

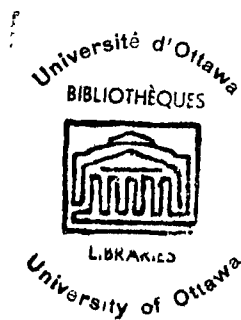
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THE EFFECT OF PUPIL SIZE ON RECOGNITION  
THRESHOLDS FOR NEUTRAL AND TABOO  
WORD STIMULI

by Walter J. Leckett

Thesis presented to the School of  
Graduate Studies of the University  
of Ottawa as partial fulfillment  
of the requirements for the degree  
of Master of Arts



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## CURRICULUM STUDIORUM

Walter J. Leckett was born on July 16, 1946, in Winnipeg, Manitoba. He received the Bachelor of Arts degree in Psychology from the University of Manitoba in 1967.

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## INTRODUCTION

For over a period of two decades the phenomenon of perceptual defense has been studied at great length in an attempt to account for the interaction of personality variables and perception. Although numerous attempts have been made to account for the systematic relationship found between emotionally arousing stimuli and recognition thresholds, i.e., perceptual defense, the problem is still unresolved and the controversy continues even today. Accounts of perceptual defense have ranged from Freudian interpretations of unconscious forces, to subception, perception without awareness, response suppression and response bias hypotheses. In spite of these explanations and more recently developed methodologies to account for the perceptual defense phenomenon, it still is not fully explained. No doubt there in fact may exist a multitude of factors to account for the phenomenon.

The present study has sought for an explanation of perceptual defense through the pupillary response mechanism. It is through the pupillary response of dilation and constriction to psychological variables, as well as the effects changes in pupil size may have on visual acuity, that suggest the pupillary response as one plausible mechanism, although certainly not the only one, to account for the heightened recognition thresholds to emotional stimuli found in perceptual defense

studies. To examine the pupillary response as a plausible mechanism for perceptual defense, the present research manipulates pupil size through the use of artificial pupils by employing contact lenses. The effect of different artificial pupil sizes on recognition thresholds for neutral and taboo word stimuli is examined.

The basic problem presented for this study is, therefore, what is the possible role of the pupillary response mechanism in accounting for the phenomenon of perceptual defense? More specifically, what effect do different pupil sizes have on the recognition thresholds of neutral and taboo word stimuli?

Through exploration of some of the mechanisms, such as the pupillary response, that may affect the process of perceptual defense, it is hoped that a greater understanding of this process will be reached based on more objective methods than arbitrary ascribing it to mentalistic or unconscious forces. A greater appreciation may then be reached regarding the complexity and extensiveness of the mechanisms involved.

In examining the problems this paper presents a review of the literature exploring, first, the area of perceptual defense, second, how the pupillary response may be implicated as a mechanism in perceptual defense and, third, the effects pupil size can have on visual acuity and

thus recognition thresholds. The basic hypotheses are then formulated and presented for examination.

Following the hypotheses, the experimental design is presented. It gives a description of the sample, apparatus, experimental procedure, methods of analysis and statistical design. In the design is found the unique feature of this study, namely, the employment of contact lenses for artificial pupils.

Next are presented the results of the experimentation and a discussion of the findings, in particular for the effect the artificial pupil sizes have on recognition thresholds of the stimulus words, and the implications for the present study as well as future research.

A summary follows the experimental design and an appendix is included for additional reference.

## CHAPTER I

### REVIEW OF THE LITERATURE

The present chapter presents a review of the literature and leads to development of the problems and hypotheses. The review illustrates how the pupillary response may be implicated as one possible mechanism to account for differential recognition thresholds characteristic of perceptual defense. The first section demonstrates that motivation can affect perception, but the process and mechanisms through which this occurs still remain obscure. In the second section the pupillary response is examined as one possible mechanism to account for such a process. The literature relating the dilation and constriction of the pupil to certain psychological phenomena leads to such a postulation. Finally, the third section discusses the relationships between pupil size, visual acuity, and recognition threshold, illustrating the respective interrelationships between changes in pupil size and concomitant changes in visual acuity and recognition thresholds. The final section presents a summary of the major findings in the literature, followed by presentation of the problems and hypotheses formulated.

## 1. Perceptual Defense Research.

Attempts to relate factors such as motivation, emotions, needs, values, and personality to perception are most evident with the directive-state theorists in the field of perception. One area of research that has persisted in this endeavor since the late 1940's is that of perceptual defense and its counterpart, perceptual vigilance. It is with studies in this field that are found experimental and theoretical attempts to account for the motivation-perception interaction and postulation of a mechanism to account for such a hypothesis. What is perceptual defense and how does it relate to the more basic question of how motivation affects perception? The present section of this review focuses its attention primarily on this question.

The term "perceptual defense" appeared in 1947 in the paper by Bruner and Postman<sup>1</sup> and was also used two years later by McGinnies<sup>2</sup> in the article entitled "Emotionality and Perceptual Defense." With these researches attempts were made to provide empirical and theoretical support for how

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1 J. S. Bruner and L. Postman, "Emotional Selectivity in Perception and Reaction," Journal of Personality, Vol. 16, No. 1, 1947, p. 69-77.

2 E. McGinnies, "Emotionality and Perceptual Defense," Psychological Review, Vol. 56, No. 5, 1949, p. 244-251.

motivation could be a factor influencing perception. Even prior to the birth of perceptual defense a number of experimental investigations illustrated the dynamic or motivational aspects of perceptual behavior. However, it was mainly the above studies that gave birth to the postulation of the perceptual defense mechanism as the process mediating between motivating conditions and perception. Bruner and Goodman's study<sup>3</sup> illustrates how the relation of the value of objects to individual needs affects their perception. A group of ten children from well-to-do homes and another ten children from poor homes estimated coin sizes in denominators of one, five, ten, twenty-five, and fifty cents by altering a circular spot of light so its area appeared equal to the coin sizes. Both groups tended to over-estimate the coin sizes, but more significantly the poor children showed greater overestimation than the rich children.

Brown<sup>4</sup> has defined the term perceptual defense in the following way:

"Perceptual defence" is a descriptive term for any systematic relationship found to hold between stimulus emotionality and the ease of recognition of stimuli.<sup>5</sup>

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3 J. S. Bruner and C. G. Goodman, "Value and Need as Organizing Factors in Perception," Journal of Abnormal and Social Psychology, Vol. 42, No. 1, 1947, p. 33-44.

4 W. P. Brown, "Conceptions of Perceptual Defence," Monograph Supplements, No. 35, of the British Journal of Psychology, 1961, vii-107 p.

5 Ibid., p. 3.

As Brown suggests, this definition is linked to the two distinct findings:

1. The finding that words of an emotionally disturbing character were more difficult to recognize than neutral words were.
2. The finding that words characteristic of a low value area were more difficult to recognize than words characteristic of a high value area were.<sup>6</sup>

Although these findings provided an experimental basis for the definition of perceptual defense, the question remained unanswered of how stimuli were determined as threatening or disturbing without their actual conscious experience. To this issue McGinnies<sup>7</sup> and Lazarus and McCleary<sup>8</sup> responded by postulation of the process of subception or discrimination without awareness. McGinnies presented eight male and eight female subjects with seven neutral words and seven "critical" words that were socially taboo in nature (e.g., "bitch," "whore," "raped") and obtained their recognition thresholds. The galvanic skin response was also recorded. The findings showed the recognition thresholds were longer for the critical than neutral words and that GSRs were greater for the pre-recognition presentations of

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6 Ibid., p. 1.

7 McGinnies, op. cit., p. 244-251.

8 Richard S. Lazarus and Robert A. McCleary, "Autonomic Discrimination without Awareness: A Study of Subception," Psychological Review, Vol. 58, No. 2, 1951, p. 113-122.

the critical words than for the pre-recognition presentations of the neutral words. According to McGinnies:

The findings are interpreted as representing conditioned avoidance of verbal symbols having unpleasant meanings to the observer. The stimulus word serves as a cue to deeply embedded anxiety which is revealed in autonomic activity as measured by the GSR. Avoidance of further anxiety is contemporaneously aroused in the form of perceptual defence against recognition of the stimulus object.<sup>9</sup>

While providing further support for the perceptual defense hypothesis, McGinnies also seemed to be postulating the existence of an unconscious discrimination process within the autonomic nervous system. Lazarus and McCleary<sup>10</sup> have provided further support for such a process with their finding of greater GSR responses to previously "shocked" syllables than those not earlier conditioned with shock.

The above findings have not escaped criticism. A number of authors have argued that the perceptual defense phenomenon can be accounted for in terms of response parameters rather than a strictly perceptual process. Alternative explanations for perceptual defense have thus been proposed in the form of word frequency, response suppression, and response bias. Howes and Solomon<sup>11</sup> were the major proponents of the word frequency issue. Their argument was that the frequency of

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9 McGinnies, op. cit., p. 251.

10 Lazarus and McCleary, op. cit., p. 113-122.

11 D. Howes and R. L. Solomon, "A Note on McGinnies' 'Emotionality and Perceptual Defense'," Psychological Review, Vol. 57, No. 4, 1950, p. 229-234.

usage of the words overrides the affective value of the words used in the experiments. These same authors also drew attention to another issue, namely, that the subjects may have withheld or suppressed their responses to the emotional words because of embarrassment involved in reporting taboo words to the experimenter. Higher thresholds are thus interpreted as due to subjects' suppressing their responses. The greater galvanic skin responses to taboo words could also be seen as related to this feeling of embarrassment. In essence it is suggested that perceptual defense may not be perceptual at all, but rather has its basis in the response probabilities of the individual within a social context. The type of material utilized in the perceptual defense experiments has also been criticized. For example, Brown<sup>12</sup> argues that the taboo words employed are not necessarily anxiety-provoking or threatening to the subjects used.

In his examination of converging operations for perceptual defense, Natsoulas<sup>13</sup> has well illustrated how many researchers have attempted to provide various methods, experimental designs and operations to distinguish the relative contributions of perceptual and response effects in

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12 Brown, op. cit., vii-107 p.

13 Thomas Natsoulas, "Converging Operations for Perceptual Defense," Psychological Bulletin, Vol. 64, No. 6, 1965, p. 393-401.

perceptual defense. In general, the aim has been to illustrate the workings of perception without confounding by other variables. The studies by Blum,<sup>14</sup> Mathews and Wertheimer,<sup>15</sup> Minard<sup>16</sup> and Bootzin and Natsoulas<sup>17</sup> have all attempted to provide possible "pure" measures of perceptual defense separated and unconfounded from response bias effects. Although the methods vary among these researches, they generally attempted to obtain separate measures of perceptual defense and response bias effects, then partial out the influence of the response bias. In the Mathews and Wertheimer<sup>18</sup> experiment, for example, the response bias measure was obtained by use of blank trials in addition to the stimulus trials. Responses to blank trials provided measures of response bias which were then subtracted from measures for stimulus trials that were correctly responded

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14 G. S. Blum, "Perceptual Defense Revisited," Journal of Abnormal and Social Psychology, Vol. 51, No. 1, 1955, p. 24-29.

15 A. Mathews and M. Wertheimer, "A 'Pure' Measure of Perceptual Defense Uncontaminated by Response Suppression," Journal of Abnormal and Social Psychology, Vol. 57, 1958, p. 373-376.

16 J. G. Minard, "Response Bias Interpretation of Perceptual Defense, A Selective Review and an Evaluation of Recent Research," Psychological Review, Vol. 72, No. 1, 1965, p. 74-78.

17 Richard R. Bootzin and Thomas Natsoulas, "Evidence for Perceptual Defense Uncontaminated by Response Bias," Journal of Personality and Social Psychology, Vol. 1, No. 5, 1965, p. 461-468.

18 Mathews and Wertheimer, op. cit., p. 373-376.

to. Positive scores gave support to perceptual defense effect. This approach is still criticized for not adequately distinguishing between perceptual and response effects. The results could also be supportive of the "stimulus-effect hypothesis" that views perceptual defense as a two-stage process: the first involves activation of a conflict by the stimuli, and the second is this generated conflict's effect on response behavior. Thus, defensive behavior might also be seen as occurring at the response level as well.

Another group of researchers including Goldstein,<sup>19</sup> Goldstein, Himmelfarb and Feder,<sup>20</sup> Zajonc,<sup>21</sup> and Ruiz and Kraus<sup>22</sup> has failed to provide evidence of perceptual defense that could not be explained in terms of response bias. Goldstein<sup>23</sup> illustrated that response bias to anxiety-

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19 Michael J. Goldstein, "A Test of the Response Probability Theory of Perceptual Defense," Journal of Experimental Psychology, Vol. 63, No. 1, 1962, p. 23-28.

20 Michael J. Goldstein, S. Himmelfarb and Walda Feder, "A Further Study of the Relationship between Response Bias and Perceptual Defense," Journal of Abnormal and Social Psychology, Vol. 64, No. 1, 1962, p. 56-62.

21 R. B. Zajonc, "Response Suppression in Perceptual Defense," Journal of Experimental Psychology, Vol. 64, No. 3, 1962, p. 206-214.

22 Rene A. Ruiz and Herbert H. Kraus, "Perceptual Defense Versus Response Suppression," Journal of Psychology, Vol. 69, No. 1, 1968, p. 33-37.

23 Goldstein, op. cit., p. 23-28.

provoking words may be sufficient to produce a perceptual defense effect by using a stimulus-absent experimental group. Members of this group were merely shown typewritten hash-marks while led to believe that they were words being presented subliminally. This group, as well as the stimulus-present group, then had to choose a response from an eight-word list containing four neutral and four anxiety-arousing words. The difficulty inherent with such a design, however, is that the subjects in the absent group may believe they perceive a word and thus respond accordingly. Perception may have occurred even in the absence of actually presented stimulus words. Goldstein, Himmelfarb and Feder<sup>24</sup> used emotional-neutral word pairs with subjects required to locate spatially the word asked for by the experimenter. A position response bias was found so that subjects tended to call emotional words on the left and neutral words on the right. There was, however, no indication of the subjects' accuracy of locating emotional versus neutral words. Another difficulty is apparent when subjects have had prior exposure to the stimulus words, since there may occur a prior habituation to the emotional stimuli. Zajonc<sup>25</sup> has used an interesting design by having subjects say a neutral word on recognition

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<sup>24</sup> Goldstein et al., op. cit., p. 56-62.

<sup>25</sup> Zajonc, op. cit., p. 206-214.

of a taboo word and vice versa. Longer recognition thresholds to taboo words could thus be ascribed to perceptual defense since giving the taboo response is eliminated. Likewise, higher thresholds for either neutral or taboo stimuli when a taboo response is required would support the response bias explanation. The results failed to support the perceptual defense effect.

As evidenced by these researchers, all the methodological attempts to separate perceptual and response effects in accounting for perceptual defense have met with continued problems and difficulties that continue to plague this area. Why does this state of affairs exist? Can in fact the two effects be separated? Are there alternative approaches to the problem?

Dixon<sup>26</sup> has very recently attempted to come to grips with some of these questions and has provided a novel theoretical and experimental approach to dealing with the major issues. Dixon suggests that within the perceptual defense paradigm there exists inherent logical difficulties.<sup>27</sup> The major ones involve use of tachistoscopic presentation of the stimuli and, second, the use of the same paradigm for investigating as demonstrating the phenomenon. Use of

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<sup>26</sup> N. F. Dixon, Subliminal Perception: The Nature of a Controversy, London, McGraw-Hill, 1971, xiv-363 p.

<sup>27</sup> Ibid., p. 188-190.

tachistoscopic presentation allows for the possibility of obtaining partial cues regarding what the word is as it is exposed. Such a part-cue response-characteristic model is also suggested by Kempler and Wiener.<sup>28</sup> It is thus extremely difficult to know how much information the subject gains about the stimulus as it is flashed. The second difficulty illustrates the confusion of roles of the stimulus material which not only affects phenomenal representation, but also that which is presented, and that by which the representation is reported. Dixon has also pointed out the complexity of the situation by illustrating the involvement of other systems between the stimulus and response. The three systems involving sensory, judgmental and response all contribute to the outcome and in turn may be affected by such variables as receptor sensitivity as well as past learning and arousal level. Observation of the final outcome may thus be insufficient and must necessarily include preceding events. As an alternative the Awareness Threshold is suggested by Dixon as more advantageous. This would in effect eliminate any bias toward negative report and eliminates the effect the meaning of the stimulus may have on subjective reports.

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<sup>28</sup> Bernhard Kempler and Morton Wiener, "Personality and Perception in the Recognition Paradigm," Psychological Review, Vol. 70, No. 4, p. 349-356.

The basic experimental approach adopted by Dixon<sup>29</sup> to study perceptual defense was to measure change in sensitivity for one eye while stimulus material was presented at subliminal intensities to the other eye. The results tended to confirm that subliminally presented emotional stimuli presented to one eye produced changes in threshold for the other eye. Dixon, however, interprets his results not as showing perceptual defense to be purposive, but rather merely as a gating effect on sensory inflow.

Further questions raised by Dixon are where and how does this gating process occur? Does the change in sensory sensitivity occur at the peripheral or central level? The researches previously cited have not focused on these questions but rather have limited themselves only to the methodology of the perceptual defense phenomenon. As Natsoulas points out, the question of "how the emotional character of the stimulus may have its negative effects upon the perceptual process itself"<sup>30</sup> remains unresolved and may lie in further development of psychological and neurophysiological theory. Hutt also summarizes the problem in a succinct fashion when he suggests that "there are perceptual defence and vigilance effects over and above the effects of

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29 Dixon, op. cit., p. 191.

30 Natsoulas, op. cit., p. 401.

stimulus familiarity and response bias"<sup>31</sup> and has further stated that "there still remains the problem, however, of the process through which motivation influences stimulus threshold."<sup>32</sup>

It is these problems concerning the process and mechanisms involved in affecting changes in sensory thresholds that is to be examined more fully in the following section of this review.

## 2. Pupillary Response as a Plausible Mechanism.

The hypothesis that the pupillary response may be implicated as a process for explaining heightened thresholds to emotionally laden words in perceptual defense studies is examined in this section. First, a physiological interpretation of perceptual defense is presented, followed by a review of studies related to the pupillary response mechanism.

Theoretically perceptual defense can be viewed in terms of psychological threat or anxiety. Approaching the perceptual defense phenomenon in this way, Chodorkoff and Chodorkoff<sup>33</sup> suggest that perceptual defense can be seen as

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<sup>31</sup> L. D. Hutt, Selective Attention: The Relationship between Pupil Size and Recognition, Ph.D. thesis, Ann Arbor, Michigan, University Microfilms, 1970, p. 21.

<sup>32</sup> Ibid., p. 21-22.

<sup>33</sup> B. Chodorkoff and J. Chodorkoff, "Perceptual Defense: An Integration with Other Research Findings," Journal of General Psychology, Vol. 58, January 1958, p. 75-80.

a negative feedback process involving the reticular formation. It is possible, therefore, that threatening stimuli would not reach awareness as a result of the reticular formation's suppressing or inhibiting action on the receptor modalities. The authors point out the importance of such feedback loops in affecting recognition when they state:

Threatening stimuli may be discriminated by the individual before he fully recognizes them, because the affective reaction of fear or anxiety precedes recognition. Alterations in recognition thresholds are affected as a consequence of the affective reaction and are mediated by feedback loops. Thus, the feedback loop between autonomic discharge and perception acts to decrease or increase exteroceptive input i.e. raised or lowered recognition thresholds, so that there will be decreased or increased awareness of and reactivity to threatening stimuli.<sup>34</sup>

It is thus apparent that thresholds within particular sense modalities at the peripheral level may be increased resulting in decreased awareness of external threatening stimuli.

Dixon<sup>35</sup> has also provided a more recent model to account for perceptual defense in terms of where perceptual defense effects can be mediated. The flow diagram as illustrated on page 15 illustrates five possible regulator channels. Channels 1 and 2 are dependent upon conscious perception of at least partial cues and may affect sensory

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<sup>34</sup> Ibid., p. 77.

<sup>35</sup> Dixon, op. cit., p. 256.

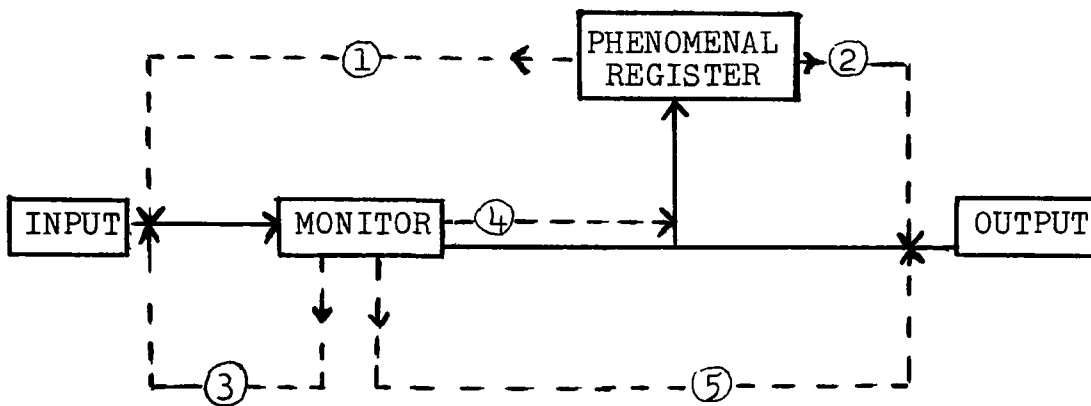


Figure 1.- Flow Diagram for the Perceptual Defence Effect.

N. F. Dixon, Subliminal Perception: The Nature of a Controversy, London, McGraw-Hill, 1971, p. 256.

inflow or response decision processes. Channel 3 involves centrifugal peripheral gating, but this is rejected on logical grounds as the main principle underlying the perceptual defense effect. Channel 5 can affect response processes but would not account for perceptual defense based on changes in sensory sensitivity. With channel 4 the results of pre-awareness discrimination act "forwards" (in time) upon the processes underlying phenomenal representation of the stimulus. This last site of regulation is favored by Dixon on the basis of logical, behavioral and physiological evidence. Thus, three possible explanations for the perceptual defense effect are presented: (1) a reduction in sensitivity of the peripheral receptor (centrifugal control of peripheral receptor); (2) a central filter process involving blockage of threatening as well as other material (central gating of sensory inflow); and (3) a central mechanism involving changes in criteria for decisions based upon cognitive experiences. Although evidence exists to support peripheral gating out of stimuli, Dixon suggests the central mechanisms may be more important and thus favors the higher level in explanation of perceptual defense effects.

In addition to the regulatory functions performed by the peripheral and cortical receptor areas are the reticular activating system and other centers in the hypothalamus and nuclei that are involved in mediation of emotional processes

in the limbic cortex. The division in the central nervous system of the classical sensory pathways and non-specific diffuse projection system of the reticular formation makes it more plausible that stimuli may be projected to primary cortical areas but not necessarily reach the level of awareness or recognition. Dixon's physiological model on page 18 shows how some of these mechanisms may be interrelated. The P1 projection illustrates how sensory information may be carried along the classical afferent pathways but conscious awareness is impeded as a result of insufficient activation from the reticular activating system (P2). Discrimination without awareness might also be related to insufficient duration or intensity of the stimulus to activate the reticular formation (P3). Cortical control over the reticular formation via cortico-reticular projection, P4, may also account for heightened or lowered thresholds for emotional stimulus material. Integrating this model for perceptual defense and the evidence he has presented, Dixon provides the following summary:

Summarizing the data, from these various sources, it seems first, that the cortex can respond differentially to the meaning of stimuli which are too weak, or too brief, to elicit phenomenal representation, second, that the outcome of such "discriminations" may affect memoric, emotive, and covert response processes, third, that awareness of the stimulus and its sequelae depends upon a certain minimum level of interaction between specific and non-specific sensory effects and, fourth, that the latter depends partly upon the general level of activation, partly upon signal strength, and partly upon cortico-reticular interaction.<sup>36</sup>

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<sup>36</sup> Ibid., p. 278.

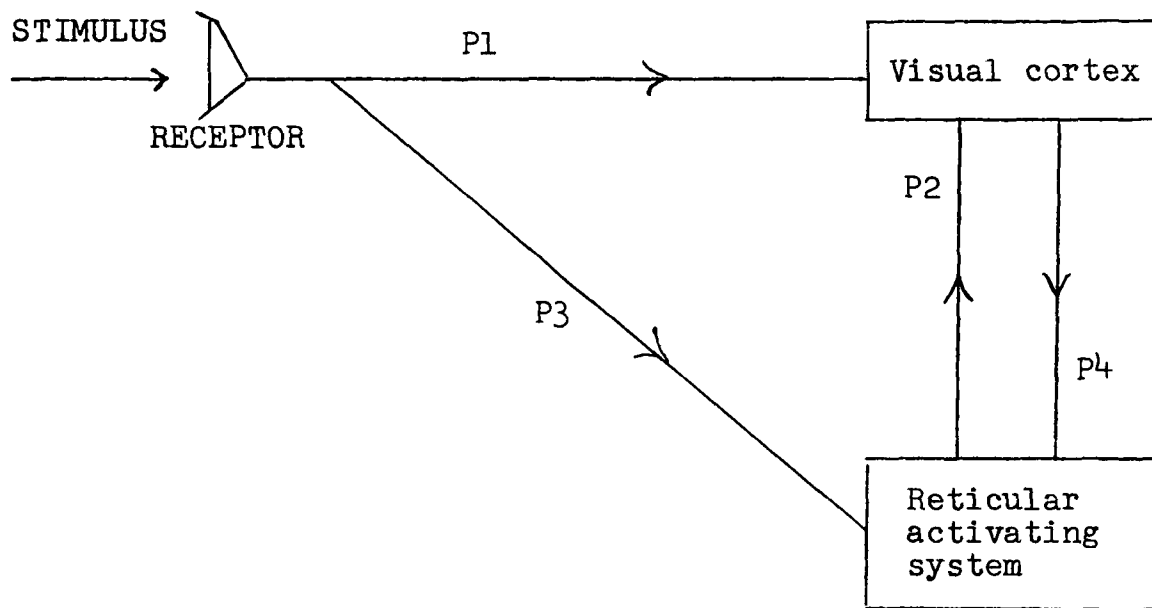


Figure 2.- Possible Physiological Model for Perceptual Defence.

N. F. Dixon, Subliminal Perception: The Nature of a Controversy, London, McGraw-Hill, 1971, p. 272.

It is apparent from these models and statements that the long debated phenomenon of "discrimination without awareness" may indeed have possible justification on the basis of more extended and complex physiological processes. It is now certainly not to be dismissed lightly as an impossible or illogical explanation for the perceptual defense effect.

Other evidence has been presented to show how the receptor process in one sense modality can be interfered with by presentation of stimuli to another sense modality so as to prevent sensory messages from reaching awareness or consciousness. The reticular formation is involved in this process as a selective central inhibitory mechanism that operates for filtering sensory impulses. In the experiment by Hernandez-Peon, Scherrer and Jouvets<sup>37</sup> electrical impulses were recorded from the cochlear nucleus of cats and delivered to loudspeakers near the cats while they were exposed to three types of stimulus to attract the animal's attention. Presentation of visual stimuli (two mice in a closed bottle) resulted in a reduction in auditory responses in the cochlear nucleus compared to previous control

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<sup>37</sup> R. Hernandez-Peon, H. Scherrer and M. Jouvets, "Modification of Electrical Activity in the Cochlear Nucleus during 'Attention' in Unanesthetized Cats," Science, Vol. 123, 1956, p. 331-332.

responses. Removal of the mice led to a return to auditory responses characteristic of the control periods. In conclusion, the authors explain the possible role of a central inhibitory mechanism that excludes sensory messages from perception and consciousness when they state the following:

The present observations suggest that the blocking of afferent impulses in the lower portions of a sensory path may be a mechanism whereby sensory stimuli out of the scope of attention can be markedly reduced while they are still in their trajectory toward higher levels of the central nervous system. This central inhibitory mechanism may, therefore, play an important role in selective exclusion of sensory messages along their passage toward mechanisms of perception and consciousness.<sup>38</sup>

Pribram's<sup>39</sup> neurophysiological model of emotion provides further support for a possible gating out of stimuli which may have aroused or initiated disturbing emotional states, by means of preparatory processes that eradicate perturbation and re-equilibriate the organism. In discussing psychopathy, Hare<sup>40</sup> hypothesizes the disorder is related to this "operation of inhibitory defensive mechanisms that exert control over sensory input that would ordinarily

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38 Ibid., p. 332.

39 K. H. Pribram, "Emotion: Steps toward a Neuropsychological Theory," in D. C. Glass (ed.), Neuropsychology and Emotion, New York, Rockefeller University Press and Russell Sage Foundation, 1967, p. 3-40.

40 Robert D. Hare, Psychopathy: Theory and Research, New York, Wiley, 1970, x-138 p.

have disturbing consequences."<sup>41</sup> Psychopaths thus would tend to "tune out" or "selectively modulate input" that would be potentially disturbing.

From these theoretical models and evidence it can be concluded that there is some support for the postulation of a type of peripheral gating process that may play a role in the perceptual defense process. It is apparent that a multitude of complex physiological mechanisms are involved in such a process. However, for purposes of the present research, the concern is mainly how the pupillary response as one of these mechanisms may be involved. More specifically the question raised is whether visual recognition thresholds can be heightened or lowered as a result of changes in the pupillary response.

The researches of Hess<sup>42</sup> and Hess and Polt<sup>43</sup> concerned with the pupillary response as a psychological measure may serve to further enlighten the role the pupillary response may have in the perceptual defense effect. When viewing emotionally stimulating or interesting stimuli, subjects

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<sup>41</sup> Ibid., p. 35.

<sup>42</sup> Eckhard Hess, "Attitude and Pupil Size," Scientific American, Vol. 212, No. 4, April 1965, p. 46-54.

<sup>43</sup> Eckhard Hess and James M. Polt, "Pupil Size as Related to Interest Value of Visual Stimuli," Science, Vol. 132, No. 3423, August 1960, p. 349-350.

are generally found to show pupillary dilation. Hess and Polt<sup>44</sup> have reported that men show greater pupillary dilation responses to pictures of nude females, while females showed greater dilation to pictures of a baby, mother and baby, and nude male. Hess, Seltzer and Shlien<sup>45</sup> also reported differential pupil responses for male hetero- and homosexuals with the homosexuals exhibiting greater pupillary responses to pictures of nude males than nude females, whereas the reverse was true for the heterosexuals. Besides dilation, Hess<sup>46</sup> has also indicated finding pupillary constriction responses to unpleasant stimuli such as sharks, dead bodies, and cross-eyed children. Because of such observations, Hess contends that "constriction is as characteristic in the case of certain aversive stimuli as dilation is in the case of interesting or pleasant stimuli."<sup>47</sup>

Individuals, however, tend to respond somewhat differentially to such negatively aversive pictorial stimuli. Some subjects initially respond with pupillary dilation, but with repeated exposures pupil response is negative. Hess

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<sup>44</sup> Ibid., p. 349-350.

<sup>45</sup> Eckhard Hess, Allan L. Seltzer and John M. Shlien, "Pupil Response of Hetero- and Homosexual Males to Pictures of Men and Women: A Pilot Study," Journal of Abnormal Psychology, Vol. 70, No. 3, p. 165-168.

<sup>46</sup> Hess, op. cit., p. 46-54.

<sup>47</sup> Ibid., p. 48.

maintains that the reason pupillary response is so often found to be positive is because of the increased autonomic activity, shown by GSR changes, that dilates the pupils. With diminishing autonomic activity there is diminished dilation and the negative pupil response is more evident. An unpublished experiment cited by Hess<sup>48</sup> presents some evidence to support the constriction hypothesis. After being hypnotized, subjects were shown some blank slides. They were instructed that one of the slides was an extremely pleasant picture, while another was unpleasant and distasteful. The former instruction illicited dilation while the latter resulted in constriction of the pupils. Under a no instruction condition, subjects' pupils showed no changes.

Following the findings of Hess and his associates, that the pupil generally dilates to pleasant stimuli and constricts to unpleasant stimuli, Hutt and Anderson<sup>49</sup> have suggested the pupil response as a plausible mechanism of perceptual defense and have offered some support for the constriction hypothesis. The mechanism is described as operating in the following manner:

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48 Eckhard Hess, "Pupillometrics: A Method of Studying Mental, Emotional, and Sensory Processes," in Norman S. Greenfield and Richard A. Sternback (eds.), Handbook of Psychophysiology, New York, Holt, Rinehart & Winston, 1972, p. 491-531.

49 L. D. Hutt and J. P. Anderson, "The Relationship between Pupil Size and Recognition Threshold," Psychonomic Science, Vol. 9, No. 8, 1967, p. 477-478.

It seems plausible to suppose that taboo words used in perceptual defense studies initiate pupil contraction, thus admitting less light into the eye and raising recognition threshold, i.e. perceptual defense. Conversely, pleasant stimuli initiate pupil dilation, thus admitting more light into the eye and perhaps lowering recognition threshold, i.e. perceptual vigilance.<sup>50</sup>

Forty introductory psychology students, 20 males and 20 females, were exposed to twelve words ranging in emotional connotation--taboo, pleasant, and unpleasant. Each of the emotional words was paired with a neutral word matched in terms of frequency and structural characteristics. The first part of the experiment consisted of recording pupil size while subjects viewed the words each for a period of ten seconds. After pupillometric presentation, the same words were presented tachistoscopically using an ascending method of limits. Using pupil size and recognition threshold data to neutral words as their baseline, the authors compared this standard with pupil size and recognition threshold of the paired emotional words. Mean pupil diameter and mean recognition threshold for the neutral word pair were compared to the mean pupil diameter and mean recognition threshold for the emotional word pair resulting in pupil size difference scores and recognition threshold difference scores for each word pair and for each subject. Using these difference scores

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<sup>50</sup> Ibid., p. 477.

for pupil size and tachistoscopic recognition threshold for emotional and neutral words, the authors obtained a small but significant negative correlation of  $-.189$ , supporting their hypothesis of pupillary dilation and constriction as factors in perceptual defense. Such a finding implicates the pupillary constriction response as an avoidance mechanism for gating out emotionally threatening or unpleasant stimuli, but does not necessarily prove that changes in pupil size cause variations in recognition thresholds. Goldwater has suggested that Hutt and Anderson provide "no independent evidence to show that subjects actually showed pupillary constriction to emotional words."<sup>51</sup> Lehr and Bergum<sup>52</sup> also found pupil size associated with "very pleasant" pictorial stimuli to be significantly greater than that associated with "unpleasant" stimuli. Although a constriction response is implied, Goldwater<sup>53</sup> again notes that there is no evidence presented for constriction to the unpleasant stimuli.

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<sup>51</sup> Bram C. Goldwater, "Psychological Significance of Pupillary Movements," Psychological Bulletin, Vol. 77, No. 5, 1972, p. 340-355.

<sup>52</sup> D. J. Lehr and B. Bergum, "Objective Measures of Program Appeal," National Society for Programmed Instruction Journal, Vol. 5, 1966, p. 7-10.

<sup>53</sup> Goldwater, op. cit., p. 340-355.

Tanck and Robbins<sup>54</sup> have found that persons who exhibit tension in the area of aggression show pupillary contraction when viewing aggressive stimuli. Thirty female students were given three personality measures, the Dream Incident Technique (DIT), the Edwards Personal Preference Schedule (EPPS), and the Repression-Sensitization Scale (RS). Each subject was also exposed to experimental video-tape scene presentations portraying themes of sex, aggression, achievement, affiliation, nurturance, dominance, and order. Pupil responses were recorded while subjects viewed the scenes, and were correlated with scores on the personality measures. Significant positive correlations between DIT measures of nurturance, sex, and achievement, and pupil responsiveness were found. Tension in these areas seems to produce an orienting or approach response. Of importance is the finding of a negative correlation of  $-.60$  between the DIT aggression measure and pupillary dilation to the aggression scenes. The interpretation of this finding suggests that aggression possesses strong negative social valence relative to other motives. Persons with aggressive problems would find such stimuli discomforting and thus

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<sup>54</sup> Roland H. Tanck and Paul Robbins, "Pupillary Reactions to Sexual, Aggressive, and Other Stimuli as a Function of Personality," Journal of Projective Techniques and Personality Assessment, Vol. 34, No. 4, 1970, p. 277-282.

would avoid them. Pupillary contraction is seen here as a possible avoidance response and is congruent with theory and research that postulates avoidance as a defensive reaction to anxiety. The authors thus suggest that their findings are consistent with the perceptual defense hypothesis.

In his investigation of pupillary size as an index of preference, Barlow<sup>55</sup> has also found a constriction response. Using five male subjects, photographs ranging from most pleasant to least pleasant were presented while pupil size was recorded. It was found that subjects' pupils dilated for the most pleasant and constricted for the least pleasant of positive stimuli which consisted of semi-erotic photographs. Similarly, for neutral stimuli consisting of photographs of houses, pupils dilated for the most pleasant and constricted for the least pleasant. Aversive stimuli, comprising news photographs of starving or injured, resulted in pupillary constriction with only a few exceptions. Another study by Barlow<sup>56</sup> using pupil size as an indicator of political preference also revealed pupil constriction. Three groups

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<sup>55</sup> J. D. Barlow, "Pupillary Size as an Index of Preference," Perceptual and Motor Skills, Vol. 31, 1970, p. 331-336.

<sup>56</sup> -----, "Pupillary Size as an Index of Preference in Political Candidates," Perceptual and Motor Skills, Vol. 28, 1969, p. 587-590.

of subjects classified according to their political preferences of white conservative supporters of George Wallace, white liberal supporters of Lyndon Johnson, and Negro supporters of Lyndon Johnson were shown slides of these respective leaders as well as slides of Martin Luther King and an unidentified white subject. Subjects from the white conservative preference group exhibited pupillary dilation to the George Wallace slide, but pupillary constriction to the slides of Johnson and King. Both the white and Negro liberal political preference groups showed pupillary constriction to the Wallace slide, but pupillary dilation to the slides of Johnson and King.

From these studies it is apparent that pupillary dilation is associated with preferred or positively valued stimuli, while the constriction response is related to non-preferred or negatively valued stimuli.

Some studies using stimuli other than pictorial presentation of stimulus material have also found dilation to pleasant stimuli and constriction to unpleasant stimuli. While investigating the effect of stimulus size on pupil variations, Polt and Hess<sup>57</sup> found individual subjects responded with both dilation and constriction responses. The

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<sup>57</sup> J. M. Polt and Eckhard Hess, "Changes in Pupil Size to Visually Presented Words," Psychonomic Science, Vol. 12, No. 8, 1968, p. 389-399.

stimuli consisted of four words: hostile, squirm, flay, and nude. Analysis of individual rather than group pupillary responses revealed both dilation and constriction. The authors suggest that in a study by Paivio and Simpson<sup>58</sup> this individual response becomes obscured with the combination of subject and/or stimuli for analysis. The constrictive response is thus viewed as a highly individualistic response that makes it difficult to generalize as to what constitutes a "negative" stimulus. Polt and Hess suggest that the pupillary response may thus be related to perceptual defense and vigilance by stating the following:

Constriction, as an individual phenomenon, could be related to perceptual vigilance [...]. If the nature of the arousal associated with the word is threatening, the reaction could well involve "shutting out" the stimulus via pupillary constriction.<sup>59</sup>

Such a conclusion is congruent with Hutt and Anderson's finding of a negative correlation between pupil size and recognition threshold.

Guinan<sup>60</sup> has also investigated the relationship between pupil size and emotional words. Three words having

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58 A. Paivio and H. M. Simpson, "The Effect of Word Abstractness and Pleasantness on Pupil Size during an Imagery Task," Psychonomic Science, Vol. 5, No. 2, 1966, p. 55-57.

59 Polt and Hess, op. cit., p. 390.

60 J. E. Guinan, "An Investigation on the Relationship between Pupil Size and Emotional Words," Dissertation Abstracts International, Vol. 27 (9-B), 1966, p. 3286-3287.

the lowest and highest "emotionality scores," as determined by GSR measures and the Semantic Differential, were presented to twenty-eight subjects for a period of five seconds. Mean pupil size recordings for twenty-seven out of the twenty-eight subjects were found to be larger to the emotional than neutral words. Analysis of the significant interaction between time and emotionality revealed no significant difference in pupil sizes to emotional and neutral words during the first 2.5 second interval. However, there was significantly greater pupil size differences to emotional than to neutral words during the latter 2.5 seconds. Although this study illustrates that emotional and neutral words may have a differential effect on pupil size there is no real support for the constriction response. Instead a greater pupillary dilation to emotional words is interpreted as "a measure of generalized autonomic response to emotionally meaningful stimuli."<sup>61</sup>

Although the bidirectionality nature of the pupil response has been seriously challenged, Hess<sup>62</sup> still contends that pupil size changes in two opposite directions, with positive affect yielding dilation and negative affect resulting in constriction. The constriction response, as seen from the studies just reviewed, has been found mainly under

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61 Ibid., p. 3287.

62 Hess, op. cit., 1972, p. 491-531.

conditions where stimuli are pictorially presented. Attempts to replicate the findings of Hess<sup>63</sup> using pictorial stimuli have largely met with contradictory results. Woodmansee<sup>64</sup> argues that there is no other physiological indicators of emotion that possess this bidirectional characteristic. In his study a group of "equalitarian" (N=11) and a group of "Anti-Negro" (N=11) college females were compared on their pupillary responses to four "Negro-content" photographs. Using a repeated trials design, it was found that on the first presentation of the stimuli the anti-Negro subjects had an average PR of -0.10%, whereas the equalitarian group had an average PR of -2.65.<sup>65</sup> Five anti-Negro subjects had average constriction responses but only one equalitarian subject gave a constriction response. These results agree with Hess but when the data were averaged across all eight presentations of the stimuli the groups did not differ. The discrepancy between the first trial results and the remaining trials is explained in terms of changes in the nervous system arousal. Woodmansee states:

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63 Hess, op. cit., 1965, p. 46-54.

64 J. J. Woodmansee, "An Evaluation of Pupil Response as a Measure of Attitude toward Negroes," Dissertation Abstracts, Vol. 26, 1966, p. 6896-6897.

65 PR is the change in pupil diameter from the presentation of a control picture to the presentation of the succeeding Negro content stimulus, expressed as a per cent of pupil diameter during the control picture.

Pleasant stimuli cause the arousal system to be excited and the pupillary dilator muscle to be activated. The anticipation of an unpleasant stimulus also causes the arousal system to be excited with concomitant expansion of the pupil, but the actual presence of the disliked stimulus serves as a relief from the excited anticipation. This latter sequence results in an apparent constriction response which is in reality the relaxation of the dilator muscle.<sup>66</sup>

Since Woodmansee obtained the affect-related response early in the presentation of the stimuli, it is possible that the response diminished later in subsequent trials due to pupillary adaptation effect found by Lehr and Bergum.<sup>67</sup> Over a series of trials the pupil size thus would be expected to decline, consequently cancelling out any effect the individual constriction responses may have when the data are analyzed across all trials for all subjects.

Another study using pictorial stimuli also challenges the findings of Hess. Peavler and McLaughlin<sup>68</sup> designed an experiment to determine if dilation responses could overcome increase in luminance utilizing pictorial stimuli. Four male and four female college students were presented with pictorial

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<sup>66</sup> Woodmansee, op. cit., p. 6897.

<sup>67</sup> D. J. Lehr and B. Bergum, "Note on Pupillary Adaptation," Perceptual and Motor Skills, Vol. 23, 1966, p. 917-918.

<sup>68</sup> W. S. Peavler and J. P. McLaughlin, "The Question of Stimulus Content and Pupil Size," Psychonomic Science, Vol. 8, No. 12, 1967, p. 505-506.

stimuli depicting (a) a champagne glass, (b) a Picasso painting of horses, (c) a movie actress, and (d) a female nude "pin-up." Control stimuli (blank slides) were 0.6 ft-c less in over-all illumination compared to the test stimuli. Thus, a constriction response would be expected to the test stimuli as a result of the greater amount of light falling on the retina. The opposite, however, was found, with significantly greater dilation to the pictorial stimuli with the nude stimulus resulting in significantly greater pupillary responses compared to the other test stimuli. The results have important implications since they suggest that a dilation response to provocative and psychologically significant stimuli can override a constriction response that might be expected with increases in luminance. It seems quite possible then that the impact of psychological stimuli on pupillary response can outweigh the impact of the physical characteristics of the stimulus.

Tinio and Robertson<sup>69</sup> have found that subjects dilated rather than constricted to stimuli suggestive of hostility. Two groups of subjects were employed, one a

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<sup>69</sup> Fillipinas Tinio and Malcolm Robertson, "Examination of Two Indices of Hostility: Fantasy and Change in Pupil Size," in Proceedings of the 77th Annual Convention of the American Psychological Association, Washington, D.C., American Psychological Association, Vol. 4, 1969, p. 173-174.

High Hostility (HH) group and the other a Low Hostility (LH) group. These groups were exposed to five hostility cards from the TAT and five control cards also from the TAT. Mean pupil sizes were recorded over a period of three trials (1 second after slide presentation; after 5 more seconds; and 10 seconds after the subject started his story to the slide) for the hostile and control cards for each subject. As expected, the HH group had significantly higher hostility scores on the hostile cards than the LH group, but the two groups failed to differ significantly in pupil response on either the hostile or control cards. For both groups the hostile cards illicited significantly more dilation, not constriction, than did the control cards. As noted by the authors, their results bring into question previous findings of pupillary dilation to positive stimuli and constriction to negative stimuli. In explaining their results, they note that the stimuli used may not have been unpleasant for many college males used, and the more demanding task for subjects on the hostile cards could have produced the greater dilation. Subjects' verbalizations of their stories could also have inflated pupillary dilation scores.

Another study employing pictorial stimuli that has failed to support the bidirectionality of the pupillary

response is that by Nunnally et al.<sup>70</sup> Nine slides of affect-related pictures varying from very pleasant to very unpleasant on a nine-point scale were shown to thirty subjects. Examples of a neutral slide included a middle-aged woman sitting in a flower garden; a positive slide, the face of a pretty female fashion model; a negative slide, a man with a cancerous growth on his face. The results showed mean pupil size for the positive stimuli was significantly larger than for neutral stimuli. However, there was no significant difference for the neutral and negative stimuli. Lack of such a difference calls into question the existence of a constriction response to negative stimuli.

Not only have experiments employing pictorial stimuli failed to validate the bidirectional nature of the pupillary response, but other studies utilizing non-pictorial and non-visual stimuli have failed to confirm such a conclusion. Paivio and Simpson,<sup>71</sup> in using pleasant and unpleasant words, did not find any significant difference in pupil responses. Subjects were exposed to six concrete and six abstract nouns with half of each group rated as pleasant and the other half

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70 J. C. Nunnally, P. D. Knott, A. Duchnowski, and R. Parker, "Pupillary Response as a General Measure of Activation," Perception and Psychophysics, Vol. 2, 1967, p. 149-155.

71 Paivio and Simpson, op. cit., p. 55-57.

rated as unpleasant. The effects of the pleasantness-unpleasantness were insignificant. Hess argues that constriction effects to the unpleasant words may have been inhibited as a result of the mental activity involved in the imagery task. The effect elicited by the words may thus be quite different from that elicited by pictorial stimuli. This might account for the tendency not to find constriction responses when other mental tasks are required of the subject.

Peavler and McLaughlin,<sup>72</sup> in another experiment, investigated the bidirectional nature of the pupillary response as an indicator of positive and negative affect of visually presented material. Stimuli were derived from one hundred nouns rated on seven-point scales for the dimensions of "bad-good" and "neutral-very important." The ratings were then compiled and divided into three levels of low, medium, and high. For each of the fifty college women involved in the ratings, 3 X 3 matrices were compiled. Nineteen subjects who had one word in each cell were chosen to participate in the study with their individual words serving as stimuli for each of them. Control stimuli (five Xs) and test stimuli were displayed by use of slides. Comparison of mean diameters and percentage change in pupil size of control and test slides proved insignificant. Also, no relationship was

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72 Peavler and McLaughlin, op. cit., p. 505-506.

found between pupil diameter and rated level of words on the two scaled dimensions. From this study there would seem to be little relationship between pupil diameter and rated pleasantness of words. Such findings again raise questions regarding the constriction response to negative stimuli. It is possible that the stimuli used in the study were not potent enough to produce either dilation or constriction responses. Peavler and McLaughlin also suggest that Hess's results may be artifactual and constriction may be related more to inflation of the control baseline level.

Using thirty-six stimuli consisting of both verbal and pictorial material, Collins, Ellsworth and Helmreich<sup>73</sup> related changes in pupil size and ratings on the three semantic differential dimensions. Eight Yale undergraduates rated the stimuli using fourteen polar adjectives on the evaluative, activity and potency dimensions and were exposed to the stimuli while pupil size was recorded. For each subject, correlations between pupil size and the semantic differential ratings were computed, as well as pooled within-class correlations for all eight subjects. The correlations yielded a significant positive correlation between pupil size

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<sup>73</sup> B. E. Collins, P. C. Ellsworth and R. L. Helmreich, "Correlations between Pupil Size and the Semantic Differential: An Experimental Paradigm and Pilot Study," Psychonomic Science, Vol. 9, No. 12, 1967, p. 627-628

and the potency scale of the semantic differential, but only for pictorial stimuli and not for the verbal attitude statements. Extrapolating from Hess's findings of pupil dilation to preferred political candidates, the authors suggest pupil size should be correlated with the evaluative dimension (good-bad) of the semantic differential. Contrary to this suggestion, the evaluative dimension was not found to be related to changes in pupil size. In addition, an opposite trend was observed with a pattern of greater dilation in response to stimuli rated as potent. The authors suggest such results may not be totally inconsistent with Hess since "pin-up" pictures and favored political candidates may be considered as potent stimuli thus producing increased pupil sizes.

Vacchiano et al.<sup>74</sup> have examined the effect of value-linked words on the pupillary response. Following the perceptual defense literature which suggests personal values affect recognition thresholds of low and high valued words, it was hypothesized that high valued words would illicit dilation whereas low valued words should illicit constriction. Thirty-six words representing each of the six values measured

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<sup>74</sup> Ralph B. Vacchiano, P. S. Strauss, S. Ryan and L. Hochman, "Pupillary Response to Value-linked Words," Perceptual and Motor Skills, Vol. 27, No. 1, 1968, p. 207-210.

by the Allport Vernon Lindzey Study of Values were presented to twelve subjects. Nine trials with two words per trial were presented for a period of ten seconds during which the subject was told to concentrate on the meaning of each word. Using a number of measures of pupil size to the high, low, and neutral value words, the study failed to find any consistent relationship between pupil size and word value. It is possible, however, that the instructions asking subjects to concentrate on the meaning of the words could have produced ongoing mental activity that would produce greater pupillary dilation, thus overriding any constriction effect that might appear. Another problem raised by the authors is their presentation of word pairs where high and low value words were paired together but never with neutral words. Thus, because of possible interest aroused by the high and low words compared to the neutral words there would have been a "spurious similarity in responses."

Nunnally et al.,<sup>75</sup> instead of using unpleasant or negative pictorial and verbal stimuli, employed anticipation of gunshot while recording pupil size changes. Subjects were instructed that a gunshot may or may not be fired at the number 3 during presentation of a series of numbers ranging from 1 to 5. The gunshot was fired prior to the

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75 Nunnally et al., op. cit., p. 149-155.

experiment to show the subject what it sounded like, but in fact was never fired during any presentation of the number sequences. The threat of the gunshot clearly showed large increases in pupil size prior to when the gunshot was expected to fire (number 3). Dilation then decreased significantly for the remainder of the sequence. Although gunshot might be interpreted as a noxious stimulus and thus would be expected to produce a constriction response, the findings of the study predicted the opposite. However, it is possible that with such a strong stimulus expected, subjects were responding with a form of orienting reaction which would certainly lead to dilation. Although the results would seem to challenge Hess, it is questionable if the assumption can be made that the stimuli of gunshot is noxious but one that is startling and would lead to a very strong orienting reflex.

The constriction response to negative stimuli also has been seriously questioned on the basis of physiological evidence and certain methodological difficulties.

Constriction seems to run contrary to the position that emotional reactions, whether positive or negative, result in predominantly sympathetic arousal of the autonomic nervous system, thus eliciting pupillary dilation. Loewenfeld<sup>76</sup>

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<sup>76</sup> I. E. Loewenfeld, "Pupil Size," Survey of Ophthalmology, Vol. 11, 1966, p. 291-294.

contends that all sensory and psychological stimuli dilate the pupil with the exception of light which can constrict it. Lowenstein and Loewenfeld<sup>77</sup> have concluded also that cortical, thalamic and hypothalamic impulses produced by sensory and emotional stimuli will result in dilation due to their inhibiting effect on the pupillary sphincter. In most cases it would seem the dilation pupillary response predominates over the constriction response. Is it possible that since the dilation response is much stronger, any constriction response is inhibited and thus not observed? This has been suggested already in studies of pupillary response where mental activity can inhibit constriction and the response recorded is thus one of dilation. The stimuli used would thus seem to require a strong enough impact to produce a constriction response that would override the dilation response. A study by Hakerem and Sutton<sup>78</sup> examining pupillary response at visual thresholds suggests such a situation is possible at least for light stimuli. Their conclusions are the following:

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<sup>77</sup> Otto Lowenstein and Irene E. Loewenfeld, "The Pupil," in H. Davson (ed.), The Eye, New York, Academic Press, Vol. 3, 1962, p. 231-267.

<sup>78</sup> Gad Hakerem and Samuel Sutton, "Pupillary Response at Visual Threshold," Nature, Vol. 212, 1966, p. 485-486.

The data also indicates that the mechanisms which control pupillary contraction are less sensitive and therefore require more energy, than the mechanisms which control pupillary dilation. At low energy levels a dilation is obtained when the light is seen. This may be related to the fact that the light is acting as a signal. This interpretation is supported by the fact that dilation is the response of the pupil to all other sensory stimuli. At somewhat higher energy levels the contraction system as a higher response to light comes into play, and when the light is seen the contraction may be found riding on the dilation response. At still higher energy levels the contraction is longer and swamps the dilation response.<sup>79</sup>

From this is it not possible that a similar phenomenon occurs with psychological stimuli? With potentially strong arousing emotional stimuli, could not the constriction response reach a higher energy level and thus swamp the dilation response? The analogy would seem appropriate. This may also explain some of Hess's findings with strong aversive stimuli. Stimuli classified as unpleasant or negative in many studies may not have been potent enough to illicit a constriction reaction since dilation would predominate. This may also partially account for some of the contradictory evidence in these studies examining the bidirectional nature of the pupil. The physiological mechanisms that may be involved in such a process are not yet fully known but with the complexity of the eye, subcortical and cortical structures, such a process might not be totally disregarded.

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79 Ibid., p. 486.

The inconsistency in the pupillary response research may be related also to certain methodological problems inherent in designing the experiments. Woodmansee<sup>80</sup> points out that a major weakness with Hess's postulation of constriction is that he has found it only with pictorial stimuli and has not replicated the aversion-constriction hypothesis with non-visual stimuli, such as distasteful liquids or unpleasant music. Employing visual displays confounds the physical characteristics of the stimuli with their psychological characteristics. Because of influences of the light reflex, focusing attention on different parts of the stimulus could affect constriction of the pupil if certain areas are brighter than others. The continually shifting character of the pupil due to shifts in arousal state can have an effect on the basal pupil size. The basal pupil size observed in control periods thus is not constant and changes throughout the experiment. Comparisons of this basal pupil size with pupil size during the test period thus can affect the recordings of dilation or constriction. The near-vision reflex or accommodation effects can also influence pupil size. Pupil constriction coincides with convergence of the eyes and accommodation of the lens while viewing near objects.

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80 J. J. Woodmansee, "Methodological Problems in Pupillographic Experiments," in Proceedings of the 74th Annual Convention of the American Psychological Association, Washington, D.C., American Psychological Association, Vol. 1, 1966, p. 133-134.

As a result of some of these control difficulties in using visual stimuli, their use in studies exploring the psychological implications of emotional stimuli on pupil size is questioned. There are ways to circumvent some of these problems, as illustrated by Woodmansee<sup>81</sup> and Goldwater,<sup>82</sup> but the results must still be interpreted with caution.

The present section of this review has explored the possible involvement of the pupillary response as a plausible mechanism to account for the differential recognition thresholds to affective stimuli of perceptual defense studies. The dilation-constriction hypothesis to account for pupillary reactivity to affectively toned stimuli provides the basis for such a postulation. The studies reviewed here provide contradictory results with respect to the bidirectional nature of the pupil response. However, the possibility still remains that the constriction response may be seen as avoidance of emotionally threatening stimuli. The next section of this review continues to explore how pupil size may be implicated as a mechanism of perceptual defense, specifically through its effects on visual acuity and recognition threshold.

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81 Ibid., p. 133-134.

82 Goldwater, op. cit., p. 344.

### 3. Pupil Size, Visual Acuity, and Recognition Thresholds.

It is possible that through the effects of pupillary dilation and constriction on visual acuity, i.e., tachistoscopic recognition threshold, the pupil is implicated as a mechanism in perceptual defense. Visual acuity is the spatial resolving capacity of the visual system. Since tachistoscopic recognition thresholds also reflect resolving capacity under brief exposure durations, the pupillary response could be an important determinant of obtained recognition thresholds. If the stimulus material used in perceptual defense studies illicitly an emotional response from the subject, changes may occur in pupillary diameter which would either enhance or interfere with visual acuity and correspondingly reduce or increase recognition thresholds. An aversive stimulus illicitly a constriction response would thus reduce visual acuity and raise recognition thresholds. A pleasant stimulus illicitly a dilation response would increase visual acuity and lower recognition thresholds. Such a general conclusion must, however, be qualified within certain limits of pupil size.

There is widespread agreement among researchers such as Cobb,<sup>83</sup> Leibowitz,<sup>84</sup> Campbell and Gregory<sup>85</sup> and Riggs<sup>86</sup> that visual acuity under standard conditions is optimal for pupil diameters between 2 and 5 mm. However, as Westheimer<sup>87</sup> explains, when the pupil diameter falls below 2 mm. diffraction interferes with the quality of the retinal image, thus affecting visual acuity. This diffraction is a major limiting factor for acuity with a pupil size of 1 mm. or less. Likewise, aberrations account for the decrease in acuity with large pupil diameters. That is, the optical imperfections which prevail at the periphery of the lens result in the scattering of the light and a consequent reduction in acuity.

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83 P. W. Cobb, "The Influence of Pupillary Diameter on Visual Acuity," American Journal of Physiology, Vol. 36, 1915, p. 335-346.

84 Herschel Leibowitz, "The Effect of Pupil Size on Visual Acuity for Photometrically Equated Test Fields at Various Levels of Luminance," Journal of the Optical Society of America, Vol. 42, No. 6, 1952, p. 416-422.

85 F. W. Campbell and A. H. Gregory, "Effect of Pupil Size on Visual Acuity," Nature, Vol. 187, 1960, p. 1121-1123.

86 L. A. Riggs, "Visual Acuity," in C. H. Graham (ed.), Vision and Visual Perception, New York, Wiley, 1965, p. 321-349.

87 Gerald Westheimer, "Visual Acuity," in P. R. Farnsworth (ed.), Annual Review of Psychology, Palo Alto, California, Annual Reviews, Vol. 16, 1965, p. 359-380.

The data from Leibowitz<sup>88</sup> relating the effect of pupil size on visual acuity for photometrically equated test fields shows that visual acuity rapidly improves with pupil size increases, but improves more slowly until a maximum level is reached. Further pupil size increases result in decreased acuity. Also, these increases and decreases in visual acuity are even larger depending on the general luminance level. At the highest luminance levels (e.g., 100 mls.) rate of increases in visual acuity is greatest, whereas at lowest luminance levels this rate gradually decreases along with a steeper drop in acuity after the maximum level has been attained. At a level of 10 millilamberts, the maximum acuity was found with a 3.86 mm. pupil. Above this level was observed a gradual decrease in visual acuity. Maximum acuity for three lower levels of luminance (1, 0.10, and 0.01 ml.) was found with the 2.77 mm. pupil size, after which visual acuity decreased with further increases in pupil size. Thus, it can be concluded that at the various luminance levels, acuity increases up to a maximum level with increases in pupil size, then gradually decreases with further increases in pupil diameter. Furthermore, the maximum level of pupil size reached which is most effective for best visual acuity is dependent on the level of luminance.

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88 Leibowitz, op. cit., p. 416-422.

Campbell and Gregory<sup>89</sup> have also made it clear that at low levels of luminance, larger pupillary diameters are advantageous, whereas with increased luminance a decrease in pupillary size would decrease aberrations and enhance visual acuity. The pupillary light reflex is thus seen as providing optimum apertures for visual acuity over wide ranges of luminance.

In summary, changes in pupil diameter, within certain ranges and at various levels of luminance, can affect visual acuity and in turn recognition thresholds. Pupillary responses of constriction and dilation elicited by pleasant or unpleasant stimuli respectively, will thus result in lowered and raised recognition thresholds as a consequence of the changes in visual acuity with variations in pupillary apertures. Constriction responses below 2 mm. and dilation response exceeding 5 mm. would tend to lead to decreased visual acuity and heightened recognition thresholds. The evidence reviewed here thus further implicates the pupillary response as a mechanism in perceptual defense.

#### 4. Statement of the Problem and Hypotheses.

Perceptual defense has been one area of research that has attempted to deal with the process by which motivation influences perception. Numerous attempts to account for the

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<sup>89</sup> Campbell and Gregory, op. cit., p. 1121-1123.

perceptual defense phenomenon through either perceptual or response parameters alone have left the process still unexplained. The present research aims to examine this process and other mechanisms that may be involved in the perceptual defense phenomenon.

The evidence reviewed here implicates the pupillary response as one possible mechanism to account for the perceptual defense effect. There seems to exist a gating out of potentially threatening stimuli for the organism. Such a tuning out of disturbing stimuli may also occur at the peripheral receptor sensory levels. It is at this level that pupillary reactivity may be involved.

The review presented here suggests that dilation is elicited by pleasant stimuli and pupillary constriction is elicited by unpleasant or aversive stimuli. Dilation can thus be viewed as an approach response, whereas constriction is seen as an avoidance response. The bidirectional nature of the pupillary response has, however, been challenged, and it still seems speculative that the pupillary response is related to emotionality via dilation to positively toned stimuli and constriction to negatively toned stimuli.

The effect of pupil size on visual acuity further implicates the pupillary response as a mechanism affecting lowered and heightened thresholds in perceptual defense.

Changes in visual acuity are accompanied by changes in pupil size so that within certain limits constriction of the pupil results in a decrease in visual acuity, while dilation leads to enhanced visual acuity. Further decreases in pupil size or increases in dilation beyond these limits has the effect of reducing visual acuity. It is suggested that within the perceptual defense paradigm changes in pupil size to emotionally loaded words will affect visual acuity, thus raising or lowering recognition thresholds.

It is within this context that the present research primarily aims to examine the role of pupillary dynamics in perceptual defense. More specifically, the aim has been to explore the effect of pupil size on recognition thresholds of neutral and taboo words commonly utilized in the perceptual defense paradigm. In this research pupil size was manipulated experimentally as the independent variable, through use of artificial pupils made from contact lenses, to see the effect on recognition thresholds of neutral and taboo words. This does not prove the pupil response as the only essential causative mechanism for differential recognition thresholds in perceptual defense, but will make it more plausible that pupillary response may be involved in such a process. It was expected that the smaller pupil sizes, characteristic of constriction, would result in higher recognition thresholds,

while larger pupillary apertures, characteristic of dilation, would result in lowered recognition thresholds.

In view of the studies reviewed in this chapter, this research has focused its attention on the following problems:

1. What is the possible role of pupillary responses as a plausible mechanism in accounting for the phenomenon of perceptual defense?
2. More specifically, what effect do variations in pupil size have on recognition thresholds of visually presented taboo and neutral words?

From these problems the following hypotheses to be tested in this research are stated in null form as follows:

1. There is no significant difference in recognition thresholds between different pupil size conditions for neutral and taboo words.
2. There is no significant difference in recognition thresholds of neutral and taboo words under different pupil size conditions.

The following chapter presents a description of the instrumentation, procedure, and method for examining the presented problems and hypotheses.

## CHAPTER II

### EXPERIMENTAL DESIGN

The present chapter will present a discussion of the sample used, the apparatus, method and experimental procedure, methods of analysis and the statistical design.

#### 1. The Sample.

The sample consisted of three males from the Faculty of Psychology at the University of Ottawa. Two of the subjects were students at the faculty while the third subject was a technician. The mean age of the subjects was twenty-five years. Prior to the experiment, each of the subjects was tested for near and far visual acuity, vertical and lateral phoria, using the Bausch and Lomb Ortho-rater. Scores of 20/17 were obtained on the Snellen Visual Acuity Rating Scale for near and far vision for each of these subjects. Both the vertical and lateral phoria scores indicated that the three subjects were all in the average range for both near and far vision. All subjects showed normal color vision. None of the subjects wore corrective lenses.

#### 2. Apparatus.

(a) A Scientific Prototype three-channel dodge type, Tachistoscope, Model GB, was used to present the stimulus

material. The luminance of the field, as measured by the Spectra Pritchard Photometer, model 1970-PR, was equal to 9.29 foot-candles in both the blank channel and display channel. Channel 1 was used for displaying the stimulus words while the blank channel contained an X to serve as a central focal point for the subject. The blank channel also served to maintain the level of light adaptation during the inter-stimulus intervals. A five-inch viewing hood was attached to the end of the viewing scope of the tachistoscope with a stretch elastic band attached to the hood. The band was placed around the back of the subject's head while he was positioned with his eyes in the viewing hood so that he would keep his head in a fairly stable position. Viewing distance from the subject to the stimulus was forty-one inches.

(b) The Stimulus Material.- A sample word list consisting of eight Neutral and eight Taboo words was chosen from previous studies on perceptual defense by Nothman,<sup>1</sup>

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<sup>1</sup> F. H. Nothman, "The Influence of Response Conditions on Recognition Thresholds of Taboo Words," Journal of Abnormal and Social Psychology, Vol. 65, No. 3, 1962, p. 154-161.

Postman, Bronson and Groppers,<sup>2</sup> and Sales and Haber.<sup>3</sup> From this initial list of sixteen words, four neutral and four taboo words were selected for this study such that four neutral-taboo word pairs were formed. Each member word of the separate neutral-taboo word pairs was equated in terms of the number of letters and frequency of occurrence in the English language as determined by the Thorndike-Lorge<sup>4</sup> frequency count. The four neutral-taboo word pairs with their frequencies of occurrence are listed as follows:

<u>Neutral-Taboo Word Pairs</u>	<u>Frequency</u>
MIXER-PENIS	1
TALLY-WHORE	4
KNACK-RAPED	13
BLUNT-PRICK	30

For presentation of the stimulus material, each stimulus word was typed in pica upper case lettering, centered on 5" X 7" white index cards and inserted into the same size stainless steel card holders. Each word was 7/8"

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2 L. Postman, W. C. Bronson and G. L. Groppers, "Is There a Mechanism of Perceptual Defense?" Journal of Abnormal and Social Psychology, Vol. 48, No. 2, 1953, p. 215-224.

3 Bruce D. Sales and Ralph N. Haber, "A Different Look at Perceptual Defense for Taboo Words," Perception and Psychophysics, Vol. 3, 1968, p. 156-160.

4 E. L. Thorndike and I. Lorge, The Teacher's Word Book of 30,000 Words, New York, Bureau of Publications, Teachers College, Columbia University, 1944, xii-274 p.

in length and 1/8" in height, subtending a visual angle of less than one degree in arc. The word ALBUM and the numbers 71482 were also used as warm-up stimuli before presentation of the stimulus words and were presented in the same manner as the stimulus material.

(c) A unique feature of the present study is the employment of contact lenses for the use of artificial pupils, so that precise control could be obtained over the size of the pupil as well as having the artificial pupil size as close to the eye as possible. In this way the artificial pupil served as much as possible as a substitute for the natural pupil and also permitted free movement of the eye during the actual experiment. The method of employing artificial pupils is a technique that has been successfully applied, for example, in the study of the effects of pupil size on retinal image size<sup>5</sup> and visual acuity.<sup>6</sup> In the study by Campbell and Gregory<sup>7</sup> the artificial pupil was a tube 33 cm. long and 3 cm. in diameter with a disc at the end carrying apertures of 1-8 mm. in 0.5 mm. intervals.

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<sup>5</sup> W. R. Biersdorf and J. C. Baird, "Effects of an Artificial Pupil and Accommodation on Retinal Image Size," Journal of the Optical Society of America, Vol. 56, 1966, p. 1123-1129.

<sup>6</sup> F. W. Campbell and A. H. Gregory, "Effect of Pupil Size on Visual Acuity," Nature, Vol. 187, 1960, p. 1121-1123.

<sup>7</sup> Ibid., p. 1122.

Although this method allows placing the artificial pupil close to the eye, it still is not in direct contact with the eye. The method employed in the present study of having the artificial pupil in direct contact with the eye decreases aberrations such as diffraction of light, that still may occur between the actual pupil and the artificial pupil.

Three pairs of contact lenses consisting of black acrylic plastic, circumscribing pupil sizes of 2 mm., 4 mm., and 6 mm., were used as the artificial pupils in this study. The actual pupil size aperture was clear while the remainder of the lens was black. The lenses, as constructed by the Plastic Contact Lens Company Limited (Canada), were made with a large diameter of 9 mm. and curvature equal to 43.5 diopters so that they could be worn comfortably by any subject having near average curvature of the natural lens. The basis of both the right and left lenses were equal, and although the back vertex of the right and left lenses for each pupil differed slightly, this was not significant enough to affect the resolving power of the lens and thus would not affect visual acuity. A diagram of a contact lens serving as an artificial pupil is presented in Figure 3, on page 57.

(d) One of the difficulties in this experiment was to maintain a large natural pupil diameter while the larger

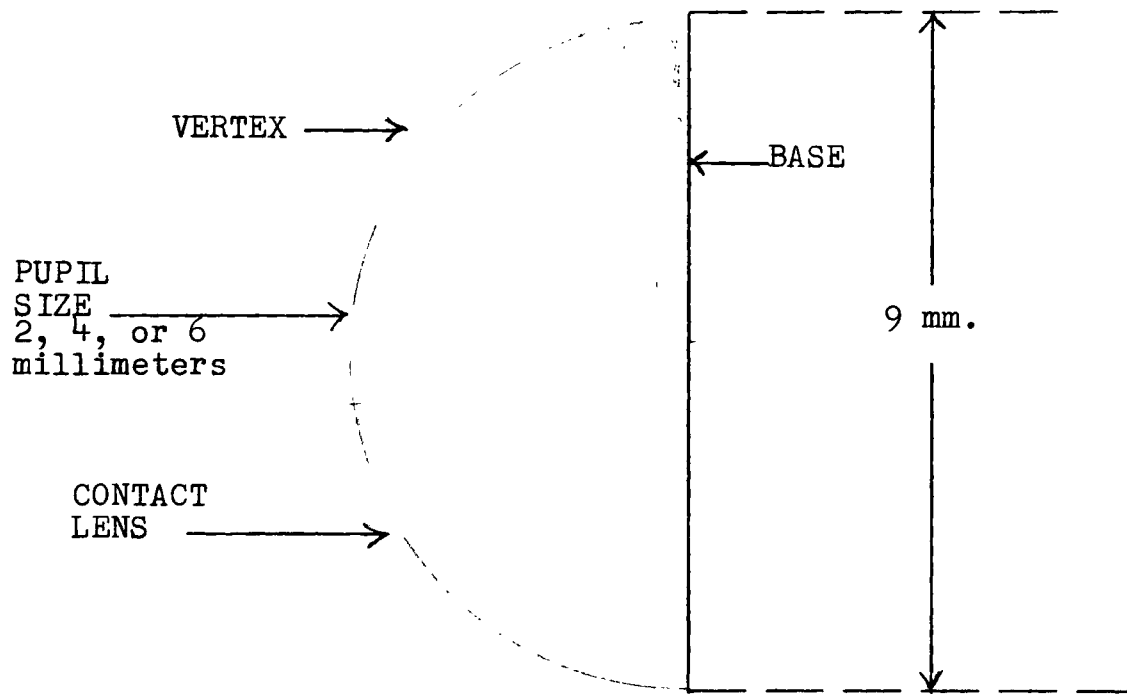


Figure 3.- Diagram of Contact Lens Serving as the Artificial Pupil.

artificial pupil size was worn. One particular study by Campbell and Gregory<sup>8</sup> dilated the pupil by instilling 2 per cent homatropine hydrobromide into the conjunctival sac. The present study employed a 10 per cent solution of Phenylephrine Hydrochloride (brand name--Neo-synephrine hydrochloride). It is basically a synthetic sympathomimetic compound structurally similar to epinephrine and ephedrine. This particular drug was used because it served to cause mydriasis without effectively paralyzing the ciliary muscle of the lens. Accommodation of the lens was thus not affected, causing little negative effect on visual acuity. The drug was also employed because of its ability to rapidly dilate the pupil and its relatively short recovery period.

### 3. Presentation Procedure.

The experimental procedure involved essentially two parts: (1) the preparation of the subject, and (2) presentation of the stimulus material. Preparation of the subjects will be discussed first.

(a) Preparation of the Subject.- On entering the darkened laboratory the subject was seated in a reclining chair. A nurse assistant subsequently administered four drops of phenylephrine hydrochloride (10%) to the

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<sup>8</sup> Ibid., p. 1122.

conjunctival sacs of each eye, each drop being given at five-minute intervals. On visual inspection by the experimenter, when subject's pupils were dilated, the subject then inserted the contact lenses to both the right and left eyes. Each subject previously had two practice sessions in the insertion and removal of the contact lenses before the entire experiment was conducted. Once each lens was inserted, the subject was given 5 - 10 minutes to adapt to the lenses.

After the subject reported feeling comfortable with the lenses, he was seated at the viewing hood of the tachistoscope and the following instructions were read:

This is a study in perception. One word will be presented in this machine at various intervals of time. Each word will be presented with a 4-second interval between each presentation of the word. I will present each word at extremely brief exposure intervals, gradually increasing the exposure interval until you can recognize the word, by pronouncing it aloud. Sometimes you will probably not be absolutely sure what the word is. Do not hesitate to guess. Only one response will be required for each trial. Each time fixate on the X, that is where the word will appear.

Now we will run some warm-up trials to acquaint you with the procedure. During this practice I will present 5 arbitrary digits on each trial, then practice using a word. Keep your head in this rubber eyepiece at all times while the words are presented. Fixate on the X, that is where the digits and words will appear. I will say "ready" each time before I start with each word.

After three warm-up trials for both the numbers and the word ALBUM were completed, the experimenter gave the

Now we are ready to begin with the words. Remember to indicate recognition by saying the word aloud, and do not hesitate to guess what the word might be. Are there any questions?

(b) Presentation of the Stimulus Material.- Following the instructions, the experimenter proceeded to display the stimulus material. For the present study the function selector switch on the tachistoscope was set at  $1 \leftrightarrow B$  so that there would be an oscillation between channel one and the blank channel for prescribed time intervals. The stimulus words were displayed tachistoscopically in channel one for a certain time interval (e.g. 10 msec.) followed by the display in the blank channel for four seconds duration, which served as the interstimulus interval. After the blank display the stimulus word in channel one was then again displayed but this time with a different time interval (e.g. 15 msec.). During the interstimulus interval the experimenter adjusted the time intervals for the display of the stimulus words in channel one. A fixed random order was used to display the words so that a taboo word always followed the presentation of a neutral word. The word list was constructed by first placing all the neutral words in a fixed random order so that each neutral word appeared five times. The taboo words were then also placed in a fixed random order so that each appeared five times. The taboo words, as arranged, were then combined with the neutral word

list so that each taboo word followed a neutral word. This same order of word presentation was employed for all three subjects and under all pupil size conditions. An ascending method of limits was used to determine recognition thresholds.<sup>9</sup> The starting points were varied from 5 msec. to 30 msec. increasing by increments of 5 msec. until the word was recognized by the subject. A descending series was not employed as it was found in pilot trials using the words that a subject would encounter difficulty in making a judgment regarding "not recognizing" the word since he knew what the word already was. This is similar to a study by Helson and Fehrer<sup>10</sup> who had to give up a descending series when studying the illumination level necessary for perceiving a visual form, since it was difficult for the subject to decide when he no longer could see the form as he already had knowledge of it. Forty trials were given to each subject so that each word was exposed five times. When the subject reported recognizing the word, a plus sign was recorded and the ascending series discontinued. The next word was then inserted into channel one and another trial given.

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9 J. P. Guilford, Psychometric Methods, New York, McGraw-Hill, 1954, ix-597 p.

10 H. Helson and E. V. Fehrer, "The Role of Form in Perception," American Journal of Psychology, Vol. 44, No. 1, 1932, p. 79-102.

Each subject was given a total of four sessions: one practice session, and three experimental sessions. The practice session determined recognition thresholds for the neutral and taboo words using the same procedure just described, with the exception that no drug was administered nor were any contact lenses worn by the subjects. The three experimental sessions were run on three separate days, each day using one of the three different pupil size conditions. For each of the three subjects, pupil size order was varied so as to control for possible practice effects and avoid illiciting bias on the part of the subject. The pupil size order for subject one was 4-6-2 mm., for subject two, 6-2-4 mm., and for subject three, 2-6-4 mm. Each of the experimental sessions lasted approximately two hours, including the administration of the drug, insertion of the lenses, and presentation of the stimulus material.

After completing the experimental sessions, subjects were given another session which will be referred to in this paper as the Fully Dilated Condition. Under this condition, phenylephrine hydrochloride was administered as previously described, but subjects did not wear the artificial pupils. They were subsequently given the recognition threshold task using the very same stimulus material and the method that was used under the three pupil size conditions. On completion

of the recognition threshold task, the experimenter photographed the subjects' fully dilated natural pupils. For this purpose a Wollensak-Dumont Cro Polaroid camera was used, with an  $f$  setting of 4 and a time exposure of 25 msec. Subject then inserted the 4 mm. artificial pupil for the right eye. Another photograph was then taken of the right eye with the contact lens in place.

In summary, recognition thresholds for neutral and taboo words were obtained, using the method of limits ascending series, with a number of trials, while pupil size was varied through the use of artificial pupils made from contact lenses. Each subject served under each of the three experimental pupil size conditions and, in addition, received a fully dilated condition under which no artificial pupil was employed and only recognition thresholds were obtained. To determine the size of the fully dilated natural pupil, photographs were taken of subjects' fully dilated natural pupils and also the artificial lens in the right eye. The next section will examine the methods of analysis and statistical design of the data.

#### 4. Methods of Analysis and Statistical Design.

For each trial the stimulus limen, that is the recognition threshold, was determined using the midpoint

between the two stimulus values where the change occurred and subject reported recognition of the word. The limens or thresholds, in milliseconds, were combined and averaged for each of the neutral and taboo words. The data obtained were thus mean recognition thresholds for both neutral and taboo words, respectively, for each subject under the three different pupil size conditions.

The design of this research, as described by Winer,<sup>11</sup> employed a two-factor analysis of variance with repeated measures on two factors. The design is presented in Figure 4 on page 65. Use of this design permitted each subject to serve as his own control under the experimental conditions, thus minimizing the contribution of individual differences as well as being able to employ a smaller sample of subjects. The economy of subjects in the present study was an important factor due to the employment of contact lenses for artificial lenses, the training of the subjects for insertion and removal of the lenses, the use of a drug in preparation of the subjects, and the actual length of time required of each subject for the actual participation in the experiment. Increasing the number of observations for each subject also enabled better control and precision to be obtained. For

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<sup>11</sup> B. J. Winer, Statistical Principles in Experimental Design, New York, McGraw-Hill, 1962, x-672 p.

PUPIL SIZE IN MM.

STIMULUS WORDS	2 mm.	4 mm.	6 mm.
NEUTRAL	X1 X2 X3	etc.	etc.
TABOO	X1 X2 X3	etc.	etc.

Figure 4.- Design of Two-factor Analysis of Variance with Repeated Measures on Two Factors.

the analysis of variance only the three artificial pupil size conditions were included in the analysis. Neither the practice session nor the fully dilated conditions were included as these were not strictly part of the major variables being considered in this study. If the subject had worn clear opaque contact lenses during the practice session, it may have served as a legitimate control condition. However, in this research the practice session mainly served to familiarize the subject with the procedure and thus cannot be considered as a control condition.

The fully dilated condition was given mainly for exploratory purposes after a certain trend was observed in the recognition threshold data for the three pupil size conditions. The trend observed indicated a decrease in recognition thresholds from two to six millimeters, that is, with the increase in pupil diameter recognition thresholds tended to show a decrease. The questions arose, would this decreasing trend continue with increases in pupil size, or would there be an increase in recognition threshold if the pupil diameter increased further? To answer these questions the actual pupil diameter of the fully dilated pupil had to be determined. In order to do this, the photographs that were taken of the subjects' eyes were enlarged to 8" X 10" prints. From these enlargements ten measures of the right

eye, using a compass and millimeter ruler, were taken each of both the fully dilated natural pupil and the artificial pupil. These ten measures were subsequently averaged to give the mean pupil size for the fully dilated natural pupil and artificial pupil for each subject. Since the measurements from the enlargements did not give the actual diameter of the fully dilated pupil, a conversion formula was used to convert to the actual diameter of the fully dilated pupil. From this formula the diameters, in millimeters, of the actual fully dilated natural pupils of each subject were determined and are presented in the following chapter.

The present chapter has presented a discussion of the experimental design and procedures used in this research. This paper will now proceed to the next chapter concerning the presentation and discussion of the results.

## CHAPTER III

### PRESENTATION AND DISCUSSION OF RESULTS

The present chapter deals with the results of this research and their discussion. Section 1 presents the recognition threshold results for both the three artificial pupil size conditions and the fully dilated condition. Section 2 presents a discussion of these results with their implications for the present study as well as for future research.

#### 1. Presentation of the Results.

In Table I on page 69 is presented the analysis of variance for recognition thresholds of neutral and taboo words under the three artificial pupil size conditions. From this table it can be seen that there is no significant effect of the pupil sizes and word stimuli on recognition thresholds. Also, there is no significant interaction effect between the word stimuli and artificial pupil size conditions, and no significant interaction effect between the word stimuli and subjects. However, the interaction between the artificial pupil sizes and subjects is found to be significant at the .05 level, indicating that the subjects did differ in their recognition thresholds under the different artificial pupil size conditions. Concerning the hypotheses presented in the

Table I.-

Analysis of Variance of Recognition Thresholds for Neutral  
and Taboo Words under Three Different Pupil  
Size Conditions.

Source of Variation	SS	df	MS	F Ratio	Sig.
Between Subjects	873.01	2	436.51		
Within Subjects					
A (Pupil Size)	320.20	2	160.10	2.68	N.S.
B (Words)	1.68	1	1.68	.34	N.S.
AR	239.28	4	59.82	13.00*	.05
BR	9.88	2	4.94	1.07	N.S.
AB	40.11	2	20.06	4.36	N.S.
ABR	18.43	4	4.60		

\*  $p < .05$ ,  $F_{.95}(4, 4) = 6.39$

first chapter of this paper, the results indicate a failure to reject the hypotheses that there is no significant difference in recognition thresholds of neutral and taboo words under different pupil size conditions, and that there is no significant difference in recognition thresholds between different pupil size conditions for neutral and taboo words.

Table II on page 71 and Figures 5, 6 and 7 on pages 72, 73 and 74 present the mean recognition thresholds and standard deviations for all the word stimuli under each pupil size condition and fully dilated condition, for each individual subject. From Table II and Figures 5, 6 and 7 it can be seen that both subjects one and two show a trend of decreases in recognition threshold as the artificial pupil diameter increases from 2 mm. to 6 mm. Subject three, however, does not follow this same general trend of decreases in recognition threshold as the pupillary aperture increases. Comparison of the 6 mm. artificial pupil size condition and the fully dilated condition shows an increase in recognition threshold for subjects one, and two, but a decrease in recognition threshold for subject three. This comparison is illustrated in Table III on page 75, along with the differences between the 6 mm. artificial pupil size and fully dilated pupil size condition, for each subject. The fully dilated condition is based on the converted measures taken from the enlarged photographs to give the size for the fully dilated natural pupil, as was described in the previous chapter.

Table II.-

Mean Recognition Thresholds (msecs.) and Standard Deviations for All Word Stimuli (both Neutral and Taboo), under Three Different Pupil Size Conditions and Fully Dilated Condition.

Subject	Recognition Thresholds							
	2 mm.		4 mm.		6 mm.		F.D.*	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
One	47.38	11.24	45.75	14.21	34.63	8.46	43.50	8.45
Two	28.63	6.56	25.00	11.49	24.00	7.70	29.88	8.70
Three	47.25	15.85	29.00	10.01	35.38	12.97	25.25	10.32

\* Fully dilated condition

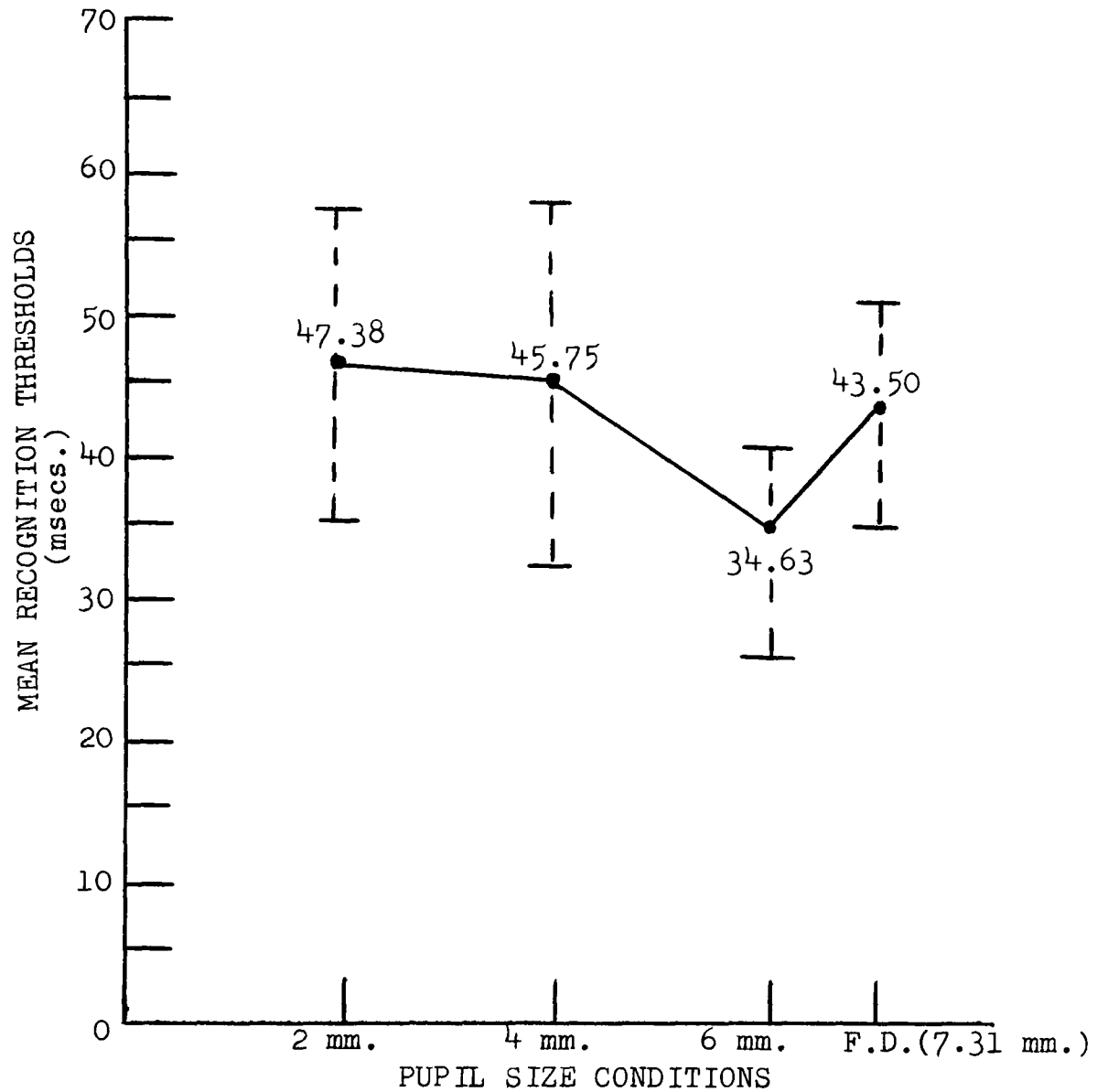


Figure 5.- Mean Recognition Thresholds of Subject 1 for All Word Stimuli under Each Pupil Size Condition and Fully Dilated Condition. (Vertical lines mark one standard deviation above and below the mean.)

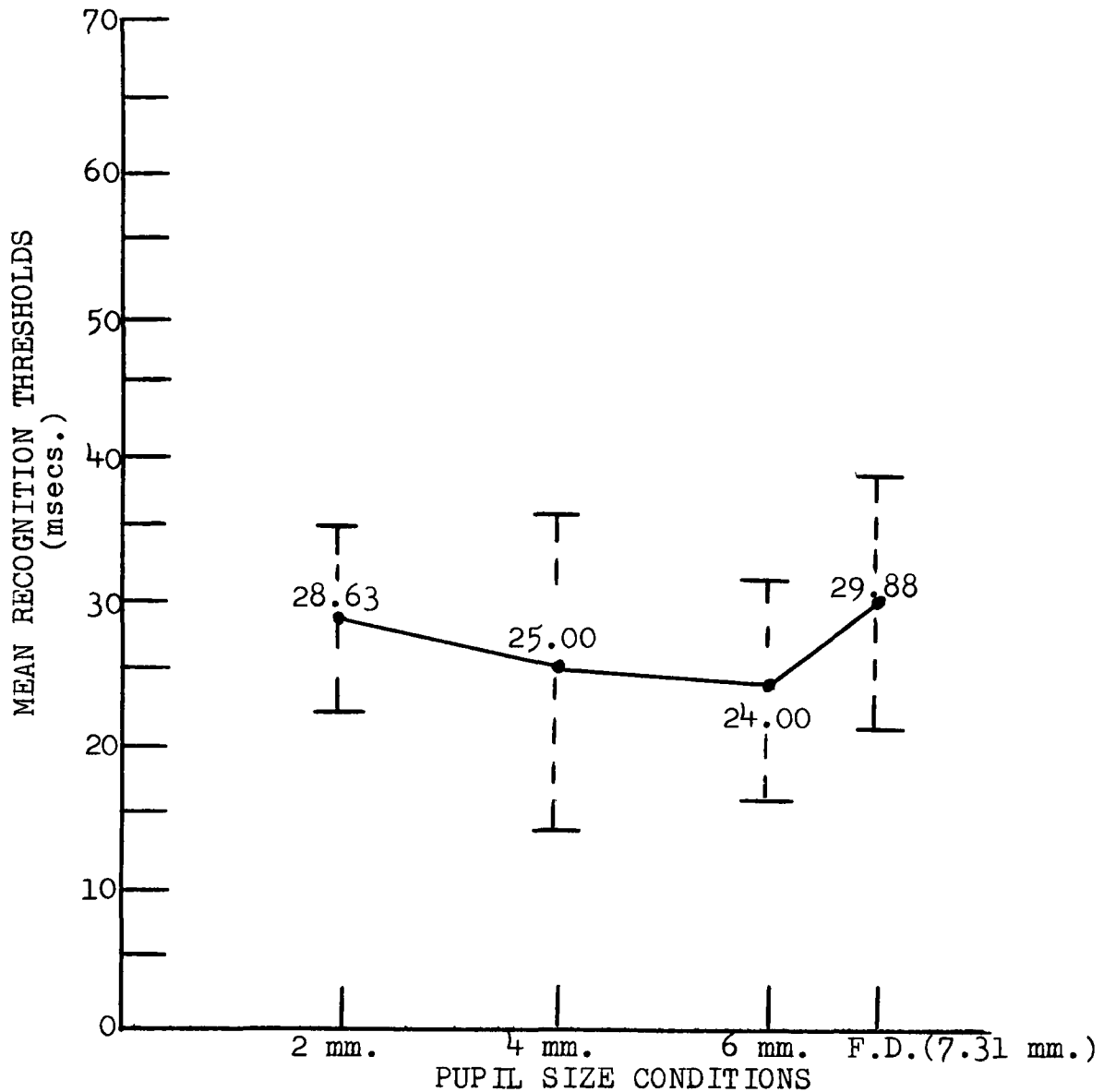


Figure 6.- Mean Recognition Thresholds of Subject 2 for All Word Stimuli under Each Pupil Size Condition and Fully Dilated Condition. (Vertical lines mark one standard deviation above and below the mean.)

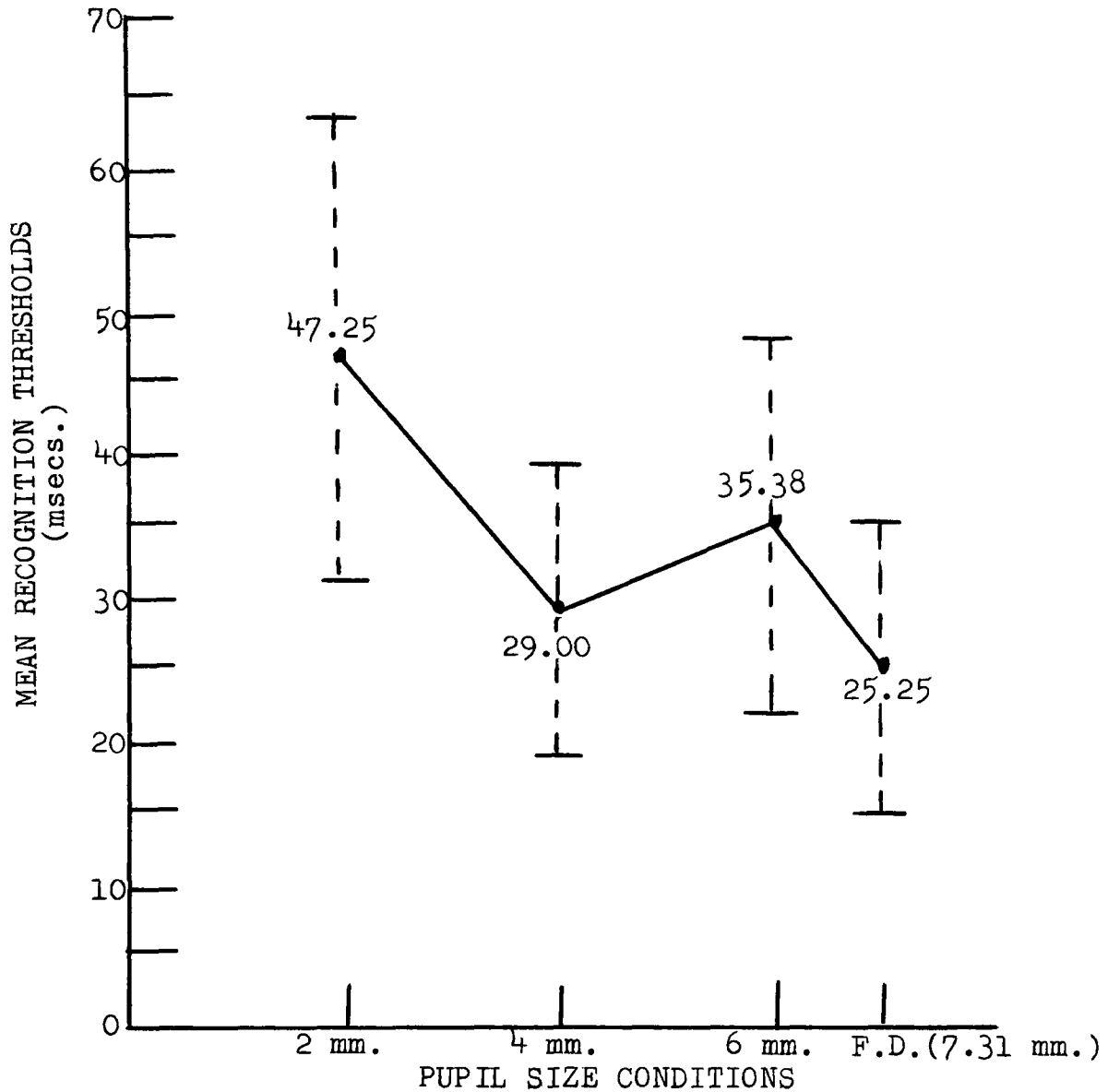


Figure 7.- Mean Recognition Thresholds of Subject 3 for All Word Stimuli under Each Pupil Size Condition and Fully Dilated Condition. (Vertical lines mark one standard deviation above and below the mean.)

Table III.-

Mean Recognition Thresholds (msecs.) for All Word Stimuli  
(both Neutral and Taboo) under the 6 mm. Pupil Size  
and Fully Dilated Conditions for Each Individual  
Subject.

Subject	Recognition Thresholds		
	6 mm.	Fully Dilated	Difference
One	34.63	43.50	8.87(I)*
Two	24.00	29.88	5.88(I)
Three	35.38	25.25	10.13(D)**

\* I signifies increase in recognition threshold.

\*\* D signifies decrease in recognition threshold.

Table IV on page 77 represents the results of the pupil diameters for each subject's fully dilated natural pupil after conversion. The pupil diameter scores for each subject are 7.89 mm. for subject one, 7.11 mm. for subject two, and 6.93 mm. for subject three. Averaging the pupil diameter for all the subjects reveals a mean fully dilated natural pupil diameter equal to 7.31 mm. It may be noted that the diameter of the fully dilated natural pupil does not exceed the 9 mm. diameter of the artificial pupil lens. There is approximately a 1 mm. to 2 mm. difference between the fully dilated natural pupil and the artificial pupil with the latter being the greater in diameter.

The recognition threshold data for the neutral, taboo, and neutral-taboo words combined (all word stimuli) for all the subjects, under the three different pupil size conditions and fully dilated condition, are presented in Table V on page 78 and in Figures 8, 9, and 10 on pages 79, 80 and 81. Examination of all these figures again illustrates the very distinct trend of decreasing recognition thresholds as the artificial pupil size increases from 2 mm. to 6 mm. Thus, there is observed a general decrease in recognition threshold as the artificial pupil diameter enlarges. Similarly, the reverse is evident that, as the artificial pupil diameter decreases from 6 mm. to 2 mm., recognition thresholds for the neutral and taboo words

Table IV.-  
Pupil Diameters (mm.) of the Fully Dilated  
Natural Pupil.

Subject	Pupil Diameter
One	7.89
Two	7.11
Three	6.93
Mean	7.31

Table V.-

Mean Recognition Thresholds (msecs.) and Standard Deviations for Neutral, Taboo, and Neutral-Taboo Words Combined, under Three Different Pupil Size Conditions for All Subjects.

Words	N	Recognition Thresholds							
		2 mm.		4 mm.		6 mm.		F.D.	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Neutral	3	39.33	13.68	35.00	17.36	32.25	13.03	32.83	12.72
Taboo	3	42.83	15.56	31.50	12.00	30.42	8.99	32.92	11.32
Neutral- Taboo	3	41.08	14.70	33.25	14.96	31.33	11.23	32.88	11.99

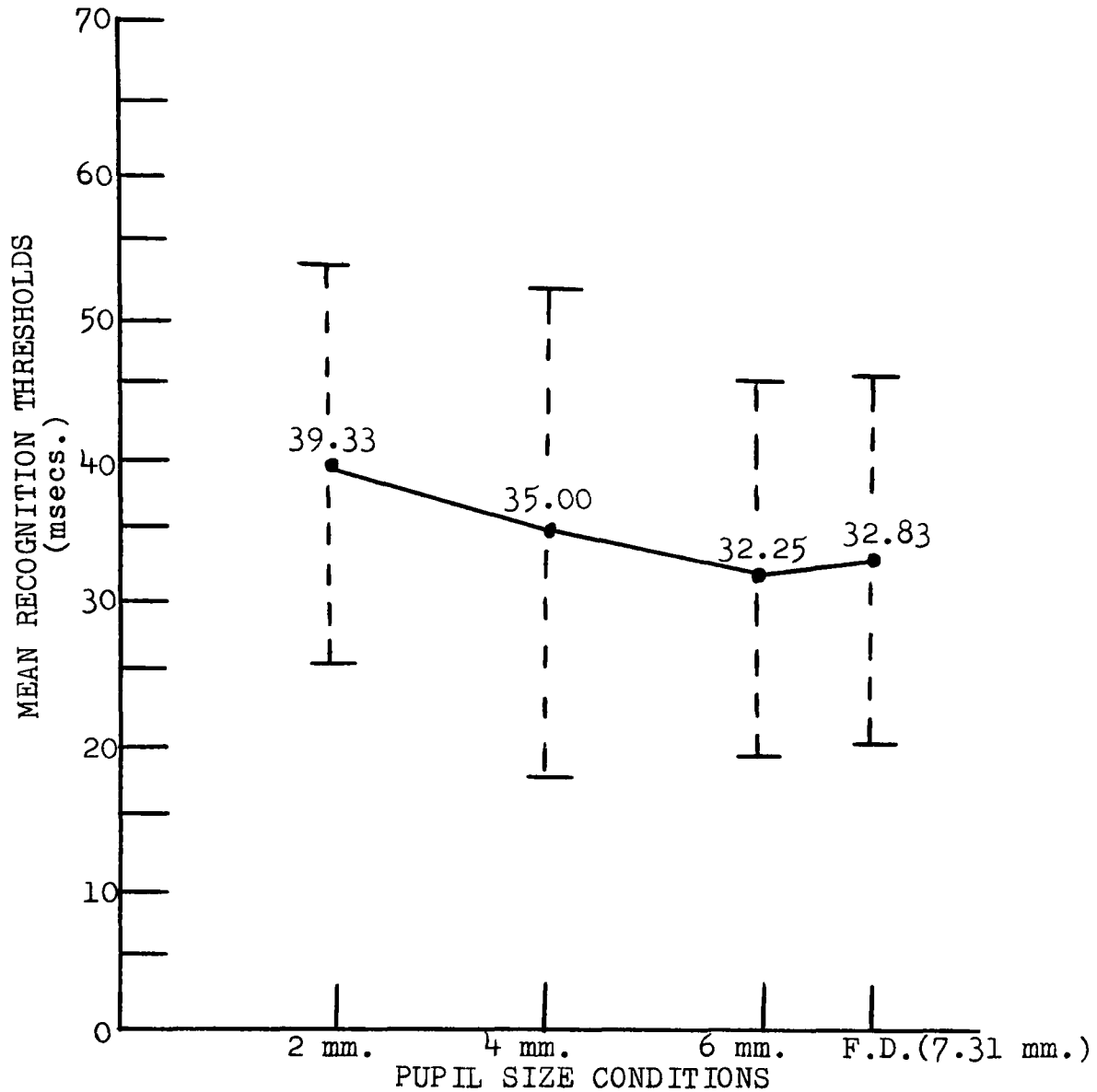


Figure 8.- Mean Recognition Thresholds of All Subjects for Neutral Words under Each Pupil Size Condition and Fully Dilated Condition. (Vertical lines mark one standard deviation above and below the mean.)

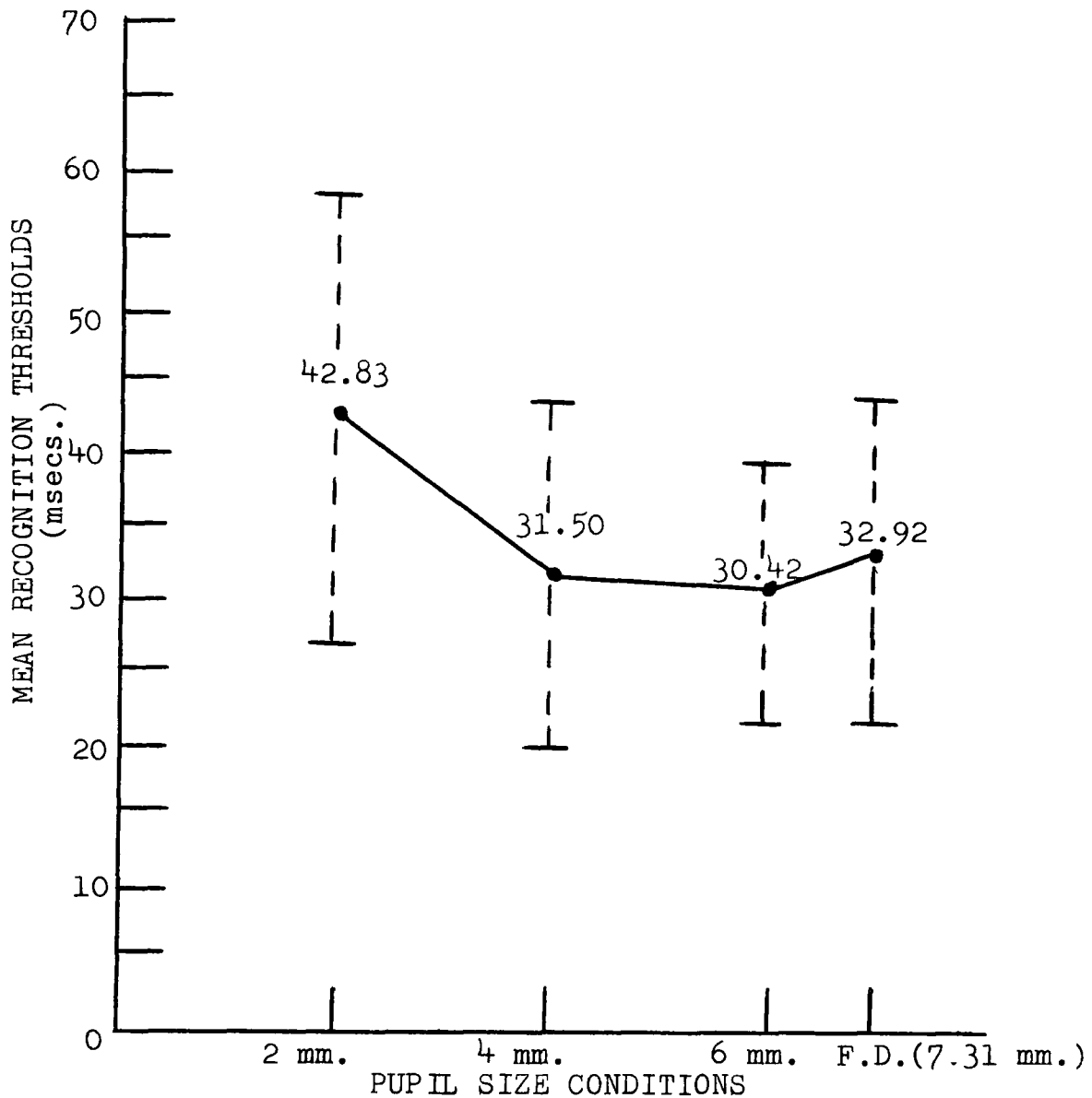


Figure 9.- Mean Recognition Thresholds of All Subjects for Taboo Words under Each Pupil Size Condition and Fully Dilated Condition. (Vertical lines mark one standard deviation above and below the mean.)

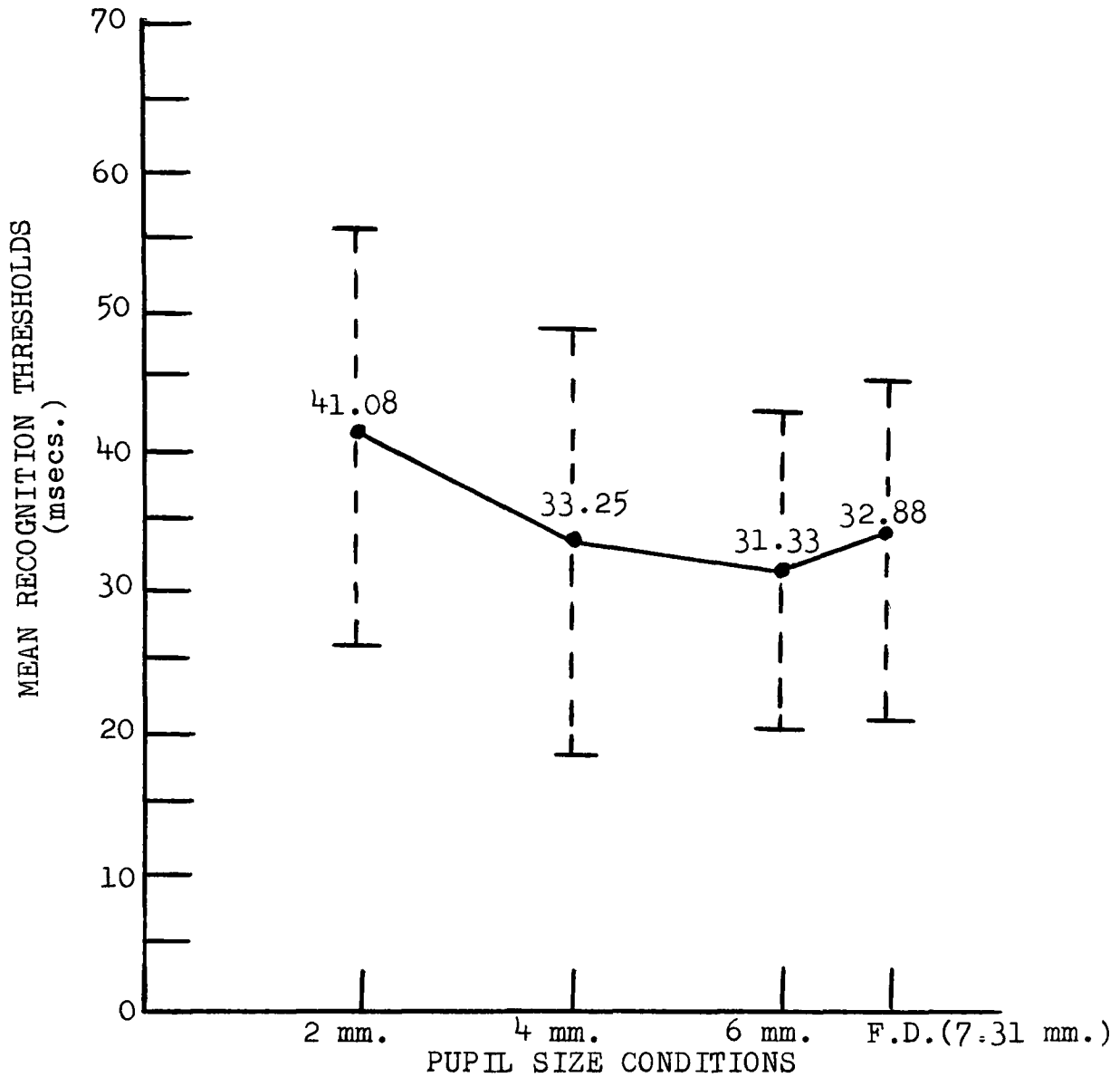


Figure 10.- Mean Recognition Thresholds of All Subjects for All Word Stimuli under Each Pupil Size Condition and Fully Dilated Condition. (Vertical lines mark one standard deviation above and below the mean.)

increase. The general decrease in recognition threshold with increasing artificial pupillary aperture is seen to be greater between the 2 mm. and 4 mm. artificial pupil sizes than between the 4 mm. and 6 mm. pupil sizes.

Comparison of the 6 mm. artificial pupil size and the fully dilated condition shows that there are increases in recognition thresholds from the 6 mm. pupil size condition to the fully dilated condition. Table VI on page 83 represents these increases and the differences between the two pupil size conditions. These increases are based on the average recognition thresholds for all the subjects under the fully dilated condition where each subject differed slightly in pupillary diameter measures. These increases in recognition threshold with a larger pupillary diameter may have implications for pupil diameters that exceed a certain maximal level since such increases are seen as possibly interfering with, rather than improving, recognition thresholds.

## 2. Discussion of the Results.

The findings from the present research support the hypothesis that changes in artificial pupil sizes, ranging from 2 mm., 4 mm., and 6 mm. have an effect on the recognition thresholds of neutral and taboo words commonly used in perceptual defense studies. The general trend observed was

Table VI.-

Mean Recognition Thresholds (msecs.) for Neutral, Taboo, and All Word Stimuli under the 6 mm. Pupil Size and Fully Dilated Conditions for All Subjects.

Words	N	Recognition Thresholds		
		6 mm.	Fully Dilated	Difference
Neutral	3	32.25	32.83	.58(I)*
Taboo	3	30.42	32.92	2.50(I)
Neutral and Taboo	3	31.33	32.88	1.55(I)

\* I signifies increase in recognition threshold.

that increases in pupillary diameter resulted in gradually decreasing recognition thresholds. The reverse of this may also be stated, that with decreases in pupillary diameter higher recognition thresholds resulted. Pupillary apertures extending beyond 6 mm. tended to result in slight increases in recognition thresholds. From these trends between variations in pupil size and recognition thresholds, a curvilinear relationship might be apparent but would need further investigation and extension of the larger pupil size ranges to support such a notion. The neutral and taboo words used in this study were found to have no significant differential effect on recognition thresholds. Thus, concerning the hypotheses tested in this study the findings failed to reject the first hypothesis that there is no significant difference in recognition thresholds between different pupil size conditions for neutral and taboo words, as well as the second hypothesis that there is no significant difference in recognition thresholds of neutral and taboo words under different pupil size conditions.

The findings show how variations in the pupillary diameter may have an effect on recognition thresholds of neutral and taboo stimuli. Since no differences were found between the neutral and taboo words under the

different pupil size conditions, under the conditions of this experiment, the taboo words did not seem to have any effect on recognition thresholds. The interesting pattern of decreasing recognition thresholds with increases in pupil size has been found and perhaps may be accounted for in particular through the use of the contact lenses as artificial pupils. This is seen as being the major contributor to this pattern because of the exacting control the lenses provided over the pupil size by having the pupil diameter so close to the eye.

The general trend found in this study is largely in agreement with evidence showing that different artificially controlled pupil sizes do have an effect on visual acuity. As is the case in previous studies relating pupil size and visual acuity, smaller pupil sizes are associated with reduced visual acuity while larger pupil sizes are associated with better visual acuity. The recognition threshold data in this experiment concur with such a trend. In addition, Leibowitz<sup>1</sup> has concluded that as pupil size

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<sup>1</sup> Herschel Leibowitz, "The Effect of Pupil Size on Visual Acuity for Photometrically Equated Test Fields at Various Levels of Luminance," Journal of the Optical Society of America, Vol. 42, No. 6, 1952, p. 416-422.

increases acuity improves rapidly at first then more slowly before a maximum value of acuity is reached. The present findings are again congruent with such a trend. As can be seen from Figures 8, 9 and 10, at first the decrease in recognition threshold between the 2 mm. and 4 mm. pupil size conditions is rapid, then it is a more slow decrease between the 4 mm. and 6 mm. pupil sizes. Visual acuity has also been found to improve with increases in pupil size up to a certain level then tends to decrease as the pupil gets larger. Leibowitz<sup>2</sup> cites the reason for this as dioptric aberrations that reduce visual acuity as the pupil gets larger. The findings in this study support this suggestion of a decrease in visual acuity with further enlargements of the pupil after a certain level is reached, as shown by the slight increases in recognition threshold from the 6 mm. pupil size condition to the fully dilated condition.

As summarized by Westheimer<sup>3</sup> previous research has shown that visual acuity is maximal for pupil diameters between 2 mm. and 5 mm. Leibowitz<sup>4</sup> points out, however, that such a range is also highly dependent on the level of

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2 Ibid., p. 416-422.

3 Gerald Westheimer, "Visual Acuity," in P. R. Farnsworth (ed.), Annual Review of Psychology, Palo Alto, California, Annual Reviews, Vol. 16, 1965, p. 359-380.

4 Leibowitz, op. cit., p. 416-422.

luminance used since with lower luminance levels the drop in visual acuity from the maximum acuity level is steeper. The data from this study are not in complete agreement with this range since the recognition thresholds are found to have continued decreasing even with the 6 mm. pupil size. This apparent enhanced visual acuity as evidenced by this continual decrease in recognition threshold might be explained by the nature of the stimulus material used in this study. In studies on visual acuity the common test stimuli used are different patterns of gratings having fairly small visual angles. For example, in a study by Campbell and Gregory<sup>5</sup> vertical lines of different separation were used as patterns of gratings. The largest test object used by these authors was 5.7 min. in contrast to the visual angle of 12.0 min. for the words employed in this study. These same authors have suggested the maximum level of pupil size could well be a function of the size of the test object. Also for larger test objects, pupil size may be less well defined.

What are the implications of the present findings in terms of the over-all problems presented in this paper? It is found that pupil size changes can have an effect on

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<sup>5</sup> F. W. Campbell and A. H. Gregory, "Effect of Pupil Size on Visual Acuity," Nature, Vol. 187, 1960, p. 1121-1123.

recognition thresholds but how is this in fact related to the phenomenon of perceptual defense? The implication seems to be that if the stimuli used in the perceptual defense paradigm do affect the pupillary response such that dilation is illicited by pleasant stimuli and constriction illicited by aversive stimuli, then recognition thresholds would in turn be affected through the changes in pupil size. More specifically, if taboo or negative stimulus material can produce a constriction response in the pupil, the present findings illustrate how such a decrease in the size of the pupil could produce an increase in recognition threshold for such stimuli, thus accounting for the differential recognition thresholds for neutral and taboo stimuli in perceptual defense. The important question, however, is whether in fact such aversive stimuli can produce a constriction response. The evidence, as presented in the review of the literature of this paper, has certainly illustrated the continued debate over this unresolved question. Another crucial question is related to how large do changes in pupil size have to be to have a significant effect on recognition thresholds? Stated another way, what is the magnitude of change in pupil size needed before a change in recognition threshold is evidenced? The present findings are limited in that they do not answer the debate regarding whether the pupil constricts to unpleasant stimuli or

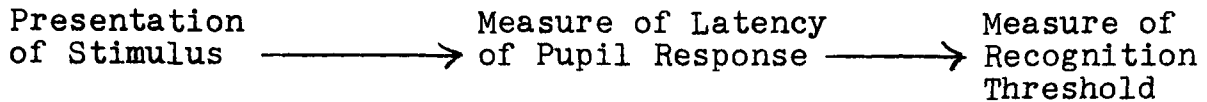
dilates to pleasant stimuli, nor do they answer how large shifts in pupil size are needed to have an effect on recognition thresholds. Further research would be required to examine both these questions.

Although a strict causal interpretation that the changes in the pupillary response causes changes in recognition thresholds cannot be made from the present findings, it does make such a hypothesis more plausible. The findings certainly do lend further support to Hutt and Anderson's<sup>6</sup> finding of a significant negative correlation between pupil size and recognition threshold. In order to arrive at a more causal interpretation, the crucial question to be answered is whether changes in the pupil response proceed or occur prior to changes in recognition threshold. As Hutt<sup>7</sup> has described, it would have to be shown that the "latency of the pupil response is less than the duration of the recognition threshold for a particular stimulus." The sequential analysis for presentation of stimuli would thus appear as follows:

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<sup>6</sup> L. D. Hutt and J. P. Anderson, "The Relationship between Pupil Size and Recognition Threshold," Psychonomic Science, Vol. 9, No. 8, 1967, p. 477-478.

<sup>7</sup> L. D. Hutt, Selective Attention: The Relationship between Pupil Size and Recognition, Ph.D. thesis, Ann Arbor, Michigan, University Microfilms, 1970, p. 45.



Such a sequential analysis would require an on-the-line analysis of the pupillary response while aversive or pleasant stimuli were being displayed.

To proceed with such an analysis the writer wishes to recall the model presented by Dixon on page 18 of this paper. As will be recalled, the model attempts to account for the phenomenon of discrimination without awareness. It does this by positing that stimuli may reach the cortex through the classical afferent pathways but because of insufficient cortical activation would not be detected. Likewise, there could also be cortical control over the reticular system to inhibit its activation of the visual cortex. In examination of electroencephalograph correlates of threshold regulation, it is interesting that Dixon and Lear<sup>8</sup> find a relationship between the recognition thresholds of certain types of stimulus material and the pre-recognition occipital electroencephalograph. Using alpha as an index of activation, it was found that low thresholds for emotion-provoking stimuli (perceptual vigilance) were preceded by enhanced activation, i.e., reduced alpha state, while heightened thresholds for

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<sup>8</sup> N. F. Dixon and T. E. Lear, "Electroencephalograph Correlates of Threshold Regulation," Nature, Vol. 198, June 1963, p. 870-872.

emotional stimuli (perceptual defense) were preceded by a depressed cortical activation pattern, i.e., increased alpha. Sequentially there is first an initial discrimination of the stimulus, then this initial discrimination determines the level of cortical activation which will subsequently affect the recognition threshold. How does the pupillary response then relate to such a model?

Dilation of the pupil is known to be characteristic of arousal level. A high level of arousal is usually associated with dilation while lower levels of arousal may be associated with smaller pupil sizes. The pre-awareness cortical activation levels described above would suggest that enhanced activation would be accompanied by pupillary dilation. Thus, with larger pupil size the recognition thresholds would be lowered.

Reduced cortical activation is accompanied by constriction of the pupil and thus heightened recognition thresholds. Greater pupillary constriction, presumably a measure of relaxation, has also been observed<sup>9</sup> during periods of internal focusing than other conditions. Such

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<sup>9</sup> Niles Bernick and Mark Oberlander, "Effect of Verbalization and Two Different Modes of Experiencing on Pupil Size," Perception and Psychophysics, Vol. 3 (5A), 1968, p. 327-330.

focusing has been found by Gendlin and Berlin<sup>10</sup> to be associated with reduction in tension. In such a state of internal focusing, it is apparent that thresholds for external stimuli would be heightened. In effect it may be argued from Dixon's model that the changes in pupillary response would occur prior to the recognition thresholds, thus in turn affecting recognition threshold duration. The pupillary response thus comes close to being a more plausible mechanism to account for the perceptual defense effect. However, it is seen that the peripheral gating out of stimuli at the level of the pupil may in fact be of lesser importance than more complex cortically controlling mechanisms that would have incidental consequences on the pupillary response. The writer believes that Dixon's model brings us closer to a greater understanding of the perceptual defense effect based on cortical arousal and its relation to pupillary dynamics.

The present study has demonstrated the role of the pupillary response in affecting recognition thresholds by manipulating the pupil size through the use of artificial pupils and examined their effect on recognition thresholds.

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<sup>10</sup> Eugene T. Gendlin and Jerome L. Berlin, "Galvanic Skin Response Correlates of Different Modes of Experiencing," Journal of Clinical Psychology, Vol. 17, 1961, p. 73-77.

Such an approach could be further extended to more definitively delineate the effect pupil size does have on recognition thresholds. This present study might be expanded by further research using more than three different pupil sizes with finer steps between them to determine how large changes in pupil size might be needed to affect changes in recognition threshold. A control condition, using just opaque artificial lenses might also be introduced to compare with other pupil sizes in order to perhaps enlighten the debate concerning the dilation-constriction response to pleasant-unpleasant stimuli. It might also be important to examine the larger pupil sizes to see if there would be an increase in recognition threshold once the pupil exceeds a certain maximum level. However, under normal experimental conditions it may be questioned if the shifts in pupil size would be so great to cover the large changes in pupil size, so generalization to the real situation might be difficult. Under the perceptual defense paradigm the pupillary response may not constrict as low as 1 mm. or dilate as much as 7 mm. Use of artificial pupils may give some information that degrees of change in pupil size will affect recognition thresholds, but a more valuable form of research might be to record pupil size as the dependent variable.

As has already been suggested, the latencies of the pupil response relative to the duration recognition threshold

may be more profitable an approach to clarify the pupillary response's involvement as a causal mechanism. Because of the complications involved in recording pupil size changes to visually presented material, such a design might yield contaminated results. The alternative would be to use the non-visual auditory mode of stimulus presentation. This kind of research would certainly be more direct and allow for wider ranges of interpretation and generalization.

A final area for further research might include the employment of both awareness thresholds and recognition thresholds as proposed by Dixon. Such a paradigm could include combining a number of measures such as EEG, GSR and HR along with pupil size. It would prove valuable to have corresponding measures of the arousal state of the cortex and pupil size to see if these would correlate while at the same time recording the latencies of the pupillary response and duration recognition thresholds. Such research would combine the previous research suggestion with a more sophisticated perceptual defense paradigm.

With such future research possibilities ahead, the writer would like to end with the statement that this study is just a beginning in the exploration of the role of pupillary dynamics. The pupillary response is thus seen as having more possibilities for exploration that will no doubt be carried out through future research.

## SUMMARY AND CONCLUSIONS

The pupillary response is suggested as a plausible mechanism to account for perceptual defense findings of heightened recognition thresholds to emotional stimuli. Within the perceptual defense paradigm it is thought that taboo words could illicit a constriction response leading to heightened recognition thresholds, while pleasant or neutral stimuli would illicit pupillary dilation, and thus lowered recognition thresholds. It is through the effect of changes in pupil size on visual acuity that suggests recognition thresholds for word stimuli used in perceptual defense studies would be affected. Thus, for neutral and taboo stimuli, higher recognition thresholds would be expected with smaller pupillary apertures and lower recognition thresholds would be expected with larger pupillary apertures. The hypotheses of no significant differences in recognition thresholds between different pupil size conditions for neutral and taboo words, and no significant differences in recognition thresholds of neutral and taboo words under different pupil size conditions, were both upheld.

To evaluate these hypotheses, three artificial pupil sizes ranging from 2 mm., 4 mm., and 6 mm. were manipulated as the independent variable through use of contact lenses

worn by the subject. Neutral and taboo word stimuli were then displayed tachistoscopically, using the method of limits, to three male subjects. A fully dilated condition was also introduced to examine the effect larger pupillary diameters beyond 6 mm. might have on the recognition thresholds. It was found that both the pupil size conditions and the word stimuli had no significant effect on recognition thresholds. However, the general pattern of decreasing recognition thresholds with increases in pupil size was observed and is supported by studies relating pupil size and visual acuity. The findings also showed a tendency for recognition thresholds to be slightly raised with the larger pupil sizes under the fully dilated condition.

The implications of this research are that pupil size variations may affect recognition thresholds for word stimuli, but it still cannot be concluded that it is a causative factor in accounting for raised recognition thresholds in perceptual defense. Further research might include elaboration of this present study using artificial pupils to study the effect of pupil size changes on recognition thresholds, but perhaps a more advantageous approach would be the measurement of pupil response latencies as well as duration recognition thresholds while stimuli are presented.

More complex paradigms of perceptual defense employing both awareness thresholds as well as recognition thresholds might be expanded to include other physiological and cortical measurements as well as pupil size. Such research might thus reflect the more complex cortical processes and mechanisms that may be involved in the phenomenon of perceptual defense.

## BIBLIOGRAPHY

Allport, Floyd H., Theories of Perception and the Concept of Structure, New York, Wiley, 1955, xxii-709 p.  
An essential source in the field of perception that proved most useful for the theoretical and historical context of perceptual defense.

Brown, William P., "Conceptions of Perceptual Defence," Monograph Supplements, No. 35, of the British Journal of Psychology, 1961, vii-107 p.

A comprehensive review of the earlier field of perceptual defense that discusses the major controversies, methods, and theories that attempted to account for the phenomenon. A valuable aid in providing the background for the perceptual defense area.

Bruner, J. S., and L. Postman, "Emotional Selectivity in Perception and Reaction," Journal of Personality, Vol. 16, No. 1, 1947, p. 69-77.

The classical study in the area of perceptual defense which drew attention to the perceptual processes of defense and sensitization and their relationship to emotional stimuli. Provided the impetus for the controversy of perceptual defense.

Campbell, F. W., and A. H. Gregory, "Effect of Pupil Size on Visual Acuity," Nature, Vol. 187, 1960, p. 1121-1123.  
One of the studies which gives support for the effect pupil size has on visual acuity for various test objects.

Dixon, N. F. Subliminal Perception: The Nature of a Controversy, London, McGraw-Hill, 1971, xiv-363 p.

Subliminal perception is discussed in all its facets. The author's own research on perceptual defense offers a new approach and methodology for exploring the phenomenon. A most useful source for this study, especially for the theoretical models relating cortical and subcortical structures to perceptual defense.

Goldwater, Bram C., "Psychological Significance of Pupillary Movements," Psychological Bulletin, Vol. 77, No. 5, 1972, p. 340-355.

A recent review of the literature related to the pupillary response as an index of autonomic activity in psychophysiological research. Considers pupillary dilation to psychological and physical stimuli, mental activity, the light reflex, and conditioning of the pupil response. Highlights the methodological problems inherent in pupillary research and alternatives for future research.

Guilford, J.P., Psychometric Methods, New York, McGraw-Hill, 1954, ix-597 p.

The major source book on the psychophysical methods that served as the reference for the method of limits employed in this research.

Hess, Eckhard H., "Attitude and Pupil Size," Scientific American, Vol. 212, No. 4, April 1965, p. 46-54.

In this article pupillary response is related to psychological phenomenon, and is viewed as a measure of interest, emotion, attitudes and thought processes. Particularly important is the contention that the pupil dilates to pleasant stimuli and constricts to aversive stimuli. This has provoked a controversy that is still persisting.

Hess, Eckhard H., and James H. Polt, "Pupil Size as Related to Interest Value of Visual Stimuli," Science, Vol. 132, No. 3423, August 1960, p. 349-350.

Pupil size is found to increase while viewing interesting visual stimuli. Sex differences are noted for different types of stimulus material.

Hutt, L. D., and J. P. Anderson, "The Relationship between Pupil Size and Recognition Threshold," Psychonomic Science, Vol. 9, No. 8, 1967, p. 477-478.

Evidence of a negative correlation between pupil size and recognition threshold is provided. It suggests the pupil response to emotional stimuli may be a plausible mechanism for perceptual defense and vigilance. Served as the basis on which the present study attempted to relate pupil size more causally to perceptual defense.

Leibowitz, Herschel, "The Effect of Pupil Size on Visual Acuity for Photometrically Equated Test Fields at Various Levels of Luminance," Journal of the Optical Society of America, Vol. 42, No. 6, 1952, p. 416-422.

In this study is found the basis for the relationship between pupil size and visual acuity for different luminance levels. Provided the link between pupil size and recognition threshold through the effect pupil size has on visual acuity.

Lowenstein, Otto, and Irene E. Loewenfeld, "The Pupil," in H. Davson (ed.), The Eye, New York, Academic Press, Vol. 3, 1962, p. 231-267.

A most detailed and sophisticated presentation of the muscles of the pupil and pupillary reactions. A highly recommended source for information on the pupil.

Winer, B. J., Statistical Principles in Experimental Design, New York, McGraw-Hill, 1971, x-672 p.

This well-known book in statistics served as the main source for the design and statistical analysis for this study.

Woodmansee, John J., "Methodological Problems in Pupillographic Experiments," in Proceedings of the 74th Annual Convention of the American Psychological Association, Washington, D.C., American Psychological Association, Vol. 1, 1966, p. 133-134.

Contains criticisms and descriptions of the methodological problems encountered in pupillometric research and how these can serve as serious contaminating factors. Suggestions are also made regarding how these limitations can be overcome.

APPENDIX 1

RECOGNITION THRESHOLD DATA FOR EACH SUBJECT  
UNDER EACH PUPIL SIZE CONDITION

## Recognition Threshold Data for Subject One.

Trial	Word	Recognition Thresholds			
		2 mm.	4 mm.	6 mm.	FD
1	Tally	57.5	67.5	32.5	67.5
2	Whore	52.5	67.5	47.5	57.5
3	Mixer	72.5	77.5	67.5	52.5
4	Prick	47.5	77.5	42.5	57.5
5	Knack	57.5	37.5	27.5	42.5
6	Penis	52.5	47.5	42.5	42.5
7	Blunt	47.5	27.5	27.5	52.5
8	Raped	32.5	27.5	32.5	37.5
9	Blunt	47.5	42.5	37.5	37.5
10	Penis	47.5	32.5	22.5	32.5
11	Knack	37.5	47.5	27.5	32.5
12	Whore	32.5	27.5	27.5	32.5
13	Mixer	42.5	32.5	27.5	37.5
14	Raped	37.5	37.5	42.5	32.5
15	Tally	37.5	22.5	27.5	32.5
16	Prick	52.5	42.5	32.5	57.5
17	Mixer	62.5	52.5	32.5	47.5
18	Prick	57.5	37.5	42.5	37.5
19	Tally	62.5	62.5	32.5	52.5
20	Raped	77.5	52.5	32.5	37.5
21	Blunt	42.5	42.5	27.5	47.5
22	Whore	37.5	32.5	32.5	32.5
23	Knack	52.5	57.5	32.5	47.5
24	Penis	37.5	22.5	27.5	47.5
25	Knack	32.5	37.5	27.5	37.5
26	Raped	42.5	52.5	52.5	47.5
27	Blunt	67.5	47.5	37.5	42.5
28	Penis	37.5	37.5	32.5	37.5
29	Tally	37.5	62.5	37.5	42.5
30	Prick	42.5	52.5	32.5	37.5
31	Mixer	42.5	62.5	37.5	42.5
32	Whore	52.5	52.5	37.5	52.5
33	Tally	52.5	62.5	32.5	42.5
34	Prick	57.5	47.5	42.5	47.5
35	Knack	47.5	47.5	32.5	47.5
36	Whore	47.5	47.5	32.5	52.5
37	Mixer	32.5	37.5	37.5	37.5
38	Prick	42.5	42.5	37.5	37.5
39	Blunt	32.5	32.5	22.5	42.5
40	Penis	42.5	32.5	27.5	37.5

## Recognition Threshold Data for Subject Two.

Trial	Word	Recognition Thresholds			
		2 mm.	4 mm.	6 mm.	FD
1	Tally	47.5	62.5	42.5	47.5
2	Whore	37.5	52.5	32.5	47.5
3	Mixer	32.5	42.5	27.5	42.5
4	Prick	27.5	47.5	12.5	42.5
5	Knack	37.5	47.5	32.5	37.5
6	Penis	37.5	12.5	17.5	22.5
7	Blunt	32.5	12.5	37.5	37.5
8	Raped	32.5	27.5	17.5	27.5
9	Blunt	22.5	27.5	17.5	22.5
10	Penis	22.5	17.5	22.5	22.5
11	Knack	32.5	17.5	32.5	22.5
12	Whore	27.5	12.5	17.5	27.5
13	Mixer	22.5	17.5	22.5	27.5
14	Raped	27.5	12.5	17.5	22.5
15	Tally	22.5	12.5	17.5	17.5
16	Prick	32.5	27.5	32.5	47.5
17	Mixer	32.5	22.5	42.5	32.5
18	Prick	27.5	17.5	22.5	27.5
19	Tally	27.5	22.5	22.5	37.5
20	Raped	22.5	17.5	22.5	52.5
21	Blunt	37.5	12.5	17.5	22.5
22	Whore	27.5	27.5	22.5	32.5
23	Knack	17.5	17.5	17.5	32.5
24	Penis	22.5	17.5	17.5	22.5
25	Knack	22.5	27.5	17.5	22.5
26	Raped	32.5	22.5	22.5	22.5
27	Blunt	27.5	22.5	22.5	27.5
28	Penis	27.5	27.5	17.5	22.5
29	Tally	22.5	27.5	17.5	17.5
30	Prick	22.5	22.5	22.5	27.5
31	Mixer	27.5	27.5	42.5	32.5
32	Whore	22.5	17.5	22.5	27.5
33	Tally	22.5	22.5	27.5	27.5
34	Prick	22.5	27.5	27.5	27.5
35	Knack	37.5	22.5	27.5	27.5
36	Whore	27.5	32.5	27.5	27.5
37	Mixer	32.5	32.5	17.5	27.5
38	Prick	17.5	17.5	22.5	27.5
39	Blunt	32.5	22.5	22.5	22.5
40	Penis	37.5	22.5	17.5	27.5

## Recognition Threshold Data for Subject Three.

Trial	Word	Recognition Thresholds			
		2 mm.	4 mm.	6 mm.	FD
1	Tally	47.5	67.5	52.5	22.5
2	Whore	57.5	32.5	52.5	12.5
3	Mixer	32.5	32.5	52.5	22.5
4	Prick	92.5	17.5	37.5	22.5
5	Knack	52.5	42.5	27.5	22.5
6	Penis	42.5	17.5	42.5	27.5
7	Blunt	37.5	27.5	42.5	22.5
8	Raped	37.5	37.5	32.5	62.5
9	Blunt	47.5	37.5	32.5	27.5
10	Penis	62.5	22.5	22.5	32.5
11	Knack	27.5	22.5	47.5	47.5
12	Whore	42.5	22.5	17.5	17.5
13	Mixer	47.5	22.5	12.5	17.5
14	Raped	37.5	27.5	12.5	22.5
15	Tally	27.5	37.5	17.5	32.5
16	Prick	37.5	17.5	62.5	27.5
17	Mixer	72.5	32.5	32.5	12.5
18	Prick	72.5	17.5	22.5	27.5
19	Tally	37.5	27.5	32.5	22.5
20	Raped	37.5	37.5	32.5	22.5
21	Blunt	52.5	22.5	57.5	32.5
22	Whore	42.5	37.5	27.5	17.5
23	Knack	37.5	27.5	37.5	17.5
24	Penis	32.5	22.5	32.5	12.5
25	Knack	42.5	22.5	52.5	12.5
26	Raped	77.5	27.5	32.5	17.5
27	Blunt	67.5	17.5	37.5	27.5
28	Penis	57.5	32.5	32.5	12.5
29	Tally	32.5	42.5	32.5	17.5
30	Prick	27.5	17.5	27.5	17.5
31	Mixer	52.5	42.5	57.5	32.5
32	Whore	22.5	32.5	62.5	17.5
33	Tally	42.5	27.5	27.5	22.5
34	Prick	37.5	22.5	32.5	22.5
35	Knack	27.5	12.5	22.5	37.5
36	Whore	42.5	27.5	37.5	27.5
37	Mixer	62.5	32.5	32.5	32.5
38	Prick	67.5	32.5	27.5	42.5
39	Blunt	52.5	27.5	27.5	27.5
40	Penis	62.5	32.5	32.5	37.5

APPENDIX 2

ABSTRACT OF

The Effect of Pupil Size on Recognition Thresholds  
for Neutral and Taboo Word Stimuli

## APPENDIX 2

### ABSTRACT OF

#### The Effect of Pupil Size on Recognition Thresholds for Neutral and Taboo Word Stimuli

Numerous attempts have been made to account for the phenomenon of how motivating factors influence perception. One area that has attempted to deal with this broader issue is that of perceptual defense. In spite of different forms of explanation for the existence of perceptual defense, it still remains unexplained. Alternative ways of approaching the phenomenon are being developed, especially related to the neurophysiological basis of perceptual defense. The present study has been concerned in particular with the pupillary response as one plausible mechanism that may be involved. Some evidence exists to show that pupillary response and recognition thresholds are negatively related, but this still does not prove the pupillary response is a causal mechanism in perceptual defense. It is the pupillary response to emotional stimuli and its effects on visual acuity that suggest it may have a role to play in explaining the results of perceptual defense.

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1 Walter J. Leckett, Master's thesis presented to the School of Graduate Studies of the University of Ottawa, Ontario, September 1973, ix-108 p.

In this research pupil diameter was manipulated as the independent variable through use of artificial pupil sizes made from contact lenses. Pupil sizes included 2 mm., 4 mm., and 6 mm. diameters. In addition, a fully dilated condition was introduced, where no artificial pupil was worn. The objective was to see the effect of the different pupil sizes on the recognition thresholds for neutral and taboo words used in previous perceptual defense studies. It was expected that larger pupil diameters would result in a decrease in recognition thresholds, while smaller pupil sizes would result in an increase in recognition thresholds. Three male subjects were exposed to the neutral and taboo words under each of the different pupil size conditions. The words were displayed tachistoscopically using the method of limits, and recognition thresholds were recorded in milliseconds.

The results confirmed the hypothesis of no significant differences in recognition thresholds between different pupil size conditions for neutral and taboo words as well as the hypothesis of no significant differences in recognition thresholds of neutral and taboo words under the different pupil size conditions. The general trend of decreases in recognition threshold with increases in pupillary

diameter was noted, with possible increases in recognition threshold with further increases in pupillary diameter. Thus, pupillary response may be a plausible mechanism in perceptual defense, but such a hypothesis needs further exploration.

Further research could examine the role of pupillary response in perceptual defense more directly through use of latencies of pupillary response and duration recognition thresholds. Other models of perceptual defense, based on cortical, sub-cortical mechanisms, and employing different methodologies for examining the phenomenon may lead to a more thorough understanding and appreciation of the processes and mechanisms that are involved.