A PRELIMINARY STUDY ON THE GEOMETRICAL ILLUSION OF MOTION PATH: THE KINETIC ILLUSION

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Geometrical illusions occur in the form of the apparent displacement of motion path, not only as the illusion in the static figures. Using the Poggendorff illusion, the geometrical illusion of motion path (*the kinetic illusion*: KI) was compared with that of static stimulus (*the static illusion*: SI). Main findings were as follows:

1) The magnitude of the kinetic illusion (KI) was a function of the motion velocity.

2) The angle between the vertical strip and the oblique motion path also influenced the magnitude of KI.

3) The interaction of velocity effect and angle effect was significant.

4) Under some conditions, the magnitude of KI was significantly higher than that of the static illusion (SI). Under other conditions, however, KI was significantly lower than SI.

In the traditional studies on geometrical illusions, the static figures have been used as stimuli. Geometrical illusions, however, can be observed under the different condition from them. It is the very condition of motion.

Recently, Cohen (1967) indicated that the phenomenal motion velocity changes when the motion path of the moving stimulus is bounded by the Müller-Lyer figure, and concluded that the cause of the change is attributed not to the phenomenal space of the Müller-Lyer figure, but to the enclosing nature of the figure. When the study of Cohen is looked from the different point of view, it is probable that under such a condition a change occurs in another aspect of motion, i.e. the apparent change of the motion path. If motion is introduced into geometrical figures other than the Müller-Lyer figure, that is, if the parallel lines of the Hering, Wundt, and Zöllner illusion figure or the oblique line of the Poggendorff figure are replaced by moving stimuli, how are the phenomenal motion paths affected by the figures? However, it is not certain whether the change of the apparent motion path is similar to that of the static figures of geometrical illusions, or not. The relation between geometrical illusions of static figures and that of the motion path has not been almost studied. So, it seems to be interesting to deal with the problem.

In this paper, tentatively, the geometrical illusion of the static figure will be called

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the static illusion (SI), and the geometrical illusion of motion path *the kinetic illusion* (KI). The purposes of the present experiment are;

1) to compare the magnitude of the kinetic illusion with that of the static illusion,
2) to investigate the effect of the motion velocity and that of the other relevant factor to the illusion.

The Pogendorff illusion is taken as an example of geometrical illusions in the present study.

Method

Subjects: Five male graduates served as subjects. All of them had some knowledge about geometrical illusions.

Apparatus and Stimuli: The Poggendorff illusion was used as material in this experiment. The stimulus display consisted of a vertical black strip which was mounted on the screen of a cathode ray oscilloscope (NIHON KOHDEN, VC-7A) and a spot of the oscilloscope whose motion path traverse the vertical strip obliquely from left to right (see Fig. 1). The width of the strip was 30 mm, and the diameter of the screen was 115 mm. Except the screen of the cathode ray tube (CRT), other parts were covered with black screen of 50 cm×65 cm. The angle between the strip and the motion path of the spot was adjusted by tilting the CRT. The CRT used in this experiment was a special one whose spot was almost trace-less. The color of the spot was bluish purple, and the diameter of the spot was about 1 mm.

For the measurement of the magnitude of the illusion, the motion path of the spot changed in the middle of the screen behind the black strip (see Fig. 1). The right part of the motion path could be shifted upward or downward in parallel with the straight extension of the left part. The shift was caused by changing the input voltage of the oscilloscope from two delayed pulse generators (NIHON KOHDEN, SD-1).

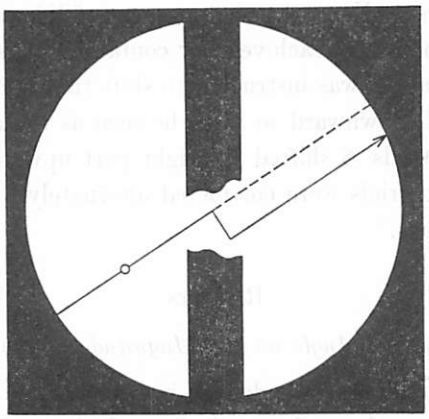


Fig. 1. Stimulus display.
The small open circle indicates the spot of the oscilloscope, and the oblique solid line indicates the motion path of the spot.

Procedure:

(i) *Measurement of the Magnitude of the Kinetic Illusion (KI)*

Two parameters were induced. One was the motion velocity of the spot, and the other was the angle between the vertical strip and the oblique motion path. The angles were 30° and 60°. The velocities were 2, 5, 10, 20, and 50 cm/sec.

S was seated 60 cm in front of the stimulus display, with his face fixed. *S* was instructed to fixate the center of the strip, and to adjust the right part of the oblique motion path so as to be seen as the straight extension of the left part by a variable resistor which controlled the input voltage to the oscilloscope. The start button of the trigger pulse generator (NIHON KOHDEN, SW-1) which triggered single sweep of the oscilloscope and the delayed pulse generators was under the control of *S*. *S* could press the button voluntarily and adjust the right part observing the motion path.

The difference between the objective and apparent continuity of the left and right part was measured by a monitor synchroscope in amplified scale.

(ii) *Measurement of the Magnitude of the Static Illusion* (SI)

The static oblique line was produced on the screen of the CRT by successive sweeps of the oscilloscope which was recurrently triggered by the trigger pulse generator. The sweep speed was 1 msec/cm, and the recurrence frequency of the trigger was 78.125 Hz. Under this condition, the motion path of the spot was seen as a static luminous line without the impression of flicker. Other procedures in measuring the magnitude of SI were the same as in measuring KI.

S was tested in two experimental sessions, which intervened on the same day in the intermission of about 30 minutes. 3 *S*s out of 5 were tested under the condition of the angle=30° in the first session, and under 60° condition in the second session. The rests of *S*s were tested in the inverse sequence. In each session, the magnitude of SI was measured at first. Next, the measurement of KI was taken for each velocity. The measurement of SI or KI for each velocity contained 3 ascending and 3 descending trials. In descending trials, *S* was instructed to shift the right part of the motion path (in KI) or the line (in SI) downward so as to be seen as the apparent extension of the left part. In ascending trials, *S* shifted the right part upward in the same way. The ascending and descending trials were conducted alternately. Each *S* was tested under all experimental conditions.

Results

Effects of the Velocity and the Angle on the Magnitude of the Illusion

The magnitude of the illusion was defined in terms of the vertical distance between the right oblique motion path or the static line which *S* adjusted as the apparently straight extension of the left part and the objective extension. The mean magnitude of the illusion of 5 *S*s for each condition is shown in Table 1. The values were calcu-

Table 1. Mean magnitude of the kinetic and the static illusion for 5 *Ss*.

	Angle / Velocity	30°	60°
Kinetic	2 cm/sec	Mean 2.86 mm SD 0.58	0.32 mm 0.24
	5 cm/sec	Mean 4.52 mm SD 1.80	0.45 mm 0.67
	10 cm/sec	Mean 5.53 mm SD 2.24	0.88 mm 1.02
	20 cm/sec	Mean 5.64 mm SD 1.75	0.56 mm 1.09
	50 cm/sec	Mean 5.57 mm SD 1.93	−0.79 mm* 0.80
Static		Mean 2.94 mm SD 0.58	1.50 mm 0.23

*— denotes the reversed illusion.

lated by averaging the 3 ascending and 3 descending trials. Fig. 2 also indicates the mean magnitude of the illusion for each velocity and angle condition. Results of analysis of variance for the magnitude of KI in relation to the velocity and the angle are summarized in Table 2. The motion velocity influenced the magnitude of the illusion (F=6.514, df=4/16, p<.01). Effect of the angle was also significant (F=46.041, df=1/4, p<.01). There was a significant interaction between the velocity and the angle (F=10.757, df=4/16, p<.01). As to the angle effect, 30° condition always caused significantly higher magnitude of the illusion than 60° condition, regardless of the velocity. However, the velocity effect was more complicated. From Fig. 2, it may be suggested that the magnitude of the illusion was not a simple decreasing or a simple increasing function of the velocity. Under 30° condition, the magnitude was high in relatively low velocities. Under 60° condition, the magnitude was lowest in the highest velocity. Especially under 60° condition the lowest velocity (2 cm/sec) caused the reversed illusion in 4 *Ss* out of 5. In this case, the right part was judged as the appaently straight extension of the left part when the right part shifted upward from the objective extension. This was the reversed appearence of the Poggendorff illusion. However, this tendency was not statistically significant.

Comparison of KI with SI

The relation between the magnitude of KI and that of SI was affected by the interaction of the angle and the velocity. Under the condition of the angle=30° the magnitude of KI was significantly higher than SI in lower velocities; 2 cm/sec (p<.05) and 5 cm/sec (p<.05). Inversely, under 60° condition KI was significantly lower than SI in higher velocities and in the lowest velocity; 50 cm/sec (p<.01), 20 cm/sec

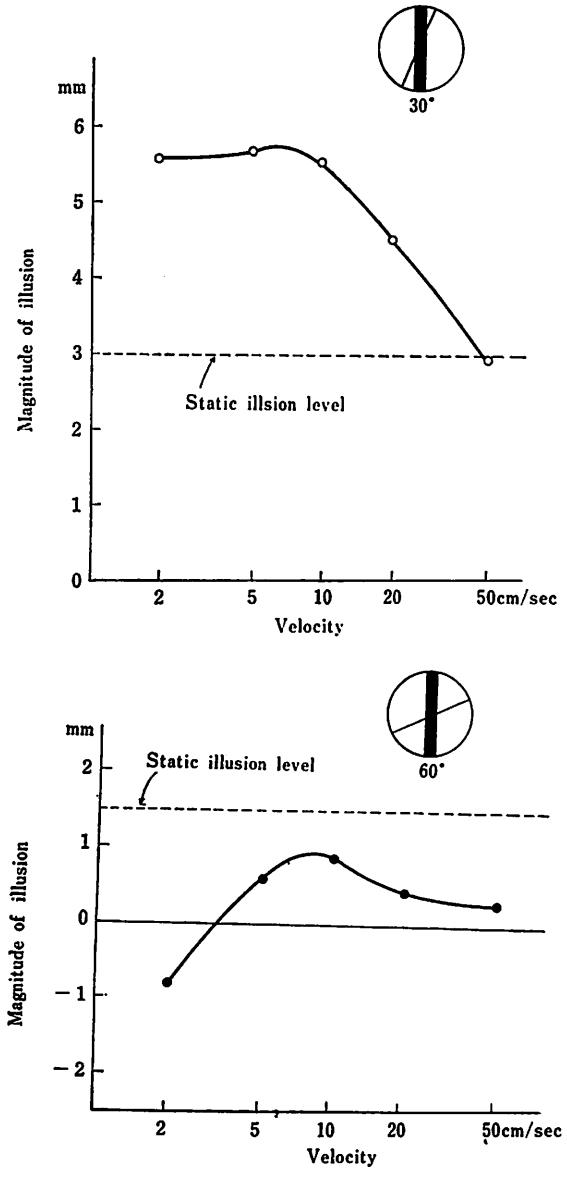


Fig. 2. Magnitude of the kinetic illusion as a function of the motion velocity. Broken lines indicate the the magnitude of the static illusion.
Upper (○), angle=30°; Lower (●), angle=60°.

($p<.05$), and 2 cm/sec ($p<.01$). In other velocities no statistically significant difference was found between KI and SI.

Discussion

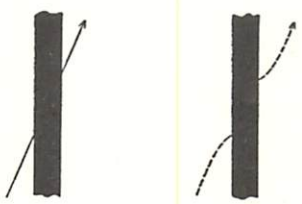
The relation between the kinetic illusion (KI) and the static illusion (SI) was not

Table 2. Analysis of variance for the magnitude of the kinetic illusion.

Source	*df*	*MS*	*F*	*p*
Angles (A)	1	257.140	46.041	.01
Velocities (V)	4	4.195	6.514	.01
Subjects (*S*)	4	16.363		
A×V	4	4.905	10.757	.01
A×*S*	4	5.585		
V×*S*	16	0.644		
A×V×*S*	16	0.456		

so simple. One of them is not always higher than the other regardless of the velocity or the angle. However, it is not deducible from the present results what is the direct cause which enhanced or lowered the magnitude of KI in comparison with the level of SI.

In a explanation of the Poggendorff illusion, the cause of the illusion is attributed to the overestimation of the acute angle. Bird (1973) postulated that the overestimation of the angle was caused by 'high-order lateral interaction'. In the present experiment, in fact, the presence of such an effect was suggested. Most of *S*s reported the apparent curvature of the motion path near the vertical strip, and for that reason appealed the difficulty of the judgement in the relatively slow velocities under 30° condition (see Fig. 3) And the reports were accompanied by the illusion of



(a) (b)

Fig. 3. (a) Objective motion path of the spot (—→).
(b) Apparent motion path reported by *S*s (- - →).

high magnitude. However, the following fact makes it difficult to applicate the simple analogy of the explanation in the illusion of the static figure to the kinetic Poggendorff illusion: In 4 *S*s out of 5, the reversed illusion occurred in the slowest velocity under 60° condition, and the positive illusion occurred in the different velocities under the same angle condition. As to the kinetic Poggendorff illusion, the conclusive explanation must be kept back until further examinations are added. In the present experiment, some parameters which are expected to affect the magnitude of the illusion (for example, the width of the strip, the length of the oblique line, the tilt of the strip, and the direction of the motion etc.) remained unexamined.

The most important point of the present experiment is the very fact that the geometrical illusion could occur in the form of the apparent change of the motion path, i.e. the kinetic illusion. Moreover, it might be noted that the KI is not restricted

to the Poggendorff illusion. The author himself observed that the kinetic illusion could occur in other geometrical illusions, such as the Zöllner, Wundt, and Hering illusion, using the similar stimulus display of the oscilloscope. So, the present study is the preliminary investigation of the kinetic illusion.

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