulse". Wiggers defines "pulse" as the expansions of the vessels which the pressure pulse produces in any part of the arterial system. With regard to the BVP Weinman, thus, answers his question as follows:

"The radial plethymographic transducer placed above the artery "sees" therefore the changes in the diameter of this vessel and the transducer on the finger tip or on the forehead integrates changes in the diameter of many small vessels". (Weinman, 1967).

The BVP component of photoplethysmographic measurement, then, would seem the much likelier index of vasomotor tone and actual blood flow.

However, BV and BVP usually covary. As Hertzman and Dillon (1940) state:

"Simultaneous registration of finger pad volume and finger pad volume pulse usually shows an excellent qualitative correlation when vasomotor responses to psychic stimuli, loud noises, a deep breath, and the cold pressor test are observed. The changes in volume are in such responses generally proportional to the changes in amplitude of the volume pulse ...". (Hertzman & Dillon, 1940).

According to Hertzman and Dillon (1940), however, this covariance of BV and BVP does not appear so clearly with forehead circulatory measurement.

Finally, the majority of Western psychophysiological studies employing photoplethysmographic measurement of peripheral circulation have focussed on BVP as the preferred index. This also influenced the present choice.
6.1.3 **Studies employing BVP measurement.**

Studies employing forehead BVP as the index of cephalic vasomotor responding have, almost without exception, found that responses to stimuli were of a biphasic nature. With moderately intense tones Hord and Ackerland (1968) and Keefe and Johnson (1970), cited earlier, report the forehead BVP component of the OR to be biphasic (constriction followed by dilation). The findings, reported in Chapter 2, of such biphasic response patterns to the pleasant, interesting and boring stimuli are in accord with these reports of a biphasic OR component. Hare, Wood, Britain and Shadman (1970) and Hare, Wood, Britain and Frazelle (1971) also noted biphasic responses to complex visual stimuli. The effects of signal value investment on the more extensive constriction response to the unpleasant homicide pictures (reported in Chapter 3) lend further support to the contention that the BVP component of the OR is biphasic. The observed pattern of forehead BVP to the unpleasant homicide pictures, reported in Chapter 2, indicates that although a biphasic pattern is suggested, constriction is much more extensive. The Maltzman, Kantor and Langdon (1966) result of more extensive BVP constriction to high arousal than to low arousal words is in accord with the notion that the BVP component of the DR is characterized by a more extensive constriction reaction. However, Raskin, Kotses and Bever (1969b) recorded forehead BVP from Ss who were presented with either 80 db or 120 db of white noise (0.5 sec. duration). These workers hypothesised that 80 db stimulation would give rise mainly to the vasodilatory component of the OR, while vasoconstriction, evidencing the presence of the DR, would become apparent at 120 db. The presentation of both intensities, however, elicited pronounced forehead BVP constriction. The extent of this constriction was not significantly related to the stimulus intensity. Raskin et al. (1969b) conclude that BVP recorded from the forehead skin does not differentiate ORs and DRs.
However, as pointed out earlier, Sokolov (1965) regarded 80 db as within the range for DR operation. It is possible that both stimulus intensities in the Raskin et al. experiment gave rise to DRs. The lack of a substantial secondary, dilative component of the forehead BVP response in their experiment would seem to support such an assertion. Nord and Ackerland (1968) and Keefe and Johnson (1970) using less intense auditory stimuli observed a large secondary dilative phase. Recently Cohen and Johnson (1971) observed biphasic forehead BVP responses to both moderate and intense auditory stimulation. Stimulation was 20 presentations of either a 60 db or 100 db tone. Tone duration was relatively long (10 sec.). In each intensity condition 10 tones were of 1000 Hz and 10 of 990 Hz. Within a condition these two frequencies of tones were randomly presented. Cohen and Johnson (1971), as cited earlier, also manipulated signal value; by instructing Ss in the signal group to discriminate high and low frequency tones by pressing a relevant button. The general pattern of forehead BVP responding observed was constriction followed by dilation. However, only on trials 1 and 19 of the 20 trials did BVP show a significant effect of intensity. BVP was also found to be insensitive to changes in signal value i.e. the imposition of a discrimination task. In the present study signal value manipulation by means of memory instructions and the innovation of a looking time paradigm both resulted in significant changes in BVP response. The affair is complicated by a recent communication received from Cook. Cook (personal communication 1971) observed that although pulse volume responses were biphasic, some relationship with stimulus intensity existed. Cook employed a dependent, within-S design, Ss receiving a series of 600 Hz tones. The moderately intense tones were of 65 db intensity, while the intense tones were 120 db intensity. No information is available about the stimulus duration.
6.1.4 Studies employing BV measurement.

Recent experiments measuring BV level as the critical index of forehead vasomotor change have been equally ambivalent in their support for the earlier Soviet findings. Raskin, Kotses and Bever (1969a) presented Ss with white noise of varying intensity (40, 60, 80, 100, 120 db), stimulus duration (0.5 and 5 sec.) and inter-stimulus interval (15 and 45 sec.). An independent-S design was employed. These authors noted no effect of any of the three variables on the pattern of forehead BV changes. In contrast to the consistent Soviet observations of constriction of BV to intense stimuli, and dilation to moderate stimuli (Vinogradova & Sokolov, 1957; Luria & Vinogradova, 1959; Sokolov, 1963a; Sokolov, 1965; Vinogradova, 1955; Vinogradova, 1968), Raskin et al. (1969a) report increases in BV (i.e. dilation) to all stimulus intensities, and conclude that BV is generally an insensitive measure.

"On the basis of these data it may be concluded that changes in forehead BC (BV) do not provide an adequate index for reliably differentiating ORs and DRs". (Raskin, Kotses & Bever, 1969a).

Raskin, Kotses and Bever (1969b), using only the 80 and 120 db intensities of white noise, and the one stimulus duration (0.5 sec.) and one inter-stimulus interval condition (mean interval was 45 sec.), again found that the BV response was mainly dilatory. Greater BV dilation was, in fact, observed for Ss exposed to the 120 db noise. This is in direct contrast to the findings of the Soviet workers. However, stimulus repetition did reveal emerging constriction (decreased BV) at both intensities. As Raskin et al. report:

1. Raskin et al. (1969a, 1969b) and Cohen & Johnson (1971), use the term "blood content (BC)" for what is referred to as "blood volume (BV)" in this thesis.
"... the form of the BC response following the 80 db stimulus consisted of an initial increase and a subsequent decrease for early stimulations. Repeated stimulations at 80 db resulted in habituation of the initial increase in BC and a progressive change towards larger decreases in BC in later beats. The BC response to 120 db evidenced much larger initial increases in BC. Following repeated stimulations, the initial increase in BC habituated, and a decrease in BC developed in later beats. (Raskin, Kotses & Bever, 1969b).

Cohen and Johnson (1971)², in the study cited earlier also measured forehead BV changes. These workers observed monophasic increases in BV (i.e. dilation) with both 60 and 100 db tones. The two stimulus intensities used did not exert a different effect on BV. This was true for all 20 stimulus trials. BV was also insensitive to signal value change.

Contrary to these findings Cook (1970 and personal communication) observed BV responding in line with the Soviet findings. Monophasic constriction was observed with 120 db (600 Hz) tones. 65 db tones, on the other hand, elicited mainly dilatory responding.

6.1.5 Aim of present experiment.

In view of these recent contradictory findings, it was felt that further exploration of forehead vascular responses to intense and moderate auditory stimuli was desirable. The Soviet observations of differential vasoconstriction responding to moderate and intense auditory stimuli is central to their dichotomous representation of arousal responses as ORs and DRs. Pilot observations made before commencing the work on affective visual stimuli indicated differential BVP responding to moderate and intense 1000 Hz tones. However, no systematic beat-by-beat analysis of the BVP record was undertaken.

² An extended report of this study was obtained from Cohen and Johnson and some of the discussion relates to this fuller report.
Another reason for reconsidering forehead vasomotor responses to auditory stimuli is the lack of attention the comparability of BV and BVP indices has received. While, as cited earlier, Hertzman and Dillon (1940) found excellent correlation between BV and BVP responding for the finger circulation, the relationship between the two plethysmographic components with respect to the forehead circulation is not so clear. Although the data of Cohen and Johnson (1971) and Raskin, Kotses and Bever (1969b) suggest that BV and BVP do not covary, the graphical representations of Hord and Ackerland (1968) indicate a close correspondence. Clarification is needed.

The present experiment, then, was designed to determine whether forehead BV and BVP measurement does, in fact, differentiate the response to moderate and intense auditory stimulation and does provide an adequate means of distinguishing ORs and DRs. Since the differentiation of ORs and DRs is based almost exclusively on forehead circulatory responding to simple auditory stimulation, the present investigation is, in essence, a reconsideration of the validity of the Soviet dichotomous formulation of physiological patterning. Such an investigation will also provide useful information on the relationship between the BV and BVP components of the photoplethysmographic representation of forehead vasomotor reactions.

6.2 Method.

6.2.1 Subjects.

Twelve male undergraduates, enrolled in an introductory psychology course at the Australian National University served as subjects (Ss). Ss were paid A$1 for participating in the experiment which lasted approximately 1 hour. Undergraduates with reported hearing defects were excluded. Two Ss were eliminated from the experimental pool because of vasomotor hyper-reactivity (discussed in Chapter 2) and thus analysis will be reported on 10 Ss.
6.2.2 Design.

A dependent $S$ design was used. The advantages of a design in which $S$s are exposed to all stimulus conditions have been discussed previously (Chapter 2). The auditory stimuli were pure tones of 1000 Hz. Two intensities of tone were employed; 60 db and 100 db. These intensities were considered appropriate for the elicitation of the OR and DR respectively. As Sokolov states:

"A sound of medium intensities (60 db) evokes reciprocal reactions in the head and the hand (OR), and a strong stimulus (80 and 100 db) results in complementary constriction (DR)". (Sokolov, 1965).

$S$s received 20 presentations of the 1000 Hz tone, 10 successive presentations at 60 db intensity and 10 at 100 db. Half of the $S$s received the moderate tones first, half the intense tones first. In contrast to Cook (1970) who used a presentation procedure which intermingled tone intensities, "in order to minimize the effects of stimulus repetition", the present design of exposing the tones in intensity blocks regarded stimulus repetition as a variable of interest, likely to yield useful information about the habituation characteristics of the vasomotor response to the two intensities.

Stimulus duration was 2 sec. This was intermediate between the long stimulus duration employed by Cohen and Johnson (1971) and the short duration used by Raskin, Kotses and Bever (1969b). The intertrial interval varied randomly from 20 sec. to 40 sec. with a mean of 30 sec.

6.2.3 Stimulus presentation and calibration of stimulus intensity.

The auditory stimuli were programmed by means of a punched tape and tape reader and presented automatically using a locally fabricated solid state timing circuit. The 1000 Hz tones were produced by a Hewlett Packard Frequency Oscillator Model 241A. The signal from the oscillator was amplified by a Newmarket Packaged Circuit Amplifier Model
The signal from the oscillator was amplified by a Newmarker Packaged Circuit Amplifier Model PC4 and presented to the S via Sony Model DR-3A headphones.

Since the intensity of the tone is critical to the appearance of the differential forehead vasomotor response care was taken to ensure that the tones were exactly 60 and 100 db. The intensities of the tone were calibrated at the earphones using a Bruel and Kjaer Model 2203 Sound Level Meter and a Model 4152 Artificial Ear.

6.2.4 Forehead blood volume pulse and blood volume measurement.

BVP measurement has been described previously (see Chapter 2). To obtain a record of forehead BV level the BVP signal from the Grass Model 7P8 preamplifier was fed into the driver amplifier of the adjacent polygraph channel. Whereas the \(\frac{1}{2}\) amp high frequency switch of the driver amplifier was set at 75 Hz for BVP recording, the driver amplifier used for BV recording was set at .1 Hz. This latter setting effectively shuts off the high frequency component of the plethysmograph signal, leaving only a record of the slower changes of BV level without large superimposed BVPs. In this way BVP and BV were represented on adjacent polygraph channels. Since the input to the second driver amplifier from the 7P8 preamplifier occurred after the polarity switch BV changes were represented in an inverted fashion. This reversed polarity was an unavoidable consequence of the set-up used for BV measurement. Thus, as opposed to the usual BV display, in the present set-up an upward pen deflection represented a decrease in BV, a downward deflection indicated BV increase.

6.2.5 Procedure.

S was seated in a comfortable armchair in a sound-attenuated, temperature controlled room. Temperature was kept constant at 70°F. After transducer attachment (for description see Chapter 2) S was
instructed that he would hear a series of tones. It was impressed upon S that no behavioural response was or would be required of him. He was asked to remain as still as possible during stimulus presentation. The headphones were then attached and the experimenter retired to the adjoining room that housed the polygraph and stimulus presentation equipment. Five minutes were spent calibrating the recording apparatus and allowing S to relax. S was then informed (via intercom.) that stimulus presentation would begin in approximately two minutes.

6.3 Results.

Examples of BV and BVP responding to the 60 and 100 db tones are given in Figures 6.1 and 6.2. Increases in BV are indicated by downward pen deflections. Upward pen deflections reflect decreases in BV level.

6.3.1 Forehead blood volume pulse.

A beat-by-beat analysis of forehead BVP was undertaken as before. The amplitude of each of the first 10 ordinal pulses immediately following stimulus onset was expressed as a deviation (in mv.) from the average of the 5 pulses immediately prior to stimulus onset. These values were then averaged across the ten stimulus trials for each intensity. Averaged values were then meaned across Ss. Figure 6.3 presents the mean BVP change for these first 10 ordinal pulses for each intensity. Inspection of Figure 6.3 indicates that whereas the BVP response pattern for the 60 db tone is biphasic (constriction followed by dilation), response to the 100 db tone involves much more emphatic and extensive BVP constriction, although an initial dilation appears on the first 2 post-stimulus pulses.

To provide some indication of the change in BVP response with stimulus repetition, the BVP data was averaged over successive 2-trial blocks for each intensity of stimulation. Thus for each intensity five
Chart speed = 5.0 mm/sec.

N.B. BVP increases to a characteristic deflection at a particular tone. The numbers denote the response to the 60 db tone. (The numbers denote.)

Figure 6.1: Parahedal BVP and BVP response to the 60 dB tone.
FIGURE 6.2 Forehead BVP and BV response to the 100 db tone. (The numbers denote onset of a particular tone). N.B. BV decrease is characterized by an upward pen deflection. Chart speed = 5.0 mm/sec.
response patterns were obtained: the first representing the mean response to the first two stimulus presentations, the second representing the mean pattern to trials three and four, and so on. Figure 6.4 shows these mean BVP response patterns averaged across successive 2-trial blocks for the 60 db intensity stimulus. Figure 6.5 presents such patterns for 100 db stimulation. Both figures reveal little in the way of BVP habituation with stimulus repetition.

A three factor (repeated measures design) analysis of variance was performed on the forehead BVP data. The results of the analysis are summarized in Table 6.1. Highly significant main effects were obtained for stimulus intensity, and pulses; the latter indicating, as Cohen and Johnson (1971) point out, that forehead BVP is consistently sensitive to stimulation. The only other significant effect was the intensity x pulse interaction, revealing that the 10 post stimulus pulses were not uniformly affected by stimulus intensity. As might be expected from inspection of Figures 6.4 and 6.5, the analysis of variance revealed that stimulus repetition exerted no notable influence on the forehead BVP response to either tone intensity.

6.3.2 Forehead blood volume.

Forehead BV analysis also focussed on the first 10 ordinal beats following stimulus onset. A prestimulus baseline was determined by averaging the deviation from chart centre of the 5 pulses immediately prior to stimulus onset. The deviation of the 10 pulses, immediately following stimulus onset, from chart centre was completed. Each of these values was then expressed as a deviation from the computed prestimulus baseline level. As mentioned previously, upward pen deflections with respect to prestimulus level reflected decreases in BV and downward deflections represented increases in BV. These deflection values for the first 10 ordinal pulses were then averaged across 10 stimulus trials for each intensity of stimulation. These averages were subsequently meaned across Ss and the resultant mean...
FIGURE 6.3 Mean forehead BVP response.

BVP mv.

Ordinal pulse

60db
100db
FIGURE 6.4  Forehead BVP response averaged for successive 2-trial blocks:

60 db stimulation.
FIGURE 6.5 Forehead BVP response averaged for successive 2-trial blocks: 100 db stimulation.
TABLE 6.1
Analysis of Variance of forehead BVP data.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stimulus Intensity</td>
<td>1681.47</td>
<td>1</td>
<td>1681.47</td>
<td>55.97</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Stimulus Repetition</td>
<td>291.01</td>
<td>9</td>
<td>32.33</td>
<td>1.37</td>
<td>ns</td>
</tr>
<tr>
<td>Ordinal Pulse</td>
<td>5600.28</td>
<td>9</td>
<td>623.23</td>
<td>50.14</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Subjects</td>
<td>117.08</td>
<td>9</td>
<td>13.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjects x Intensity</td>
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deflections for the first 10 ordinal pulses are shown in Figure 6.6. Inspection of Figure 6.6 reveals dissimilar responding to the two different tone intensities. Mean response to the 60 db tone appears as a monophasic increase in BV, whereas a monophasic decrease in BV is revealed to the 100 db stimulus.

To provide an indication of stimulus repetition effects, the BV data was treated in a similar way to the BVP data, i.e., BV data was averaged over successive 2-trial blocks. The five such patterns of BV changes for 60 db tone stimulation are shown in Figure 6.7. Inspection of Figure 6.7 shows some change in the extent of BV increase with stimulus repetition, the largest increase in BV occurring in the first two trials. Figure 6.8 shows such BV response patterns for the 100 db tone. The most striking feature of such a representation is the extensive increase in BV level apparent for the first two stimulus presentations. Monophasic decreases in BV level are apparent for subsequent stimulus trials, although these decreases are less apparent for trials 7 and 8.

Statistical analysis of the BV data was similar to that employed for the BVP data. The results of the analysis of variance of the forehead BV data are summarized in Table 6.2. As with BVP, BV analysis also yielded a highly significant main effect of stimulus intensity. However, unlike BVP, BV appeared highly susceptible to stimulus repetition. The significant effects observed for the intensity x repetition and repetition x pulse interactions reveal that this susceptibility of BV to stimulus repetition is intensity dependent and not uniformly apparent over all the 10 post-stimulus pulses employed in the analysis. As with BVP, the effects of stimulus intensity on BV responding were also dependent upon ordinal pulse. The significant secondary interaction observed in the present analysis indicates that within the two intensities of stimulation, stimulus repetition effects are apparent for different pulses. Collapsing the two almost mirror-image monophasic curves
FIGURE 6.6  Mean forehead BV response.

- Increase
- BV mv.
- Decrease

Ordinal pulse

60db
100db
FIGURE 6.7 Forehead BV response averaged for successive 2-trial blocks: 60 db stimulation.
FIGURE 6.8 Forehead SV response averaged for successive 2-trial blocks: 100 db stimulation.
### TABLE 6.2
Analysis of variance of forehead BV data.

<table>
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<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
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<td>Intensity x Repetition</td>
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<td>&lt;.05</td>
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<td>2.05</td>
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<td>729</td>
<td>15.27</td>
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</table>
shown in Figure 6.6 would result in little in the way of overall pulse variation. This would account for the observed lack of main effect of ordinal pulse.

6.4 Discussion.

6.4.1 Forehead blood volume pulse.

The results of the present investigation indicate that forehead BVP is sensitive to changes in intensity. In this the results contrast with the recent findings of Cohen and Johnson (1971), and Raskin, Kotses and Bever (1969b). Cohen and Johnson, employing the same stimulus intensities as the present experiment, observed intensity effects in only two of the twenty stimulus trials. The use of independent-S designs in the Cohen and Johnson and the Raskin et al. studies could account for the lack of observed intensity effects. The advantage of employing a dependent-S design for studies involving physiological measurement, in terms of greater efficacy in estimating treatment effects for a given cost, is discussed in Chapter 2. When between-S variance is large, an independent S design, which includes such variance in its estimation of treatment effects, is likely to provide a lower estimate of treatment effects than a dependent-S design.

The present observation of biphasic BVP responding (constriction followed by dilation) apparent with the presentation of the moderate 60 db tone, is in line with the findings of other workers using moderately intense auditory stimulation (Ford & Ackerland, 1968; Keefe & Johnson, 1970). Constriction followed by pulse dilation was also apparent with the pleasant, interesting and boring visual stimuli employed in earlier experiments (see Chapters 2 and 3). It would appear that the BVP component of the OR is biphasic, and that the monophasic dilatory changes reported by Soviet researchers, result not from the use of a less precise description of the forehead BVP data, as previously suggested, but from
the employment of a different index of forehead vascular change, namely BV level. Cohen and Johnson (1971) also report biphasic BVP changes to their 60 db intensity tone. However, they report responding of a biphasic nature to 100 db stimulation, whereas the present data indicate that BVP responding to an intense auditory stimulus involves almost exclusive constriction over the 10 post stimulus pulses. Raskin et al. (1969b), monitoring 12 post stimulus pulses also failed to observe a secondary dilative BVP phase with intense auditory stimulation (80 db and 120 db). This extensive BVP constriction revealed by the present data is consistent with the similarly persistent constriction observed earlier with the unpleasant homicide pictures (see Chapters 2 and 5) and with the extensive forehead BVP amplitude decreases observed recently by Maltzman, Smith, Kantor and Mandell (1971) in a stressful examination situation. It would appear that whereas the forehead BVP component of the OR is represented by a byphasic response, in which dilation is preceded by a constriction phase, unpleasant, stressful and intense stimulation is accompanied by more extensive BVP constriction.

The present findings reveal forehead BVP to be insensitive to stimulus repetition. Keefe and Johnson (1970) also found no evidence of forehead BVP response habituation. These workers observed no notable differences among the BVP response patterns to the first, second and fourteenth presentation of their moderate auditory stimulus (1000 Hz tone, 40 db above auditory threshold). Raskin et al. (1969b) also found no overall effect of stimulus repetition on forehead BVP. However, when analysis was conducted on maximum change score (obtained by computing the mean constrictive change on post-stimulus beats four and five) Raskin et al. found a significant decrease in maximum change (i.e., less constric-
tion) as a result of stimulus repetition. Similarly Cohen and Johnson (1971) found no overall effect of stimulus repetition. Again, however, when analysis was performed on a maximum change score (this time the
maximum dilatory change) a significant habituation effect was evidenced. Preliminary analysis of the present BVP data, employing maximum dilatory and maximum constriction change scores for response to the 60 db stimulus, revealed no significant change in either maximum score with repetition of the 60 db tone. For the 100 db intensity stimulation, analysis of the maximum constriction change score again yielded no effect of stimulus repetition. However, in the present experiment Ss received only 10 presentations of each stimulus intensity. Cohen and Johnson (1971) and Raskin et al. (1969b) employed 20 and 30 stimulus repetitions respectively. It is possible that with an increased number of stimulus repetitions significant forehead BVP habituation effects would develop.

6.4.2 Forehead blood volume.

The patterns of forehead BV changes observed to the intense and moderate auditory stimuli in the present experiment are in line with the observations of the Soviet researchers (e.g. Vinogradova & Sokolov, 1957; Sokolov, 1963a; Vinogradova, 1965). Monophasic increases in BV were observed to the 60 db tones. Such monophasic increases in forehead BV to moderate stimuli have also been observed by several Western researchers (e.g. Hertzman & Dillon, 1939; Royer, 1965; Raskin, Kotses & Bever, 1969a; Cohen & Johnson, 1971; Cook, personal communication). Prominent exceptions are Hord and Ackerland (1968) who report that sleeping Ss show biphasic forehead BV responding to moderate auditory stimulation. It would appear, that, in waking Ss at least, the forehead BV component of the OR is manifest as a monophasic increase in BV. Controversy has arisen recently, however, over the nature of the forehead BV response to intense stimulation, and whether physiological arousal patterns can be adequately dichotomised into ORs and DRs on the basis of forehead BV measurement. Whereas Soviet research has repeatedly found monophasic decreases in BV to accompany the presentation of intense or unpleasant stimulation, recent attempts to replicate this finding in Western laboratories have often
proved unsuccessful. Raskin et al. (1969a,b) and Cohen and Johnson (1971) report mainly BV increases with intense auditory stimulation. However, Cook (1970, and personal communication), reports results in line with the earlier Soviet observations. The present observation of monophasic decreases in BV with intense auditory stimulation reinforces these recent findings by Cook and the earlier findings of Sokolov and his coworkers. In the present experiment although BV increases were apparent on the first one or two presentations of the 100 db tone, this pattern was quickly superceded by one of monophasic BV decrease with repeated stimulus presentation. This transition from BV increase to decrease with intense stimulation is well documented by Sokolov (1963a).

"Where the intensity of the stimulus is high, but not high enough to produce an immediate defense reaction, a complicated combination of orientation and defense reactions develops. The initial reaction shows the features of the orientation reflex. With repetition of the stimulus, this is displaced by the defense reaction, and the stimulus, which initially produced cephalic vasodilation and hand vasoconstriction now gives rise to vasoconstriction at both sites". (Sokolov, 1963a, p. 46).

What does one make of these patently contradictory observations on the nature of the BV response to intense stimulation, Two features which seem to distinguish those studies observing differential decreases in BV to intense stimuli from those finding increases in BV are 1. phototransducer placement and 2. experimental design. The present study, and those of Cook (1970 and personal communication) employed temporal placements similar to that used by the Soviet researchers (cf. Vinogradova, 1965 and Chapter 2 of the present thesis). Cohen and Johnson's (1971) transducer was located on the centre of the forehead. Cook (personal communication) reports "regular" behaviour only at the temporal site. Although Raskin et al. (1969a) are not explicit concerning transducer placement, Raskin et al. (1969b) indicate that the transducer "was attached to the surface of the forehead above the left
eyebrow\". Such a position would approximate to that used in the present study. Secondly the Cohen and Johnson and both Raskin et al. studies employed independent-S designs. The present experiment and those of Cook used a dependent-S design. The Soviet workers also reveal a preference for repeated measures designs (cf. Cole & Maltzman, 1968). However, although an independent-S design, employing between S variance in its estimation of treatment effects, is likely, when between S variance is high, to underestimate treatment effects, it is unlikely to affect the absolute response direction i.e. the observation of BV increase to intense auditory stimulation is unlikely to result from the choice of design.

The present observation of stimulus repetition effects on forehead BV responding is paralleled by the similar findings of Raskin et al. (1969a,b). These workers noted that this overall change in BV responding with repeated stimulation resulted mainly from smaller increases in BV being apparent with later stimulations. Cohen and Johnson (1971) report a similar attenuation of BV increase with repeated stimulation. The present results, although revealing this sort of trend for BV response to the 60 db intensity stimulation, indicate that the effect of stimulus repetition on response to intense stimulation results from the transition from monophasic BV increases for the first two stimulus presentations to decreases in BV with later stimulations.

6.4.3 Comparison of BVP and BV response measures.

Several differences in the nature and form of the two indices of cutaneous forehead circulatory changes emerge from the present data. Firstly, whereas the BVP response to the 60 db tone is biphasic, changes in BV with such stimulation are monophasic. This discrepancy immediately points to the independence of the two components of photoplethysmographic measurement. If, as is postulated, the BVP reflects changes in arteriolar tone, while BV level reflects primarily the content of the capillary and
venous bed (e.g., Hertzman & Dillon, 1940), such independence would not appear surprising, since as Abramson (1967) points out, the diameters of veins may change independently from changes in arteriolar resistance. The independence of BV and BVP is nowhere demonstrated more dramatically than in the first two presentations of the 100 db tone. Figure 6.2(a) shows extensive BVP constriction associated with marked BV increase.

The independence or specificity of cardiovascular response measures is aptly demonstrated by recent work showing that two closely associated cardiovascular measures; systolic blood pressure (BP) and heart rate (HR), can act independently. Shapiro, Tursky, Gershon and Stern (1969), Shapiro, Tursky and Schwartz (1970a), and Brener and Kleinman (1970) have shown that providing Ss with feedback and reward for increases or decreases in systolic BP leads to learned control of BP without corresponding changes in HR. Further, Shapiro, Tursky and Schwartz (1970b) have demonstrated the corollary of this, i.e. that Ss can similarly learn to control HR without similarly changing BP. Recently, Schwartz (1972) has shown that individuals can learn to integrate these two learned controls i.e., increase or decrease HR and BP jointly or simultaneously lower one and raise the other. A further notable difference between BV and BVP aspects of the forehead vascular reaction is that whereas the BVP response to the moderate 60 db tone appears resistant to habituation, BV changes are highly susceptible to stimulus repetition. However, several researchers have reported that OR habituation, as measured in different physiological systems, does not proceed at the same rate (e.g., Johnson & Lubin, 1967; Stern & Plapp, 1969).

6.4.4 Blood volume, blood volume pulse and sensitivity regulation.

Several difficulties emerge from the present discussion for Sokolov's (1963a) major proposition that forehead vascular changes, via their correspondence with cerebral vascular changes, reflect alterations in perceptual sensitivity. Firstly if one considers the BVP, supposedly
signifying arteriolar tone, as the most likely reflection of changes in cerebral flow, difficulties arise over the biphasic nature of its manifestation to pleasant, interesting or just moderately intense stimulation. This preliminary constriction phase should reflect a parallel cerebral constriction and an initial sensitivity attenuation. Such attenuation contrasts sharply with the view of the OR functioning to facilitate stimulus reception (e.g. Sokolov, 1960, 1963a,b). Further, the general discrepancies in the observed BV response to intense stimulation, belies the postulated role of forehead BV responses and associated cerebral circulatory changes in the attenuation of sensitivity to intense stimulation. Consequently the penultimate chapter of the present thesis reviews the evidence relating stimulus intensity, perceptual sensitivity and the concepts of ORs and DRs, and reports an investigation undertaken to examine the relationship between stimulus intensity, forehead vaso-motor changes and perceptual sensitivity.
CHAPTER 7
ORIENTING AND DEFENCE REACTIONS: THEIR ROLE IN SENSITIVITY REGULATION AND PERFORMANCE.

7.1 Introduction.

The aim of the final experiment to be reported in this thesis was to examine the role of the OR and DR in performance and to thus derive information critical to Sokolov's (1960, 1963a) assertions concerning the impact of these responses on perceptual sensitivity. Consequently it was essential to comprehensively review the existing evidence for such a formulation.

7.1.1 The role of ORs and DRs in stimulus reception.

In support of the contention that the OR produces heightened sensitivity to environmental stimulation, Sokolov (1963a) described several experiments in which an OR elicited by an auditory stimulus produced an increase in the sensitivity to visual stimuli. Sokolov initially made visual threshold determinations by recording both self-report and physiological indices of response to the visual stimuli (in these studies predominantly occipital EEG and SCR were employed as physiological response indices). After a particular light intensity was determined to be subliminal, a 73 db tone was presented. This tone, as expected, evoked an OR as indicated by a SCR and EEG alpha blocking. In the presence of the OR § responded to the previously subliminal light stimulus as indicated by both behavioural and physiological indices. Thus the interpolation of an auditory stimulus which elicits an OR results in a subliminal visual stimulus becoming liminal. Further evidence of the intimate connection between such sensitivity changes and the physiological components of the OR is offered by Sokolov's (1963a) observations on the temporal parallel between the reduction of visual sensitivity and OR persistence. As the auditory stimulus was repeated the physiological components of the OR
habituated. OR extinction to the tone was paralleled by a rise in visual threshold such that the same test light intensity no longer evoked a response. However, if the auditory stimulus now acquired signal value or significance by, for example, association with a motor response such as fist clenching, the OR response (as indicated again by a SCR and EEG alpha blocking) reappeared. The acquisition of signal significance by the extraneous auditory stimulus also produced a marked rise in visual sensitivity, and the $S$ once more manifested a response to what had been a subliminal light intensity. According to Sokolov the rise in visual sensitivity resulting from the introduction of an extraneous signal stimulus is more marked than that to a non-signal stimulus.

Many other researchers in different contexts have reported that the receptiveness of one sense modality can be influenced by the accompanying stimulation of another modality. For example, Hartmann (1933) found that the interpolation of a moderate auditory, olfactory, and cutaneous stimulation increased vernier visual sensitivity. Symons (1963) increased the range of interpolated stimuli, observing that concomitant olfactory, gustatory, thermal and proprioceptive stimulation produced significant increases in visual sensitivity. Gregg and Brogden (1952) provide evidence that these facilitatory sensitivity effects are not confined to the visual modality. They found that a low intensity visual stimulus increased auditory sensitivity.

Although not reporting specific experimental details Sokolov (1963a) indicates that the employment of an intense auditory stimulus (90 - 105 db), likely to elicit a DR instead of an OR, results in a fall in sensitivity replacing the increase. Sokolov cites the findings of Steklova (1957).

"It was observed that a loud sound, which at first resulted in a rise of light sensitivity, with repetition started to give rise to its decrease". (Sokolov, 1963a, p. 104).
The recent findings of Siddle and Mangan (1971) confirm the differential influence of high and low intensity stimulation on perceptual sensitivity. These workers found that high intensity visual stimulation (120 ft. candles) tended to decrease auditory sensitivity while low intensity visual stimulation (12 ft. candles) increased auditory stimulation. The paradigm was essentially similar to that described by Sokolov. Auditory threshold determinations were made prior to and after the onset (3 - 5 secs.) of the visual stimuli. Whereas 5 Ss in the high intensity group showed improved sensitivity and 10 showed decreased sensitivity, in the low intensity group 12 Ss showed increased sensitivity while only 3 evidenced sensitivity decrements. Further, in the low intensity group sensitivity increase was maximal when the SCR evoked by the visual stimulus was large, i.e. sensitivity increment was directly related to SCR amplitude. However, in the high intensity group the reverse result was true i.e. sensitivity decrement was directly related to SCR amplitude. These results firmly associate the OR with sensitivity increment and the DR with sensitivity decrement. Such an interpretation derived from the SCR data demands a preliminary assumption that the SCR appears as a component of both the OR and DR (evidence for this is cited in Chapter 1), and that the SCR associated with the DR is of greater amplitude and persistence than that associated with the OR. It would thus seem reasonable that larger SCRs exhibited to the intense stimulation imply more in the way of DRs, while larger SCRs exhibited to the low intensity visual stimulation imply more emphatic ORs: hence the differential relationship between SCR amplitude and sensitivity change observed for the two intensities of visual stimulation. Comparison between the amplitude of SCRs elicited by the two intensities of interpolated stimulus yielded a significant difference, the high intensity stimulation evoking the greater responses.
7.1.2 The role of ORs and DRs in learning and performance.

According to Sokolov (1960, 1963a) the heightened sensitivity associated with the OR leads in turn to increased information intake and the facilitation of learning and performance. For example, the elicitation of ORs by stimuli facilitates their conditioning. Maltzman and Raskin (1965) described a series of experiments in which Ss with relatively large ORs, compared with those exhibiting small ORs, showed superior performance on several learning tasks. Ss showing high ORs (SCR component of the response was monitored) to the first UCS, a 1 sec. burst of white noise, evidenced significantly more extensive semantic conditioning of SCR than Ss exhibiting low initial ORs. The high OR Ss also showed more in the way of awareness of the experimental contingencies. However, Morgenson and Martin (1968) argue that since this study employed SCR as the measure of both OR amplitude and CR amplitude their results, rather than providing evidence for the role of the OR in conditioning, provide evidence mainly of within-system responsiveness i.e., it is possible that Ss, who manifest large SCRs initially, continue to do so throughout the course of the experiment. Morgenson and Martin point out that it is essential to have different measures of the OR and learning in order to assess the influence of one on the other. Consequently they employed 3 measures of OR amplitude and subsequent autonomic conditioning (SCR, finger pulse volume, and pulse rate). Again a semantic conditioning paradigm was employed. UCS was an aversive 106 db, 1000 Hz tone of 1 sec. duration. Highly significant correlations between OR and CR amplitude were observed within but not across physiological response systems, "suggesting that CR amplitude might be regarded as an augmentation of initial response amplitude differences". However, Maltzman and Mandell (1968), replying to these findings of Morgenson and Martin, report results relating OR magnitude to performance measured in entirely different response systems. Maltzman and Mandell report that SCR and SCL predict
the course of subsequent conditioned EEG alpha blocking and vice versa. SCR/SCL and the amount of alpha blocking induced by the first word in a 24 word habituation list were taken as the two measures of individual differences in OR magnitude. A key word interspersed among uncorrelated words was the CS. UCS was a burst of 110 db white noise. Recently Zeiner and Schell (1971) point out that much of the discrepancy between the outcome of such studies might arise from the particular stimulus used to assess initial OR amplitude i.e. whether high and low orienters were assessed on the basis of response to the innocuous CS (usually a word) or the usually noxious UCS (intense noise or tone). These workers argue that assessment on the basis of response to the noxious UCS is more likely to differentiate groups differing in DR magnitude than OR magnitude, and it is unlikely that a positive relationship exists between DR magnitude and conditioning performance. A negative relationship would be expected. They suggest that only innocuous stimulus (CS) assessment should provide a positive correlation between initial response magnitude and conditionability. Their results bear out these predictions. Only assessment based on response to the innocuous stimuli was found to give rise to a reliable, positive relationship between OR amplitude and subsequent conditioning performance. It is unfortunate for the possible generality of their results, that Zeiner and Schell employed only within-response system measurement. SCR was employed to discriminate high and low orienters and to estimate the extent of conditioning. However, the previously cited study of Maltzman and Mandell (1968), in which initial response assessment was made with an innocuous stimulus, did employ an intermodal response paradigm. As cited, differences in one response system predicted later conditioning in another system.

Maltzman and Raskin (1965) also present evidence that high OR Ss show superior paired associate learning than low OR Ss. Ss were classified as high and low orienters on the basis of the magnitude of the
SCR component of the OR manifest to the first word heard in a semantic conditioning experiment conducted 5 days earlier. Two lists of paired associates were used: a difficult list with high-response competition and an easy list with low-response competition. A sex-OR interaction complicated the findings. However, on the difficult list high OR men were reliably superior to low OR men in terms of response speed and trials to reach criterion. Repeating this experiment, using only male Ss, Nies (1964) found that the high OR group was superior to the low OR group in all phases of performance on both lists.

7.1.3 Stimulus intensity and performance.

Most of the studies described so far have employed the measurement of some physiological parameter or other. However, indirect evidence concerning the impact of ORs and DRs on performance can be obtained from studies which, although not employing physiological response descriptors, have explored the effects of moderate and intense stimulation on performance.

Research in which behavioural efficiency has been examined in terms of the impact of intense stimulation is voluminous. The discussion that follows will focus on a very small part of that research: mainly that in which intermittent auditory stimulation has been employed. Auditory stimulation seems the most favoured experimentally. Further, since the physiological processes being dealt with in the present thesis have been investigated as phasic short-term changes, information derived from experimental paradigms employing prolonged, continuous auditory stimulation presents interpretative difficulties.

Woodhead (1964a) presents evidence that bursts of intense noise during information intake impair subsequent performance on an arithmetic task. The task involved the subtraction of a 4 digit number from a 6 digit number. Ss were given 10 secs. to encode a 6 digit
number projected on a screen. A 4 digit number was then exposed and remained visible until S had indicated the completion of the problem. Four groups of Ss were employed. For the first noise group a 1 sec. burst of 100 db noise (rocket firing) was presented 4 sec. after the first number appeared on the screen i.e. during the encoding or memorizing period. For Ss in the other noise condition, the burst of noise began 5 sec. after the display had changed i.e. while the answer was being calculated. Two relevant no noise control groups were run. Every S of the first control group was paired with an S in the first noise group in terms of problem order. Ss within the other noise and control group were similarly matched. Forty different subtraction problems were given on each of the 3 successive days of testing. Data analysis focussed on the third day because "by the third day, it was believed that the noise would not attract attention simply on account of its unfamiliarity". The results showed that "if the burst of noise occurred while S was attempting to memorize the six-digit number visible for a limited period, his subsequent calculation was more likely to be wrong". Bursts of noise during the actual calculation period did not affect the variability of Ss' calculating time or calculation accuracy. This result, strongly suggesting that performance impairment through intense auditory stimulation occurs because of the attenuation of stimulus or information intake capabilities, is consistent with the Soviet conception of a DR operating to decrease perceptual sensitivity and stimulus intake.

A parallel experiment by Woodhead (1964b) confirmed these results. The task in this experiment required Ss to search successive displays of 10 random digits. Each row of digits was displayed for 2 sec. and in all 4500 digits were displayed. One hundred and eighty-one of the digits were encircled in black ink. S was instructed that when he saw a ringed digit he should look for the same number without a ring
among the following displays and cross it out on each appearance. On the appearance of another ringed number S was to forget the previous one and begin crossing out examples of this new ringed number. The auditory stimuli were 1 sec. bursts of rocket fire as before. Three groups of Ss were exposed to the task. For the first group noise intensity was 110 db, in the second group 70 db, and the third group was a no noise control. Each of the two noise conditions were presented with the appropriate intensity of stimulation 4 times during practice and 5 times during the test; in the second, fifth, seventh, eleventh and fourteenth minutes. The practice presentations were employed to overcome the effects of unfamiliarity. The effects of noise were examined for the 30 sec. following the 1 sec. noise burst and at the corresponding times in the no noise control condition. The results revealed that more errors were made following bursts of 110 db noise than at the same times in the no noise condition. Difference between errors made for the 110 db and 70 db stimulation conditions approached significance. Differences between the 70 db and the no noise condition were not significant although Woodhead remarked that the overall results "revealed a tendency for fewer answers to be omitted in 70 db than in Q (no noise)". This difference seemed to be particularly located in the critical periods of test performance i.e. 30 sec. after the noise presentation. It is doubtful whether predicted OR and DR influence operates over the full 30 sec. post stimulus critical period, and it is a pity that Woodhead does not report the influence of noise on shorter latency performance. However, the results are encouraging particularly with respect to predicted DR influence. The role of the DR in attenuating perceptual sensitivity can again be readily invoked to explain the effects of the intense noise, especially since the type of error noted by Woodhead to be susceptible to loud noise was failure to perceive or properly encode a particular circle. The slight tendency for the moderate 70 db noise to reduce omission errors,
offers some support to the notion that such stimuli elicit ORs which increase perceptual sensitivity.

While these experiments by Woodhead strongly implicate the DR in the attenuation of perceptual sensitivity, they contribute little to the case for association between the OR and heightened sensitivity and subsequent performance facilitation. Complementary evidence for the OR is provided by a study conducted by McGrath (1963). The task used in this study demanded the detection of slight increments in the brightness of an intermittent light (on for 1 sec., off for 2 sec.). Such increments occurred at random intervals at an average of 24 per hour. On 4 of the 8 experimental sessions 72 db white noise was presented during task performance. On the other 4 sessions, a wide variety of auditory stimuli (instrumental and vocal music, portions of television dialogue, traffic sounds, "random thumpings" and so on) replaced the continuous noise. Modal intensity of these various stimuli was 72 db. A different programme of this sort was presented on each of these 4 sessions. Significantly more brightness decrements were detected under the variety-auditory stimulation than under the white noise condition. Since the OR is primarily a response to stimulus change more frequent and larger ORs would be expected in the variety-stimulation condition than the continuous noise condition. OR habituation to the latter would be relatively rapid. Further, Berlyne (1966) also describes the OR as a response to stimulus complexity. More complex stimulus arrays elicit larger and more persistent ORs. The results of this experiment can be interpreted as indicating that an extraneous stimulus array which is likely to elicit large and persistent ORs, facilitates performance on a central task more than extraneous stimulation which is highly likely to result in rapid OR extinction. Additional support for this interpretation arises from McGrath's findings that this differential effect on performance appeared during the later periods of the experimental
sessions. McGrath repeated this experiment using an auditory or acoustic detection task. A "no distraction" condition was compared with a variety-visual stimulation condition (S was presented with various sorts of interesting photographs). More signals were again detected in the variety stimulation condition.

7.1.4 ORs and DRs and performance on a simple reaction time task.

The last two sections have, for the most part, dealt with tasks of some complexity involving a multitude of factors likely to be influential in their execution efficiency other than fluctuations in information intake. The observation of simple reaction time (RT) performance or efficiency presents an obvious and flexible paradigm with which to evaluate the role of ORs and DRs in the regulation of perceptual sensitivity. A large portion of the variance in RT performance associated with stimulus manipulations undoubtedly reflects changes in the stimulus intake and processing side of the phenomenon (cf. Woodworth and Schlosberg, 1954).

Several well established parameters influencing RT performance can be accounted for parsimoniously by invoking physiological ORs and DRs.

Psychologists have known for a long time that a warning signal prior to the RT stimulus reduces RT (cf. Woodworth and Schlosberg, 1954). According to Sokolov (1963a) signal stimuli evoke large and persistent ORs. It is probable that such large and persistent ORs and the increment in stimulus sensitivity are intimately involved in this RT facilitation. Empirical support for such an inference is offered by the findings of Lansing, Schwartz and Lindsley (1959), who explored the relationship between occipital EEG changes to an alerting or warning signal and subsequent RT performance. Two conditions were employed. In one, Ss received a warning buzz shortly before the RT visual stimulus (foreperiod varied from 50 to 1000 msec.) while in the other, control,
condition no warning signal was presented. RTs in the former condition were significantly faster than those in the latter condition. This was particularly so for the longer foreperiod. Trials in the control condition were trichotomised in terms of the extent of alpha rhythm present immediately preceding RT stimulus onset: good alpha, poor alpha and no alpha trials. There were no significant differences in RT between these subconditions. However, results for the warning signal condition indicated that as alpha blockade becomes effective RTs were progressively reduced. Sokolov (1963a) considered a progression toward desynchronisation, including alpha blockade as the EEG component of the OR. The results of this experiment would strongly implicate the OR in the facilitation of RT performance observed with the introduction of a warning signal. A similar relationship between RT performance and alpha blockade was noted by Fedio, Mirsky, Smith and Parry (1961). Hermelin and Venables (1964), on the other hand, found no evidence that RT is faster when the RT stimulus falls into a period of alpha blocking than when it does not. However, whereas the Lansing et al. (1959) and Fedio et al. (1961) studies employed auditory forewarning signals, the Hermelin and Venables study used a visual warning. Hermelin and Venables cite evidence that such modality differences may account for this discrepancy in results. While visual stimuli may selectively block alpha in the parieto-occipital area, acoustic stimuli are more likely to produce desynchronisation in the auditory projection area. Further, while visual stimulation seems more effective in producing alpha blocking, it is suggested that auditory stimulation is more behaviourally and physiologically arousing. However, a more parsimonious explanation of the discrepancy between the studies, cited above, arises from the very intense warning signal employed by Hermelin and Venables (1000 ft. lamberts)
1076 millilamberts = 95 db above threshold). The employment of such an intense warning stimulus coupled with a highly irregular foreperiod, such that the stimulus has remarkably reduced signal significance (Hermelin and Venables varied six foreperiods randomly across 36 trials: 5, 1, 2, 4, 6 and 8 sec.), is more likely to elicit a DR than an OR (Sokolov, 1963a). A positive relationship of the sort observed by Lansing et al. (1959) would not be expected. Further evidence of the relationship between cortical electrical activity and RT performance is provided by a study conducted by McAdam, Knott and Rebert (1969) which monitored the cortical slow potential changes first observed by Walter and his associates (e.g. Walter, 1964; Walter, Cooper, Aldridge, McCallum & Winter, 1964). This phenomenon, dubbed Contingent Negative Variation (CNV), was discovered by Walter in the course of a study of responses evoked in non-specific brain areas (usually frontal areas) when two stimuli were regularly presented in association. Analyzing EEG activity using an electronic averaging device, he attempted to determine what effects the occurrence of the second stimulus had on the response evoked by the first. It was discovered that the prolonged, slow, surface negative portion of an evoked potential (CNV) habituated or extinguished relatively quickly if a single stimulus was repeated or if two non-meaningful stimuli were presented repeatedly in association. However, if the second of a stimulus pair was then made a signal for a behavioural response, this slow potential CNV re-appeared, developed amplitude, and proved extremely resistant to extinction. This slow potential CNV would appear to parallel in persistence peripheral physiological components of the OR, such as SCR, when elicited by stimuli signalling a later behavioural response. McAdam et al. (1969) presented

1. The reader is referred to S. Howard Bartley, The psychophysiology of vision, in S. S. Stevens (Ed.), Handbook of experimental psychology, (1951), Page 945.
Ss with pairs of clicks with instructions to press a key after the second click. RTs were monitored and inter-click interval was varied. CNV amplitude was found to vary with inter-click interval in the same fashion as RT speed, such that CNVs were lower and RTs longer as the interval increased.

The observation of changes in other physiological systems during the RT foreperiod seems to implicate the OR in RT improvement. The occurrence of cardiac deceleration following a preparatory warning signal is reasonably well established (e.g., Coquery & Lacey, 1966; Lacey & Lacey, 1966; Obrist, Webb & Sutterer, 1969). These studies have all found a consistent deceleration during RT foreperiod and this deceleration has been found to correlate at a moderate level with RT performance (Obrist, Webb & Sutterer, 1969). Since cardiac deceleration is regarded as a component of the OR (Lynn, 1966; Graham & Clifton, 1966), these results are consistent with the view that the OR is implicated in RT performance facilitation via a warning signal.

Many other studies strongly support the involvement of the physiological components of the OR in RT performance. For example, Andreassi (1966) measured simple RT to aperiodic 70 db tones. No warning signal was used in this experiment. SCL, regarded by Sokolov (1963a) as reflecting tonic orientation or a tonic OR, was monitored continuously. For each S RT trials were subdivided according to SCL. The fastest RTs were observed on those trials in which SCL was highest. In a more recent experiment Andreassi, Rapisardi and Whalen (1969) recorded RTs to signals which occurred at either fixed or variable intervals. The decreased RTs found in the fixed interval condition were associated with high SCLs and a greater number of SCRs.

Sokolov (1963a) also provided evidence that intense stimulation, which was normally associated with a DR, would, having acquired signal significance, evoke physiological responses indicative of a stable OR.
One would thus expect intense auditory warning stimuli, at least those associated with reasonably regular foreperiods, to elicit ORs and thus be associated with faster RTs. Goranson and Meyers (1969) reported that the effect of an intense auditory warning stimulus (90 db) was to facilitate RT performance, in fact more so than lower intensity warning signals. These workers employed a fixed foreperiod of 4 sec.

The association of the OR in RT facilitation with the introduction of a warning signal is strengthened by consideration of foreperiod variations affecting the RT facilitation effect. Firstly, this facilitatory effect appears limited to certain foreperiods. A consensus of findings would tend to limit the effect to about 8 sec. after warning stimulus onset (cf. Woodworth & Schlosberg, 1954). The temporal limit also permits maximal orienting as revealed by most physiological indices. Further, Klemmer (1956) has shown that the reduction of RT due to the warning signal is influenced by the variability of the foreperiod. Varying this preparatory interval between a warning click and the RT light stimulus, Klemmer found that the facilitation effect decreased with increased variability of foreperiod. It is probable that in such situations the warning stimulus by virtue of its reduced signal significance elicits smaller amplitude ORs. Smaller ORs should reflect less in the way of heightened sensitivity and thus performance would be facilitated to a lesser degree. Although, with highly irregular and variable foreperiod intervals, moderately intense or weak warning stimuli have been found to decrease RT to some extent (e.g. Lansing, Schwartz and Lindsley, 1959; John, 1964), evidence exists that intense stimuli in such situations are associated with slow RTs. Kohfeld (1969) measured RTs to 30, 60 and 90 db tones, presented in random order. The RT stimulus was preceded by a 0.5 sec. duration ready signal also of either 30, 60 or 90 db intensity. Foreperiod was varied randomly (either 1, 2 or 3 sec.). Kohfeld reports the common finding (cf. Murray, 1970) that
RT underwent a steady decrease with RT stimulus intensity. However, the opposite relationship between intensity and RT was observed with variations in ready signal intensity. In a consecutive experiment Kohfeld employed the same 3 intensities of auditory RT stimulus. However, a light stimulus was employed as the ready signal. The light stimulus was scaled (Stevens, Mack & Stevens, 1960) such that the 3 intensities employed corresponded in subjective magnitude to the 90, 60 and 30 db tones used previously. Foreperiod was varied as before. RTs were again longest for the high intensity ready signal. This relationship is opposite to that noted by Goranson and Meyers (1969) with a fixed foreperiod and can be explained by assuming the occurrence of the DR to an intense stimulus with reduced signal significance.

To summarize then, the results of the RT experiments cited above indicate that, irrespective of its intensity, a warning signal followed by a fixed or reasonably regular foreperiod will result in faster RTs. When warning stimuli vary markedly with regard to their temporal associations with the RT stimulus, low or moderate intensity stimulation tends to facilitate RT performance, while intense warning stimuli result in longer RTs. This synopsis is distilled from the results of experiments employing drastically different procedures and must at this stage be treated with caution. Such findings, however, can be neatly handled by Sokolov’s formulation of OR and DR operation and their proposed impact on sensitivity.

The experiment about to be described examines the influence of ORs and DRs on simple RT performance in an attempt to provide a critical test of their roles in the regulation of perceptual sensitivity ascribed to them by Sokolov.

It was predicted that the presence of an ongoing OR, as indicated by forehead BV increase and a biphasic forehead BVP response, would facilitate RT performance. While the presence of a DR, as revealed
by forehead BV decrease and a more extensive BVP constriction response, would be associated with slower RTs. The following, more specific hypotheses were formulated:

1. It was predicted that auditory warning signals bearing an invariant temporal relationship with a visual RT stimulus would elicit ORs, as indicated by the previously described forehead vasomotor response patterns, and the subsequent effect on RT performance would be facilitatory. Since such warning stimuli have a high signal significance this effect would be directionally unaffected by warning stimulus intensity.

2. When the presentation of an extraneous auditory warning stimuli is such that it bears no systematic temporal relationship to a visual RT stimulus, high intensity (100 db) and low intensity (60 db) auditory stimuli of this sort would be expected to exert different effects on forehead vasomotor behaviour and RT performance. Only the behaviour for particular instances of warning, or rather extraneous, stimulus temporal variation, when the auditory stimulus preceded the RT stimulus within the span of OR and DR influence (say, less than 8 sec.), would be expected to reveal such differential effects. For these critical instances it was predicted that moderate intensity stimulation would elicit ORs with associated quicker RTs, while the presentation of intense stimulation would evoke forehead vasomotor responses more in line with the DR and subsequent RT performance would be impaired.
7.2 Method.

7.2.1 Subjects.

Ss were 30 (16 male and 14 female) undergraduates enrolled in an introductory psychology course at the Australian National University. They were paid A$2 for their participation in the experiment which lasted approximately 1½ hours. All Ss were, as far as could be determined by preliminary questioning, right-handed.

7.2.2 Design.

Ss were randomly assigned to one of two conditions, with the proviso that each condition must be balanced in terms of the number of male and female Ss assigned to it. Simple RT responses were recorded to a 1 sec. duration light stimulus of moderate intensity. Each S received 60 RT trials. Three inter-trial intervals were used (20, 30 and 40 sec.). These were varied randomly with a mean interval of 30 sec.

In one condition, the signal condition, 1000 Hz warning tones (1 sec. duration) preceded the light stimulus in two thirds of the trials, while in the remaining 20 control trials no warning signal was given. A fixed foreperiod of 5 sec. occurred between warning signal onset and RT stimulus onset. Warning signal intensity was either 60 or 100 db (60 db in 20 trials, 100 db in 20 trials). The appearance of trials with and without warning signals was also randomly varied. The distribution of trials is shown in Figure 7.1. The numbers shown in the figure represent RT trial intervals; the letters signify tone intensity. Nine trials were chosen as key or critical trials. Three of these trials (8th, 30th and 47th) contained 60 db warning signals, 3 contained 100 db signals (15th, 37th and 40th) and 3 control trials contained no warning tone (10th, 26th and 45th). These key trials are indicated in Figure 7.1 by encircled letters. For each intensity of warning signal, one of the critical trials occurred in a 20 sec. inter-trial interval trial, one in a 30 sec. trial and one in a 40 sec. trial. A similar sample was taken
FIGURE 7.1
Stimulus presentation schedule.

Signal Condition

20  40  30  30  40  20  40  30  20  30  40  40  20  30  20  30  40
B  C  B  A  B  C  C  (B)  C  (A)  B  C  B  A  (C)  A  A

20  20  40  30  20  30  40  30  20  30  40  20  40  40  30  20  30
C  A  B  C  A  A  A  C  (A)  C  C  B  (B)  A  B  C  A

20  20  40  30  40  30  20  30  30  40  40  20  20  30  20  40  20
A  B  (C)  B  C  (C)  C  A  B  B  (A)  A  (B)  C  A  B  B

30  40  40  20  30  20  40  30  40
A  C  B  A  C  B  B  B  A

Key

Critical Trials
0 tone (A)
60 tone (B)
100 tone (C)

Other Trials
A = 0 tone
B = 60 tone (5 secs. before light)
C = 100 tone (5 secs. before light)
for the no warning signal trials.

In the other condition, the non-signal condition, the same number of 60 db and 100 db tones were presented along with the RT stimuli. However, in the non-signal condition the tones bore no consistent temporal relationship with the RT stimulus. The temporal sequence of tones and lights for this condition is shown in Figure 7.2. This second schedule is more difficult to follow and some clarification is desirable. The numbers 20, 30 and 40 again represent RT trial intervals (in secs.). The letters A, B, C again signify tone intensity (A signifying no tone). The Roman numerals suffixing these letters indicate the temporal occurrence of the tones within the particular RT interval. For example, a 40 sec. RT interval with a 60 db tone occurring after a quarter (i.e. 10 sec.) of the interval has elapsed is represented by the notation 40 BI, where 40 indicates a 40 sec. interval, B the occurrence of a 60 db tone, and I its occurrence after a quarter of the interval has elapsed. The letter D in Figure 7.2 signifies the occurrence of 2 tones within the RT interval. The Roman numeral in this case indicates the intensity and intensity order of these tones. For example DII indicates the occurrence of 2 tones, the first being 100 db and the second being 60 db. The Arabic numeral notation suffixing D signifies the temporal location of the 2 tones within the RT interval. For example, 30 DII signifies a 30 sec. trial interval in which 2 tones were presented, the first being 100 db and second being 60 db as indicated by II; the Arabic numeral I reveals that the first tone (60 db) occurred after a quarter of the 30 sec. interval had elapsed (i.e. after 7.5 sec.), while the second tone (100 db) occurred after a half of the interval had elapsed (i.e. after 15 sec.). Pilot investigations indicated that with this presentation schedule Ss did not experience any temporal association between tone and light and did not regard or employ the tones as warning signals for the light. However, in 3 critical
**FIGURE 7.2**

Stimulus presentations schedule.

<table>
<thead>
<tr>
<th>Non-signal condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 40 30 30 40 20 40 30 20 30 40 40 20 30 20 30</td>
</tr>
<tr>
<td>B1 CI A A A CI A (B) A (A) CIII DII2 A DIV2 (C) CII</td>
</tr>
<tr>
<td>40 20 20 40 20 20 40 30 20 30 40 40 20 30 40 20 40 20 30 40</td>
</tr>
<tr>
<td>A DIV1 CIII BIV A A A A BI (A) BIII BII A (B) A A</td>
</tr>
<tr>
<td>20 30 20 20 40 20 30 20 30 40 40 40 20 20 30 20 20 30</td>
</tr>
<tr>
<td>A DII3 A DI3 (C) A CIV (C) A DII1 BIV DIII3 (A) A (B) A</td>
</tr>
<tr>
<td>20 40 20 30 40 20 30 20 40 30 40 20 30 30 30 40 40 20 30 40 40</td>
</tr>
<tr>
<td>DIII1 A BII A DII2 A BIII CIV A CII A A</td>
</tr>
</tbody>
</table>

**Key**

- **Critical Trials**
  - 0 dB tone (A)
  - 60 dB tone (B)
  - 100 dB tone (C)

- **Other Trials**
  - A = 0 tone
  - BI = 60 dB after $\frac{1}{2}$ of RT trial interval has elapsed
  - BII = 60 dB after $\frac{1}{2}$ of RT trial interval has elapsed
  - BIII = 60 dB simultaneously with light (at end of interval)
  - BIV = 60 dB after $\frac{3}{4}$ of RT trial interval has elapsed

- **Notations**
  - DI = 60 dB tone followed by 100 dB tone
  - DII = 100 dB tone followed by 60
  - DIII = 100 dB tone followed by 100
  - DIV = 60 dB tone followed by 60

- **Notations**
  - 1 = first tone after $\frac{1}{2}$ of interval, second after $\frac{3}{4}$ of interval has elapsed
  - 2 = first tone after $\frac{1}{2}$ of interval, second after $\frac{3}{4}$ of interval has elapsed
  - 3 = first tone after $\frac{3}{4}$ of interval, second after $\frac{3}{4}$ of interval has elapsed
trials for the 60 db tone and 3 for the 100 db tone, the tone appeared 5 sec. before the light. These critical trials were exactly the same as those in the signal condition (i.e. the 8th, 30th and 47th for the 60 db tone; 15th, 37th and 40th for the 100 db tone). Three trials (10th, 26th and 45th) in which no tone occurred were again regarded as control trials. These non-signal critical trials were also identical to the corresponding signal condition critical trials with respect to inter-trial interval. Inspection of Figure 7.2 reveals the critical trials as encircled letters.

RT and forehead BV and BVP were monitored throughout stimulus presentation, but attention was focussed on these critical trials in both conditions.

7.2.3 Apparatus and dependent variable measurement.

The RT stimulus was a single light source of moderate intensity and comprised a mounted 24V General Electric miniature lamp which was located approximately 90 cm. from S at eye level (for the sedentary observer). A standard telegraph key clamped to the right arm of S's chair was used as the manipulandum. The tones were generated, amplified, presented and their intensity calibrated as described in the previous chapter. Stimulus presentation was controlled automatically by punched paper tape, tape reader and the electronic equipment described earlier (Chapter 6). An output from the control apparatus was fed into a Grass event marker to produce a characteristic mark for the light and each of the two tone intensities. In the previous experiments reported in the present thesis only a standard single event mark was employed. RT was recorded to the nearest .001 sec. on a locally fabricated electronic timer. Forehead BV and BVP measurement has already been adequately described.
7.2.4 Procedure.

On arriving at the experimental session Ss were given standard instructions concerning the task. However, these instructions differed somewhat for the two experimental conditions. Ss in the signal condition were told that the experiment "involves the measurement of physiological correlates of reaction time performance" and that they were to "press a telegraph key as quickly as possible after the onset of a light". They were told that warning or "get ready" signals (tones) would appear about 5 secs. before the light in two thirds of the trials. Ss in the non-signal condition were given similar instructions with regard to the main purpose of the experiment and the usual RT instruction to press the key as quickly as possible. However, concerning the occurrence of the tones, they were informed that an additional, but separate purpose of the present experiment was to gauge the physiological reaction to auditory stimulation. Thus they would hear occasional tones.

S was then seated in a comfortable armchair, with the attached telegraph key, in a sound attenuated, temperature controlled room. S's attention was directed to the light source and instructions were given to "get the feel of the telegraph key". After the transducer and headphones had been attached the experimenter retired to the adjoining room that housed the control and recording equipment. The lights were dimmed in both rooms and 10 minutes spent calibrating the recording apparatus and allowing S to relax and become dark adapted. S was then instructed (via intercom.) that experimental trials would begin in about 2 minutes. Preceding the experimental trials 3 practise RT trials (no tones) were given. These were not scored.

7.3 Results.

Data analysis focussed on the critical trials in each condition.
7.3.1 Reaction Time.

For each S the average RT for each of the 3 x 60 db, 3 x 100 db and 3 x no tone critical trials was computed. These values were meaned across Ss for each experimental condition. These mean RT values for the critical trials of each type in each condition are shown in Table 7.1. An overall analysis of the averaged RT data (two factor, mixed design) yielded a significant effect of condition ($F = 10.63$, $d.f = 1/28$, $p < .005$) and tone intensity (0, 60 and 100 db) ($F = 33.97$, $d.f = 2/56$, $p < .001$) on RT. A highly significant interaction effect between condition and intensity was also noted ($F = 51.66$, $d.f = 2/56$, $p < .001$). Statistical analysis was then performed within each of the two experimental conditions. Within the non-signal condition the effect of stimulus intensity was highly significant ($F = 23.39$, $d.f = 2/28$, $p < .001$). t-tests were then computed to compare the RTs for the 0, 60 and 100 db trials. The mean RT observed for the trials with the 100 db extraneous stimulus was significantly longer than that for the 60 db trials ($t = 2.56$, $d.f = 14$, $p < .05$), and that for the no tone trials ($t = 2.45$, $d.f = 14$, $p < .05$). No significant difference was observed between RTs for the 60 db and the no tone trials. Similar analysis within

<table>
<thead>
<tr>
<th>Condition Intensity</th>
<th>Non-signal</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>no tone</td>
<td>.408</td>
<td>.487</td>
</tr>
<tr>
<td>60 db</td>
<td>.404</td>
<td>.271</td>
</tr>
<tr>
<td>100 db</td>
<td>.443</td>
<td>.290</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>56</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>14</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>
the signal condition revealed a significant effect of trial type (0, 60 or 100 db) on RT performance ($F = 52.80$, $df = 2/28$, $p < .001$). $t$-tests were computed as before, and revealed that the mean RT for trials in which there was a warning signal was significantly faster than for trials in which no such signal was given. (For the 60 db - no tone comparison, $t = 9.18$, $df = 14$, $p < .001$; for the 100 db - no tone comparison $t = 7.04$, $df = 14$, $p < .001$). This facilitatory effect was independent of the two intensities of warning signal employed; no significant difference was observed between RTs preceded by 60 db warning tones and those preceded by 100 db tones. Comparison across conditions using independent $t$-tests revealed effects of conditions on the RTs manifest to all 3 types of trials. For the no tone trials RTs were significantly longer in the signal condition ($t = 2.68$, $df = 28$, $p < .05$). On the other hand, for the 60 db and 100 db tone trials RTs were significantly longer in the non-signal condition ($t = 5.15$, $df = 28$, $p < .001$, and $t = 6.56$, $df = 28$, $p < .001$ respectively). All $t$-tests were two-tailed.

7.3.2 Forehead vasomotor responding.

Examples of forehead BV and BVP tracings obtained during the present experiment are shown in Figures 7.3 and 7.4.

7.3.2.1 Forehead blood volume pulse.

Forehead BVP analysis also focussed on the critical trials. A beat-by-beat analysis of the first 6 ordinal pulses between tone onset and RT light onset was undertaken and their amplitudes expressed as deviations from the mean amplitude of the 5 pulses immediately prior to tone onset. The deviation values of each of these 6 pulses was then averaged across the 3 critical instances of each tone intensity. The average values were then meaned across Ss for each experimental condition. Figure 7.5 shows the mean forehead BVP pattern of the first 6 ordinal pulses after critical tone onset for each tone intensity in each condition.
**FIGURE 7.3** Forehead BVP and BV response in the signal condition.

N.B. BV increase is characterized by a downward pen deflection.

Chart speed = 2.5 mm/sec.
FIGURE 7.4  Forehead BVP and BV response in the non-signal condition.
N.B. BV increase is characterized by a downward pen deflection, BV decrease by an upward pen deflection. Chart speed = 2.5 mm/sec.
Inspection of Figure 7.5 reveals that the most marked BVP constriction occurs with the 100 dB tone in the non-signal condition. The forehead BVP response pattern to both the 60 and 100 dB tones in the signal condition was similar to that described previously (cf. Chapter 6) as the forehead BVP component of the OR. Although there was little evidence of secondary dilation, this undoubtedly resulted from the necessary restriction of analysis to 6 post-stimulus pulses. Least BVP change with stimulation was apparent with the 60 dB tone in the non-signal condition.

The outcome of an overall analysis of variance (three factor mixed design, with repeated measures of two factors) is shown in Table 7.2. Further analysis was then conducted within each of the two experimental conditions. In short, the analytical strategy was similar to that applied to the RT data. A two factor (repeated measures design) analysis of variance computed on the non-signal data yielded significant effects for both tone intensity ($F = 5.83, df = 1/14, p < .05$) and ordinal pulse ($F = 9.70, df = 5/70, p < .001$) on forehead BVP. The intensity x pulse interaction effect was also highly significant ($F = 3.89, df = 5/70, p < .001$). A similar analysis on the signal condition data indicated that for this experimental manipulation BVP varied significantly only with ordinal pulse ($F = 10.64, df = 5/70, p < .001$).

7.3.2.2 Forehead blood volume.

The forehead BV data was handled in an identical manner to the BVP data. Analysis again focussed on the first 6 ordinal pulses following tone onset in the critical trials in each condition. The deviation of these pulses from chart centre was determined. An estimate of pre-stimulus baseline was obtained by calculating the mean deviation of the 5 pre-stimulus pulses from chart centre. Each of the 6 post-stimulus pulse deviations was then expressed as a deviation from this
Figure 7.5 Mean forehead BVP response pattern to each tone intensity for each condition.
### TABLE 7.2

Analysis of variance of forehead BVP data.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>total</td>
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<td>359</td>
<td>30.80</td>
<td>2.19</td>
<td>ns</td>
</tr>
<tr>
<td>condition (signal - nonsignal)</td>
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<td>1</td>
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<tr>
<td>between Ss</td>
<td>424.53</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>error between Ss</td>
<td>393.73</td>
<td>28</td>
<td>14.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>within Ss</td>
<td>2121.55</td>
<td>330</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>intensity</td>
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<td>78.30</td>
<td>3.52</td>
<td>&lt;.10</td>
</tr>
<tr>
<td>ordinal pulse</td>
<td>307.84</td>
<td>5</td>
<td>61.57</td>
<td>12.26</td>
<td>&lt;.001</td>
</tr>
<tr>
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<td>1</td>
<td>87.72</td>
<td>3.95</td>
<td>&lt;.10</td>
</tr>
<tr>
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<td>2.77</td>
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<tr>
<td>intensity x pulse</td>
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<td>0.93</td>
<td>0.65</td>
<td>ns</td>
</tr>
<tr>
<td>error within Ss</td>
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<td>308</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>error 1</td>
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<td>22.20</td>
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<td></td>
</tr>
<tr>
<td>error 2</td>
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<td>140</td>
<td>5.04</td>
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<td>error 3</td>
<td>200.92</td>
<td>140</td>
<td>1.44</td>
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</tbody>
</table>
pre-stimulus baseline level. The BV change values computed in this manner were then averaged across the 3 critical instances of each intensity of tone for each S in the same fashion as the BVP values. These average values were then meaned across Ss for each experimental condition. The mean BV patterns thus obtained are shown in Figure 7.6. Inspection of Figure 7.6 reveals that, whereas response to the 100 db tone in the non-signal condition appears as a monophasic BV decrease and an increase is evidenced to the 60 db tone, both intensities of tone in the signal condition elicit monophasic BV increase. The results of a three factor analysis of variance on BV data are summarized in Table 7.3. Inspection of Table 7.3 indicates that, except for ordinal pulse effect, all main and interaction effects are significant. As for the forehead BVP data, analyses of variance were then computed within the two experimental conditions. The outcome of these analyses was noticeably similar to that already described for BVP. For the non-signal condition significant effects on BV were observed for tone intensity ($F = 22.48, df = 1/14, p < .001$) and ordinal pulse ($F = 2.85, df = 5/70, p < .05$). The intensity x pulse interaction was also significant ($F = 4.06, df = 5/70, p < .005$). For the signal condition only ordinal pulse significantly influenced forehead BV ($F = 3.71, df = 5/70, p < .005$).

7.3.2.3 Forehead blood volume and blood volume pulse changes prior to the visual RT stimulus in the no tone control trials.

The above analysis of BVP and BV data has assumed that the period immediately prior to the onset of the visual RT stimulus in the no tone control trials, in both signal and non-signal conditions, is characterized by a "zero plethysmogram" i.e. that the 6 pulses preceding light onset in these trials do not deviate from the 5 pulses immediately prior to these. An empirical check was undertaken to evaluate this assumption. BV and BVP were computed for these critical no tones trials
FIGURE 7.6  Mean forehead BV response pattern to each tone intensity for each condition.
### TABLE 7.3
Analysis of variance of forehead BV data.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
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<td>659.07</td>
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<td>&lt;.001</td>
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<td>65.907</td>
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</tr>
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<td>within Ss</td>
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<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>intensity</td>
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<td>1</td>
<td>299.03</td>
<td>6.72</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>ordinal pulse</td>
<td>24.60</td>
<td>5</td>
<td>4.92</td>
<td>0.60</td>
<td>no</td>
</tr>
<tr>
<td>condition x intensity</td>
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<td>1</td>
<td>576.84</td>
<td>12.96</td>
<td>&lt;.005</td>
</tr>
<tr>
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<td>5</td>
<td>22.98</td>
<td>13.99</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>intensity x pulse</td>
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<td>5</td>
<td>5.19</td>
<td>8.95</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>condition x intensity x pulse</td>
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<td>19.71</td>
<td>33.98</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>error within Ss</td>
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<td>308</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>error 1</td>
<td>1246.25</td>
<td>28</td>
<td>44.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>error 2</td>
<td>1159.68</td>
<td>140</td>
<td>8.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>error 3</td>
<td>81.50</td>
<td>140</td>
<td>0.58</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
in exactly the same way as for the critical trials in which a tone did precede the visual RT stimulus. The 6 pulses immediately following hypothetical tone onset in the no tone control trials were expressed as deviations from the 5 pulses prior to hypothetical tone onset.

The results for both BVP and BV are presented in Figure 7.7. As expected, there was little BVP and BV change for the 6 pulses immediately prior to visual RT stimulus onset.

7.4 Discussion.

The results of the present experiment indicate an intimate association between ongoing forehead vasomotor responding and contemporary RT performance. Whereas the elicitation of an OR, (as indicated by forehead BV increase and characteristic BVP response) by an auditory warning signal appeared to facilitate subsequent RT performance, the occurrence of physiological responses more in line with the DR (BV decrease and more extensive BVP constriction) were associated with slower RTs.

An invariant temporal relationship between a warning tone and a RT light stimulus resulted in the elicitation of vasomotor responses to the tone indicative of the OR. The nature and extent of these responses appeared to be independent of whether the warning tone was of 60 or 100 db intensity. Visual RTs recorded were notably faster for warning signal trials than for the corresponding control trials in which no warning signal was given. They were also faster than RTs recorded to light stimuli following tones which bore no fixed temporal relationship to them.

In the non-signal condition, where tone and light were not related in any consistent or predictable fashion, high and moderate intensity tones differed significantly in their influence on forehead vasomotor responding and on RT performance. In this situation an intense tone occurring 5 sec. before the RT stimulus elicited decreases
FIGURE 7.7 Forehead BVP and BV change prior to RT stimulus onset in no tone control trials.
in BV and marked BVP constriction, responses indicative of the DR. RTs following these intense tones were longer than those for comparable moderate tones and no tone critical trials. The presentation of moderate tones in this non-signal condition were not associated with marked changes in RT performance. However, it is probable that the impact of the 60 db tones in such circumstances declined rapidly with stimulus repetition. If this was the case, very little in the way of facilitatory effect would be expected. The minimal changes in forehead BVP as a result of nonsignal moderate tone presentation would support such a notion. Further, a simple check revealed that the largest BV increase and fastest RT occurred with the first 60 db critical trial.

The differential effects of auditory stimulus intensity of forehead BVP as a result of a change in stimulus signal value or significance is in line with those effects reported previously with changes in the signal value of affective visual stimuli (see Chapters 3 and 5) and confirms the susceptibility of the forehead BVP parameter to such manipulations. In line with the findings of Sokolov (1963a) change in tone signal value also influenced the impact of intensity on forehead BV changes.

The general observations on RT performance are in line with the findings of previous workers who used fixed and highly irregular fore-periods (cf. e.g. Woodworth & Schlosberg, 1954; Kohfeld, 1969). The observation of significantly longer RTs for the no tone control trials in the signal condition than in the non-signal condition is not surprising when one considers the different stimulus presentation schedules and the different expectancies probably entertained by the Ss in the two condition. Inspection of Figures 7.1 and 7.2 indicates that while only 20 no tone trials occurred in the signal condition, there were 20 such trials in the non-signal condition. The greater incidence of no tone trials in the non-signal could account for the RT performance difference. Further, in the
signal condition Ss undoubtedly "expect" the occurrence of a tone as the first event in a RT trial since a tone preceding the light is the most likely occurrence. Ss in the non-signal condition would not be expected to entertain such rigid expectancies.

In conclusion then, as far as differences in RT performance can be assumed to result from vicissitudes in stimulus reception and sensitivity, the present findings support Sokolov's (1963a) contentions regarding the roles of the OR and DR in the regulation or tuning of perceptual sensitivity. The association of the differential forehead vasomotor changes that reflect the OR and the DR with respective increases and decreases in perceptual sensitivity is strongly favoured.
CHAPTER 8
CONCLUDING REMARKS

8.1 Summary of results.

The initial experiments described in the present thesis were undertaken to test the generality of the dichotomous formulation of arousal patterns as ORs and DRs suggested by Sokolov (1963a). According to Sokolov, ORs occur to novel, moderately intense stimulation and the observed physiological components of the reaction are involved in the heightening of perceptual sensitivity. The DR, on the other hand, occurs to unpleasant, intense or noxious stimulation and is associated with the attenuation of sensitivity to ongoing stimulation. The observation of forehead vasomotor responding, according to Sokolov and Vinogradova (e.g. Vinogradova & Sokolov, 1957; Sokolov, 1963a) provides for the clearest differentiation of ORs and DRs. By virtue of its postulated correspondence with cerebral vasomotor behaviour (Hertzman & Dillon, 1939; Vinogradova & Sokolov, 1957; Sokolov, 1963a), forehead vasomotor responding has been considered to reflect the tuning of perceptual sensitivity (Sokolov, 1963a). The present observation of extensive forehead BVP constriction, indicative of the DR, to the unpleasant homicide pictures and BVP responses to the other sorts of pictures more in line with ORs (although initial constriction was observed to precede the dilatory response) was extremely encouraging and suggested that such a dichotomous formulation of arousal reactions represented a useful model with which to describe affective experience. Affective experiences of an unpleasant sort appear to be associated with physiological responses reflecting sensitivity attenuation, while positive affective experience seems linked to responses implicated in the increase of sensitivity and stimulus reception.

In contrast to the consistent Soviet findings regarding differential forehead vasomotor responding to moderate and intense simple
physical stimuli the results of recent Western investigations have not been uniformly confirmatory. The penultimate experiment, reported here, was undertaken to re-examine the nature of forehead vasomotor responding to simple auditory stimuli. The results were in line with the Soviet findings. Again forehead BVP was observed to be susceptible to stimulation differences, this time differences in tone intensity. As before, a biphasic BVP component of the OR was observed. Forehead BV, which appears to be the more likely constituent of the forehead plethysmographic response employed by Sokolov and his colleagues was also sensitive to stimulus intensity. Whereas monophasic BV increases were found with moderately intense tones, intense tones elicited BV decreases. The final experiment reported was undertaken to assess the influence of the OR and DR on performance of a simple sensori-motor task, and thus gauge the validity of a central assumption in Sokolov’s dichotomous formulation i.e. that the OR and DR are associated with the tuning of perceptual sensitivity. Evidence was obtained that implicated the OR in the heightening of perceptual sensitivity and associated the DR with sensitivity attenuation.

The investigation of individual differences in the extent of the DR as indicated by the amount of forehead BVP constriction yielded disappointing results. In Chapter 5 several explanations were proposed for the low correlations obtained and a number of recommendations made for future exploration in this area. Two further suggestions may be made here. Firstly, as a result of the present work, it is considered that future studies would probably benefit from the recording of both BV and BVP changes, since these indices may not be measuring the same aspects of circulatory response (Hertzman & Dillon, 1940; Weinman, 1967). Secondly, a simpler stimulus paradigm might reduce much of the “noise” undoubtedly associated with reaction to complex affective visual stimuli (e.g. the influence of dynamic factors on self-report to such stimuli).
The presentation of a sequence of simple physical stimuli of high intensity would allow a more comprehensive appraisal of response differences. Several response parameters could be considered: for example, DR latency, i.e. the temporal location of the often observed switch from OR to DR; the initial amplitude of the DR; DR persistence and change with repetition of the same stimulus intensity. A similar paradigm has been used to investigate individual differences in OR amplitude and persistence (e.g. Mangan & O'Gorman, 1969; O'Gorman, 1971). The easy control and manipulation of stimulus intensity provided by the employment of simple physical stimuli would allow the determination of individual DR thresholds.

8.2 Implications of the present results.

A major implication of the present results is that they demand a drastic revision of classical "activation" or "arousal theory". Duffy (1962) and Malmo (1954) depict arousal as a unidimensional continuum ranging from coma to the highest levels of excited and disorganized behaviour. These workers assert that physiological arousal components are part of the mechanism of drive and as such reveal the intensive rather than the directional aspects of behaviour. While many physiological parameters (such as the SCR, and the peripheral vasoconstriction response) do appear to reflect mainly intensive aspects of behaviour, their amplitude increasing with the intensity of stimulation, forehead vasomotor responses evidence directional responding. Since moderately "arousing" stimuli produce mainly forehead vasodilation, we would expect, within a unidimensional arousal framework, highly "arousing" stimuli would result in more emphatic dilation. As we have seen, forehead vasoconstriction is mainly elicited by such stimuli. The forehead vasomotor response direction and performance relationship evidenced in Chapter 7 of the present thesis would strongly suggest that this autonomic parameter at least is related to directional aspects of behaviour and more properly associated with stimulus enhancement and attenuation i.e. approach and avoidance than
purely energizing or arousing behavioural functions. The view that some autonomic variables reflect more than the intensive aspects of behaviour is given a further boost by Lacey's (1959, 1967) reports of directional heart rate responding as a result of the attentional demands of the experimental task (Lacey's findings on directional heart rate responding have been discussed in Chapter 1). Lacey (1967) suggests that the subtleties and sophistication of control of and influence on physiological parameters would seem to preclude the representation of changes in different autonomic channels as a monolithic activation or arousal process mobilizing the body to peak activity. As Ax (1967) comments, the concept of general "arousal" needs to be broken down into more usable constructs. The concept of ORs and DRs as functionally distinct arousal reactions provides a positive step in the acknowledgement of greater sophistication in autonomic functioning.

This aside, the present results indicate that both forehead BV and BVP are highly sensitive to stimulus differences and instructional or procedural manipulations (characterized in the present terminology as changes in stimulus signal value), and are thus extremely useful additions to those more commonly employed psychophysiological variables listed by Brown (1966). Forehead vasomotor measurement appears to be particularly apposite in studies investigating the traumatic impact of various sorts of laboratory and "real life" stressors. Such studies would undoubtedly benefit from the inclusion of a biological variable likely to give a clearer indication of prevailing distress and discomfort than variables that do not exhibit directional changes with stimulus unpleasantness and intensity. Sokolov (1963a) acknowledges this importance of forehead vasomotor measurement, "in connection with the determination of pain threshold and also in the investigation of the traumatic effects of strong auditory stimuli and industrial noises". Broadbent (1961) indicates the controversial and inconclusive state of the debate on whether intense
industrial noise affects people in a detrimental fashion or not. Some objective light might be thrown on the question of what sorts of schedules, durations and intensities of noise elicit distress and disruption by the measurement of forehead vasomotor responding.

Another application of forehead vasomotor response measurement is in the field of behaviour therapy, particularly with respect to classical aversive conditioning. This technique has been employed widely in the treatment of alcoholism, fetishism, transvestism, and habitual gambling (Yates, 1970). The paradigm in its simplest application is that of classical conditioning. For example in alcoholism (see Kanfer & Phillips, 1970, pp. 95 - 96), cues associated with alcohol (sight, smell, taste and thoughts of alcohol) serve as the CS and are paired with a noxious and/or intense UCS. The UCS's employed include such chemical agents as apomorphine and emetine which produce vomiting, white noise and electric shocks. Most workers for ease and flexibility of stimulus control use electric shocks (for reviews see Franks, 1958; Rachman, 1965). According to several Soviet studies cited previously (Luria & Vinogradova, 1959; Sokolov, 1963a; Vinogradova, 1965; Vinogradova, 1968) the pairing of a neutral stimulus with an intense or noxious stimulus results in a DR being conditioned to the neutral stimulus. Although parsimonious, it would be premature to suggest that the aversive conditioning paradigm involves the conditioning of a DR to the cues associated with the undesired behaviour. An important difference between the two situations is evident. Whereas the usual DR conditioning experiment involves CSs which are affectively neutral (usually moderately intense pure tones) the cues constituting the CS in aversive therapy are far from neutral. Being stimuli of great personal significance to the individual they are likely to elicit more stable and persistent ORs than moderately intense tones. Such stability and persistence of OR elicitation would preclude easy DR conditioning. However, the parallel between the two
paradigms exists and suggests the employment of forehead vasomotor measurement in aversive conditioning therapy. First of all, such measurement would provide an indication of whether the aversive conditioning situation does involve the conditioning of a physiological DR. Speculating further, if aversive conditioning was observed to comprise the development of a conditioned DR, forehead vasomotor response measurement might have interesting prognostic value. Success or failure in eliciting a DR, as indicated by the appropriate vasomotor response, in the first instance to the UCS, or a conditioned DR as a result of the conditioning procedure, might provide useful predictions of the success of the therapy and the probability of future relapse. Most behaviour therapists pay little more than lip service to the need for monitoring autonomic responses during the course of therapy to assess changes in the reaction of the CS. Kanfer and Phillips (1970) lament the conservatism of most clinicians with regard to recent psychophysiological innovations, their general reluctance to apply physiological measurement, and the lack of sophistication that permeates the few attempts at such application. The sensitivity of forehead vascular changes to various stimulus parameters such as stimulus intensity and the nature of affect, as observed in the present investigation, suggest forehead BV and BVP measurement might be usefully implemented in aversive conditioning therapy. The accounts of DR conditioning by Soviet workers recommend such measurement as having probable prognostic value.

8.3 Parallel responding in the forehead and cerebral vasculature.

Vinogradova and Sokolov (1957) and Sokolov (1963a) propose that the differential forehead vasomotor components of the OR and DR reflect differences in cerebral blood flow during the two reactions. According to Sokolov (1963a), the inferred changes in cerebral flow provide a basic mechanism for the increase and decrease of perceptual sensitivity associated with the OR and DR respectively. In support of
such an assertion that directional forehead vasomotor changes reflect corresponding cerebral changes, Vinogradova and Sokolov (1957) and Sokolov (1963a) cite the findings of several early Soviet studies measuring plethysmographic changes in the blood vessels of the brain in the region of particular bone defects. Sensory stimuli (light, sound and tactile stimulation, all presumably of moderate intensity) were found to produce an increase in cerebral blood flow, which habituated with stimulus repetition. Such researches also found dilation of the cerebral vessels with the application of warmth on the surface of the body, and the presence of constriction with the application of cold. These findings parallel the observations of Vinogradova and Sokolov (1957) and Sokolov (1963a) of the forehead vasomotor response to such stimuli. However, no report is given concerning the impact of intense or noxious stimulation on cerebral blood flow. A closer inspection of just how parallel the cerebral and forehead vasculatures are in their reaction to moderate and intense stimulation would seem essential.

There are at present several reliable techniques available for the determination of either total blood flow through the brain or the flow in a specific region (since it is outside the scope of the present thesis to consider these techniques the reader is referred to Bergel, 1968; Betz, 1968; Birzis & Tachibana, 1962; Ingvar & Soederberg, 1958; Kety & Schmidt, 1948; Luebbers, 1968; Mowbray, 1959). A useful application of such techniques would be the determination of the correspondence of total and regional cerebral blood flow and the forehead plethysmographic components of the OR and DR.

8.4 Sokolov's model of the OR.

Sokolov (1960) provides a comprehensive model of OR generation and habituation. This model is presented in Figure 8.1. According to the model afferent stimulation passes via the classical sensory tracts
FIGURE 8.1  SokoIov's (1960) schema for the orienting reaction.

Schema for the orienting reflex.  I. Modeling system.  II. Amplifying system.

1. = specific pathway from sense organs to cortical level of modeling system;  2. = collateral to reticular formation (represented here as an amplifying device);  3. = negative feedback from modeling system to synaptic connection between collaterals from specific pathway and R.F.;  4. = ascending activating influences from the amplifier (R.F.) upon modeling system (cortex);  5. = pathway from modeling system to amplifying system (this is the pathway through which the impulses signifying concordance are transmitted from the modeling system to the amplifying system);  6. = to the specific responses caused by coincidence between the external stimulation and the neuronal model elaborated in the cortex;  7. = to the vegetative and somatic components arising from the stimulation of the amplifying system (R.F.).
to the cortex. Excitatory impulses via collaterals from the classical sensory tracts, according to Sokolov (1960), impinge on the reticular formation (RF). (Since there is no anatomical evidence for such collaterals, excitatory RF input will be described in the present thesis as arriving merely via "other pathways"). According to Sokolov, incoming stimuli are compared with the prevailing cortical "neuronal model" of the stimulus world. Sokolov defines "neuronal model" as follows:

"By neuronal model is meant a certain cell system whereby the information is stored concerning the properties of a stimulus which has been presented many times". (Sokolov, 1963a, p. 286).

In the case of a novel stimulus failing to match the prevailing "neuronal model", excitatory impulses initiated in the cerebral cortex descend to the RF. Excitation of the RF from both the cortex and the "other pathways" results in the initiation of the OR. This incoming stimulus leaves a trace of its salient characteristics within the cortex and thus ultimately allows the formation of a comprehensive "neuronal model". With subsequent match between incoming stimulus and "neuronal model", no cortical excitatory pulses are sent to the RF. Further, a blocking

* This statement needs qualification.

Although evidence of collaterals at the level of the RF is considerable for some sensory inputs, e.g. auditory, there is little evidence for such collaterals from other inputs, e.g. fine tactile; kinaesthetic sensation. (Truex & Carpenter, Human Neuroanatomy, 6th Ed. P.318).

The term "other pathways" is introduced here to allow the author exit from anatomical discussion. For the present conceptual model, as long as information of sensory input arrives at the "amplifying system", it does not matter how, or whether such input is similarly conveyed for all sensory input channels.
"The defence and orientation reactions are similar in that they develop in response to non-specific qualities of stimuli. In the case of the defence reflex it is only the intensity of the stimulus which must reach a certain level". (Sokolov, 1963a, pp. 48 - 49).

This suggests that cortical analysis in addition to monitoring the correspondence between the properties (such as stimulus duration, frequency of occurrence etc.) of the incoming stimulus and those represented in the prevailing "neuronal model", must also assess the intensive or threatening aspects of stimulation. Judgement of a stimulus as threatening somehow results in the initiation of a DR instead of an OR. How are the intensity or threatening aspects of the stimulus array analyzed separately from other stimulus properties?

One answer is that they are not. A formulation might be entertained that DR initiation stems from extensive incoming stimulus - prevailing "neuronal model" discrepancy or mismatch, whereas less extensive mismatches initiate ORs, i.e. the extent of its discrepancy from the prevailing "neuronal model" determines whether a particular stimulus elicits an OR or DR. Parallel formulations to this, with respect to the extent of discrepancies between the perceived stimulus and an internal representation or model of the stimulus world, have received a certain amount of favour from a number of psychologists over the past 20 years (e.g. McClelland, Atkinson, Clark & Lowell, 1953; Tarantino, 1970).

Most of these formulations have employed Helson's (1959) concept of "adaptation level" to describe the internal representation of the stimulus world. Similarities between "adaptation level" and Sokolov's "neuronal model" are at once apparent. According to Helson (1959) the "adaptation level" defines the range of stimulation within which adaptive responding is not required. It defines the momentary adjustment of an individual and is a function of the stimuli to which the individual has been previously exposed. McClelland et al. (1953) and Tarantino (1970) suggest that discrepancies between adaptation level and
contemporary stimulus perception give rise to affective reactions and propose that, whereas small discrepancies or mismatches give rise to reactions pertaining to positive affect, unpleasantness and negative affective reactions stem from large discrepancies. Although the terminology and theoretical orientations differ radically, there is a striking parallel between the formulations of McClelland et al. (1953) and Tarantino (1970) and the proposition being presently entertained, especially in the light of the association between the DR and OR on the one hand, and negative and positive affect on the other, emphasised earlier in this thesis. However, there is empirical evidence which would argue against such a notion, e.g. the finding (cf. Sokolov, 1963a; Chapter 6 of present thesis) that when stimulus intensity is high but not high enough to produce an immediate DR, an OR will appear initially, the DR occurring with later stimulus repetitions. According to the above formulation this finding implies that the most extensive stimulus-model discrepancies do not occur on initial stimulus presentations, but only after several repetitions of the stimulus, a notion at odds with Sokolov’s (1960, 1963a) presentation of neuronal model development.

A more likely proposition can be suggested which involves the independent analysis of stimulus familiarity and stimulus threat or noxiousness. Whereas the analyzer for familiarity is, as Sokolov asserts, a momentary and ever changing model of the stimulus world, the analyzer responsible for assessment of whether a stimulus is threatening or not would presumably entail a much more stable and permanent account of what is conducive to an individual’s state of “well-being”. Speculating further, the initiation of an OR or DR would be based on the relative excitation in the two analytical systems. If the noxious or threatening aspects of the stimulation are considerable, excitation emerging from the discrepancy between such stimulation and this stable neural catalogue of what is conducive to “well-being” would then be substantial and likely to
A DR would thus be immediately initiated. Because of the relatively immutable nature of this model, subsequent comparisons with stimulus repetition would not alter the extent of the discrepancy and consequent excitation. The DR to such noxious stimulation would thus be highly resistant to habituation. Sokolov (1963a) reports that unlike the OR, the DR is exceptionally resistant to habituation. However, when stimulation is not quite so intense or threatening, it is conceivable that greater relative excitation might initially emerge from the analyses of stimulus unfamiliarity than from the analyses of the threatening aspects of the stimulus. Dominant excitation in the OR analyzer would lead to an OR being initiated. However, with stimulus repetition, the development of a neuronal model of the stimulus in the OR analyzer, would gradually decrease the stimulus-model discrepancy and consequent excitation would be decreased. The DR analyzer, which has remained relatively constant in terms of excitation, would now, in the wake of decreasing excitation in the OR analyzer, emerge as the dominant excitatory focus, and a DR would be initiated. Such a formulation would thus account for the often observed transition from OR to DR with some intensities of stimulation.

The inclusion of a second analytical system responsible for the assessment of whether a stimulus is noxious or not and thus the initiation of the DR, demands reconstruction of the RF amplifying system.

1. For the sake of brevity the analyzer responsible for assessment of stimulus unfamiliarity will be referred to as the OR analyzer, while that responsible for assessment of the noxious aspect of the stimulus will be referred to as the DR analyzer.
as conceived by Sokolov (see Figure 8.1). As Lynn (1966) points out, those autonomic and somatic components pertaining to the mobilization of an organism's resources for activity are common to both response systems. It is proposed by the author of the present thesis that these component reactions are initiated by mismatch within the OR analyzer resulting in excitation from the OR analyzer impinging on the RF. Such excitation, coupled with the excitation arriving at the RF via the "other pathways" results in the initiation of those autonomic responses common to both ORs and DRs. Habituation or extinction of such non-specific responses occurs when there is 'neuronal model' - incoming stimulus match within the OR analyzer, resulting in a lack of cortical excitation impinging on the RF and also the blocking of excitatory RF input via the "other pathways". Thus the initiation of those autonomic responses common to both ORs and DRs results solely from the analysis of stimulus familiarity. On the other hand, it is proposed that those autonomic reactions associated with the tuning of perceptual sensitivity are triggered on the basis of the relative excitation from both the OR and DR analyzers impinging on probably different RF centres from those handling non-specific response components. Whether reactions associated with attenuation or heightening of sensitivity are initiated depends, as suggested previously on the relative extent of the excitation emerging from the two analyzers. Thus this model proposes that mobilization of the bodies resources for action is initiated on the basis of an analysis of stimulus unfamiliarity. Whether these resources are to be directed towards increased to decreased contact with the stimulus depends on the relative excitation arising from the contemporary analyses of unfamiliarity and noxiousness or threat.

Without supportive data further structural speculation would be pointless. However, there are indications that the model proposed above is not without some independent empirical backing. Consider the
behaviour of the SCR and the forehead vasomotor response to an intense stimulus. The SCR, being a non-specific response (i.e. it occurs as part of both the OR and DR), is initiated by mismatch within the OR analyzer. SCR habituation or extinction, according to the model formulated above, occurs with the emergence of a "neuronal model" of the stimulus in the OR analyzer, and the consequent absence of cortical excitation impinging on the RF and the blocking of the RF input via the "other pathways". Initiation of the DR-specific forehead vasoconstriction response, on the other hand, results from extensive excitation from the DR analyzer impinging on another part of the reticular amplifying system. Habituation of the forehead vasoconstriction component of the DR occurs if stimulus input matches the almost immutable representation, embodied in the DR analyzer, of what is not harmful to the organism. From such considerations it would be predicted that the SCR manifest to this intense stimulation should habituate since habituation, in this case, depends only on the construction of a "neuronal model" within the OR analyzer that short-circuits the effects of stimulus unfamiliarity. The forehead vasoconstriction response, on the other hand, should be highly resistant to habituation, since habituation of this response depends not on the reconstruction of what is familiar but on the reconstruction of what is more or less harmful. Sokolov (1963a) reports data to show that the SCR occurring to intense stimulation does habituate while the forehead vasoconstriction response habituates much more slowly or not at all. As Sokolov states:

"... while painful stimulation of the skin is maintained, the galvanic skin response, in some cases, grows weaker and may be completely extinguished. This process of extinction is slow but still does take place and is in some respects more similar to the (albeit quicker) process of extinction of the vasomotor component of the orientation reaction, than to the defence reaction which replaces the former and which persists". (Sokolov, 1963a, pp. 59 - 60).
STATISTICAL NOTE

In the analysis of variance models used, to check that variances due to experimental error were homogeneous, Hartley's test and Bartlett's test were computed where appropriate. Only moderate departures from homogeneity of variance were observed and Winer (1962) has pointed out that moderate departures do not seriously affect the sampling distribution of the $F$ statistic. The work of Box (1953), cited by Winer (1962), has shown that the distribution of the $F$ ratio in analysis of variance is affected relatively little by inequalities in the variances which are pooled into the experimental error. With regard to the use of tests for homogeneity of variance, Box (1953) writes:

"To make the preliminary tests on variances is rather like putting to sea in a rowing boat to find out whether conditions are sufficiently calm for an ocean liner to leave port".

All $t$-tests in the present study were conservatively tested as two-tailed. However, the following tests can be regarded as planned. The outcome of these planned tests should not demand such conservative interpretation. In Chapter 2, $t$-tests conducted on the PSI self-report measure can be regarded as a check on the manipulation and as such are planned tests. In Chapter 4, when it is specifically and reasonably predicted that flexor muscle activity increments should be largest for the unpleasant block of slides, $t$-tests computed to examine this prediction can be regarded as planned. Similarly, in Chapter 5, the test of the incidental proposition that people will look longer at cartoons than at unpleasant homicide pictures can be considered planned. Finally, in Chapter 7, tests undertaken to assess the hypotheses concerning the impact of signals and proximal non-signalling stimuli on RT performance must be regarded as planned.
I.1.3 Instructions for rating after stimulus block presentation.

Below is a list of words and phrases which can be used to describe your feelings. Please check the word or phrase which best describes the way you felt on seeing the last group of slides. Check only one word or phrase.

I.2 Davitz list of words.

I.2.1 Items comprising list.

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<tr>
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<td>Love</td>
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<tr>
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<td>Awe</td>
<td>Frustration</td>
<td>Pride</td>
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<tr>
<td>Boredom</td>
<td>Gaiety</td>
<td>Relief</td>
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<tr>
<td>Cheerfulness</td>
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<tr>
<td>Contempt</td>
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<td>Hope</td>
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<td>Determination</td>
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<td>Surprise</td>
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<tr>
<td>Dislike</td>
<td>Irritation</td>
<td></td>
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</table>
1.2.2 Instructions for completion of Davitz list.

You are provided with a set of common terms which people use to label their feelings or emotional experiences. Could you please tick off the terms which apply to your feelings with respect to the stimuli you have just seen. Tick off as many or as few as you think accurately describe your feelings during the presentation of each slide. To help you in this task you are provided with 8 in. x 10 in. photographs of the slides. However, use these only as recall cues. It is your experiences during slide presentation that are important here.
APPENDIX II. PERSONALITY INVENTORY.

1.1 Repression-sensitization scale.

1.1.1 Items in scale and scoring procedure.

1. I wake up fresh and rested most mornings. True False

2. My hands and feet are usually warm enough. True False

3. My daily life is full of things that keep me interested. True False

4. There seems to be a lump in my throat much of the time. True False

5. Once in a while I think of things too bad to talk about. True False

6. At times I have fits of laughing and crying that I cannot control. True False

7. I feel that it is certainly best to keep my mouth shut when I’m in trouble. True False

8. I find it hard to keep my mind on a task or job. True False

9. I seldom worry about my health. True False

10. I have had periods of days, weeks, or months when I couldn’t take care of things because I couldn’t get going. True False

11. My sleep is fitful and disturbed. True False

12. Much of the time my head seems to hurt all over. True False

13. I am in just as good physical health as most of my friends. True False

14. I prefer to pass by school friends, or people I know but have not seen for a long time, unless they speak to me first. True False

15. I am almost never bothered by pains over the heart or in my chest. True False

16. I am a good mixer. True False

17. I wish I could be as happy as others seem to be. True False

18. Most of the time I feel blue. True False

19. I am certainly lacking in self-confidence. True False

20. I usually feel that life is worth while. True False

21. It takes a lot of argument to convince most people of the truth. True False
22. I think most people would lie to get ahead. True False
23. I do many things which I regret afterwards (I regret things more or more often than others seem to). True False
24. I have very few quarrels with members of my family. True False
25. My hardest battles are with myself. True False
26. I have little or no trouble with my muscles twitching or jumping. True False
27. I don't seem to care what happens to me. True False
28. Much of the time I feel as if I have done something wrong or evil. True False
29. I am happy most of the time. True False
30. Some people are so bossy that I feel like doing the opposite of what they request, even though I know they are right. True False
31. Often I feel as if there were a tight band about my head. True False
32. I seem to be about as capable and smart as most others around me. True False
33. Most people will use somewhat unfair means to gain profit or an advantage rather than to lose it. True False
34. Often I can't understand why I have been so cross and grouchy. True False
35. I do not worry about catching diseases. True False
36. I commonly wonder what hidden reason another person may have for doing something nice for me. True False
37. Criticism or scolding hurts me terribly. True False
38. My conduct is largely controlled by the customs of those about me. True False
39. I certainly feel useless at times. True False
40. At times I feel like picking a fist fight with someone. True False
41. I have often lost out on things because I couldn't make up my mind soon enough. True False
42. It makes me impatient to have people ask my advice or otherwise interrupt me when I am working on something important. True False
43. Most nights I go to sleep without thoughts or ideas bothering me. True False
44. I cry easily. True False
45. I cannot understand what I read as well as I used to. True False
46. I have never felt better in my life than I do now. True False
47. I resent having anyone take me in so cleverly that I have had to admit that it was one on me. True False
48. I do not tire quickly. True False
49. I like to study and read about things that I am working at. True False
50. I like to know some important people because it makes me feel important. True False
51. It makes me uncomfortable to put on a stunt at a party even when others are doing the same sort of things. True False
52. I frequently have to fight against showing that I am bashful. True False
53. I seldom or never have dizzy spells. True False
54. My memory seems to be all right. True False
55. I am worried about sex matters. True False
56. I find it hard to make talk when I meet new people. True False
57. I am afraid of losing my mind. True False
58. I frequently notice my hand shakes when I try to do something. True False
59. I can read a long while without tiring my eyes. True False
60. I feel weak all over much of the time. True False
61. I have very few headaches. True False
62. Sometimes, when embarrassed, I break out in a sweat which annoys me greatly. True False
63. I have had no difficulty in keeping my balance in walking. True False
64. I wish I were not so shy. True False
65. I enjoy many different kinds of play and recreation. True False
66. In walking I am very careful to step over sidewalk cracks. True False
67. I frequently find myself worrying about something. True False
68. I hardly ever notice my heart pounding and I am seldom short of breath.  True  False
69. I get mad easily and then get over it soon.  True  False
70. I brood a great deal.  True  False
71. I have periods of such great restlessness that I cannot sit long in a chair.  True  False
72. I dream frequently about things that are best kept to myself.  True  False
73. I believe I am no more nervous than most others.  True  False
74. I have few or no pains.  True  False
75. I have difficulty in starting to do things.  True  False
76. It is safer to trust nobody.  True  False
77. Once a week or oftener I become very excited.  True  False
78. When in a group of people I have trouble thinking of the right things to talk about.  True  False
79. When I leave home I do not worry about whether the door is locked and the windows closed. True  False
80. I have often felt that strangers were looking at me critically. True  False
81. I drink an unusually large amount of water every day. True  False
82. I am always disgusted with the law when a criminal is freed through the arguments of a smart lawyer. True  False
83. I work under a great deal of tension. True  False
84. I am likely not to speak to people until they speak to me. True  False
85. Life is a strain for me much of the time. True  False
86. In school I found it very hard to talk before the class. True  False
87. Even when I am with people I feel lonely much of the time. True  False
88. I think nearly anyone would tell a lie to keep out of trouble. True  False
89. I am easily embarrassed. True  False
90. I worry over money and business. True  False
91. I easily become impatient with people. True  False
92. I feel anxiety about something or someone almost all the time.  
93. Sometimes I become so excited that I find it hard to get to sleep.  
94. I forget right away what people say to me.  
95. I usually have to stop and think before I act even in trifling matters.  
96. Often I cross the street in order not to meet someone I see.  
97. I often feel as if things were not real.  
98. I have a habit of counting things that are not important such as bulbs on electric signs, and so forth.  
99. I have strange and peculiar thoughts.  
100. I have been afraid of things or people that I knew could not hurt me.  
101. I have no dread of going into a room by myself where other people have already gathered and are talking.  
102. I have more trouble concentrating than others seem to have.  
103. I have several times given up doing a thing because I thought too little of my ability.  
104. Bad words, often terrible words, come into my mind and I cannot get rid of them.  
105. Sometimes some unimportant thought will run through my mind and bother me for days.  
106. Almost every day something happens to frighten me.  
107. I am inclined to take things hard.  
108. I am more sensitive than most other people.  
109. At periods my mind seems to work more slowly than usual.  
110. I very seldom have spells of the blues.  
111. I wish I could get over worrying about things I have said that may have injured other people’s feelings.  
112. People often disappoint me.  
113. I feel unable to tell anyone all about myself.
114. My plans have frequently seemed so full of difficulties that I have had to give them up.

115. Often, even though everything is going fine for me, I feel that I don't care about anything.

116. I have sometimes felt that difficulties were piling so high that I could not overcome them.

117. I often think, "I wish I were a child again".

118. It makes me feel like a failure when I hear of the success of someone I know well.

119. I am apt to take disappointments so keenly that I can't put them out of my mind.

120. At times I think I am no good at all.

121. I worry quite a bit over possible misfortunes.

122. I am apt to pass up something I want to do because others feel that I am not going about it in the right way.

123. I have several times had a change of heart about my life work.

124. I have a daydream life about which I do not tell other people.

125. I have often felt guilty because I have pretended to feel more sorry about something than I really was.

126. I feel tired a good deal of the time.

127. I sometimes feel that I am about to go to pieces.

The responses underlined are scored 1. Sensitizers are characterized by a high score, repressors by a low score.

II.1.2 Instructions for scale administration.

This inventory consists of numbered statements. Read each statement and decide whether it is true or false as applied to you. If the statement is true or mostly true as applied to you indicate this by circling the word "True" that suffixes the statement; if it is false or not usually true circle the word "False". Please attempt an answer to every item.
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