THE LAWS OF VISUAL MINUTHESES: * THE THRESHOLD PRE-EXPOSURE TIME AND THE EQUILIBRIUM TIME FOR A PROJECTED NEGATIVE AFTER-IMAGE.¹

By Leonard T. Troland.

THE following is a preliminary report of one of a series of investigations being carried out to determine the laws which govern the decay of a semicircular after-image, variously produced, but always projected on a circular, luminous field of its own diameter, so as to fill one-half of this field.

In the present experiment four different ranges of the spectrum were employed, and the brightness of the uniform stimulus fields in which they were presented were made equal, by the flicker photometer, to 31.6 candles per square metre. The stimulus field was provided with a central fixation point, always visible, had an angular diameter of 3.38 degrees, and was viewed through an artificial pupil—of 2.36 mm. diameter—against a dark background. Five minutes' dark adaptation was allowed before beginning a set of measurements. The results given are for the writer's right eye.

The relation selected for study was $t_q = f(t_p)$, where t_p is the preliminary time of exposure of the eye to the first semicircle, and t_q is the time from the moment of exposure of the second semicircle until the minuthetic (or "fatigue") contrast disappears. The three cases tested were: $t_p = 300$ seconds (which is practically equivalent to $t_p = \infty$), $t_p = 30$ seconds, and $t_q = 0$.

The last case involves a determination of the "threshold preexposure time," or the minimum time which will produce a noticeable minuthesis under the given conditions. This was attempted by the method of "constant stimuli." Four hundred observations were made on each color, the right- and left-hand sides of the field being presented first, an equal number of times. If, at the first instant of exposure of the second half of the field, the preexposed half looked darker than the other, the contrast

* The writer has proposed the term *minuthesis* to designate, in place of the inappropriate word "fatigue," any decrease in the sensitivity of a sense organ, due to stimulation.

¹ To be published in the *Journal of Experimental Psychology*.

was called negative; if brighter, it was called positive. The results follow:

Color	Wave-length, in $\mu\mu$	t_p in σ^*	Number of trials					
			Right first			Left first		
			Positive	Equal	Negative	Positive	Equal	Negative
Red	666.5 - 689.3	35.0	1	27	22	2	30	18
		57.2	1	15	34	0	18	32
		78.6	0	6	44	3	7	40
		100.2	0	2	48	0	1	49
Yellow	574.2 - 587.4	35.0	9	19	22	2	13	35
		57.2	7	15	28	0	14	36
		78.6	4	12	34	1	8	41
		100.2	0	6	44	1	3	46
Green	516.0 - 525.4	35.0	12	23	15	7	28	15
		57.2	10	23	17	3	21	26
		78.6	12	13	25	4	10	36
		100.2	6	11	33	0	8	42
Blue	445.7 - 451.0	35.0	17	20	13	1	23	26
		57.2	14	16	20	0	11	39
		78.6	11	15	24	1	10	39
		100.2	0	5	45	1	1	48

$\sigma = 0.001$ second.

Calculation of these results, by the traditional method of "right and wrong cases," judgments of negative contrast being regarded as "right," gives the following values for the threshold:

Color	Threshold time		Space error σ	Corrected threshold σ
	Right first σ	Left first σ		
Red	52.50	50.35	- 1.08	51.43
	($h = .0944$)	($h = .03204$)		
Yellow	46.50	- 4.198	- 25.35	21.15
	($h = .01231$)	($h = .008115$)		
Green	70.15	55.75	- 7.20	62.95
	($h = .01052$)	($h = .01684$)		
Blue	70.75	30.60	- 20.08	50.68
	($h = .01413$)	($h = .01406$)		

The large space errors are probably due to a slight lack of uniformity in the stimulus field.

The average values found for t_a , with $t_p = 30$, and $t_p = 300$ seconds, respectively, are given in the following table. Each average represents ten trials.

Color	Preëxposure time, t_p , = 30 seconds			
	Right first, seconds	Equality time, t_q Left first, seconds	Space error, seconds	Corrected value, seconds
Red	86.2 (A. D. = 2.2)	92.5 (A. D. = 3.0)	3.2	89.4
Yellow	90.6 (A. D. = 2.1)	95.3 (A. D. = 1.6)	2.4	93.0
Green	91.5 (A. D. = 3.1)	93.3 (A. D. = 3.8)	0.9	92.4
Blue	76.5 (A. D. = 1.8)	89.1 (A. D. = 3.8)	6.3	82.8

Color	Preëxposure time, t_p , = 300 seconds			
	Right first, seconds	Equality time, t_q Left first, seconds	Space error, seconds	Corrected value, seconds
Red	156.8 (A. D. = 4.7)	143.9 (A. D. = 2.3)	-6.5	150.4
Yellow	180.0 (A. D. = 6.5)	164.1 (A. D. = 4.5)	-8.0	172.1
Green	162.4 (A. D. = 4.0)	152.4 (A. D. = 3.7)	-5.0	167.4
Blue	147.2 (A. D. = 3.8)	146.3 (A. D. = 4.3)	-0.5	146.8

Since t_q , for $t_p = 300$, represents closely equilibrium conditions of sensitivity, it may be called the "equilibrium time."

This work is now being repeated with other subjects and under improved conditions. The results are ultimately intended to test a theoretical equation for $t_q = f(t_p)$, deduced from assumptions with regard to the chemical nature of the retinal process.

Research on the Corrosion Resistance of Copper Steel. D. M. BUCK and J. O. HANDY. (*The Journal of Industrial and Engineering Chemistry*, vol. 8, No. 3, March, 1916.)—Sheet steel and iron-containing copper show greatly-increased corrosion resistance when exposed to atmospheric conditions. The most effective amount of copper to be used for this purpose is approximately 0.25 per cent. Smaller amounts of copper down to as little as 0.04 per cent. have a considerable influence in lessening corrosion, but the results are not so good as with the higher amount. Previous investigation has indicated that 0.15 per cent. copper is in nearly all cases as efficient as 0.25 per cent. Higher amounts of copper up to 2 per cent. give little or no added benefit. Copper is as necessary in the so-called "pure irons" to insure corrosion resistance as it is in normal open-hearth and Bessemer steels.