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The effect of the motion direction on the magnitude of the kinetic illusion (KI), which was defined as the apparent displacement of the motion path in the stimulus configuration of geometrical illusions, was investigated in the stimulus configuration of the Poggendorff illusion. The results in comparison with the traditional illusion of static stimulus (the static illusion; SI) revealed following characteristics of the kinetic illusion: (a) The effect of the motion velocity on the magnitude of KI was statistically significant, making us confirm the result of the previous study. (b) The directions of motion had differential effects on the magnitude of KI. (c) Especially, a significant difference in the magnitude of KI was found between the vertical-downward (↓) and the vertical-upward (↑) directions. The result seemed to suggest the possibility of another approach to the heterogeneity of phenomenal space in the perception of motion.

In the previous study (Nihei, 1973) it was noted that geometrical illusions occur not only as an illusion in static figures but also in the form of the apparent displacement of motion path. For example, when the oblique line is replaced by a motion path of a spot in the stimulus configuration of the Poggendorff illusion, the motion path is observed to show a similar displacement to that observed in the static line figure. Such an illusion in the form of the displacement of motion path was called the kinetic illusion (KI) which is distinguished from the traditional geometrical illusion of static lines (the static illusion; SI). The investigation on the effect of the motion velocity revealed following characteristics of KI: (a) The magnitude of KI was a function of the motion velocity. (b) Under some conditions the magnitude of KI was significantly higher and lower under others than that of SI. (c) The effect of the interesect angle between the vertical strip and the motion path was also significant. (d) The Interaction of the velocity effect and the angle effect was significant.

Thus, in the previous experiment, the effects of the motion velocity and the intersect angle were investigated. However, one of the factors which are expected to influence the magnitude of the kinetic illusion remained unexamined. The primary purpose of the present investigation is to examine the effect of that factor, the direction of motion, on the magnitude of the kinetic illusion in the stimulus configuration of the Poggendorff illusion. In the static illusions, the effects of the orientation of the illusory figure on the magnitude of the illusion have been reported with the Zöllner illusion (Morinaga, 1933), the Poggendorff illusion (Leibowitz & Toffy, 1966), and so on. Do the directions of motion have differential effects on the magnitude of the kinetic illusion in the same way as the orientations of the figure in the static illusion ?

In addition, the effect of the motion velocity on the illusion is investigated again in the present experiment.

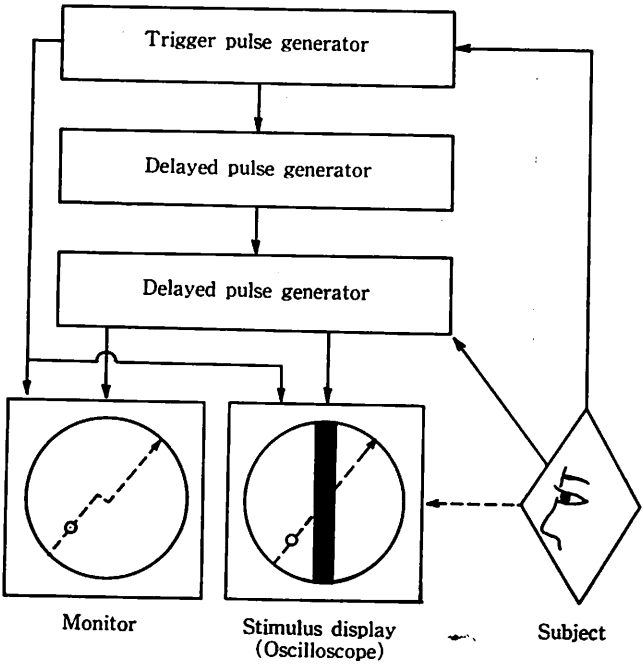

Fig. 1. Diagram of the apparatus.

Method

Subjects: Three male undergraduates ranging in age from 22 to 27 years served as *S*s. All of them had the knowledge of the Poggendorff illusion.

Apparatus and stimuli: Fig. 1 shows the diagram of the apparatus, and the apparatus was detailed in the previous report (Nihei, 1973). The stimulus configuration used in the present experiment consisted of a black paper strip and a moving light spot whose motion path traversed the strip obliquely. A sweep spot of an oscilloscope was used as the moving spot. The direction of the motion and the intersect angle between the strip and the motion path could be easily varied by tilting the oscilloscope. The part of the motion path where the spot went out of the strip shifted downward or upward in parallel with the other part. The shift could be produced by the adjustment of the input voltage to the oscilloscope from a pulse generator (NIHON KOHDEN, SD-1). For the measurement of the static illusion, a static line was produced in the same stimulus display by the simultaneous recurrent triggering of high frequency (78.125 Hz) of the oscilloscope and two delayed pulse generators. The way of the shift of the line was the same as that of the motion path.

The width of the strip which was mounted on the screen of the oscilloscope was 30 mm (2.87° in visual angle), and the diameter of the screen was 115 mm (10.98°). The intersect angle between the strip and the motion path or the static line was held constant at the angle of 30° through all the experimental conditions.

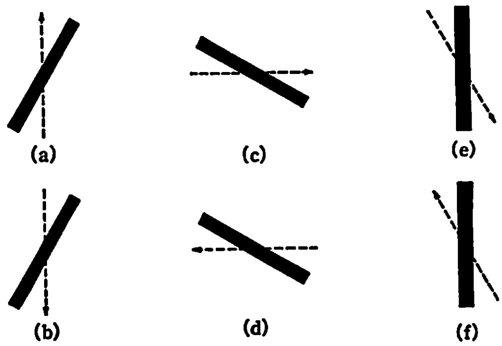

Fig. 2. The 6 stimulus configurations used in this experiment. The directions of motion are (a) 0, (b) 6, (c) 3, (d) 9, (e) 5, and (f) 11 o'clock.

Procedure: The effects of six motion directions on the magnitude of the illusion were compared. They were the directions of 0, 3, 5, 6, 9 and 11 o'clock (Fig. 2). The velocities of the motion of the spot were 2, 10, and 50 cm/sec (1.91, 9.55, and 47.75 deg/sec in visual angle respectively). In all the measurements of the magnitude of the illusion for the six directions, the static condition was included in addition to the three velocities. A combination of the velocities and the motion directions made 24 experimental conditions in total.

The magnitude of the illusion was measured by the method of adjustment three or more ascending and three or more descending trials were made for each experimental condition. The conditions of the motion directions were randomized. All the experimental conditions were given to each subject.

S was seated in front of the stimulus display with his face fixed in a lighted room. The distance between his eyes and the display was 60 cm. There was no fixation point, but *S* was instructed to fixate the center of the black strip during his adjustment. *S* shifted the part of the motion path where the spot went out of the strip downward (in descending trials) or upward (in ascending trials) by the adjustment of a dial until the part appeared to lie on the straight extension of the other part. And under the static conditions, *S* shifted the line in the same way as that.

The magnitude of the illusion was defined as the distance between the adjusted part and the actual extension of the other part, and was measured with a monitor oscilloscope on a magnified scale.

Table 1. The magnitude of the kinetic illusion in various motion directions and velocities, and the magnitude of the static illusion as a function of the orientation of the line (Mean of the results of 3 *S*s, in mm).

	Direction (Orientation) / Velocity	0 ↑	3 →	5 ↘	6 ↓	9 ←	11 o'clock ↖
Kinetic	2 cm/sec	4.38	3.26	10.32	5.92	3.63	7.64
	10 cm/sec	3.21	4.11	8.94	4.54	3.56	7.25
	50 cm/sec	1.32	1.16	4.26	2.10	1.10	3.76
Static		1.24	1.34	3.30	1.19	1.53	3.37

Results

The mean magnitudes of the illusions of 3 *S*s for each condition are presented in Table 1. Fig. 3 indicates the magnitude of the kinetic illusion as a function of the motion direction and the motion velocity.

The analysis of variance for the magnitude of the kinetic illusion showed that the differences in the magnitude of the illusion among the three velocities were statistically significant ($F=7.40$, $df=2,4$, $p<.05$). The effect of the motion direction was also significant ($F=10.29$, $df=5,10$, $p<.01$), and the interaction of the two effects was significant ($F=2.66$, $df=10, 20$, $p<.05$). And further, the effects of the motion directions were statistically examined among the directions. As the result, significant

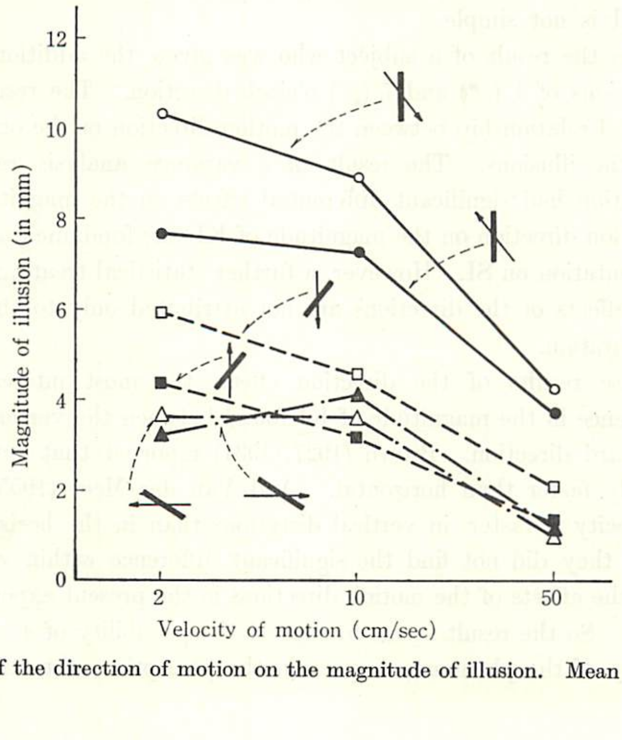

Fig. 3 Effect of the direction of motion on the magnitude of illusion. Mean results of 3 *S*s.

differences in the magnitude of KI were found between the directions of 6 (↓) and 0 (↑) o'clock (F=32.75, df=1,2, p<.05), between 5 (↘) and 3 (→) o'clock (F=40.71, df=1, 2, p<.05), between 5 (↘) and 9 (←) o'clock (F=54.57, df=1,2, p<.05), and between 5 (↘) and 0 (↑) o'clock (F=20.09, df=1,2, p<.05).

Thus, the effects of the motion directions were found to be significant. However, those differences may not be attributed to only the effect of the motion direction itself. For the effect of the rotation of the illusory figure on the magnitude of the static Poggendorff illusion has been reported (Leibowitz & Toffy, 1966), and the variation of the motion direction was necessarily acconpanied by the rotation of the stimulus configuration in the present experiment. To separate the effect of the rotation from the direction effect, the magnitude of SI was taken away from that of KI for the result of each condition, and an analysis of variance was carried out for the remaining magnitude of the illusion. The result of the analysis revealed that the significance of the differential effects of motion directions was not weakened by the treatment of the subtraction (F=5.60, df=5,10, p<.05).

Discussion

The present result agreed with that of the previous study in the statistical significance of the velocity effect on the magnitude of the kinetic illusion. Relatively lower velocities tended to produce a larger magnitude of the illusion than high velocities. However, the significant interaction of the velocity effect and the effect of direction indicated that the relationship between the motion velocity and the magnitude of KI is not simple.

Fig. 4 shows the result of a subject who was given the additional measurements under the conditions of 1 (↗) and 7 (↙) o'clock direction. The result will present a somewhat detailed relationship between the motion direction or the orientation and the magnitudes of the illusions. The result of a variance analysis revealed that the directions of motion had significant differential effects on the magnitude of KI. The effect of the motion direction on the magnitude of KI was fundamentally similar to that of the figure orientation on SI. However, a further statistical treatment indicated that the differential effects of the directions are not attributed only to the rotation of the stimulus configuration.

Among those results of the direction effect, the most interesting one is the significant difference in the magnitude of KI found between the vertical-downward and the vertical-upward direction. Brown (1927, 1931) reported that vertical movements are phenomenally faster than horizontal. And Van der Meer (1955) found that the phenomenal velocity is faster in vertical directions than in the horizontal right direction. However, they did not find the significant difference within vertical directions. The analysis of the effects of the motion directions in the present experiment assumed a different aspect. So the result seems to suggest the possibility of another approach to the heterogeneity of the phenomenal space in the perception of motion.

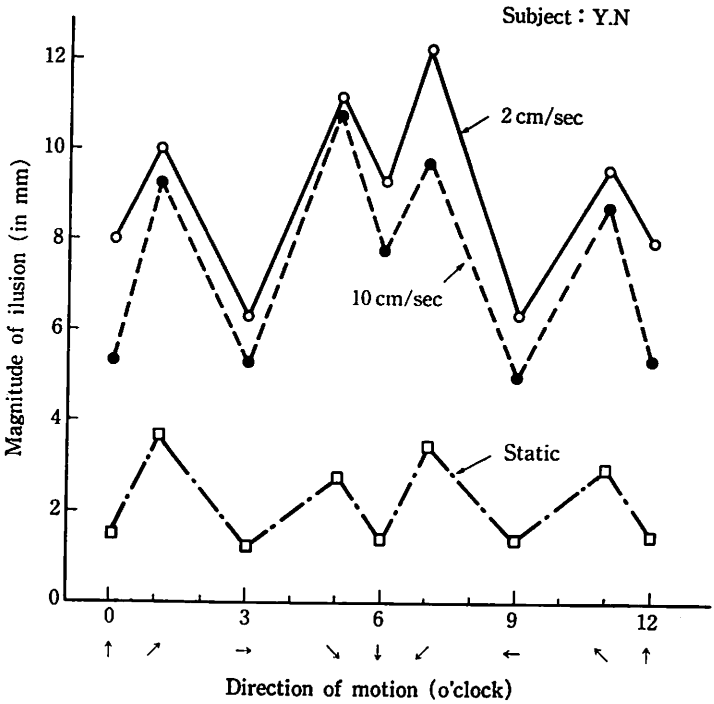

Fig. 4 Magnitude of the illusion as a function of the direction of motion. Result of a subject.

Thus it was made clear that the direction of motion influences the magnitude of the kinetic illusion. However, considerations for the following two things should be required in further investigations to grasp the whole aspects of the phenomenal change of the motion in such situations. In the first place, apparent curvatures of motion path near the strip were reported again by all subjects under lower velocity conditions as in the previous study. The patterns of the curvatures were inconsistent among *Ss*. And the extent of the curvature was not measured in the present investigation. In the second, the stimulus configuration used in this experiment was similar to that used in the study on the tunnel phenomenon by Maruyama & Iwasaki (1973). They reported that the motion of a moving spot, which traversed a shelter (a black strip) rectangularly, required certain time delay behind the shelter for an impression of a smooth passage. In the present experiment, the impression of a smooth passage was investigated as to the motion path but not as to the time course of the motion.

It may be clear now what will be required in the further investigation.

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