Kolbanov V.V.
Anisotropy and “golden proportions” in visual apparent motion

*I. P. Pavlov First Medical University
(Russia, St.Petersburg)*

doi: 10.18411/gdsn-28-02-2019-13

idsp: scienceconf-28-02-2019-13

Abstract

Visual phenomenon of apparent motion (β -motion) was investigated monocularly and binocularly in 22 men. Distance between light sources was 6° in each of eight meridians of visual field, flash duration – 25 ms, variable time delay between flashes – from 75 to 150 ms.

Time ranges of the phenomenon were from 75 to 140 ms in the centre of visual field and from 80 to 150 ms in parafoveal areas. In the region of blind spot apparent motion had the same character as in other meridians within $12-18^\circ$ eccentricity. Minimal time delay with phenomenon beginning was in left meridian, with phenomenon disappearance – in left, right and lower meridians of visual field. Maximal time interval for phenomenon disappearance was in the upper part of visual field. Differences between meridians were similar during the monocular and binocular observations, but binocular variations were smaller.

These results make it possible assuming that brain mechanisms of the visual apparent motion are kindred with analysis of real motion.

Moreover, the “golden proportion” was discovered between delay durations corresponding to phenomenon appearing and disappearing.

Keywords: light flashes. central and periphery vision, monocular and binocular observation, visual apparent motion, anisotropy, “golden proportion”.

Introduction

Apparent motion is the visual illusion in which the visual movement perception appear in the absence real object motion. First investigator who discovered this phenomenon was S.Exner [1] , but by far later M.Wertheimer [13] made first attempt to analyse in detail the dependence this illusion on several parameters complex. For the phenomenon explanation Wertheimer proposed a hypothesis of excitation spreading according to which interaction between excitations conditioned by both stimuli take place in brain or in the retina. According to Wertheimer opinion the phenomenon may appear with pause between light stimuli from 60 to 200 ms. Later by efforts of many authors another parameters of apparent motion were studied and classified. According to majority of classifications apparent motion was named as optimal motion (ϕ -phenomenon) or as β -motion. Its appearance is conditioned by many parameters among which next may be named as main:

- stimuli intensity,
- stimuli dimensions and forms,
- exposition duration,
- angular distance between stimuli,
- time delay between stimuli,
- repetition frequency of stimuli pair,
- observation continuance.

Interdependence between these parameters does not studied finally, but some fundamental interrelations were formulated in form five laws of Korte [7] . According these laws optimal motion may appear within delay range 80 ... 400 ms [9].

Results of some authors investigations demonstrate perceptive nature of this illusion. Phenomenon beginning are connected with existence of motion direction detectors selective oriented and having anisotropic peculiarities [4]. Visual ”motion inertia” is explained by special

connections between directoral sensitive motion detectors which create feedback and provide “pre-tuning” of detectors disposed farther along the rectilinear trajectory [10].

Arguments in favour of central mechanisms of apparent motion presumably in primary cortex regions are received indirectly. Notions about cortical interaction between adjacent neurons have a central place in explanations of physiological essence of this illusion [2].

In comparison of real and apparent motions perception some distinctions are revealed [5], but psychophysiological investigations much more convince in correctness of hypothesis about identity their mechanisms [11]. Probability of apparent motion appearance in dependence on time delay showed relative uniformity within the limits about 6° [6]. However minimal distance between stimuli (threshold) increased with eccentricity from 6 to 25 degrees [3].

Formal evidence of harmony in a great many psychophysiological processes (“golden section”) was revealed by some Russian investigators [12]. This fact impelled me to additional mathematical analysis of time parameters in observed phenomenon. Calculation of the ratio between time-intervals corresponding to apparent motion appearance and disappearance was expedient.

Materials and method

This investigation purpose was the elucidation (clearing up) of anisotropy character in apparent motion phenomenon.

The panel in frontal flatness (campimeter) with light emitting diodes was used for the phenomenon investigation along eight meridian of visual field. Apparent motion was observed monocularly and binocularly by 22 adult men. Light flashes duration and time interval between two flashes were provided by circular rotation of metal conductor gliding along the arc with two stripe of metal closing the electric circuit. Distance between stripes was changing for the regulation time delay between two stimuli. Contact and pause were conditioned by motor rotation with angular velocity 1 per second. Distance between light source in each meridian was redirected to visual field centre (0 ... 6 degrees) or to near periphery (12 ... 18 degrees). Flash succession had a centrifugal character.

Phone illuminance was 10 lx, both stimuli had angular size 14 minutes in diameter, flashes luminance – 5 cd/m², each flash duration – 25 ms.

Results and discussion

The investigation results are demonstrated in tables 1 and 2. Both tables have identical construction. In first column are named visual field meridians, at columnes 2 and 5 - time intervals between flashes appropriate to phenomenon appearance (A, ms), columnes 3 and 6 - disappearance time (D, ms), columnes 4 and 7 - ratio of appearance to disappearance time (A/D).

Table 1

*Intervals between light flashes (ms) producing the sensation of apparent motion
in the visual field centre*

Meridians	Monocular vision			Binocular vision		
	A	D	A/D	A	D	A/D
<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>
Left	79.5±3.2	129.0±4.8	0.616	76.8±2.9	125.3±4.9	0.613
Left-upper	82.0±3.1	134.1±5.0	0.611	78.7±3.0	129.3 ±4.9	0.609
Upper	86.7±3.1	140.0±4.9	0.619	82.7±3.0	135.2±5.0	0.612
Upper-right	84.1±3.2	139.3±4.9	0.619	81.3±3.1	133.3±5.1	0.610
Right	80.9±3.2	133.0±5.2	0.608	79.3±3.0	130.0±5.1	0.610
Right-lower	83.3±3.2	137.0±5.0	0.608	79.6±3.1	130.2±5.0	0.611
Lower	79.4±2.9	129.0±4.9	0.616	76.4±3.0	124.5±4.9	0.614
Lower-left	82.2±3.3	134.7±5.1	0.610	77.2±2.9	126.1±5.0	0.612

Table 2

*Intervals between light flashes (ms) producing the sensation of apparent motion in paracentral
parts of visual field*

Meridians	Monocular vision	Binocular vision
-----------	------------------	------------------

	A	D	A/D	A	D	A/D
1	2	3	4	5	6	7
Left	90.6±3.3	146.7±4.9	0.618	84.8±2.5	138.1±4.8	0.614
Left-upper	95.5±3.3	156.2±5.1	0.611	88.4±2.3	142.2±4.9	0.613
Upper	96.7±3.3	157.0±5.3	0.616	88.9±2.2	144.5±4.7	0.615
Upper-right	94.6±3.3	155.0±5.7	0.610	88.9±2.6	144.9±5.0	0.614
Right	90.9±3.4	149.4±5.5	0.608	85.3±2.6	140.6±5.0	0.607
Right-lower	91.0±3.3	147.3±5.5	0.618	85.5±2.9	139.9±5.1	0.611
Lower	90.1±3.1	146.2±5.6	0.616	83.3±2.8	134.8±5.0	0.618
Lower-left	91.1±3.2	147.8±5.6	0.616	85.3±2.6	139.9±4.9	0.612

Obtained results permit notice that pauses between flashes corresponding to phenomena appearing and disappearing always are less in the visual field centre than at near periphery. Thresholds of time delays decrease when the observation is binocular against the monocular. Differences between meridians have almost identical character with monocular and binocular observations but they have quantitative distinction only. Threshold light flashes delay is minimal in the lower half of visual field. By indirect way these results testify about mainly central nervous phenomenon mechanisms so far as images incidence on the non-identical retinal regions can't provide information cultivate identity in retinal neuronal chains. Binocular interaction facilitating the phenomenon appearance can't find the explanation of the illusion essence by peripheral mechanisms only. These mechanisms localized probably in central neuronal nets of visual system, accomplishing furthermore real motion analysis. In region of the blind spot apparent motion retain same qualitative peculiarities as in other meridians attached to same eccentricity. There was not a single event of phantom flash in the region of blind spot as in Lockhead a.o. investigations [8]. Optimal motion in this zone preserve its smoothness and thus confirm its central origin.

Extrapolation of apparent motion trajectory is fulfilled some better during binocular observation than at monocular. Apparently this advantage is conditioned by binocular summation least of all. Interocular distinctions and excitation synchronization in visual centres have far greater importance in such case.

Common peculiarity is exposed in all visual field meridians. Time intervals of phenomenon appearance in ratio to disappearance time (A/D) fluctuate near to 0.618 in accordance to the law of "gold section".

1. Exner S. Ueber das Sehen von Bewegungen und die Theorie des zusammen-gesetzten Auges // Sitzungsab. d. k. Akad. d. Wissensch., Wien. – 1876. – III Abth. – Bd. 72, Heft 8, Abt. 3. – S. 156 – 190.
2. Foster D. H., Thorson J., McIlwain J. T., Biederman-Thorson M. The fine-grain movement illusion: a perceptual probe of neuronal connectivity in the human visual system // Vision Res. – 1981. – Vol. 21, No 7. – P. 1123 – 1128.
3. Foster D. H., Gravano S., Thorson J. Acuity for fine-grain movement illusion varies little with retinal eccentricity, unlike that for two-dot spatial resolution. // J. Physiol., Gr. Brit. – 1982. – Vol. 328. – P. 36 – P.37.
4. Hirata T. Perceived direction of apparent movement //Tohoku Psychol. Folia. – 1982. Vol.41, No 1-4. – P. 35 – 41.
5. Kolers P. A. The illusion of movement // Scientific American. – 1964. – Vol. 211, No 4. – P. 98 – 106.
6. Kolers P. A., Grunau M., von. Fixation and attention in apparent motion // Quart. Journ. exp. psychol. – 1977. – Vol. 29, No 3. – P. 389 – 395.
7. Korte A. Kinematoskopische Untersuchungen // Ztschr. f. Psychol. – 1915. – Bd. 72, Heft 1-2. – S. 193 – 296.
8. Lockhead G. R., Johnson R. C., Gold F. M. Saltation through the blind spot // Percept. Psychophysics. – 1980. – Vol. 27, No 6. – P. 545 – 549.
9. Neehaus W. Experimentelle Untersuchung der Scheinbewegung // Arch. f. d. gesammte Psychologie. – 1930. – Bd. 75, Heft 1-2, S. 315 – 458.
10. Ramachandran V. S., Anstis S. M. Extrapolation of motion path in human visual perception // Vision Res. – 1983. – Vol. 23, No 1. – P. 83 – 85.

11. Robins C., Shepard R. N. Spatio-temporal probing of apparent rotational movement // Percept. Psychophysics. – 1977. – Vol. 22, NO 1. – P. 12 – 18.
12. Subbota A. G. “Golden section” (“Sectio aurea”) in medicine. – 2nd ed. - St.Petersburg, 1996. – 168 p. (Russian)
13. Wertheimer M. Experimentelle Studien über das Sehen von Bewegung // Ztschr. f. Psychologie. – 1912. – Bd. 61, Heft 1. – S. 161 – 265.