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Pupillary Size as an Index of Preference.

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**The Louisiana State University and Agricultural
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PUPILLARY SIZE AS AN INDEX OF PREFERENCE

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Psychology

by

Jerry Dean Barlow

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TABLE OF CONTENTS

	PAGE
TITLE PAGE	i
ACKNOWLEDGMENTS	ii
LIST OF TABLES	iv
ABSTRACT	vi
INTRODUCTION	1
The Basic Physiological Response	1
Intellectual Activities	3
Affective Behavior	4
The Classification of Pupillary Response	7
METHOD	9
Subjects	9
Apparatus	9
Procedure	11
RESULTS	13
DISCUSSION	30
SUMMARY	34
REFERENCES	36
VITA	39

LIST OF TABLES

TABLE	PAGE
1. Mean Percentage Change in Pupillary Area for Subjects while Viewing Five Semi-erotic, House, and Aversive Photographs in order of Magnitude of Change (Each Mean Based on 20 Observations)	14
2. Subjective Ranking Compared to Pupillary Ranking with Resulting Spearman Rank Correlation Coefficients of <u>Ss</u> Viewing Five Semi-erotic Photographs	17
3. Subjective Ranking Compared to Pupillary Ranking with Resulting Spearman Rank Correlation Coefficients of <u>Ss</u> Viewing Five Photographs of Houses	18
4. Subjective Ranking Compared to Pupillary Ranking with Resulting Spearman Rank Correlation Coefficients of <u>Ss</u> Viewing Five Aversive Photographs	19
5. Absolute Subjective Score and Absolute Pupillary Score with Pearson Product Moment Correlations of <u>Ss</u> Viewing Five Semi-erotic Photographs Listed in Order of Subjective Preference . . .	20
6. Absolute Subjective Score and Absolute Pupillary Score with Pearson Product Moment Correlations of <u>Ss</u> Viewing Five House Photographs Listed in Order of Subjective Preference	22
7. Absolute Subjective Score and Absolute Pupillary Score with Pearson Product Moment Correlations of <u>Ss</u> Viewing Five Aversive Photographs Listed in Order of Subjective Preference	24
8. Average Fisher <u>Z</u> Scores, Chi-square, and Average Pearson Product Moment Correlation Coefficients Between Absolute Subjective Scores and Absolute Pupillary Scores for <u>Ss</u> Viewing Semi-erotic, House, and Aversive Photographs	27

LIST OF TABLES (Continued)

TABLE	PAGE
9. Average Fisher <u>Z</u> Scores, Chi-Square, and Average Pearson Product Moment Correlation Coefficients Between Absolute Subjective Scores and Absolute Pupillary Scores for Each <u>S</u> Viewing Semi-erotic, House, and Aversive Photographs	28

ABSTRACT

Previous research has established that the pupil is reactive to novel stimuli and that it may serve as an index of preference particularly between choices that are polar opposites. There has been some question, however, about the capacity of the pupil to respond throughout a range of stimuli and to discriminate among choices that are more closely associated within this range.

Five Ss were shown 3 groups of photographs. The first group consisted of semi-erotic photographs, the second group of house photographs, and the third group of aversive photographs. The pupillary responses were recorded while viewing these pictures. The Ss then ranked the photographs of each group from most pleasant to least pleasant, and, using an external anchoring stimulus, gave the photographs a score between 100 and 1.

For the semi-erotic photographs the pupils of the Ss generally dilated. For the house photographs the pupils dilated for the first choices and constricted for the last choices. The aversive photographs generally resulted in pupillary constriction.

For all 3 groups of stimuli there was significant agreement among the Ss as to the pupillary rankings of the photographs that had been ranked subjectively. For the most

part when there were reversals in order between subjective and pupillary rankings they were reversals of adjacent positions.

Comparisons of the subjective scores given to the photographs with the mean pupillary absolute score associated with the same photographs yielded moderate positive correlations.

It was concluded that the pupil may serve as an index of preference not only for choices differing greatly in subjective preferences, but also between choices that may be more closely positioned on a pleasant-unpleasant continuum.

INTRODUCTION

Since the publication of the article by Hess (1965) summarizing five years of pupillary research, much interest has subsequently been evoked in the pupil as an index of interest and of ongoing brain activity.

Hess suggested that not only does the pupil reflect ongoing activity in the brain, but further that "at least with respect to visual material there is a continuum of responses that ranges from extreme dilation for interesting or pleasing stimuli to extreme constriction for material that is unpleasant or distasteful to the viewer" (Hess, 1965).

The pupil lends itself to the type of measurement necessary to plot a continuum of responses. Gross changes in the pupil size can be detected even by the naked eye while smaller changes can readily be detected through photographic techniques.

The Basic Physiological Response

The iris muscles surrounding the pupil have proved to be extremely reactive. The pupil of the human eye can vary from approximately 8 mm to 2 mm in a matter of seconds, resulting in a shrinkage of the sphincter muscle to one-fourth of its dilated length (Lowenstein and Loewenfeld, 1962), the dilated pupil allowing forty times as much light

to enter the eye as does the constricted pupil (Von Fieandt, 1966). Both the dilator and sphincter muscles are innervated through the autonomic nervous system, the dilator pupillae by the sympathetic nerves through the superior cervical ganglion, and the sphincter pupillae by parasympathetic nerves through the ciliary ganglion (Gray, 1948, and Lowenstein and Loewenfeld, 1962).

Under ordinary illumination, the drug-free pupil is in constant motion. Kuntz (1929) noted that the sympathetic division of the autonomic nervous system mediates strong emotional states of fear and pleasure accompanied by pupillary dilation. Increased sensory or emotional stimuli, even spontaneous thoughts result in pupillary dilation. In man this dilation occurs after a latent period of 0.3 to 0.5 sec.

Optimum pupillary reactivity is maintained by a sympathetic-parasympathetic balance. If the sympathetic pathway is disrupted, or if supranuclear impulses are lacking, as in sleep, the pupil is not only miotic (Adler, 1957) but the reactions to light are inextensive and sluggish (Lowenstein and Loewenfeld, 1962).

Even under relatively constant conditions the pupil shows variation. Pupillary unrest or "hippus" is a constant oscillation of pupil size and continues indefinitely in bright light and decreases as retinal adaptation occurs in

dim light.

Another variable in pupillary reactivity is age (Adler, 1957). In infancy the pupils are small; they attain their greatest size in childhood and early adulthood, and decrease again in old age.

Intellectual Activities

The research concerning the pupillary response as a direct measure of neurological activity has been consistent in its group findings. Hess and Polt (1964) found an increase in pupillary dilation as the difficulty of multiplication problems increased. The problems were given in order of increasing difficulty and the pupillary increase was present even though the within session adaptation effect would minimize the change (Lehr and Bergum, 1966). During problem solving the pupillary diameter increases until the answer is verbalized. This is followed by an abrupt decrease and then a more gradual decrease until the control size is reached. These findings are in agreement with those by Schaefer, Ferguson, Klein, and Rawson (1968).

Kahneman and Beatty (1966), using a string of digits for recall, found a loading phase during which the pupil dilated with each digit presented, and an unloading phase during which the pupil constricted as each digit was reported. The peak pupillary diameters were directly related

to the number of digits presented. The pupillary diameters were greater when digits were presented for transformation than for recall because of increased difficulty of the task. When information was given rapidly in a sentence, there was no dilation during the listening phase, but there was dilation immediately afterward when the information was acted upon.

Further support for the view that the pupil may serve as an index of mental activity came from the study by Beatty and Kahneman (1966) who found that there was pupillary dilation in short term memory tasks and even greater dilation in long term memory tasks when telephone numbers were recalled in response to a cue.

Pupillary dilation was found to be greater to abstract than to concrete words when the subjects were instructed to generate a "mental image" to the words (Paivio and Simpson, 1966; Simpson and Paivio, 1966; Simpson and Paivio, 1968; and Paivio and Simpson, 1968).

Affective Behavior

The studies of pupil size as related to interest have not been as consistent in their results as those on memory and problem solving. Hess and Polt (1960) found the pupils of male and female ss to respond differentially to pictures of semi-nude males and semi-nude females. In support of the

view that in pupillary reactivity there is a continuum of responses from extreme dilation to pleasant stimuli to extreme constriction to unpleasant stimuli, Hess and Polt (1966) found the pupil to respond differentially as a measure of taste differences and Barlow (1969) found a differential response to preferences for political personalities. In addition Hess, Seltzer, and Shlien (1965) found heterosexual and homosexual males to respond with opposite pupillary responses to pictures of men and women.

Nunnally, Knott, Duchnowski, and Parker (1967) found significant effects for heightened attention when ss viewed novel pictures, and also when the pictures differed in pleasantness-unpleasantness. Using emotional words as stimuli, Guinan (1967) found a significant difference in pupillary response between the three words with the highest and the three with the lowest emotionality scores as determined by the GSR.

In opposition to the view of Hess that there is a continuum of responses to pleasant-unpleasant stimuli, Schaefer, Ferguson, Klein, and Rawson (1968) found inconsistent changes or no change when thinking about pleasant or unpleasant experiences. Also, Scott, Wells, Wood, and Morgan (1967) were unable to find any significant differences in pupillary responses for men and women while viewing pictures of clothed and unclothed males and females. They also

found no difference between heterosexual and homosexual males while viewing pictures of males and females. They reported that there was no evidence that non-preferred stimuli resulted in pupillary constriction.

In possible explanation of the above study by Scott et al. (1967) it must be noted that the subjects were placed in an open room and the stimulus pictures were viewed on an easel in front of the ss. When a similar technique was used by Barlow (1969) there was also a lack of pupillary variation, but when the ss looked at the pictures in an enclosed viewing box there was found to be a significant variation. Apparently extraneous stimuli blunt the pupillary responses to the test pictures.

Peavler and McLaughlin (1967) found pupillary dilation to provocative stimuli, even under conditions that constriction would be expected due to increased brightness of the stimuli, but they were able to find no relationship among rated words on the "bad-good" or "neutral-very important" scales and the pupillary responses to these words. It was suggested that the words may not have been provocative enough for pupillary variation. In another study Vacchiano, Strauss, Ryan, and Hochman (1968) found no significant relationship between the pupil size and value-linked words. Paivio and Simpson (1966) also found no difference on the pleasant-unpleasant scale in an imagery task, but they noted

that the difficulty of the imagery task may have inhibited any constriction that may have otherwise occurred for the unpleasant words.

Peavler and McLaughlin (1967) suggested that the pupillary constriction to an unpleasant stimulus may be an artifact. An anticipatory effect before the stimulus presentation and a carry-over of effect after the stimulus presentation may raise the base line to a degree that the test stimulus may appear to bring about a constriction. Woodmansee (1966) also cautioned against assuming that pupillary constriction accompanies unpleasant stimuli. He suggested that constriction could be due to changes in retinal light due to contrasting light and dark areas within the picture, the effect of accommodation when the S fails to maintain fixation on the stimulus, adaptation or declining interest, and the normally high variability in the pupil size itself.

The Classification of Pupillary Response

With the exception of those studies on memory load, most of the work on pupillary reactivity has been a question of responding or not responding, dilation or no dilation. There is little information on the degree of the response. If the pupil dilates to pleasant stimuli, does it dilate less to less pleasant stimuli? If unpleasant stimuli result in pupillary constriction, does this, too, vary as the degree

of unpleasantness is altered?

Information is also needed as to whether pupillary reactivity can be classified on an individual basis, or is it limited to group data?

McCawley, Stroebel, and Glueck (1966) found the pupillary variation in psychiatric patients to exceed that of normals, but not enough for the purposes of classification. Hess and Polt (1964) found agreement for group results as to pupil size and problem difficulty, but there was not perfect agreement on an individual basis. Barlow (1969) did find perfect agreement on an individual basis for preferences shown for political personalities, but the experimental groups had been chosen for their extreme viewpoints.

Hess, Seltzer, and Shlien (1965) also found no overlap on an individual basis in the agreement of pupillary changes of heterosexual and homosexual males while viewing male and female content pictures. This result has been challenged, however, by Scott, Wells, and Morgan (1967) who got negative results in the same subject area.

This study investigated the ability of the pupillary response to lend itself to a classification continuum at several levels of emotionality. The pupillary response was recorded while ss were viewing photographs covering a wide range of interest. Rather than just a positive-negative response, it was determined if a continuum of responses could be measured within more specific levels of excitation.

METHOD

Subjects

The Ss were 5 male graduate students presently enrolled at Louisiana State University.

Apparatus

The apparatus consisted of a 3 x 3 x 5 ft. box, open at one end to allow the S to be seated with head and shoulders within the enclosure while positioned in a head rest. The box was situated on a table with its lower surface 3 ft. from the floor. At the enclosed end and slightly above the line of sight of the seated S was a 11 x 14 in. opening at which the stimulus cards were presented. Slightly below the Ss line of sight was a 3 in. aperture through which the pupil of the S was photographed. Two 200 watt incandescent lamps were mounted above a 7" x 10" translucent glass plate positioned on the upper surface of the enclosure and 10 in. in front of the plane of the S which served to illuminate the S. The illumination level at the plane of the S was approximately 175 ft. cds. when the eye faced the grey control card. The light was controlled by a rheostat which was mounted on the upper surface of the enclosure. The interior of the box was painted in a flat light grey color.

The camera used was a 35 mm Bessler Topcon Super D with 135 mm lens, using a motor drive and bulk film magazine,

and mounted on a tripod. Tri-X film was used and was processed at ASA 400.

Fifteen stimulus cards were used and were divided into 3 groups of 5 each. The first group consisted of semi-erotic photographs which served as positive stimuli to which an emotional response could be expected. The second group were photographs of houses which served as neutral stimuli to which an emotional response would not be expected, but to which an intellectual preference could still be expressed. The third group were photographs of starving or injured people to which an aversive response could be expected. The control card consisted of a white cross mounted on a background of several different shades of grey to more closely approximate the shades of grey in the stimulus photographs. The stimulus and control cards were equated for brightness to insure a constant pupillary response to light.

To insure a range within each stimulus area the photographs were selected in the following manner: Prior to the experiment, 12 photographs were used for each stimulus area (positive, neutral, and negative). Ss were asked to place the 12 photographs in order, ranging from most pleasant to least pleasant. Five photographs were then selected by the E which covered the range of the original 12 photographs.

Procedure

The Ss were seated comfortably in the enclosure with their head in the forehead and chin rest. The S's attention was directed to the stimulus card opening which was covered by a blank card. The E then presented the control card and both pupils of the S were photographed at the rate of 1 frame per sec. for 10 sec. The control card and a stimulus card were alternated for 2 successive presentations, the experimental procedure lasting 40 sec. A sixth photograph was presented first in order to familiarize the S with the procedure, and because the first stimulus presented tends to result in an exaggerated response. With 5 min. rest periods between trials, the Ss viewed the 5 stimulus photographs in an order indicated by a row of a 5 x 5 Latin square design for randomization (Wilk and Kempthorne, 1957). The Latin square was selected in a manner suggested by Winer (1962). A standard Latin square was randomly chosen from those listed by Fisher and Yates (1963) and, using two random 5 number sequences, first the columns were rearranged and then the rows. Each stimulus card was, therefore, in a particular position during presentation once and only once.

With approximately a week's delay, the second series of photographs were presented in a like manner, followed by the third series after another similar delay.

The film was processed and projected by means of a 35 mm film strip projector onto a screen at a distance of 7 ft. and the vertical and horizontal dimensions of the pupil were traced. The traced diameters of the pupil were then measured in mm and the product of these 2 numbers was determined.

Using a sixth photograph as an external anchor and giving it a score of 60, each S was asked to rank the photographs in each series in order of most pleasant to least pleasant, and to assign the photographs a score between 100 and 1 (100 being the most pleasant and 1 the least pleasant possible). The subjective absolute scores were then compared to the mean pupillary absolute scores. Therefore, the subjective preference was compared to the experimental pupillary score both quantitatively and by their order.

RESULTS

The basic data are in the form of absolute pupillary area. In order to allow time for the response to peak, percentage change scores were computed by comparing the mean of the last 5 exposures to the stimulus photographs to the mean of the last 5 exposures to the control for each presentation. The resulting percentage change was used as the dependent variable.

To test observer reliability in the scoring of the pupil, 100 frames were retraced and measured and yielded a Pearson product moment correlation coefficient of +0.93.

The means for the percentage change in pupillary area for each S while viewing the semi-erotic, house, and aversive photographs are shown in Table 1. Generally the pupils of the Ss dilated for the most pleasant of the semi-erotic photographs and constricted for the one or two least pleasant. For the photographs of the houses there was pupillary dilation for the most pleasant and pupillary constriction for the least pleasant. Except for a few exceptions, the aversive photographs resulted in pupillary constriction.

Taking the difference between the percentage change for the high response and the low response for each S while viewing the 3 stimuli groups, a range of pupillary change was determined. The minimum range was 10.98% change for

TABLE 1

MEAN PERCENTAGE CHANGE IN PUPILLARY AREA FOR SUBJECTS
WHILE VIEWING FIVE SEMI-EROTIC, HOUSE, AND AVERSIVE
PHOTOGRAPHS IN ORDER OF MAGNITUDE OF CHANGE
(EACH MEAN BASED ON 20 OBSERVATIONS)

Subject	Semi-erotic Pictures	House Pictures	Aversive Pictures
1	C + 0.38	A - 2.16	A - 6.90
	A - 7.81	C - 7.14	C -14.08
	E -10.32	D -10.20	B -18.83
	B -18.89	E -12.73	D -19.41
	D -19.18	B -13.14	E -21.36
2	C +12.14	A +11.60	B - 3.97
	D + 7.00	B + 8.40	C - 7.20
	A + 5.50	E + 2.78	A -12.58
	B - 0.84	C - 3.11	D -20.10
	E - 6.44	D - 5.60	E -21.88
3	B +14.96	A +10.54	C + 5.25
	C +11.04	E - 6.46	B + 0.16
	A + 6.59	B - 8.16	A - 7.03
	E - 3.55	C -15.19	E -12.04
	D - 4.02	D -22.13	D -19.48

TABLE 1 (Continued)

Subject	Semi-erotic Pictures	House Pictures	Aversive Pictures
4	A +12.93	C +13.22	B + 4.47
	B +12.90	B + 1.02	C - 0.13
	D + 9.78	A - 0.43	E - 5.17
	C + 8.42	D - 7.97	A - 6.25
	E - 1.87	E - 8.03	D -19.76
5	A +19.55	A + 1.68	B + 0.06
	B +11.45	B - 1.56	C - 0.07
	C + 4.51	E - 7.31	A - 8.04
	E - 6.05	C - 8.13	E - 8.07
	D - 6.76	D -14.63	D -16.31

S #1 viewing the house photographs, and the maximum range was 32.67% change which was recorded for S #3 while viewing the house photographs.

When the ranges of response of the 5 Ss to the semi-erotic, house, and aversive photographs were averaged, the mean ranges of pupillary change over the 5 stimulus photographs for each stimulus group were remarkably the same (19.65% for the semi-erotic, 19.68% for the house, and 19.54% for the aversive photographs).

The subjective ranking of the semi-erotic photographs as compared to the pupillary ranking for each S along with each Spearman rank correlation coefficient is shown in Table 2.

The Kendall coefficient of concordance (W) was used to determine the extent of agreement in the S's pupillary rankings of the semi-erotic photographs. This statistic ranges from 0 to +1.00, but the clearest interpretation is in terms of the average rs over all possible pairs of rank orders. If there were perfect agreement among the rank orders, T would be 5(1), 5(2), . . . , 5(5) across the rank orders. If there were no agreement, T would be about the same across each row. It can be seen that in Table 2 there was some agreement among rankings, but there was not complete agreement. W was found to be +0.60 which indicates

TABLE 2

SUBJECTIVE RANKING COMPARED TO PUPILLARY RANKING WITH
 RESULTING SPEARMAN RANK CORRELATION COEFFICIENTS
 OF Ss VIEWING FIVE SEMI-EROTIC PHOTOGRAPHS

Subjective Ranking	Pupillary Ranking Subjects					T
	1	2	3	4	5	
1	2	3	1	1	1	8
2	1	1	3	2	2	9
3	4	4	2	4	3	17
4	5	2	5	3	5	20
5	3	5	4	5	4	21
<u>rs</u>	+ 0.60	+ 0.50	+ 0.80	+ 0.90	+ 0.90	

a moderately high degree of agreement between rank orders ($\underline{S} = 154$, $p < .01$).

The subjective ranking of the house photographs compared to each $\underline{S}$'s pupillary ranking is shown in Table 3.

TABLE 3

SUBJECTIVE RANKING COMPARED TO PUPILLARY RANKING WITH
RESULTING SPEARMAN RANK CORRELATION COEFFICIENTS
OF $\underline{S}$ s VIEWING FIVE PHOTOGRAPHS OF HOUSES

Subjective Ranking	Pupillary Ranking Subjects					T
	1	2	3	4	5	
1	1	1	1	1	1	5
2	5	2	3	3	4	17
3	2	4	4	2	2	14
4	3	5	5	4	5	22
5	4	3	2	5	3	17
$\underline{r}$	+ 0.40	+ 0.70	+ 0.40	+ 0.90	+ 0.50	

Using the Kendall coefficient of concordance to determine agreement among the $\underline{S}$ s, a $\underline{W}$ of + 0.58 was found for $\underline{S}$ s viewing photographs of houses, again showing a moderately high degree of agreement ($\underline{S} = 145$, $p < .01$).

The subjective ranking of the aversive photographs compared to the Ss pupillary ranking is shown in Table 4.

TABLE 4

SUBJECTIVE RANKING COMPARED TO PUPILLARY RANKING WITH
RESULTING SPEARMAN RANK CORRELATION COEFFICIENTS
OF Ss VIEWING FIVE AVERSIVE PHOTOGRAPHS

Subjective Ranking	Pupillary Ranking Subjects					
	1	2	3	4	5	T
1	3	3	3	1	1	11
2	1	1	1	4	3	10
3	2	4	2	2	2	12
4	5	2	5	3	4	19
5	4	5	4	5	5	23
<u>rs</u>	+ 0.60	+ 0.50	+ 0.60	+ 0.65	+ 0.90	

The Kendall coefficient of concordance was not as high for this group of stimuli ($\underline{W} = + 0.49$), but was still significant at a lower level of confidence ($\underline{S} = 122$, $p < .05$).

Tables 5, 6 and 7 indicate the absolute subjective scores given to the 5 stimulus photographs for the semi-erotic, house, and aversive groups, respectively, and the absolute pupillary area compared to those scores. A Pearson

TABLE 5

ABSOLUTE SUBJECTIVE SCORE AND ABSOLUTE PUPILLARY SCORE
WITH PEARSON PRODUCT MOMENT CORRELATIONS OF Ss VIEWING
FIVE SEMI-EROTIC PHOTOGRAPHS LISTED IN ORDER
OF SUBJECTIVE PREFERENCE

Subject	Subjective Order of Preference	Absolute Subjective Score	Absolute Pupillary Score	Pearson Product Moment Correlation
1	A	90	870.53	$\underline{r} = + 0.71$
	C	75	884.60	
	B	62	748.25	
	D	13	743.43	
	E	1	778.31	
2	A	92	758.68	$\underline{r} = + 0.55$
	C	84	761.05	
	B	75	816.18	
	D	70	808.98	
	E	20	716.68	
3	B	50	1265.53	$\underline{r} = + 0.92$
	A	48	1232.93	
	C	40	1150.28	
	D	25	1081.89	
	E	1	1048.03	

TABLE 5 (Continued)

Subject	Subjective Order of Preference	Absolute Subjective Score	Absolute Pupillary Score	Pearson Product Moment Correlation
4	A	85	789.78	$\underline{r} = + 0.58$
	B	50	787.75	
	C	30	711.70	
	D	10	772.38	
	E	1	669.10	
5	A	70	1115.22	$\underline{r} = + 0.43$
	B	45	1010.61	
	C	25	1139.61	
	D	5	998.68	
	E	1	1042.93	

TABLE 6

ABSOLUTE SUBJECTIVE SCORE AND ABSOLUTE PUPILLARY SCORE
WITH PEARSON PRODUCT MOMENT CORRELATIONS OF Ss VIEWING
FIVE HOUSE PHOTOGRAPHS LISTED IN ORDER OF
SUBJECTIVE PREFERENCE

Subject	Subjective Order of Preference	Absolute Subjective Score	Absolute Pupillary Score	Pearson Product Moment Correlation
1	A	75	944.71	$\underline{r} = + 0.61$
	B	55	860.03	
	C	45	953.35	
	D	30	819.45	
	E	10	860.03	
2	A	95	600.83	$\underline{r} = + 0.46$
	B	50	628.25	
	C	30	549.09	
	D	10	542.36	
	E	2	567.03	
3	A	70	983.20	$\underline{r} = + 0.72$
	B	45	823.00	
	C	35	855.33	
	D	5	803.25	
	E	1	858.83	

TABLE 6 (Continued)

Subject	Subjective Order of Preference	Absolute Subjective Score	Absolute Pupillary Score	Pearson Product Moment Correlation
4	C	50	828.33	$\underline{r} = + 0.88$
	A	49	817.78	
	B	30	834.31	
	D	10	752.33	
	E	1	681.23	
5	A	80	935.56	$\underline{r} = + 0.62$
	C	48	917.89	
	B	40	968.35	
	D	10	815.10	
	E	1	868.68	

TABLE 7

ABSOLUTE SUBJECTIVE SCORE AND ABSOLUTE PUPILLARY SCORE
WITH PEARSON PRODUCT MOMENT CORRELATIONS OF Ss VIEWING
FIVE AVERSIVE PHOTOGRAPHS LISTED IN ORDER OF
SUBJECTIVE PREFERENCE

Subject	Subjective Order of Preference	Absolute Subjective Score	Absolute Pupillary Score	Pearson Product Moment Correlation
1	B	80	700.60	$\bar{r} = - 0.07$
	A	70	763.93	
	C	15	768.40	
	E	2	832.40	
	D	1	711.48	
2	A	60	505.80	$r = + 0.45$
	B	50	523.05	
	D	35	486.31	
	C	20	525.69	
	E	3	455.72	
3	A	65	827.83	$\bar{r} = + 0.43$
	C	55	911.68	
	B	45	968.40	
	D	3	770.73	
	E	1	863.53	

TABLE 7 (Continued)

Subject	Subjective Order of Preference	Absolute Subjective Score	Absolute Pupillary Score	Pearson Product Moment Correlation
4	B	80	677.30	$\underline{r} = + 0.57$
	A	70	703.28	
	C	50	734.23	
	E	15	676.20	
	D	10	608.58	
5	B	78	916.84	$\underline{r} = + 0.58$
	A	70	884.50	
	C	45	953.65	
	E	20	872.85	
	D	5	842.84	

product moment correlation coefficient is given for each S in each stimulus group. The absolute pupil size was used to pair with the absolute subjective score given the photographs to determine if a relationship existed using the basic data of the study (i.e. pupil size) without resorting to percentage change from the control.

It can be noted that as the ranges become attenuated the rs tend to become smaller. Greater pupillary reactivity could result in higher correlations.

For S #2 there was no overlap in the absolute pupillary size for the semi-erotic, house, and aversive photographs. Ss #3 and #5 showed no overlap in pupillary size between the semi-erotic and house photographs, but did show some overlap between the house and aversive photographs. Ss #1 and #4 showed some overlap among the three stimulus areas.

The sign test was used for determining the probability associated with the occurrence of 14 out of 15 positive correlations between the absolute subjective score and the absolute pupillary score and a significant relationship was found ($p < .01$).

Sample rs based on the absolute subjective score and the absolute pupillary score for each S, by means of the Fisher r to Z transformation, were converted to Z scores and an average Z was determined for all Ss viewing each stimulus group (semi-erotic, house, and aversive photographs). From

the sum of the quantities obtained by multiplying each $\underline{Z}$ score by the $\underline{d.f.}$ was subtracted a correction (the sum of the weighted $\underline{Z}$ s times the average $\underline{Z}$), the result being distributed as a value of chi-square. It can be seen that the $\underline{x}^2$ values in Table 8 indicate there was no reason to reject the hypothesis that the sample $\underline{r}$ s were drawn from the same population. The average $\underline{Z}$ could, therefore, be transformed to an average $\underline{r}$ for all $\underline{S}$ s viewing the semi-erotic, house, and aversive photographs respectively.

TABLE 8

AVERAGE FISHER $\underline{Z}$ SCORES, CHI-SQUARE, AND AVERAGE PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN ABSOLUTE SUBJECTIVE SCORES AND ABSOLUTE PUPILLARY SCORES FOR $\underline{S}$ s VIEWING SEMI-EROTIC, HOUSE, AND AVERSIVE PHOTOGRAPHS

	Average Fisher $\underline{Z}$	$\underline{x}^2$	Average $\underline{r}$
Semi-erotic photographs	0.84	1.60	0.69**
House photographs	0.84	0.88	0.69**
Aversive photographs	0.44	0.74	0.41

**Significant at the .05 level.

It can be seen that the average $\underline{r}$ for the semi-erotic and house groups was the same, while the aversive photographs resulted in a lower correlation.

Table 9 shows the average Fisher Z scores computed from the individual rs for each S while viewing the semi-erotic, house, and aversive photographs. It can be seen that the chi-square scores gave no reason for rejecting the hypothesis that the rs were drawn from the same population and, therefore, the average Z scores could be transformed into average rs.

TABLE 9

AVERAGE FISHER Z SCORES, CHI-SQUARE, AND AVERAGE PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN ABSOLUTE SUBJECTIVE SCORES AND ABSOLUTE PUPILLARY SCORES FOR EACH S VIEWING SEMI-EROTIC, HOUSE, AND AVERSIVE PHOTOGRAPHS

Subject	Average Fisher <u>Z</u>	<u>x</u> ²	Average <u>r</u>
1	0.51	1.03	0.47
2	0.53	0.02	0.49
3	0.99	1.30	0.76**
4	0.90	0.70	0.71**
5	0.62	0.10	0.55**

**Significant at the .05 level.

The average rs ranged from + 0.47 to + 0.76. The average r for the aversive group (Table 8) and for S #1 (Table 9) was reduced partly due to one no-correlation

result for S #1 for the aversive group.

When absolute pupillary scores for each experimental group were added for the 5 Ss in order of their presentation, as indicated by the Latin square used, no order effects were noted.

DISCUSSION

It might be expected that the pupils of the Ss would respond with a greater change to the group of semi-erotic pictures and aversive pictures than to the house pictures that were lacking in emotional content. This was not the case, however. All 3 stimulus groups resulted in about the same range of change (approximately 20%). An emotion inducing stimulus is not apparently necessary for a range in pupillary preference. The greatest range (approximately 33%) was found in the house pictures--a non-emotional stimulus.

Additional information may be gained by looking at the type of reversals in order found in the rankings. For Ss viewing the semi-erotic photographs there were 10 photographs out of order when the subjective and the pupillary rankings were compared. Of these 10 reversals, 8 were reversals of adjacent positions, and 2 were two places out of order.

When the Ss looked at house photographs the reversals were of a different type. For 4 out of 5 Ss, only one photograph was out of order. One was 1 place removed, 1 was two places removed, and 2 were three places removed. This resulted in a lower r because that statistic is based on the square of the difference. In 4 out of 5 Ss the house

photograph ranked last on the subjective basis was ranked higher on the basis of pupillary response. After the data was gathered, several Ss expressed a familiarity with the house. It is possible that this recognition could have resulted in a greater pupillary response. For all Ss the first photograph in order of preference was also the first photograph in order of the pupillary rankings.

The Ss' pupillary response to the aversive photographs did not follow a pattern as closely as the above, but of the 8 photographs out of order, 3 were reversals of adjacent positions and the remainder were 2 positions removed. It can be seen that although there was not perfect agreement between the subjective and pupillary rankings, there was, nevertheless, a trend toward agreement. Rather than random variations in order, most reversals that did occur were between adjacent positions.

When the mean absolute pupillary area was compared to the absolute subjective score on the individual basis, the Pearson product moment correlation coefficients ranged from + 0.43 to + 0.92 for the semi-erotic photographs, + 0.46 to + 0.88 for the house photographs, and dropped to - 0.07 to + 0.58 for the aversive photographs. Except for the one no-correlation result, the remaining 14 were moderate positive correlations. Ss expressed greater difficulty ranking the aversive photographs than the semi-erotic

and house photographs. They were able to select the high and low aversive photographs, but had difficulty in ranking all 5 photographs. This difficulty may be reflected in the lower rank order correlations and in the lower Pearson product moment correlations for the aversive group. It can be noted, however, that the first subjective choice was either in first or second place in the pupillary rankings, and the fifth or last subjective choice was either in fourth or fifth position in the pupillary rankings for all Ss, so that even in this group there was a trend toward agreement.

Perhaps the most troublesome aspect of pupillary research is in the selection of stimulus photographs that will accurately reflect the quality to be measured. In this study the semi-erotic photographs were comprised of those taken from "nudist" publications rather than the typical "pin-up" type photographs. It was felt that through this type of photograph a wider range of stimuli could be obtained and a wider range of responses could be expected. One S, however, responded in a negative manner to these photographs, while a more typical "pin-up" type of photograph may not have resulted in this type of response. The pupil appears to be extremely reactive to all levels of stimuli and great care must be taken, through the selection

of stimulus photographs, to make sure that the response sought is not confounded by the responses to extraneous stimuli.

In addition, great care must be taken in the selection of the experimental apparatus and room. Anything that may divert the S's attention from the stimulus photographs tends to blunt the pupillary response. Ideally the room should be free from extraneous sounds, furnishings, and people, so that the S's attention may more easily be directed to the photographs used.

On the basis of the data gathered for this study, it appears that the pupil can serve as a reasonably reliable index of preference, not only on greatly dissimilar choices, but also on a more continuous pleasant-unpleasant gradient as has been suggested by Hess (1965). It is possible that the pupil may prove a more accurate barometer of interest and preference than even the subjective response. If future research can establish the priority of the pupillary response over more subjective measures (e.g. verbal responses), then psychology will have at its disposal a physiological tool with which to explore responses that may have previously been clouded by both internal and external conflicts.

SUMMARY

Previous research has established that the pupil is reactive to novel stimuli and that it may serve as an index of preference particularly between choices that are polar opposites. There has been some question, however, about the capacity of the pupil to respond throughout a range of stimuli and to discriminate among choices that are more closely associated within this range.

Five Ss were shown 3 groups of photographs. The first group consisted of semi-erotic photographs, the second group of house photographs, and the third group of aversive photographs. The pupillary responses were recorded while viewing these pictures. The Ss then ranked the photographs of each group from most pleasant to least pleasant, and, using an external anchoring stimulus, gave the photographs a score between 100 and 1.

For the semi-erotic photographs the pupils of the Ss generally dilated. For the house photographs the pupils dilated for the first choices and constricted for the last choices. The aversive photographs generally resulted in pupillary constriction.

For all 3 groups of stimuli there was significant agreement among the Ss as to the pupillary rankings of the photographs that had been ranked subjectively. For the most

part when there were reversals in order between subjective and pupillary rankings they were reversals of adjacent positions.

Comparisons of the subjective scores given to the photographs with the mean pupillary absolute score associated with the same photographs yielded moderate positive correlations.

It was concluded that the pupil may serve as an index of preference not only for choices differing greatly in subjective preferences, but also between choices that may be more closely positioned on a pleasant-unpleasant continuum.

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VITA

I was born on August 27, 1932, in Salina, Kansas, and attended elementary and high school there. After taking a pre-medicine curriculum at Kansas Wesleyan University, I graduated from Southern College of Optometry in 1955 with a Doctor of Optometry degree. After a short time as a staff member of the Southern College of Optometry clinic, I was commissioned in the army reserve and served two years as the optometry officer in the U.S. Army Hospital at Fort Benjamin Harrison, Indiana. Following this I entered the private practice of optometry in Baton Rouge, Louisiana, and at the present time am still engaged in this practice. I received, from Louisiana State University, a Bachelor of Science in 1966, and a Master of Arts in psychology in 1968.

EXAMINATION AND THESIS REPORT

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Major Field: Psychology

Title of Thesis: Pupillary size as an index of preference

Approved:

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

Date of Examination:

11 July 1969