AN INVESTIGATION ON THE RELATIONSHIP BETWEEN PUPIL SIZE AND EMOTIONAL WORDS

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ABSTRACT

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A series of recent investigations have suggested a relationship between pupil size and emotional components of visual stimuli. A review of the literature revealed that while a physiological basis for a relationship between pupil size and emotional excitation could be stated, no investigator had yet demonstrated that emotional and neutral stimuli have differential effects upon pupil size. Although it is generally accepted that the pupil can be conditioned (Kimble, 1961), attempts to condition pupillary constriction or dilation (which would demonstrate that the pupil responds to psychological components of stimuli) have been equivocal. These studies were discussed and possible explanations of the negative findings were suggested.

The hypothesis of the present study was that presentation of emotional words would result in significantly different pupil reactivity (constriction or dilation) than would presentation of neutral words to the same

subjects. The words utilized were selected from published lists of words which were shown to affect behavior as measured by GSR and the Semantic Differential, and presented to a group of students. The three words with the highest and lowest "emotionality scores" were then chosen. Twenty-eight Ss were presented each of the three emotional and three neutral words for five seconds while motion picture recordings were being taken of their pupils.

It was found that overall mean pupil size of 27 out of 28 Ss was larger to emotional than to neutral words. Analysis of variance demonstrated that emotionality did have a significant effect on pupil size, and that there was also a significant interaction effect of emotionality and time (intervals). When the data for the first and last 2.5 seconds were analyzed separately, results showed that pupillary size during the first 2.5 seconds was not significantly different for emotional than neutral words. However, during the second 2.5 seconds of stimulus presentation the results clearly demonstrated that: pupil size was significantly larger to emotional than to neutral words.

Pupil dilation was discussed as a measure of a generalized autonomic response to emotionally meaningful

stimuli. Numerous research implications were suggested, both in the investigation of the characteristics of the pupil response itself, and in the utilization of the pupil response in investigating the emotional properties of visual or sensory stimuli.

Approved Bill L. Kell
Chairman

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By

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INTRODUCTION

A series of recent publications by Hess and Polt (Hess and Polt, 1965; Hess and Polt, 1964; Hess and Polt, 1960) offer evidence that the pupillary response may be utilized as a measure of affective states. In these studies the authors presented a number of visual stimuli to their subjects and then measured the diameter of each subject's pupil in relation to the manifest content of the visual stimuli. In one report (Hess and Polt, 1964) they measured pupil size of Ss during simple problem-solving procedures. The results of these studies demonstrated a relationship between pupil size and psychological components of the stimuli, and were sufficiently consistent to lead the authors to conclude that the pupil response can provide quantitative data on the psychological effects of visual and other stimulation, on complex mental activities, on interests and attitudes, and on states of emotional excitation. Hess, Seltzer, and Schlien, (1965) reported that they were able to differentiate homosexual from heterosexual males by measuring the pupil response to visual stimuli.

A number of criticisms may be directed at the above studies. On a procedural level, Hess and his associates have made no attempt to differentiate or even operationally define such variables as "interest", "emotionality", or "attitude." To the contrary, they

have hypothesized that certain visual stimuli would arouse a specified affective state, e.g. interest, and then report that the changes in pupil size were due to that particular affect. Secondly, the above reports have been more descriptive than experimental. The procedures have been loosely controlled and not reported in sufficient detail so as to allow replication. The results have been presented only in terms of direction and percentage of change, and the application of precise statistical techniques has been conspicuously absent.

It is the belief of this author that the nature of the relationship of the pupil response to definable visual stimuli has not yet been established. If the pupil response is to be considered "a new tool with which to probe the mind. . . and to establish personality differences" (Hess and Polt, 1965, p. 54), then it merits a more systematic experimental investigation.

The present study proposes to empirically validate the contention that pupil reactivity is related to affective states. More specifically, the purpose of this experiment is to establish whether there is a measureable relationship between pupil size and certain emotionally meaningful words.

While physiologists have repeatedly noted that the

pupil response is affected by emotional stimulation (Morgan, 1965; Lowenstein and Loewenfeld, 1962; Lowenstein and Loewenfeld, 1952; Brown and Page, 1939; Ury and Gillhorn, 1939; and Ferre and Bond, 1933), a review of the literature revealed that only one investigator, prior to Hess and Polt, had attempted to critically examine this phenomenon. Bender (1933) photographed S's pupils which were simultaneously exposed to light and to emotional stimuli. "Emotional stimuli" were defined as a white rat held in front of Ss' face or a pin prick. When these photographs were compared with photographs of the pupils of the same Ss' when only the light was flashed, it was found that the measured absolute size of the pupil was larger, and that the amount of time for the pupil to return to normal after the flash of light was longer when emotional stimuli were present. While statistical treatment was not applied to these data. the results were consistent in the hypothesized direction, and Bender concluded that a purely psychic stimulus may cause the pupil to dilate.

There have been a number of investigators who have attempted to condition the pupil response. The relevance of these studies for the present research lies in the fact that a pupil response to emotional components of stimulus is a learned response. Furthermore, the

conditioning studies have contributed important information about the nature of the pupil response. Watson (1916) obtained a conditioned pupil constriction to sound, but noted that pupillary conditioning was not a satisfactory way to study conditioning principles, because it was such a difficult response to obtain. Since the Watson report, there has been a continued controversy as to whether a pupil response could be conditioned at all, and if so, what experimental procedures were necessary to obtain a conditioned pupillary response.

Cason (1922); Hudgins (1933); Harlow and Stagner, (1933); Hudgins, (1935); Baker, (1938); Metzner and Baker, (1939); Harlow, (1940); Girden, (1942); and Crasilneck and McCranie, (1956) were able to condition a pupillary response to either sound or shock. Stickle and Brenshaw, (1934); Stickle, (1936); Wedell, Taylor and Skolnick, (1940); Hilgard, Miller, and Ohlson, (1941); Stern, (1948); Hilgard, Dutton and Helnick, (1949); and Young, (1954) reported experimental procedures which failed to obtain conditioning even when the conditions reported by others were exactly replicated. Other investigators (Young, 1958 and 1965; Sampson and Boslow, 1957; Gerall and Obrist, 1955; Young and Biersdorf, 1954; Girden, 1942) have found that pupillary conditioning could be obtained but that

the conditioned response was not stable or easily elicited when changes in light intensity or sound were used as the conditioned stimuli. One possible explanation for this that seems not to have been considered is that the pupil response to light itself may have some of the characteristics of a conditioned response. Lowenstein and Loewenfeld (1952) found the pupil response to changes in light intensity was not difficult to extinguish. The studies cited above have all utilized the pupillary response to light as an unconditioned response, and it is quite possible that the repeated presentation of light may have resulted in extinction of the unconditioned response before conditioning occurred. Moreover, these studies have not adequately controlled the homogeniety of the visual field. Typically, the pupil was observed by use of a telescope, and the presence of a lens resulted in different intensities of reflected light across the Ss' visual field. Interestingly enough, there have been no published reports of failure to obtain conditioning when the unconditioned stimulus was electric shock or pain. Such stimuli are usually described as "emotional." (Young, 1962; Hilgard, Dutton, and Helnick, 1949; and Girden, 1942).

In attempting to explain the negative findings of

other investigators, Girden (1942) discussed components of the pupillary response as consisting of both simple dilation and constriction, and of a "hippus" or disturbance response. The hippus refers to the continuous oscillation of the size of the pupil. Typically, the pupil changes size at a rate of 20 to 60 oscillations per minute and that this hippus may account for a pupil-size change as much as one millemeter. Crasilneck and McCranie (1956) also discuss the hippus effect and report that because of this continuous oscillation, direct observation of the pupil, even with use of a telescope or pupilograph is inefficient and inaccurate. It should be noted that all of the pupillary conditioning studies prior to 1950 utilized telescopic or pupilographic apparata.

Lowenstein and Loewenfeld (1962) have described the physiological mechanisms of the pupillary response. They state that the iris is a representative of all smooth muscle structures that are reciprocally innervated by the sympathetic system, while the pupillary sphincter (pupil constriction) is innervated by parasympathetic activity. Physiologically, there is thus reason to believe that pupil reactivity should be associated with stimuli that are emotionally laden. Bender, (1933); Brown and Page, (1939); and Ury and Gellhorn, (1939)

have also described the reciprocal relation of sympathetic and parasympathetic systems to pupillary dilation and constriction. However, there has not been sufficient evidence to suggest a directionality factor in pupil reactivity. Hess and Polt (1965) state that with respect to visual stimuli, there is a range of pupil responses from extreme dilation for pleasing stimuli to extreme constriction for unpleasant stimuli. This is contrary to Bender's finding that painful and unpleasant visual stimuli resulted in pupil dilation. It is also inconsistent with Young's (1965) report that conditioning of pupillary constriction is not possible because pupillary constriction is not part of the generalized unconditioned autonomic response to psychic stimuli.

It has been suggested by a number of authors that the pupillary response is representative of a generalized autonomic response to noxious or emotional stimuli. Young (1965) stated that such a generalized autonomic response is modified during conditioning so that changes in the size of the pupil represent changes that are occurring within the autonomic nervous system. Girden (1942) reported that pupillary dilation is a function of generalized response of the organism to noxious stimuli. McGinnies (1956) operationally defined "emotionality" as generalized autonomic activity, as measured by the

galvanic skin response, without regard to presence or absence of phenomenological content. Thus, while it may be hypothesized that pupil reactivity is related to emotionality, dilation or constriction in response to specifically "toned" words (pleasant or unpleasant) respectively, remains speculatory.

As has been stated, inadequate definition and control of the visual stimulus has been a deficiency in all of the studies relating pupil size to affective stimuli. Bender did not control the visual field or light intensity. Hess did not attempt to measure or control physical complexity or psychological meaningfulness of the stimuli used. In the proposed study words that have been judged as emotionally laden will be used. That simple words can elicit emotional responses has been repeatedly demonstrated.

Generally, at least one of three methods has been employed in demonstrating that the perception of words elicits affective arousal. Research studies on perception have used judge's ratings of emotionality. Typically, words judged as emotional have shorter or longer recognition thresholds than words judged to be neutral, (Jenkins, Russell, and Suci, 1958; Singer, 1956; Postman, Bruner, and McGinnies, 1948; Bruner and Postman, 1947).

A second procedure has been utilized in the studies on meaningfulness. The Semantic Differential or word-association techniques have been administered to groups in order to establish the meaningfulness of frequently used words. Noble (1958) has noted that emotionality is one attribute of meaningfulness. Heise (1965) recently published a "dictionary" of affective content of words as measured by the Semantic Differential.

Thirdly, galvanic skin response (GSR) measures have been shown to be associated with the emotional or affective connotation of words. Although McCleary (1950); Venables, (1955); and Watson, (1957) have questioned the used of the GSR as a measure of emotionality, Silverman, Cohen, and Shanavonian (1959) have shown that in an adequately controlled procedure, GSR varies directly with affective responses as measured by clinical interviews. McGinnies (1949) showed that emotionality as measured by GSR was significantly greater for selected "critical" words when compared with neutral words. Zajonc (1962) compared 12 taboo words with 12 neutral words and found that on every trial the taboo words exceeded the neutral words in eliciting a GSR. Noble (1958) also utilized the GSR to assign weights to words that had been judged neutral, pleasant, or unpleasant. He concluded that "judged emotionality is a reliable

attribute of verbal stimuli" (Noble, 1958, p. 16). Cohen, Silverman, and Barch (1956) studied the effects of neutral and "charged" words and also found consistent GSR's associated with emotionally-laden words. They reported that the GSR responsivity to a word stimulus is a function of the affective connotation of the stimulus and level of arousal of the subject in relation to that stimulus.

In summary, it has been shown that on a physiological basis, pupil reactivity should be related to emotional or affective components of visual stimuli. Secondly, it has been shown that words used as visual stimuli can result in the elicitation of affective states. It is therefore the hypothesis of this investigation that pupil reactivity, as measured by average pupil size, will be significantly greater when emotionally-laden words are used as stimuli than when neutral words are used as stimuli.

METHOD

Subjects. The subjects were 30 male college students from an introductory psychology course who volunteered for this experiment as partial fulfillment of the requirements of the course.

Apparatus. The apparatus (see Fig. 1) was designed and constructed following Hess and Polt (1965) with certain modifications and improvements made on the prototype. The present apparatus consisted of a rectangular box 18" high, 16" wide, and 32" long. On one end was a viewing aperture such that when S's head was in place, the right eye was directly in front of the aperture. On the opposite end there was mounted a 6" x 8" projection screen. The visual target was projected on this screen by a 500 watt 35mm. Kodak Carusel slide projector. The projector was placed 18" from the projection screen.

Inside the rectangular box a 9" x 20" chromium-coated, one-way vision screen was placed at a 45° angle across the S's line of vision between aperture and projection screen. This mirror reflected the image of S's eye directly into the lens of a 16mm. Eclair 16II motion picture camera which was mounted on the side of the box. The camera was fitted with an Angenioux 12-120mm. Zoom Lens and a +2 diopter close-up lens. The distance along the visual axis from the viewing aperture

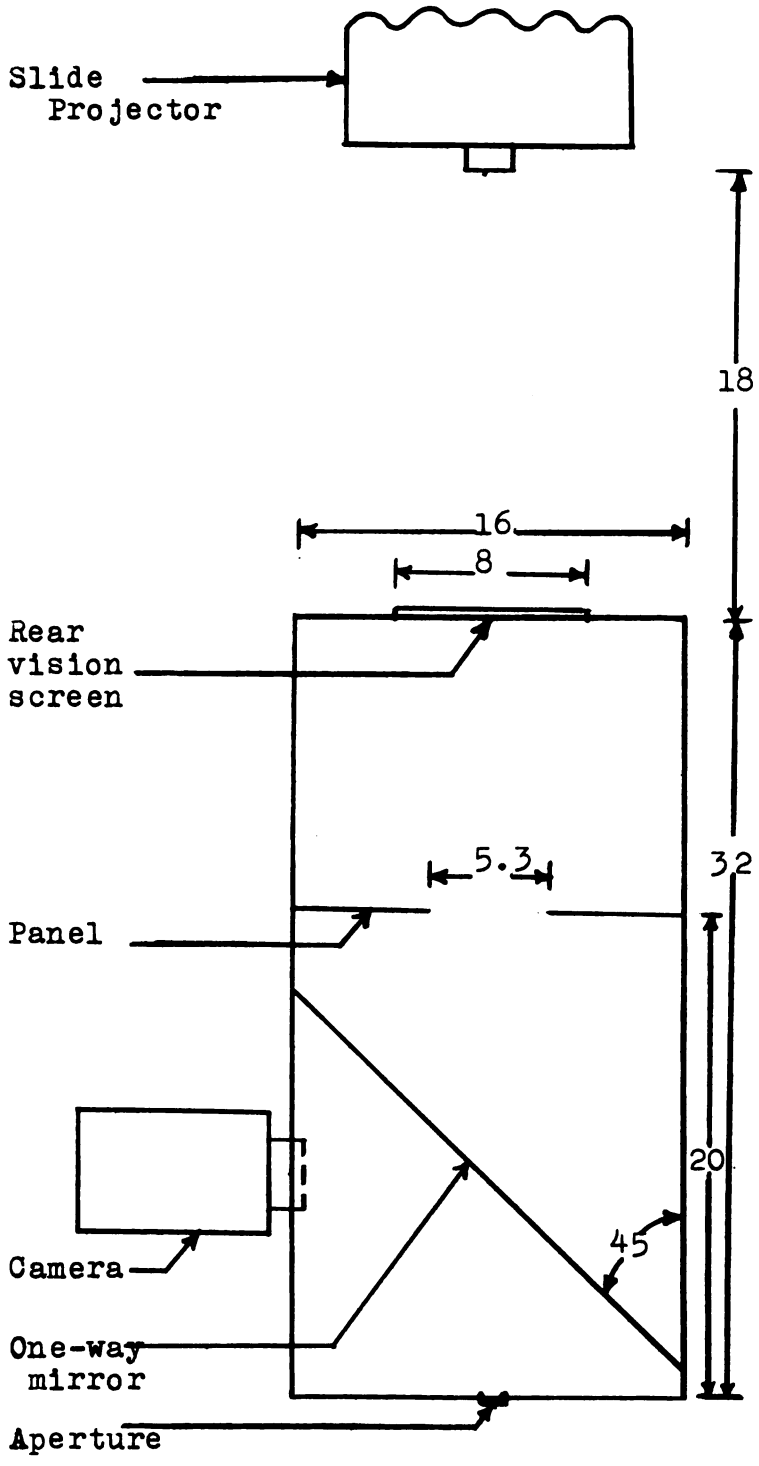

Fig. 1. Experimental Apparatus: top view.
Scale: 1/8" = 1".

to the mirror was 9". The camera lens was a 90mm. Kilfitt Macro Kilar, with a shutter speed set at .25 second at 4 frames per second. Illumination was furnished entirely by the 500-watt projector. During projection of the experimental slides, reflected light was measured at 10.6 foot candles allowing a shutter opening of F4. The camera was loaded with Kodak XXX panchromatic 16mm. film.

Also within the apparatus, 20" from the viewing aperture, was a ¼" plywood panel in which a 4" x 5.3" rectangular hole was cut. This panel was placed such that when looking through the viewing aperture, only the surface of the 6" x8" projection screen was visible.

The interior area of the apparatus, from the aperture to the panel was painted a flat black; the remainder of the interior was painted an enamel white.

Materials. The visual targets utilized in this experiment consisted of six 35mm. slides. Slides were made by imprinting Paratype symbols No. 3 upon clear plastic slides. A Pentex light meter, placed at the viewing aperture of the apparatus registered less than 300 millilamberts difference in light intensity between each word and its background. This is in accordance with Bender's (1933) finding that the reactivity

threshold of the pupil to changes in light intensity ranges from 300 to 500 millilamberts.

"Emotionality" of the words used in this study was determined in the following manner. From the published lists of words that have been shown to affect behavior, (Heise, 1965; Solarz, 1963; Zajonc, 1962; Eriksen, Azuma and Hicks, 1959; Alexander, 1938; Cohen and Silverman, 1956; Howe and Solomon, 1951; Bruner and Postman, 1947) and that have been judged to be of either affective or neutral connotation, E selected an original sample of 30 words. These 30 words consisted of three groups of three-letter, four-letter, and five-letter words, with each group containing five neutral and five emotional words. These 30 words were then presented in a random order to a group of 58 students in an introductory psychology course who were asked to sort the words into two groups; one group containing those words which were thought to be emotional, or which would be expected to elicit emotional responses; and one group containing those words that were thought to be neutral or without emotional connotation. The judgments of these students--none of whom served as Ss in the experiment--were then summed. Emotionality of the stimuli used in this study was thus describable on a scale ranging from zero (None of the 58 students judged

it to be emotional.) to 58 (All of the 58 students judged it to be emotional.) The scores of the thirty words that were originally chosen are presented in Appendix A. Controlling for frequency of usage and word-length (Rosenzweig and McNeil, 1962), the three words with the highest, and lowest scores, were then selected as the stimuli for this study. Table 1 is a presentation of these words and their corresponding scores.

Table 1. Words used as stimuli and their corresponding scores of "judged emotionality." Score indicated the number of students out of 58 who judged the word to be emotional.

Emotional Words	Score	Neutral Words	Score
Sex	55	The	0
Kiss	54	Card	10
Vomit	53	Shelf	0
Mean Emotionality	54	Mean Emotionality	3.3

Procedure. To control possible effects due to order of presentation of stimuli, a program of order of presentation for each S was devised. The program (see Appendix B)

was constructed by assigning words arranged in alphabetical order, numbers from 1 to 6, and then consulting a table of random numbers (Edwards, 1962).

Data was collected in the following manner. Ss were seated before the apparatus and given the following instructions: "Please place this eyepatch over your left eye and look into the box. We are going to project a series of slides onto the viewing screen which you are now looking at. Please try to keep your eye on the screen at all times and just react to whatever you see. We would like you to remain silent while reacting to the slides."

The E, and assistant, and a camera operator were present during the experiment. After S was given the instructions, the camera was checked for focus, and the projector was activated. After a ten-second "orientation" period, the first stimulus was presented. Each visual target was automatically presented for five seconds in the pre-programmed order for that S. The speed of the slide projector was such that there was .5 seconds of relative darkness between target exposures. Thus there were collected twenty photographs of each S's pupil in response to each visual target. After all slides were presented, each S was given a packet of 3" x 5" cards on which were printed the words they had just viewed.

They were then asked to rank order the words in order of their emotional meaningfulness.

The 3600 photographs were examined by use of a Baush and Lomb Scale Projector which projected the image of the photographed pupil onto a surface magnified 22 times. A standard mm. ruler was used to measure the size of the pupil on each frame.

RESULTS

The data of S 1 and 15 were discarded because they closed their eyes and measurement was not possible for over 25% of the photographs. The .5 second inter-target interval resulted in shading on the film which made presentation and termination of a given target easily recognized.

Recorded measurements were transformed into an approximation of actual pupil size in relation to emotional and neutral stimuli and plotted in Fig. 2. The recordings were at 3 times actual pupil size.

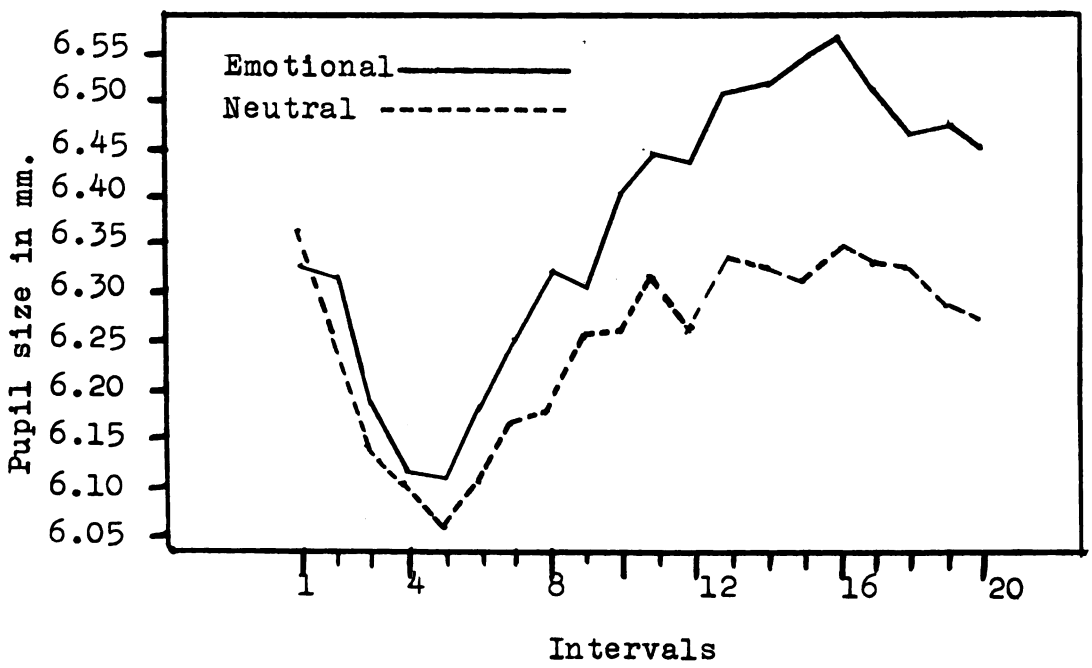

Fig. 2. Approximation of mean actual pupil size for 28 Ss during 5-second stimulus presentation.

Complete analysis of variance (Lindquist, 1953) of the data is presented in Table 2. Emotionality had a significant effect on recorded pupil size, as did words, time (intervals), and Ss. With the exception of EXS, the interaction effects were also significant.

Table 2. Analysis of Variance for emotional vs. neutral words with S=28 Subjects and I=20 intervals for each word.

Source of Variance	SS	d.f.	MS	F
Emotionality(E)	12.97	1	12.97	12.09 **
Words (W)	54.86	2	27.43	2.881*
Intervals(I)	390.71	19	20.56	5.24 **
Subjects(S)	20,114.70	27	744.98	275.86 **
E X S	29.13	27	1.08	
W X S	514.21	54	9.52	3.53 **
I X S	2,112.66	513	3.92	1.45 *
E X W	83.17	2	41.59	2.81 *
E X W X S	792.53	54	14.67	5.43 **
E X I	729.76	19	36.41	5.45 **
E X I X S	3,425.22	513	6.67	2.47 *
W X I	250.61	38	6.59	3.27 **
W X I X S	2,065.00	1,026	2.01	
E X W X I	501.27	38	13.19	4.88 **
E X W X I X S	2,772.75	1,026	2.70	
Total	33,849.55	3,359		

*P. < .05
**P. < .005

To test for significant differences between pupil size in relation to each of the words a Duncan's New Multiple Range Test (Edwards, 1962) was applied to the differences in mean pupil size of all measurements of

eaoh word. Results presented in Table 3 indicate that pupil size in two of the emotional words (kiss and vomit) was significantly larger than any of the neutral words but not significantly different from each other. Pupil size in response to "sex" was significantly larger than two of the neutral words (the and card) but not shelf.

Table 3. Duncan's New Multiple Range Test applied to the differences between mean pupil size in response to W=6 words.

	Means	the	card	shelf	sex	kiss	vomit	shortest sig. ranges at P=.05
the	18.664		.055	.096	.314	.512	.519	.224
card	18.719			.041	.259	.457	.463	.240
shelf	18.761				.218	.417	.423	.248
sex	18.979					.198	.205	.254
kiss	19.177						.007	.259
vomit	19.184							
		1	2	3	4	5	6	

Any two words not underscored by the same line are significantly different P<.05.
Any two words underscored by the same line are not significantly different P<.05.

With the exception of the sex-shelf mean difference, the emotional words resulted in significantly larger pupil size than the neutral words. When grouped across all intervals, 27 out of 28 Ss responded with a larger mean pupil size to emotional than to neutral words.

The data reported in Fig. 2 revealed that there was a

consistent initial constriction which lasted about 1.25 seconds to both neutral and emotional words, and then a recovery during which the pupil returned to approximately the same size as at stimulus presentation. From 2.5 seconds until termination of stimulus presentation the differences in mean pupil size are more clearly distinguishable. This was probably due to the .5 seconds of relative darkness between stimulus presentations and is similar to Lowenstein and Loewenfeld's (1942) dindings of a 2.5 second recovery period to momentary changes in light intensity. It was suspected that any differences in pupil size due to emotional components of the stimuli (dilation) may have been obscured by the response to change in light intensity (constriction). To test this hypothesis, the data were divided into two 2.5 second parts and separate analyses were applied to each half. Results are presented in Tables 4, 5, and 6. Examination of these Tables showed that the main effect of emotionality during the first 2.5 seconds was not significant, while during the remaining 2.5 seconds the effects were highly significant ($F=20.26$, $df=1,27$, $P<.005$).

Effects of time (intervals) were significant only during the first 2.5 seconds. The effects of words and

Table 4. Analysis of Variance for emotional vs. neutral words with S=28 Subjects and I=10 intervals: first 10 intervals.

Source of Variance	SS	d.f.	MS	F
Emotionality(E)	1.22	1	1.22	2.48
Words(W)	5.06	2	2.53	
Intervals(I)	323.76	9	35.95	37.47 **
Subjects(S)	10,383.26	27	384.56	127.33 **
E X S	13.24	27	.49	
W X S	276.75	54	5.12	1.74 **
I X S	232.88	243	.96	
E X W	29.14	2	14.57	1.52
E X W X S	517.69	54	9.58	3.17 **
E X I	79.99	9	8.89	2.35 *
E X I X S	946.67	243	3.81	1.25 *
W X I	83.89	18	4.86	2.059**
W X I X S	1,129.08	486	2.36	
E X W X I	394.22	18	21.93	7.23 **
E X W X I X S	1,467.94	486	3.02	
Total	15,885.79	1,679		

*P< .05
**P< .005

Table 5. Analysis of Variance for emotional vs. neutral words with S=28 Subjects and I=10 intervals: second 10 intervals.

Source of Variance	SS	d.f.	MS	F
Emotionality(E)	11.75	1	11.75	20.26 **
Words(W)	48.80	2	24.40	5.43 **
Intervals(I)	66.95	9	7.44	
Subjects(S)	9,731.44	27	360.42	134.98 **
E X S	15.89	27	.58	
W X S	237.46	54	4.49	1.86 **
I X S	1,879.78	243	7.73	2.89 **
E X W	54.03	2	27.01	5.36 **
E X W X S	274.84	54	5.09	1.92 **
E X I	649.77	9	72.19	7.08 **
E X I X S	2,478.55	243	10.19	3.94 **
W X I	166.72	18	9.24	4.83 **
W X I X S	935.92	486	1.93	
E X W X I	107.05	18	5.94	2.22 **
E X W X I X S	1,304.81	486	2.67	
Total	17,963.76	1,679		

*P< .05
**P< .005

Table 6. Duncan's New Multiple Range Test applied to the differences between mean pupil size in response to W=6 words: second 10 intervals.

	Means	the	card	shelf	sex	kiss	vomit	shortest sig. ranges at P=.05
the	18.753		.122	.332	.601	.693	.854	.231
card	18.875			.210	.479	.571	.732	.248
shelf	19.085				.269	.361	.522	.264
sex	19.354					.092	.253	.286
kiss	19.446						.161	.305
vomit	19.607							
		1	2	3	4	5	6	

Any two words underscored by the same line are not significantly different. P<.05.

Any two words not underscored by the same line are significantly different. P<.05.

interaction effects of emotionality X words, and of intervals X subjects was significant only during the last 2.5 seconds. Interaction effects of words X subjects was significant throughout the 5 seconds.

Clear differences between first and last halves of stimulus presentation were also evident with regards to responses to individual words. During the first 2.5 seconds, mean pupil size was not significantly different between any of the six words. During the second 2.5 seconds pupil size in response to the three emotional words were all significantly larger than pupil response to the three neutral words (P< .05) and not significantly different from each other. However, the word "shelf" resulted in significantly larger mean pupil size than

either "the" or "card" which were not significantly different from each other.

The subjects' rankings of the words in order of emotionality, and the rankings of the words in order of overall pupil size are presented in Appendix C. The sum of these rankings are presented in Table 7. Kendall's coefficient of concordance (Winer, 1962) was applied to these rankings and average correlations were computed. The average correlation of S's rankings was .850 and of rankings by pupil size .535. Both are highly significant ($P < .05$). The average correlation between rankings of words by S's in order of emotionality and rankings of words in order of scores of emotionality by students, and rankings of words by pupil size was .467 ($P < .05$). These correlations support the notion of a common factor between judged emotionality and emotionality as measured by pupil size.

Table 7. Sums and correlations of rankings of 28 subjects on emotionality of words and rankings of pupil sizes in response to words.

Word	the	card	shelf	sex	kiss	vomit	W	$r_{av.}$
S's ranking	173	126	127	50	65	64	.856	.850
Ranking by pupil size	121	113	125	91	68	69	.456	.535

DISCUSSION

> It is clear that a rapid, objective technique to evaluate changes in the intensity of affective responses, a technique that would be sensitive to minor fluctuations in the human "alertness" level would be of extreme value. (Silverman, Cohen, and Schmavonian, 1959, p. 65)

The results of this study demonstrated that when measured across time, the pupil was significantly larger when Ss were looking at emotional words than when the same Ss were looking at neutral words. The hypothesis, i.e., that emotional words would elicit significantly greater pupil reactivity than neutral words was supported.

Young (1965) reported that when pupillary constriction is elicited by an increase in light intensity, the response is a reflex constriction of the pupil itself, whereas pupil dilation to noxious stimuli is a part of a more generalized response of the total autonomic nervous system. "Pupillary constriction and dilation to light is controlled by the parasympathetic system which may be overridden by the sympathetic system under stress to produce dilation" (Young, 1965, p. 371). It is this generalized autonomic response which controls pupillary dilation to emotional stimuli. In the present study it was this generalized "emotional response" to the emotional words which resulted in the observed pupillary

dilation. The results indicate that the emotional components of the stimuli need not necessarily be noxious or painful in order to elicit the dilation response.

The procedure utilized in the present study resulted in an initial constriction-recovery response to a momentary change in light intensity between stimuli. The duration of this initial constriction-recovery response--approximately 2.5 seconds--is similar to the findings of Lowenstein and Loewenfeld (1952), Backer and Ogle (1964), and Gradle and Ackerman (1942). The mean differences in pupil size between emotional and neutral words during the first 2.5 seconds were not significant. It is suggested that the dilatory response tendency to emotional components of the stimuli was overridden by the constriction response to light. During the last 2.5 second interval the differences in pupil size to emotional and neutral stimuli were highly significant ($P < .005$). In a procedural setting where stimuli could be changed without momentary changes in light intensity, the dilation response would probably be more immediate. However, at this time such a notion can only be hypothesized.

The significant average intercorrelation between rankings by Ss of the six experimental words ($r_{av}=.850$) ($P < .05$) suggests a consistency in the perceived

emotionality of these words. When the words were ranked in order of pupil size in relation to the six words, the average correlation was also significant ($r_{av}=.535$) ($P<.05$). This suggests a strong relationship between judged emotionality and emotionality as measured by pupil size. This relationship needs further investigation, however, for the results expose some marked discrepancies between judgments of emotionality of specific words and the pupillary response to those words. The word "sex" received the highest "emotionality score" of the six words used, and received the highest ranking by Ss. However, the pupil response to this word was smallest of the three emotional words. Although overall mean pupil size to the word "sex" was larger than to any of the neutral words, it was not significantly larger than the overall mean pupil size in response to the word "shelf." Perhaps the frequent use of the word "sex" in social and commercial settings has habituated some of the emotional connotations of the word.

The results also indicate that variables other than emotionality may affect the size of the pupil. The greatest amount of observed variation was between subjects. The interaction effects of words X subjects during the first 2.5 seconds of stimulus presentation

was significant. Different subjects responded differently during this interval. Recent investigations have shown that pupil size is also affected by the orienting reflex. The orienting reflex refers to physiological or neurological organismic responses to changes in stimulation. Razran (1962) reported that pupillary changes that are part of the orienting reflex are usually dilation but non-visual sensory stimuli frequently result in a constriction that inhibits the pupillary-dilation aspect of the orienting reflex. In that the present study utilized visual stimuli, effects of the orienting reflex would also have been inhibited during the first 2.5 seconds, and may possibly have contributed to the results. Such a possibility is in need of further investigation. Another possible explanation of the significant two and three way interactions is that subjects in general respond differentially to emotionally-laden stimuli. A number of authors have reported different reaction times to emotional and neutral words (Zajonc, 1962; Alexander, 1958; Cohen, Silverman, and Barch, 1956; McGinnies, 1956). These authors, and others, (MacIntosh, 1961; Johnson, Thomson, and Frinke, 1960; and Kohn, 1960) have suggested a relationship between certain personality characteristics and responsivity to emotional stimuli.

Research implications of the present study are numerous. While characteristics of the pupillary response to light have long been known (Reeves, 1918) characteristics of the pupil response to emotional stimuli, e.g., latency reaction time, duration, etc. have yet to be investigated. Moreover, it has been shown here that pupil dilation is a response to certain emotionally-laden words; whether or not pupillary constriction may also be a component of certain emotional responses, or under what conditions dilation and/or constriction occur as part of a generalized emotional response, is only hypothetical.

Young (1965) has already hypothesized a relationship between pupil dilation and GSR. Other physiological measures of emotionality such as heart rate and respiration rate may also be related to pupil reactivity. It is apparent that pupillary activity is a multidimensional response. It has been noted that pupil size is one aspect of the orienting reflex. The hippus-effect that was observed by Girden (1942), and Crasilneck and McCranie (1956), has yet to be experimentally investigated. Hess and Polt (1965a, 1965b, 1964) have stated that pupil size is also related to interest value of stimuli, to attitudes, and to complex mental activity.

The study reported here has special value in the areas of Clinical Psychology and personality theory. The author's own interest in pupil size began as an interest in interpersonal or non-verbal cues of communication. In that pupil size is related to internal affective states, a question can be posed: Are changes in pupil size perceptible in an interpersonal situation? Also, in that pupil size is an objective measure of generalized emotional responsivity, the emotional impact of specifiable visual stimuli can now be ascertained. Miller (1966) recently reported a study which demonstrated that pupil size (emotionality) is different for chromatic than achromatic stimuli. Perhaps a "scale of emotionality" for groups of words or other visually-presented material can now be devised.

Pupilometric research may also prove to be a useful tool in research on psychodiagnosis and psychotherapy. For example, a series of stimuli representative of specifiable conflict situations can be devised, and then a person's pupil responses to those situations can be recorded. Larger pupil responses would hypothetically be related to stimuli representative of that person's problem-area. Also, changes in emotional responsivity to conflict situations may be utilized as a measure of "change" in psychotherapy. Kell and

Mueller (1966) have suggested that emotional experiences often become "compacted" into certain words or phrases. It is suggested that pupilometrics offer a procedure for detecting such compacted words or phrases of a given client. Also, changes in pupil response to these words or phrases would indicate effects of therapy.

SUMMARY

A series of recent investigations have suggested a relationship between pupil size and emotional components of visual stimuli. A review of the literature revealed that while a physiological basis for a relationship between pupil size and emotional excitation could be stated, no investigator had yet demonstrated that emotional and neutral stimuli have differential effects upon pupil size. Although it is generally accepted that the pupil can be conditioned (Kimble, 1961), attempts to condition pupillary constriction or dilation (which would demonstrate that the pupil responds to psychological components of stimuli) have been equivocal. These studies were discussed and possible explanations of the negative findings were suggested.

The hypothesis of the present study was that presentation of emotional words would result in significantly different pupil reactivity (constriction or dilation) than would presentation of neutral words to the same subjects. The words utilized were selected from published lists of words which were shown to affect behavior as measured by GSR and the Semantic Differential, and presented to a group of students. The three words with the highest and lowest "emotionality scores" were then chosen. Twenty-eight Ss were presented each of

the three emotional and three neutral words for five seconds while motion picture recordings were being taken of their pupils.

It was found that overall mean pupil size of 27 out of 28 Ss was larger to emotional than to neutral words. Analysis of variance demonstrated that emotionality did have a significant effect on pupil size, and that there was also a significant interaction effect of emotionality and time (intervals). When the data for the first and last 2.5 seconds were analyzed separately, results showed that pupillary size during the first 2.5 seconds was not significantly different for emotional than neutral words. However, during the second 2.5 seconds of stimulus presentations the results clearly demonstrated that: pupil size was significantly larger to emotional than to neutral words.

Pupil dilation was discussed as a measure of a generalized autonomic response to emotionally meaningful stimuli. Numerous research implications were suggested, both in the investigation of the characteristics of the pupil response itself, and in the utilization of the pupil response in investigating the emotional properties of visual or sensory stimuli.

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APPENDICES

APPENDIX A

Judgments of emotionality of 30 words by 58 students.

e = S judged that word to be emotional

WORD	SUBJECT																													
	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	29
about																														
bad	e	e	e	e		e	e	e	e	e	e	e	e	e	e	e	e	e			e	e	e	e	e		e	e		
belly	e	e	e	e	e	e		e	e			e	e	e	e	e	e	e	e			e	e	e		e	e		e		
blood	e	e	e	e	e	e	e	e	e	e	e	e	e		e	e	e	e	e	e	e	e	e	e	e	e	e	e	e		
card	e	e	e				e	e															e			e				
day	e				e				e			e					e		e				e		e					
death	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e		
die	e	e	e	e	e	e	e	e	e			e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e		
exam	e	e	e	e	e	e	e		e		e		e	e	e	e	e	e	e			e	e	e		e	e	e	e		
fire	e	e	e	e	e	e	e	e			e	e	e	e	e	e	e	e	e		e	e	e		e	e	e	e	e		
filth	e	e	e	e		e	e	e	e	e	e	e	e		e	e	e	e	e	e	e	e	e	e	e	e	e	e	e		
get			e			e	e						e													e	e		e		
God	e	e	e	e	e	e	e			e	e	e	e	e	e	e	e	e	e	e	e		e				e	e	e		
has			e																												
joy	e	e	e	e		e	e		e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e		
keep			e					e					e		e			e		e		e					e	e		
kiss	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e		e	e		
love	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e		
mark				e				e				e						e				e							e		
month					e				e						e																
place					e		e				e												e								
put			e																										e		
rage	e	e	e	e		e		e	e	e	e			e	e		e		e	e		e	e	e	e	e	e	e	e		
send					e					e				e									e	e							
sex	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e		
shelf																															
the																															
thing							e											e	e											
time			e		e		e									e	e	e	e	e	e									
vomit	e		e	e		e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e		e	e		

APPENDIX A (cont.)

Judgments of emotionality of 30 words by 58 students.
e= S judged that word to be emotional

WORD	SUBJECT																																						SCORE
	30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	58	
about				e								e					e																					3
bad	e	e	e	e	e	e		e	e	e	e	e		e	e	e	e	e	e	e	e	e	e	e	e		e												48
belly	e			e	e	e			e	e	e				e		e	e	e	e		e	e	e															36
blood	e	e	e		e	e	e		e	e		e	e	e		e	e	e	e		e	e	e	e	e	e	e	e											51
card	e	e						e		e																													10
day		e		e			e							e	e								e				e	e		e									16
death	e		e	e	e	e	e	e		e	e	e	e	e	e	e	e	e	e		e	e	e	e	e	e	e												53
die	e	e	e	e	e	e	e	e	e		e	e	e	e	e	e	e	e	e	e	e		e		e		e	e											47
exam	e	e	e		e	e		e		e		e	e	e	e	e		e		e		e	e	e	e	e	e	e											46
fire	e	e	e	e	e	e		e	e		e	e	e	e				e		e	e	e	e	e	e		e	e											49
filth		e	e	e	e	e	e	e		e	e	e	e	e			e	e	e	e	e	e	e	e	e		e												53
get												e												e															9
God		e	e	e	e	e	e	e	e		e		e	e	e	e	e	e			e	e	e	e	e	e	e												46
has											e																												2
joy	e	e	e		e	e	e	e	e	e	e	e	e	e		e	e	e	e		e	e	e	e		e	e												51
keep	e	e				e						e	e						e	e				e														18
kiss	e	e	e		e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e		e	e	e	e	e	e												54
love	e	e	e	e	e		e	e	e	e	e	e	e	e	e	e	e	e	e	e	e		e	e	e	e	e												54
mark		e			e		e		e				e	e	e								e			e	e												16
month	e				e																						e		e										9
place	e		e		e		e															e	e																13
put	e			e	e																																		5
rage	e		e		e	e	e	e	e	e	e	e	e	e	e	e	e	e	e	e		e	e	e	e	e	e	e	e										47
send						e														e	e								e										12
sex	e	e	e	e	e	e		e	e	e	e	e	e	e	e	e	e	e		e	e	e	e	e	e		e	e	e										55
shelf																																							0
the																																							0
thing																					e		e		e		e												7
time																e				e				e	e				e	e									15
vomit	e		e	e	e		e	e	e	e	e	e	e	e	e	e				e	e	e	e	e	e	e	e	e	e										53

APPENDIX B

Order of presentation of visual stimuli.

Subject	Order					
	1	2	3	4	5	6
1	card	the	kiss	shelf	sex	vomit
2	sex	vomit	card	kiss	shelf	the
3	shelf	kiss	the	card	sex	vomit
4	sex	card	shelf	vomit	the	kiss
5	card	the	kiss	shelf	sex	vomit
6	vomit	kiss	the	card	shelf	sex
7	the	card	vomit	shelf	sex	kiss
8	card	kiss	the	vomit	sex	shelf
9	vomit	sex	shelf	kiss	card	the
10	card	shelf	vomit	kiss	the	sex
11	vomit	card	sex	kiss	the	shelf
12	vomit	the	card	shelf	kiss	sex
13	kiss	the	shelf	sex	card	vomit
14	the	vomit	kiss	shelf	card	sex
15	the	sex	card	shelf	vomit	kiss
16	vomit	shelf	the	sex	card	kiss
17	the	card	sex	vomit	kiss	shelf
18	shelf	kiss	sex	card	the	vomit
19	the	vomit	shelf	card	sex	kiss
20	vomit	shelf	sex	card	kiss	the
21	sex	kiss	card	the	vomit	shelf
22	vomit	sex	the	kiss	card	shelf
23	sex	kiss	shelf	card	the	vomit
24	card	sex	vomit	shelf	the	kiss
25	shelf	vomit	the	sex	card	kiss
26	card	sex	the	kiss	shelf	vomit
27	the	sex	vomit	shelf	card	kiss
28	kiss	shelf	card	vomit	sex	the
29	kiss	shelf	sex	the	card	vomit
30	sex	kiss	card	vomit	shelf	the

APPENDIX C

Rankings of the six experimental words in order of mean pupil size in response to those words.

Subject	Word					
	card	kiss	shelf	sex	the	vomit
1	3	1	4	2	6	5
2	6	1	4.5	3	4.5	2
3	2	6	4	3	5	1
4	4	1	5	6	3	2
5	5	2	6	4	3	1
6	5	1	5	5	2	3
7	2	1	6	5	3.5	3.5
8	2.5	4.5	6	1	4.5	2.5
9	4	2.5	5	2.5	6	1
10	5	1	4	2	6	3
11	5	1	2	6	4	3
12	2	3	4	5	6	1
13	4	3	5.5	2	5.5	1
14	5	4	2	1	6	3
15	3.5	2	6	5	3.5	1
16	5	2	4	3	6	1
17	2	1	6	4	5	3
18	3	1	6	4.5	4.5	2
19	6	5	4	3	2	1
20	5	2	4	6	1	3
21	5	2	3	1	4	6
22	1	2	6	3	4	5
23	6	1	3	4	5	2
24	4	2	5	3	6	1
25	4.5	6	4.5	1	3	2
26	3.5	3.5	6	1	5	2
27	5	1	4	2	3	6
28	5	6	1	3	4	2
Sum of rankings	113	68	125	91	121	69
Mean rank	4.04	2.43	4.47	3.25	4.36	2.47

APPENDIX D

Immediately after S had participated, he was handed a packet of six 3 x 5" cards on which were printed in 1" block letters the six words he had just been presented. The cards were in the same programmed orders as in the experiment itself. Ss were asked to rank the words in order of their power to elicit emotional thoughts or feelings. The rankings are presented below.

Subject	Word					
	card	kiss	shelf	sex	the	vomit
1	5	3	4	1	6	2
2	4	1	5	2	6	3
3	4	3	5	1	6	2
4	4	3	5	1	6	2
5	4	2	5	1	6	3
6	5	1	4	2	6	3
7	5	3	4	2	6	1
8	5	1	4	2	6	3
9	5	3	4	2	6	1
10	5	3	4	1	6	2
11	3	1	4	2	6	5
12	4	2	5	1	6	3
13	3	2	4	1	5	6
14	5	3	4	2	6	1
15	5	3	4	2	6	1
16	4	1	5	3	6	2
17	5	3	4	2	6	1
18	4	1	5	2	6	1
19	5	3	4	2	6	2
20	5	1	4	3	6	3
21	5	2	4	1	6	1
22	5	2	4	3	6	2
23	5	3	4	1	6	1
24	5	3	4	2	6	1
25	4	2	5	3	6	1
26	1	2	5	1	6	3
27	4	2	5	1	6	3
28	4	3	5	2	6	1
Sum of rankings	121	62	123	49	167	62
Mean rank	4.20	2.16	1.66	4.23	5.76	2.13

APPENDIX E

Recorded measurements of pupil size of 28 Ss to six words at 20 intervals.

PUPIL SIZE IN RESPONSE TO THE WORD: CARD

S	Interval																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2	7	8	8	8	7	7	7	7	7	7	7	7	8	7	6	7	8	7	6	7
3	7	7	6	8	7	6	7	6	6	6	6	7	6	7	7	8	7	8	8	9
4	4	4	5	6	5	6	5	5	4	6	5	5	6	5	5	4	5	4	3	4
5	14	16	15	14	15	15	15	14	16	16	16	16	17	16	16	17	16	17	17	17
6	11	11	11	10	12	10	11	12	11	12	12	10	12	12	10	9	9	10	10	9
7	8	9	7	7	7	8	7	8	7	8	6	6	7	7	6	7	7	6	8	7
8	10	11	11	11	10	11	11	11	10	10	11	10	9	9	11	11	10	9	10	11
9	13	13	14	13	14	14	13	13	14	14	15	14	15	14	15	15	15	15	15	15
10	11	11	11	10	10	10	9	9	9	10	10	10	10	11	11	12	12	10	13	12
11	5	4	4	3	4	4	5	5	5	3	4	4	5	5	5	6	5	4	5	4
12	8	6	6	6	7	7	7	8	7	6	7	7	7	6	7	7	7	8	8	7
13	12	12	12	11	11	13	14	14	15	15	15	14	13	13	14	14	14	13	12	13
14	11	11	11	12	12	12	12	12	12	13	14	13	13	13	12	12	13	12	12	
15																				
16	9	10	9	9	8	8	9	9	9	8	8	8	8	9	8	8	9	8	9	9
17	7	6	5	6	6	5	5	5	5	4	6	7	7	7	7	7	6	7	7	7
18	10	10	9	9	8	9	10	10	10	11	11	11	11	12	12	12	12	11	11	11
19	11	10	9	10	11	12	13	14	14	14	12	12	10	10	11	10	10	10	11	11
20	5	6	5	6	6	6	5	5	5	6	6	5	4	5	5	6	6	4	5	6
21	8	7	7	7	7	7	7	7	8	8	8	8	8	7	8	8	8	8	8	8
22	5	5	4	5	4	4	5	4	5	5	6	5	6	5	6	6	6	4	5	5
23	5	4	4	3	4	4	3	4	4	4	4	3	3	4	4	4	3	4	4	4
24	12	12	12	9	10	10	10	11	9	9	10	10	10	9	10	11	11	10	10	9
25	12	12	10	11	10	10	10	9	8	9	8	9	10	10	9	9	10	9	8	9
26	12	13	12	11	11	13	13	12	12	12	12	11	12	12	12	13	11	12	11	12
27	6	5	4	5	5	4	4	4	4	5	5	5	5	5	5	5	5	6	6	5
28	7	7	7	7	8	8	7	8	8	8	8	8	8	9	9	9	9	8	7	7
29	10	10	10	9	9	9	9	9	10	9	10	9	10	10	10	10	10	10	10	10
30	8	7	6	6	7	8	8	8	8	9	10	10	8	8	8	8	8	8	8	8

APPENDIX E (cont.)

PUPIL SIZE IN RESPONSE TO THE WORD: KISS

S	Interval																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2	7	8	9	8	7	7	8	7	7	8	8	7	7	7	8	7	7	8	7	8
3	7	8	8	8	9	8	8	9	9	7	8	8	9	9	8	9	8	7	8	7
4	3	4	3	3	3	4	4	3	4	4	4	3	4	4	5	6	3	4	5	6
5	16	17	17	16	15	14	14	14	15	15	16	16	17	17	16	16	17	16	16	17
6	11	11	10	10	11	11	11	11	11	11	11	11	11	10	11	12	10	10	11	11
7	7	7	8	8	8	8	8	9	9	9	8	7	7	7	7	9	9	7	7	8
8	11	11	10	10	11	11	11	10	10	10	10	10	11	11	11	11	11	10	11	11
9	14	15	14	13	12	12	13	14	15	15	15	13	14	14	14	14	15	14	13	14
10	13	12	10	9	10	10	10	11	11	12	12	11	12	14	10	10	9	9	9	9
11	4	4	5	4	5	5	6	6	6	6	6	5	5	6	6	6	6	5	5	4
12	8	7	6	7	7	8	8	8	9	9	8	9	10	9	9	9	7	7	8	9
13	13	12	12	10	11	12	12	12	12	11	14	15	15	15	15	15	14	15	14	13
14	13	12	11	11	12	11	11	11	13	13	13	13	13	11	12	14	13	12	13	11
15																				
16	9	8	8	7	8	9	9	10	9	10	9	8	8	9	9	10	10	10	10	9
17	6	6	7	7	6	7	6	6	7	7	7	6	6	6	5	6	6	5	5	6
18	10	11	11	12	11	12	11	12	11	11	12	12	13	12	12	12	13	13	13	12
19	12	11	11	0	9	9	10	11	11	12	12	10	11	11	12	12	13	13	13	14	13
20	5	5	6	6	6	6	7	7	6	6	6	6	6	6	7	7	7	9	8	7
21	8	8	9	8	7	8	8	8	8	9	8	9	9	9	8	9	8	9	9	8
22	5	5	6	4	4	5	5	5	6	6	6	6	5	6	6	6	6	6	6	7
23	5	5	5	4	4	4	5	6	6	6	6	6	5	5	6	7	6	6	5	4
24	11	10	10	9	10	10	11	10	10	11	10	11	9	12	12	10	10	9	10	9
25	11	10	10	11	11	11	11	11	12	11	12	11	12	13	13	12	12	12	12	11
26	13	13	12	12	11	12	13	14	14	13	14	13	12	12	12	13	14	14	14	12
27	6	4	4	4	4	4	4	4	5	4	5	4	4	6	6	7	5	6	6	5
28	7	7	7	7	7	7	7	7	7	7	7	7	9	8	8	8	9	8	7	7
29	10	11	9	9	10	11	10	9	11	10	11	10	11	11	11	12	12	11	11	11
30	9	9	8	7	7	7	8	8	7	7	7	7	7	7	7	7	7	8	9	9

APPENDIX E (cont.)

PUPIL SIZE IN RESPONSE TO THE WORD: SHELF

S	Interval																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2	8	8	7	6	7	8	8	8	9	9	8	7	6	7	6	7	6	7	6	7
3	7	6	7	7	6	6	6	9	9	7	6	7	8	9	8	8	7	8	8	8
4	5	4	5	4	4	4	5	6	5	6	4	4	5	4	4	3	4	5	4	5
5	17	16	15	14	13	14	14	15	15	14	16	16	16	16	16	16	16	17	16	15
6	10	9	10	9	9	9	10	10	10	10	11	11	11	11	12	12	11	11	11	10
7	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	8	8	8
8	10	9	9	10	10	10	10	10	9	10	10	9	10	9	10	10	10	11	10	10
9	14	13	13	13	13	13	14	13	14	14	15	14	15	15	15	14	14	12	13	12
10	14	13	12	12	12	13	14	13	12	13	13	13	13	12	12	12	12	13	13	12
11	4	3	2	3	3	4	4	5	6	6	6	5	6	5	5	5	5	5	5	5
12	8	7	7	7	7	7	7	8	9	9	9	9	9	9	9	10	10	10	9	8
13	12	13	12	12	12	13	13	14	13	14	13	13	14	13	12	13	12	13	13	12
14	12	12	12	11	10	9	11	12	13	12	13	12	12	12	12	13	13	14	13	13
15																				
16	8	8	9	8	8	7	8	9	9	10	10	10	10	10	9	10	10	9	9	9
17	6	6	5	6	5	5	5	5	5	6	6	6	6	6	5	6	5	6	6	6
18	10	11	10	9	9	10	11	12	12	13	12	12	12	11	11	11	11	12	11	11
19	11	12	10	11	9	9	10	12	11	10	11	9	10	9	10	9	9	9	10	10
20	5	5	5	4	5	4	4	3	3	3	4	4	4	3	4	5	5	6	6	6
21	8	8	8	8	7	8	10	12	11	11	11	10	9	9	9	8	8	9	8	8
22	6	5	6	5	5	5	5	4	4	4	5	4	5	5	5	5	4	5	5	5
23	5	4	4	4	3	3	4	4	4	4	4	5	5	4	5	5	5	5	5	5
24	11	9	9	9	8	8	8	9	8	8	9	9	10	10	10	10	10	10	10	10
25	11	9	10	9	10	9	9	9	10	11	12	11	12	12	12	11	12	12	12	11
26	12	12	12	11	11	12	12	12	12	12	11	12	12	11	11	12	12	12	12	12
27	5	5	4	4	4	4	4	4	5	5	5	5	6	6	6	5	6	5	5	5
28	7	8	7	8	8	7	7	7	7	7	8	7	7	7	7	8	7	7	7	7
29	9	8	9	8	9	9	10	10	10	11	10	10	11	9	10	11	10	10	10	10
30	7	7	8	7	8	8	9	9	9	9	9	10	9	9	10	10	10	10	10	8

APPENDIX E (cont.)

PUPIL SIZE IN RESPONSE TO THE WORD: SEX

S	Interval																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2	7	7	6	7	7	7	6	7	6	6	7	7	8	8	8	8	8	8	8	8
3	7	7	7	8	8	8	8	9	8	8	7	8	7	8	9	9	8	7	8	7
4	5	6	5	5	4	5	6	4	3	4	3	5	6	5	5	4	5	4	4	6
5	17	16	15	15	14	14	16	16	16	16	17	16	16	16	17	16	16	15	17	18
6	10	12	10	10	9	9	10	11	11	10	11	11	12	11	10	10	10	10	10	10
7	7	7	7	8	7	7	7	6	7	7	7	7	6	5	7	8	9	8	8	9
8	10	10	10	9	10	9	10	10	10	10	11	11	11	11	11	11	10	10	10	10
9	14	14	14	14	14	13	14	14	14	15	14	15	14	14	15	16	16	14	14	14
10	12	12	12	12	11	12	14	12	12	13	14	14	13	12	13	12	12	13	12	12
11	4	4	4	3	4	3	5	5	6	6	6	4	4	5	5	5	5	5	6	5
12	7	7	6	6	6	6	7	7	7	6	5	7	6	7	7	7	7	8	9	7
13	12	12	11	11	12	12	13	13	14	13	13	13	13	13	13	13	14	13	13	13
14	12	12	12	11	12	11	12	13	12	12	12	11	12	14	13	12	12	13	13	12
15																				
16	9	10	9	8	7	7	8	9	9	9	10	10	9	10	10	10	9	10	9	10
17	6	5	5	5	5	4	5	6	7	7	7	7	7	7	6	6	6	6	6	6
18	12	12	10	10	9	10	10	10	11	11	12	12	10	11	12	12	11	12	12	12
19	9	10	9	8	9	9	9	10	9	10	12	12	10	11	12	12	12	10	12	13
20	5	4	4	4	4	4	5	4	4	5	5	6	5	5	6	6	6	6	6	6
21	9	8	8	8	8	8	9	9	8	9	10	10	10	11	11	11	10	9	8	8
22	5	5	5	5	5	5	6	5	4	4	4	4	5	4	4	4	4	5	6	5
23	4	5	3	5	4	6	4	5	6	5	6	6	6	6	6	5	6	6	6	6
24	11	10	11	9	9	9	9	10	10	10	10	11	11	10	9	9	10	9	9	10
25	10	9	10	11	11	10	9	9	8	10	11	11	11	11	11	11	10	9	9	10
26	13	13	11	11	12	12	12	13	13	13	12	14	12	13	12	12	12	12	12	13
27	7	7	6	4	6	5	5	7	7	5	6	6	6	7	7	6	6	6	6	5
28	7	8	8	8	8	7	7	8	7	7	8	7	7	8	9	8	8	7	7	7
29	11	10	8	8	8	9	9	9	9	10	10	11	11	11	11	11	11	12	11	11
30	8	8	9	9	8	7	7	7	7	8	8	8	9	9	10	11	11	10	9	8

APPENDIX E (cont.)

PUPIL SIZE IN RESPONSE TO THE WORD: THE

S	Interval																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2	7	7	7	7	8	7	7	6	7	7	6	6	7	8	6	6	7	8	6	6
3	8	9	8	8	7	7	8	9	8	7	8	7	7	8	7	6	6	6	6	8
4	6	5	4	4	4	4	4	5	4	3	4	2	3	4	4	3	3	4	6	4
5	17	17	17	15	14	15	17	15	16	16	16	16	15	16	16	16	17	16	16	15
6	11	11	11	12	10	11	12	11	10	11	12	11	10	11	10	11	12	11	11	10
7	8	7	7	7	6	8	8	8	8	7	8	8	8	8	8	8	8	8	8	8
8	11	10	11	10	11	11	11	10	10	10	10	9	10	10	10	11	10	9	10	11
9	14	15	14	14	14	14	13	14	13	13	14	14	14	15	15	13	14	13	13	14
10	12	12	10	9	8	9	8	8	9	9	9	10	10	10	10	9	9	9	8	9
11	6	5	4	4	4	3	3	3	3	3	4	4	4	5	6	5	5	5	4	4
12	8	7	6	6	6	7	7	7	7	7	7	7	7	7	8	8	9	8	7	8
13	14	13	12	10	12	12	12	12	12	13	14	14	12	13	12	12	12	13	12	12
14	13	12	12	12	12	12	12	12	12	12	12	12	12	12	13	12	12	12	12	12
15																				
16	9	8	8	9	7	9	8	9	9	8	8	8	8	8	8	8	8	8	8	7
17	6	5	6	5	6	5	5	5	6	6	6	6	7	7	7	7	7	6	6	7
18	9	9	9	8	9	10	11	11	11	10	10	11	11	12	11	12	11	11	11	11
19	11	11	10	11	10	9	10	12	12	11	12	12	10	9	8	9	9	9	9	9
20	5	5	4	5	5	6	6	5	4	5	4	5	5	5	5	6	5	5	5	6
21	10	9	10	9	8	9	8	8	9	9	9	9	9	10	9	10	9	10	10	9
22	5	5	5	4	5	6	6	6	6	6	7	6	7	6	6	6	6	6	6	7
23	5	5	4	4	5	3	4	4	5	4	4	3	4	4	4	4	3	4	4	4
24	12	12	10	9	9	9	8	9	9	9	10	11	11	9	9	10	11	10	10	9
25	11	10	10	11	11	12	12	11	11	10	10	9	10	10	9	9	9	9	9	9
26	13	12	10	12	11	11	11	12	12	13	12	13	13	13	13	13	13	12	11	11
27	6	4	4	4	5	5	6	6	6	6	5	6	6	5	6	5	6	6	6	5
28	8	8	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	7
29	11	9	9	8	9	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10
30	8	9	8	8	7	8	9	8	8	8	9	8	8	8	7	8	8	8	8	8

APPENDIX E (cont.)

PUPIL SIZE IN RESPONSE TO THE WORD: VOMIT

S	Interval																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2	7	7	6	7	8	7	8	7	6	7	6	6	7	7	7	7	7	7	7	7
3	7	7	8	8	9	6	7	6	7	8	8	8	9	9	9	8	8	9	7	7
4	4	6	6	6	5	6	5	6	4	6	4	6	6	6	6	6	6	4	5	6
5	16	17	15	15	14	16	16	11	16	16	16	15	17	18	17	16	17	17	17	17
6	10	11	11	11	11	11	11	11	11	11	12	12	12	11	11	11	10	11	11	12
7	8	7	7	8	9	8	7	8	9	9	7	8	7	6	6	7	7	7	7	7
8	10	10	11	11	9	10	11	11	11	9	10	11	10	11	10	11	10	9	10	10
9	14	13	12	12	13	14	14	13	14	15	15	15	15	16	15	15	14	15	15	15
10	13	12	10	12	12	12	12	13	12	14	14	14	15	14	13	14	15	15	14	13
11	5	5	4	4	6	5	4	5	4	4	3	3	3	4	5	5	5	6	6	6
12	8	9	8	7	7	8	7	7	7	7	7	7	7	8	7	7	7	7	8	7
13	12	12	12	10	12	13	12	12	14	14	15	15	14	15	15	14	14	14	14	15
14	12	13	12	12	13	14	14	13	13	14	14	15	13	13	13	13	12	12	13	14
15																				
16	8	7	9	9	9	8	8	9	9	8	9	9	8	10	10	10	10	10	9	9
17	5	6	6	6	6	7	7	7	7	7	8	7	7	8	8	8	7	8	8	7
18	10	12	12	12	11	12	12	12	12	11	12	13	13	11	12	13	12	12	11	11
19	10	9	9	8	9	10	9	9	11	12	12	13	12	12	13	12	12	13	13	12
20	5	5	4	4	4	5	5	5	6	6	6	6	6	7	6	7	7	7	7	6
21	8	8	8	8	7	8	9	9	10	10	10	10	11	10	11	11	10	11	9	9
22	5	4	4	4	5	5	5	5	4	5	6	6	6	5	6	6	6	6	5	5
23	4	4	4	4	3	3	3	4	3	3	4	3	3	3	3	4	3	3	3	4
24	10	10	9	9	9	8	8	9	8	9	10	10	10	10	11	11	11	11	10	10
25	11	12	12	12	12	11	12	12	12	11	12	12	12	13	13	12	12	12	11	10
26	13	11	11	10	10	11	10	11	12	12	12	12	13	13	12	12	12	11	12	13
27	6	5	5	5	5	5	5	5	6	5	6	6	6	6	6	7	7	7	6	5
28	8	7	7	7	8	8	7	7	7	8	9	8	9	9	9	9	7	8	8	7
29	10	10	9	9	9	8	8	8	8	8	9	9	9	10	10	9	10	12	10	10
30	9	8	7	7	7	7	8	7	8	8	8	9	10	10	10	10	11	10	9	8

APPENDIX F

Mean recorded pupil size of 28 Ss to each of 6 words.

S	Words							
	card	kiss	sex	shelf	the	vomit	Mean Emotional	Mean Neutral
1	7.45	7.80	7.60	7.25	6.80	6.90	7.46	7.16
2	6.95	8.10	7.80	7.35	7.35	7.85	7.91	7.21
3	4.80	3.95	4.52	4.50	4.05	5.45	4.70	4.28
4	15.75	16.55	15.15	15.25	15.85	16.25	15.98	15.61
5	10.25	10.70	10.35	9.85	10.45	11.00	10.68	10.18
6	7.20	7.85	7.20	7.20	7.70	7.45	7.50	7.36
7	10.35	10.60	10.15	9.80	10.25	10.25	10.33	10.13
8	14.10	13.85	14.30	13.60	13.85	14.10	14.08	13.85
9	10.60	10.55	12.60	12.60	9.35	13.15	12.01	10.85
10	4.40	5.25	5.05	4.60	4.30	4.65	4.98	4.43
11	6.95	8.15	6.75	7.90	7.70	7.40	7.43	7.35
12	13.25	13.10	12.75	12.80	12.50	13.35	13.06	12.85
13	10.20	10.35	10.40	10.05	10.05	10.60	10.65	10.10
14	8.60	8.90	10.10	9.00	8.15	9.90	8.93	8.58
15	6.20	6.25	5.95	5.65	6.20	7.00	6.36	5.95
16	10.65	11.20	11.20	11.00	10.35	11.30	11.20	10.63
17	11.10	11.45	10.35	10.00	10.20	11.05	10.95	10.43
18	5.35	6.45	5.01	4.40	5.01	5.65	5.71	4.93
19	7.60	8.75	9.10	9.00	9.15	9.40	9.08	8.56
20	5.00	5.50	4.90	5.05	5.65	5.15	5.18	5.23
21	3.75	4.95	5.00	4.85	4.25	3.65	4.50	4.11
22	10.35	10.15	9.90	9.30	9.80	9.70	9.95	9.81
23	8.60	11.50	10.05	10.65	10.10	11.20	10.91	10.08
24	11.75	12.10	11.80	11.65	11.30	12.25	12.05	11.56
25	4.90	4.80	5.75	4.90	5.45	5.65	5.40	5.08
26	7.80	7.80	7.95	7.25	7.55	7.85	7.87	7.53
27	9.55	10.55	10.10	9.70	9.75	9.25	9.96	9.66
28	7.95	7.75	8.50	8.75	8.05	8.55	8.26	8.25
Mean of Means	8.719	9.176	8.979	8.761	8.664	9.184	9.113	8.709