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Irradiation as a Function of Hue

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IRRADIATION AS A FUNCTION OF HUE

by

Eugene Skoff

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the Requirements for the Degree of
Doctor of Philosophy

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LIFE

Eugene J. Skoff was born in Clinton, Indiana on March 18, 1925.

He was graduated from Morton High School, Cicero, Illinois, in June, 1943. He received his Bachelor of Science degree in February, 1959, and his Master of Arts degree in Psychology in January, 1963, from Loyola University.

During World War II the author served with the 13th U. S. Army Air Force in the Southwest Pacific Theatre of War. He was attached to the 68th and 70th Fighter Squadrons serving on Guadalcanal, New Guinea, and the Philippine Islands. He was honorably discharged from active duty in January, 1946.

From 1949 to 1955 the author was employed as a package designer by the Visking Corporation in Chicago, Illinois. From December, 1959, to June, 1965, he was employed as a Caseworker for the Cook County Department of Public Aid in Chicago, Illinois. From July, 1965, to the present, the author has been employed as a Research Associate and Project Director on a five-year federal grant awarded by the National Institute of Child Health and Human Development. Administration of this award is under the jurisdiction of the Institute for Juvenile Research, Illinois Department of Mental Health, Chicago, Illinois.

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and Chief, Division of Cognitive Development
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CHAPTER I

INTRODUCTION

Irradiation, in its simplest definition, is an apparent enlargement of a bright area when exposed against a dark background. A common natural manifestation of this phenomenon is a star or planet in the night sky; irradiation makes these celestial objects appear larger than they would otherwise seem. In a geometrical-optical image such as a dark bar on a bright background, the dark bar appears narrower than would an equally wide bright bar on a dark background. According to Hemholtz (Southall, 1961) the luminous impression spreads beyond the edge of a bright area, and the dark area in like manner 'infringes over the edge in the sense that the light begins to fade within the contour where it should still have its full strength'. Irradiation is further differentiated in terms of whether it is of a positive or negative nature. According to Wilcox (1936), the infringement of a bright area on a dark bar is designated as a negative irradiation, whereas the infringement of a bright bar on a dark ground is designated as positive irradiation.

Perhaps a clearer perspective of the phenomenon of irradiation can be obtained by certain precedents established in the literature. Parenthetically, a thorough and exhaustive search of the literature has revealed a paucity of research on visual irradiation. In addition, with the exception of Liebman (1927), the main research emphasis in the available literature has been directed toward achromatic rather than chromatic irradiation.

In an early study, Liebman (1927) found that when the figure and ground of a pattern are of different colors but of the same brightness, the colors tended to blur into each other and lose their contours. Using optical illusions such as the Munsterberg, Poggendorf, Zollner, and Mueller-Lyer figures, he found that the combination of blue lines on a green background blurred most, and blue lines on a red background blurred least.

Wilcox (1932) studied the dependence of visual acuity on light intensity. Using white bars on a black background and black bars on a white background, he found that in the former at low intensities, thresholds were very high but only until a certain minimum was reached; the threshold then rose. With dark bars on a bright background, the threshold decreased continually with rising intensity - the rate of decrease becoming progressively less. Wilcox concluded that the intensities in the test object and background do not act symetrically in regard to their effect on acuity. Acuity depends not only on light intensity but also on the way light is distributed between the test object and the ground. Wilcox attributes the causes of variation in acuity to the phenomenon of irradiation.

In an early study of visual acuity (Kravkov, 1940) it was found that the apparent size of a black ray on a white ground diminished as the surrounding brilliance was increased; this effect was attributed to irradiation. However, like LeGrand (1935), Kravkov concluded that any relationship between acuity and illumination must take into account individual visual sensitivity.

Fry and Bartley (1935) recognized that stimulus dimension is an important variable in the measure of irradiation. One of the conclusions drawn from this study was that if black bars are utilized in this measure, the length of the bars does not matter significantly as long as this length is constant and at least several times longer than the width. Using bar width as a stimulus variable Fry and Cobb (1937) found that the perception of a gap between the two parallel bars was influenced by irradiation. Two sets of bars were used, each set varying only in width. If the brightness of the bars was varied and the intensity at the center of the retinal image was plotted against the intensity differences between images of bars and interval, it was found that the threshold of the narrower bars rises much more steeply with increasing bar brightness. These results were interpreted as being dependent upon the greater effectiveness of the narrow bars in setting up border interference.

Obonai and Asano (1937) using black and white lines studied both positive and negative irradiation. They found that a white line imposed on a black ground resulted in positive irradiation. When the black line on a white ground is smaller than a certain size, the result is negative irradiation. The transition from positive to negative irradiation and from negative to positive irradiation is attributed to the function of light intensity.

The first reference bearing upon the practical significance of irradiation appears in the study of Feree and Rand (1930). It was found that speed of discrimination of a gap in broken circles on white (white gap) than for white circles on black (black gap). It was concluded that irradiation in the image formed on the retina was greater for the white gap than for the black gap. Studies of legibility of black and white print yielded mixed results. Crook (1947) found no significant differences in legibility of black print on white vs. white print on black. Holmes (1931) and Taylor (1943) found a superior legibility of black type on a white ground over white type on a black ground. Luckiesh (Kuntz & Sleight, 1950) using parallel bars as acuity targets, found that black bars on a white ground yielded the same result as white bars on a black ground. This is in direct conflict to the findings of Feree and Rand (1930) who found acuity to be better for black letters on white than for white letters on black. Kuntz and Sleight (1950) found no differences in acuity using black-white type variations; these authors point out the need for extensive research bearing on the relationship between irradiation and achromatic acuity.

However, more germane to the aims of the present research is the functional relationship between chromatic acuity and irradiation. Both MacAdam and more recently Bishop have addressed themselves to the problem of color acuity. MacAdam (1949) has demonstrated that color contrast alone is a sufficient basis for color acuity. Bishop's (1966a, 1966b) results confirm this finding but also suggest that luminance contrast is more efficient than color contrast for visual acuity. But neither of these authors acknowledge that irradiation of hue might be an influencing variable.

The first recent study, with all physical differences held constant, (cf. Liebman, 1927), suggesting a relationship between hue and irradiation, is that of Teft and Wiener (1965) who investigated the effect of hue on masking of letters. It was found that yellow letters were masked more frequently than red, green or blue letters. Since all the stimuli were presented on a neutral gray background of the same brightness and were equated for brightness and chroma, there were no physical differences to which to attribute the difficulty in reporting yellow letters. In addition, Ss spontaneously reported difficulty in reporting yellow letters. This fuzziness suggested irradiation which might well interfere with pattern identification. Wilcox's old experiment (1932) demonstrating greater irradiation of light bars on a dark background than dark bars on a light ground also suggested that when figure-ground contrasts are kept equal, it does not necessarily follow that acuity or contour strength remain equal.

On the basis of research by Brody (1955), Weale (1961a, 1961b), and Hinchcliffe (1962) which indicated that visual sensitivity decreases with age, Pollack (1963), using children ranging from 8 to 12 years of age, demonstrated that contour detectability as a function of light intensity also declined with age. This decline Pollack attributes to such physiological processes as increasing lenticular density, lenticular pigmentation, decreasing pupil size, and perhaps increasing retinal pigmentation. It was therefore inferred that hue detectability thresholds would rise with age. Toward this end, Pollack (1965a), studying children from 7 to 12 years of age, failed to substantiate his hypothesis, i.e., hue detection thresholds did not follow anticipated ontogenetic trends. However, of the three hues studied, orange yielded significantly lower thresholds than either green or blue which did not differ from each other. Therefore, Pollack concludes that contour detection and hue detection processes are underlain by different receptor systems with different ontogenetic trends. These references are cited to indicate that the phenomenon of irradiation might likewise have developmental implications.

In brief review, then, this introduction has served to trace the historical treatment of irradiation. The early studies focused on the physical factors operant in irradiation such as stimulus configuration, light intensity, and figure-ground contrast. Little recognition was evidenced of how this phenomenon practically applies to man's visual world. These practical applications were demonstrated in the early studies on the legibility of print. More important here, was the recognition that irradiation might be responsible for differential visual behavior and that it was very worthy of more research focus. In spite of the recognition for the need of research, no direct investigative effort followed. The Liebman (1927) and Teft and Wiener studies indicated that irradiation has chromatic as well as achromatic implications. The recent studies of Brody (1955), Weale (1961a, 1961b), Hinchcliffe (1962), and Pollack (1963, 1965a, 1965b) have demonstrated definitive developmental considerations in visual sensitivity.

Since man's visual behavior is not exclusively achromatic, but on the contrary predominantly chromatic, and since irradiation seems to be a dynamic property of color, it would seem that a direct investigative effort would serve to enrich psychological knowledge of visual behavior. In view of the past disproportionate emphasis on achromatic aspects of irradiation and in recognition of the immediate practical and adaptive significance of color vision the aim of the present research is twofold. First, the present investigation will endeavor to provide quantitative data on the relative differences in irradiation as a property of different hues. Secondly, since children of various age levels will be the object of this study, the data are expected to reveal valuable information on the ontogenetic course of irradiation. This data will be comparatively evaluated with that obtained in the research cited above.

CHAPTER II

METHOD

A. Subjects. The Ss were 72 school children with an age range of seven to twelve years old. These age ranges generally conform to those groups utilized in the Pollack (1963, 1965a, 1965b) studies. All of the children were pupils in a suburban elementary and junior high school. Each child had 20/20 uncorrected vision with no color defects as determined by testing with a Bausch and Lomb Master Orthorater and the American Optical Company's Pseudo-isochromatic Plates.

The Ss were divided into six age groups (7,8,9,10,11, and 12 years old). There were 12 Ss in each age group - 6 boys and 6 girls each matched for age. When weather permitted mobility, testing was conducted in a mobile perception laboratory. This mobile laboratory is a self-contained unit approximately the dimensions of a public bus which houses soundproof, lightproof testing rooms, air-conditioning, and heating units powered by an electrical generator. When weather extremes precluded access to the van, testing was conducted in a small isolated room provided by the school. Light, sound, and testing conditions were equivalent to that provided by the mobile van.

B. Apparatus. The apparatus* was a custom-designed Distance Simulator (see Appendix). The entire instrumentation is enclosed in a box of masonite

* Gaertner Scientific Corporation, Chicago, Illinois

construction whose length is 77 3/4 inches, width of 15 inches, and depth of 16 inches. The interior and exterior of the box is painted a non-glare black. At the viewing end, a felt hood, conforming to the contour of the box, prevents entrance of extraneous light. Also, at this end, a scissors type elevating mechanism permits individual viewing height adjustment.

The front portion of the box (in the viewing hood) houses a binocular lens system. Incorporated with the lens system is an adjustment for individual interpupillary distance. In order to maintain proper visual angles the lens system was designed to simulate a viewing distance of 7.3 meters from the eye to the stimulus at an actual viewing distance of 182.88 centimeters. Thus, a bar separation of one millimeter at the simulated distance subtends a visual angle of ten seconds. The above arrangement was finally adopted after considerable lens design-modification based upon equal considerations of the small visual angles involved and the Munsell color values available.

Within the far end of the box was a commercial-type slide projector (Sawyer) which was modified for the presentation of the 2" x 2" stimuli. Only the automatic slide-changing mechanism and the slide cartridge were retained for use in this modification. Slides could be changed by a remote control unit.

The stimuli were front-lit by the CIE standard illuminant C provided by two GE 115-120 volt, 100 watt bulbs. Illumination level was held constant by a Raytheon ACR-500 voltage regulator which maintained an amperage of .85 amperes through both bulbs. A blower system provided cooling and prevented excessive heat build-up. Interposed between the light source and the stimulus is an electronically operated shutter. A timing device permitted a stimulus exposure from 1/10 second to 100 seconds; a push-button type control actuated the shutter.

When the subject looked into the rubber eyepieces of the binocular lenses and the shutter was opened, he saw only the front-lit stimulus at the far end of the viewing box.

The full complement of stimuli consisted of 69 slides, 23 slides for each of the three hues. Each 2" x 2" slide consisted of two parallel bars of the same hue mounted on a gray background, the background extending to the limits of the slide. The interspace between the parallel bars ranged from 2.5" of arc to 1'40" of arc. The interspace on the first slide subtended a visual arc of 2.5", the next slide 5" of arc, and then each interspace thereafter increased in steps of 5" of arc.

The width of each of the parallel bars subtended a visual angle of 1' while the length of each bar subtended an angle of 4'. The gray background on which the bars were mounted subtended an angle of 8.3' x 8.3'.

The original intent was to use the same Munsell values utilized in the Teft and Wiener study. However, these saturation values were not visually perceptible and had to be discarded. Much trial and error with various saturations and backgrounds followed. According to David MacAdam* of the Kodak Research Laboratories, it is essential that the brightness of the bars matches exactly the brightness of the background if the effectiveness of hue is to be

* Personal correspondence.

determined apart from the effectiveness of luminous contrast. Thus, the final selection of hue, brightness, and saturation was governed by the limits of color values available from the Munsell Color Company. Unfortunately, the green hue could not be matched in saturation with the other three hues, and therefore, had to be eliminated. The optimal visually discriminable values finally selected were Red 5R 5/12, Blue 7.5PB 5/12, and Yellow 5Y 8/12. The neutral gray background was N/5 for the red and blue hues and N/8 for the yellow hue. A .3 Wratten neutral density filter was used with the yellow slides to provide a brightness match with the other two hues. Thus, each hue was matched for brightness (Munsell value 5) and saturation (Munsell value 12) and brightness of ground was matched with brightness of hue (Munsell value N/5).

C. Procedure. Prior to testing, each child was dark-adapted for five minutes. During this period, general instructions were given, the apparatus was adjusted to individual viewing height, and viewing tubes were adjusted to individual interpupillary distance. With the head in the viewing hood and the eyes in the rubber eye-pieces, the child saw only the stimulus field. A very dim light on top of the apparatus at the experimenter end provided sufficient illumination for E to record responses on the data sheet. This dim light was turned on only after S was in the viewing position and thus did not disrupt experimental control.

With the head in the viewing position, the child was then shown a slide with a minimum bar separation and one of maximum separation. He was told that at times he would be able to see a gap between the bars and that at other times he would not. The child was instructed to report "Yes" when the gap was perceptible and "No" when he could not see it. A practice series was then presented to insure that the instructions were understood and to gain familiarity with the procedure.

The method of limits was used with eight trials presented in counterbalanced order for a given hue. Prior experimentation indicated that a one-second exposure for each slide was the optimal time for clear discrimination of the bars. Frequent rest periods were given. The child was instructed to report any eye fatigue immediately, and rest periods would be accordingly allowed. Each S experienced all three of the hue conditions with a one to two day interval between each pair of hue conditions.

CHAPTER III

RESULTS

Since no stable data could be obtained with the yellow hue, only results with the red and blue hues can be reported here. In general, Ss reported that the separations between the yellow bars could not be seen because the slides were "too blurry" indicating that irradiation eclipsed contour.

Mean thresholds were calculated for each S on the basis of 8 trials per hue. The relationships between irradiation, hue and age are graphically portrayed in Fig. 1. As can be seen, the lowest mean irradiation thresholds were obtained with the Red hue and the higher means with the Blue. By inspection, irradiation with both hues tended to decrease as age increased until the age of 11 with a sharper decrease with Blue than Red. Also, the differences in threshold became decreasingly smaller at each age level reaching approximate equality at the 11 year old level.

The relationship between irradiation and sex at each age level is graphically portrayed in Figs. 2 and 3. Irradiation thresholds for Red (Fig. 2) were higher for girls than for boys except at the 9 year-old level where the reverse is evident. In Fig. 3, irradiation thresholds for Blue were again typically higher for the girls than for the boys with the exception of the two earliest age levels.

Since Hartley's Maximum F Ratio of Homogeneity indicated that variances were homogeneous (F = 4.42, df = 11 and 12, n.s.) a two-way analysis between

FIG.1. IRRADIATION AS A FUNCTION OF HUE AND CHRONOLOGICAL AGE.

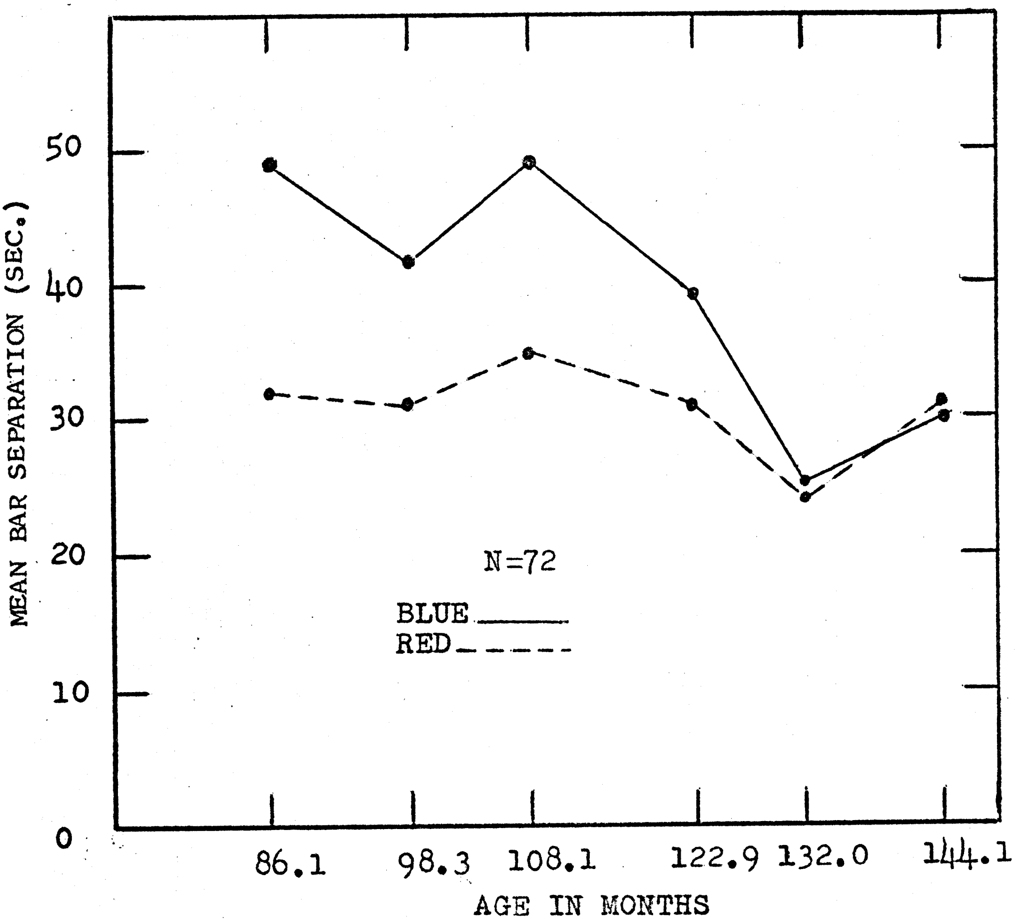


FIG. 2. IRRADIATION OF RED AS A FUNCTION OF SEX AND CHRONOLOGICAL AGE.

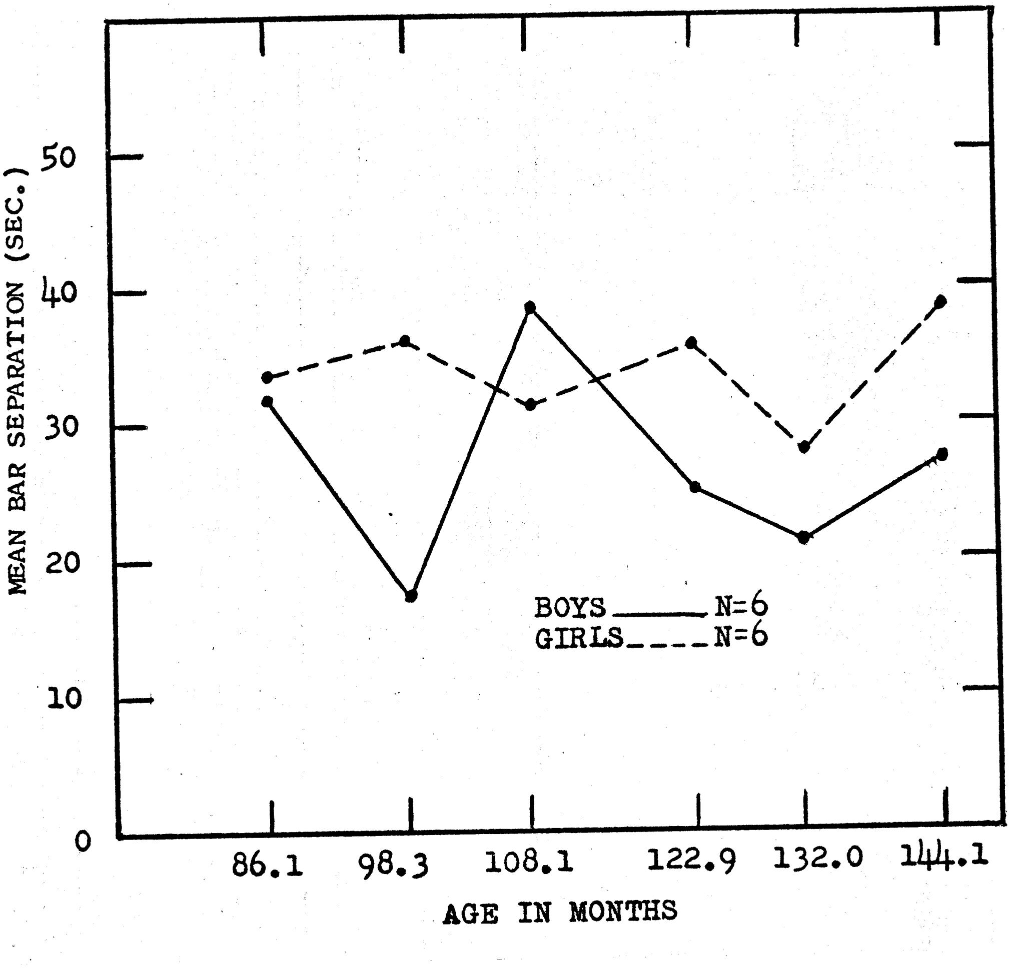
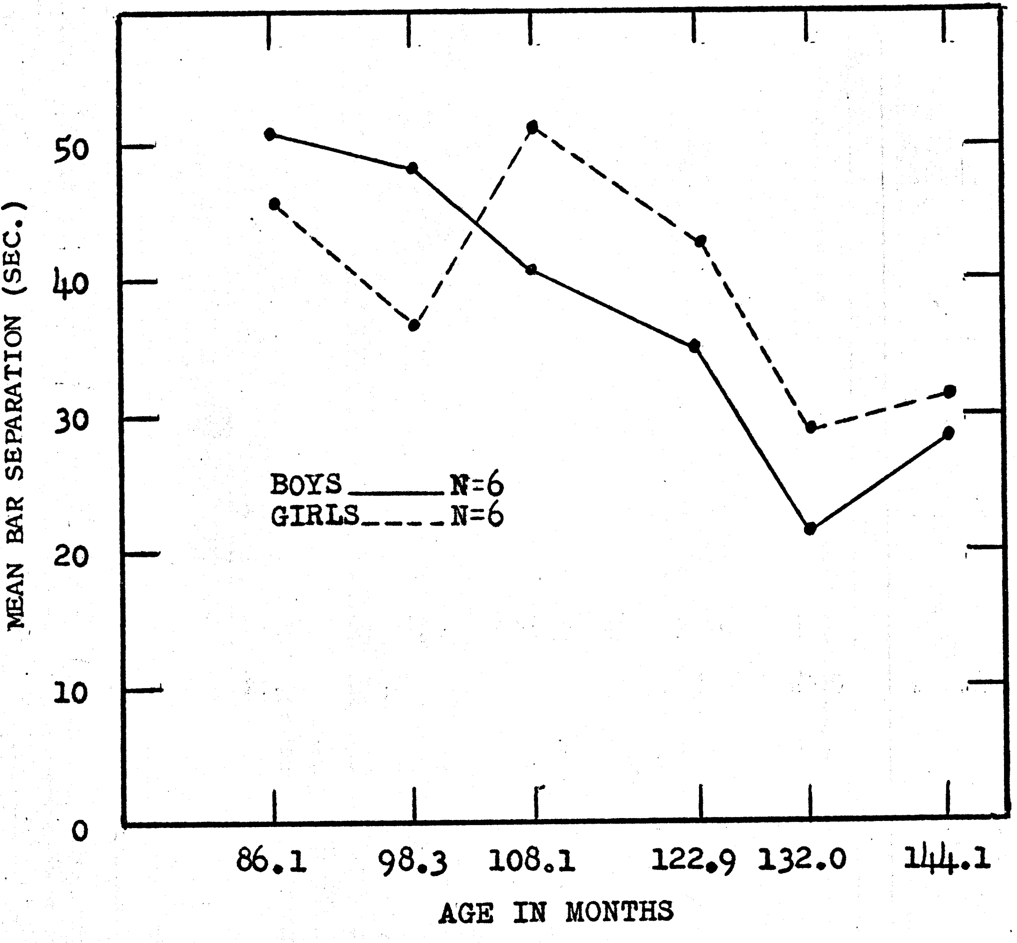


FIG. 3. IRRADIATION OF BLUE AS A FUNCTION OF SEX AND CHRONOLOGICAL AGE.



age and hue was performed. The results are summarized in Table 1. As can be seen, the main effects of age ($F = 3.60$, $df = 5$, $p < 0.01$) and hue ($F = 11.17$, $df = 1$, $p < 0.01$) were significant. However, there was no significant interaction between age and hue ($F = 1.54$, $df = 5$). Since there was a main effect of hue, a one-way analysis on Red (Table 2) resulted in an $F = .887$, $df = 5$, n.s., and a one-way analysis on Blue (Table 3) yielded an $F = 4.17$, $df = 5$, $p < 0.01$. T-tests were computed for differences between Red and Blue-irradiation at each age level (Table 4); only the difference at the 7 year-old level was significant ($p < 0.001$). T-tests for differences between pairs of age groups on each hue were computed. The data are summarized in Table 5 and Table 6. As can be seen, on the Red, the majority of the significant differences are found with the pairs at the 11 year old level. The difference between the 11 and 12 year-olds was also significant at the .01 level, and the difference between the 7 and 9 year-old level was significant at the .05 level. T-tests for differences between age pairs on Blue are summarized in Table 6. Differences between all pairs of age groups were significant at the .01 level.

Pearson product-moment correlations between irradiation (R,B), mental age (MA), and chronological age (CA) were computed. These intercorrelations are summarized in Table 7. In the Male-Female group combined ($N = 72$) both MA and CA are negatively and significantly correlated with Blue ($p < 0.01$), the correlation being higher for CA than MA. Thus, as MA and CA increase, there is a corresponding decrease in Blue-irradiation suggesting the opera-

TABLE 1. ANALYSIS OF VARIANCE OF IRRADIATION SCORES.

SOURCE	SSs	df	MS	F	p
BETWEEN Ss	22006.76	71			
AGE	7412.66	5	942.53	3.60	<0.01
Ss WITHIN GROUPS	17294.10	66	262.03		
WITHIN Ss	14707.95	72			
HUE	1935.27	1	1935.27	11.17	<0.01
AGE X HUE	1336.90	5	267.38	1.54	n.s.
HUE X Ss WITHIN GRPS.	11435.78	66	173.27		
TOTAL	56129.42				

TABLE 2. ANALYSIS OF VARIANCE OF RED-IRRADIATION SCORES.

SOURCE	SSs	df	MS	F	p
BETWEEN GRPS.	818.27	5	163.65	.887	n.s.
WITHIN GRPS.	12176.33	66	184.49		
TOTAL	12994.60	71			

TABLE 3. ANALYSIS OF VARIANCE OF BLUE-IRRADIATION SCORES.

SOURCE	SSs	df	MS	F	p
BETWEEN GRPS.	5231.29	5	1046.26	4.17	<0.01
WITHIN GRPS.	16554.62	66	250.83		
TOTAL	21785.91	71			

TABLE 4. t-TESTS FOR DIFFERENCES BETWEEN RED AND BLUE-IRRADIATION AT EACH AGE LEVEL.

AGE	7	8	9	10	11	12
σ	3.06	5.89	7.31	6.97	--	--
t	5.08	1.74	1.57	1.15	--	--
df	11	11	11	11	--	--
p	.001	--	--	--	--	--
N	12	12	12	12	12	12

TABLE 5. t-TESTS FOR DIFFERENCES BETWEEN AGE GROUPS ON RED-IRRADIATION

AGE	8	9	10	11	12
7	0.78	1.93***	0.30	4.47*	2.20
8		1.15	0.85	5.37*	0.36
9			1.61	4.86*	1.18
10				2.44**	0.61
11					3.37*

*p .01 **p<.02 ***p<.05 N=24

TABLE 6. t-TESTS* FOR DIFFERENCES BETWEEN AGE GROUPS ON BLUE-IRRADIATION

AGE	8	9	10	11	12
7	3.43	2.88	4.83	4.50	8.61
8		2.47	3.66	14.9	5.37
9			2.92	9.41	6.42
10				5.44	3.05
11					3.44

*All ts significant at the .01 level.
N=24

TABLE 7. PEARSON rs BETWEEN RED-IRRADIATION(R), BLUE-IRRADIATION(B), CHRONOLOGICAL AGE(CA), MENTAL AGE(MA)[1], AND MALES AND FEMALES(M-F).

CONDITION	M-F COMB.	MALE	FEMALE
CA-MA	.84*	.81*	.88*
CA-R	-.12	-.22	-.02
CA-B	-.42*	-.52*	-.32***
MA-R	-.18	-.19	-.16
MA-B	-.31*	-.42*	-.17
R-B	.27**	.26	.27
N	72	36	36

[1] Lorge-Thorndyke Intelligence Test

*p<.01 **p<.02 ***p<.05

tion of both an intellectual and maturational factor. A significant positive correlation was also found between R-B irradiation ($r = .27$, $p < 0.02$). Differences between the sexes were also found with negative correlations between MA-B and CA-B, the differences being greater for the Males. High positive MA-CA correlations were significant in all the sex conditions, and it was suspected that this result was responsible for the significant negative correlation between MA and Blue-irradiation conditions and the non-significant negative MA and Red-irradiation. This suspicion was confirmed when CA was partialled out. All the significant MA-B correlations were severely reduced to non-significance. The MA-R correlations were severely reduced to zero. Thus, CA exerts the major influence on the correlations found here.

CHAPTER IV

DISCUSSION

Since visual acuity was held constant, hues were matched for saturation and brightness, target and ground were of equal brightness, and light source was precisely controlled, it may be reasonably concluded that the blue hue exhibited greater irradiation than the red. However, interpretation must be guarded since no quantitative data on yellow or green were available. The blurredness of the yellow hue, as reported by the Ss, is consistent with the findings of Teft and Wiener (1965) in that lack of resolution data suggested that irradiation interfered with contour identification. In terms of spectral sensitivity, the greater irradiation of blue over red is rather difficult to explain; it would seem that greater irradiation would be found in the region of the longer red wave lengths rather than in the shorter blue.

Since Pollack (1963) found that contour detection decreased with age, but hue detection (1965a) did not, the results of the present study suggest that the sensation of hue requires contour if ontogenetic trends are to be distinguished. However, in the present study, which used comparable age groups (7 to 12 years old), the detection of color contour increased with age rather than decreased. As in the Pollack (1965a) study, thresholds for red were lower than for the blue. However, blue thresholds tended to increase with age whereas in the present study they decreased. The ontogenetic course of red was somewhat similar in that there was a slight tendency for red thresholds to decrease with age.

The findings here are not consistent with those of Brody (1955), Weale (1961a, 1961b), and Hinchcliffe (1962) who demonstrated that visual sensitivity decreased with age. The data are consistent with those of Slataper (1950) who found that visual sensitivity rapidly accelerated from about two years old to puberty and thence a gradual decline. Riesen _et_._al_.(1964), using very young monkeys (20-60 days old), found consistent improvement in acuity suggesting that the directional trend can be established quite early in infancy. An important consideration in developmental studies of visual sensitivity is juvenile hypermetropia (farsightedness). Weale (1963) reports studies which confirm that hypermetropia increases from the first years of life to thirteen years old and then decreases until the late teens. Therefore, superior juvenile acuity may well be a function of increasing hypermetropia.

The absence of a relationship between intelligence and visual performance found in the present study is consistent with the findings of Pollack (1965a, 1965b), Slaton (1958), and Dispensa (1939). In contrast, Loranger and Misiak (1959) report that acuity can be related to intelligence. However, Weale (1963) cautions that relationships reported between visual sensitivity and intelligence must be interpreted with caution since the relationship may be due to some other common source. This need for caution was aptly demonstrated in the present study wherein prior to partialling out CA there was a significant relationship between MA and Blue-irradiation. However, Weale points out that questions of comprehension and intelligence cannot be entirely ruled out.

A further consideration here is the relationship between irradiation and color acuity. The data indicate that, since irradiation was greater for the blue hue than the red, it may be logical to conclude that color acuity would be better for the red than for the blue. However, this conclusion must be guarded, for the superiority of red over blue seems to vanish at the 11 year old level. Within the age limits studied here the proposals of MacAdam (1949), Cavonious (1965), and Bishop (1966a), that color contrast alone is a sufficient basis for acuity rather than luminous contrast, is somewhat supported. It must be pointed out here that the low N used in the cited studies (MacAdam, N = 1, Cavonious, N = 1, Bishop, N = 4, Ns in all studies were adults) precludes a comparison in depth with the present investigation. Obviously, there is a great need for more research effort on color acuity.

The presence of sex differences at each age level was blurred because of reversals in threshold direction (Fig. 2, Fig. 3). Since the N of 6 in each age group was quite small, the data does not lend itself to statistical treatment. Generally, the males had lower thresholds than the females in both hue conditions. In addition, CA-R and CA-B correlations (Table 7) were much higher for the males than for the females. With the exception of Dispensa's (1939) study, the literature offers little evidence for sex differences in visual capacity. Dispensa reports, in a comparison of 1891 females with an equal number of males, that the females had more physiological visual defects than the males. Unfortunately, however, no comparison of acuity was made between non-defective males and females.

There is an obvious need for quantitative data on sex differences in visual sensitivity, and future research should be alerted to these potential differences for their value in child development.

CHAPTER V

SUMMARY

This research represented an effort to compare the differential effects of irradiation as it relates to hue, chronological and mental age, visual acuity, and sex.

Seventy-two school children varying in age from 7 to 12 years old an with no visual defects participated in the study. Irradiation was measured by obtaining separation thresholds for rectangular parallel colored bars — red, yellow, blue, on a neutral gray background. The colored bar targets were matched for brightness and saturation, the brightness of the bars being matched with the brightness of the ground. The viewing apparatus, which incorporated a binocular lens system, was a custom-designed Distance Simulator which provided precise control of illumination, stimulus exposure, and viewing distance.

An analysis of the data yielded the following results:

1. Irradiation effects were greater for the blue hue than for the red. No data were obtained with the yellow hue because intense irradiation prevented resolution thresholds.
2. Decided ontogenetic trends were distinguished in blue-irradiation thresholds where significant differences were found between all age levels. Less impressive trends were obtained with red-irradiation where significant differences were found

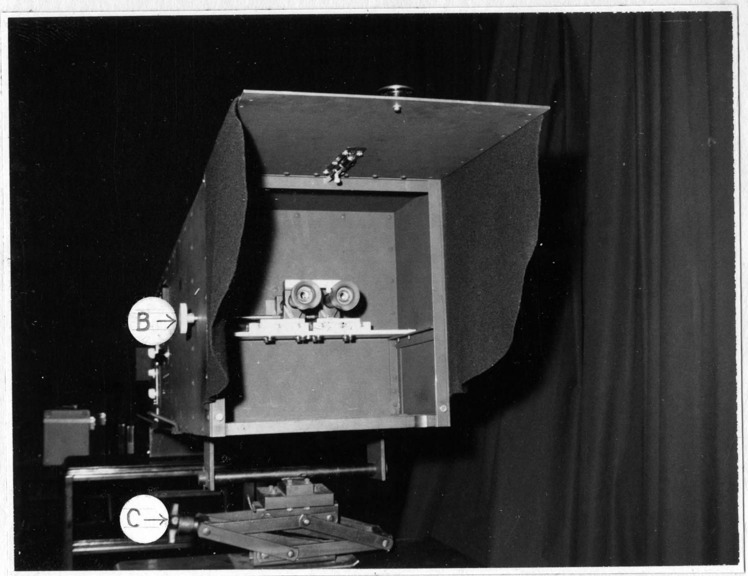
predominantly between the lower and upper age levels.

3. Significant negative correlations were found between chronological age and blue irradiation. That is, as age increased, irradiation decreased. Correlations between chronological age and red-irradiation were negative but not significant.
4. There was no correlation between irradiation and mental age.
5. Sex differences were observed, but the data did not warrant generalizations.

The results were discussed and their relevance to cited research and perceptual development was evaluated. While the findings here did not yield broad and definitive conclusions, a groundwork for future investigation was laid. But the phenomenon of irradiation will require much additional investigative effort before it assumes its proper perspective in visual perception.

APPENDIX

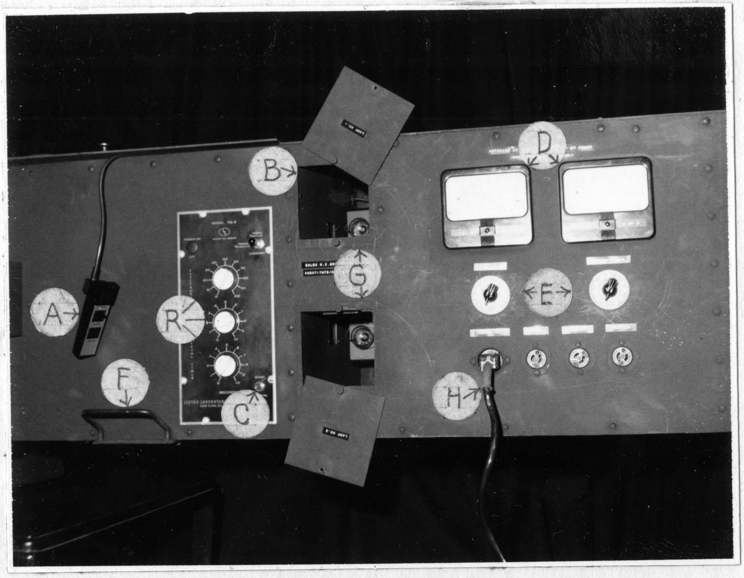
SUBJECT IN VIEWING POSITION



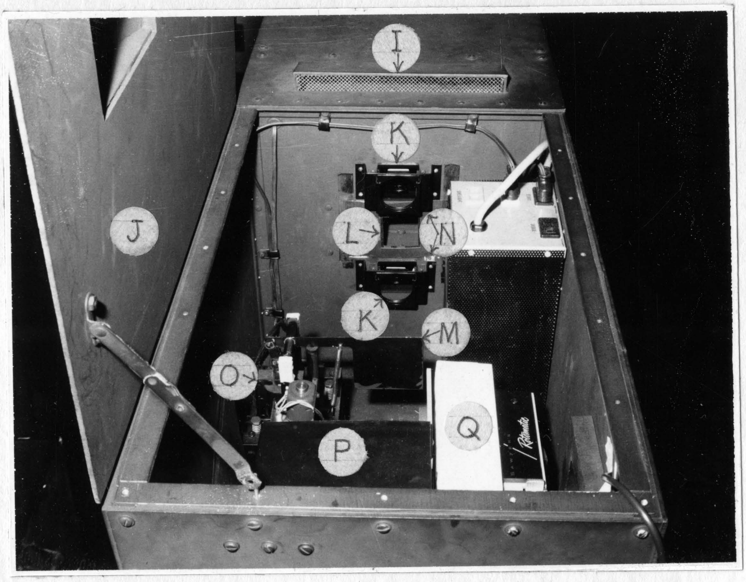
VIEWING HOOD

LEGEND

A-Binocular lens and eye-pieces.
B-Interpupillary distance adjustment.
C-Elevating adjustment.



CONTROL PANEL



STIMULUS PRESENTATION COMPARTMENT

LEGEND

A-Automatic slide changer.
B-Bulb access.
C-Shutter trip.
D-Ammeters.
E-Ampere controls.
F-Carry handle.
G-Bulbs.
H-Voltage regulator.
I-Blower outlet.
J-Access door
K-Light apertures.
L-Viewing aperture.
M-Shutter.
N-Filter receptacle.
O-Electromagnetic shutter-actuator.
P-Slide changer.
Q-Slide cartridge.
R-Shutter timing-selectors.

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APPROVAL SHEET

The dissertation submitted by Eugene Skoff has been read and approved by members of the Department of Psychology.

The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

May 29, 1967
Date

Edmund P. Marx
Signature of Adviser PK