A New Speed Illusion: Blind Illusion

Yining Tong, Hiroyoshi Todo, Jian Sun, Xiaoxiao Qian

Abstract—**Visual illusion is a specific perception that is inconsistent with the objective fact formed by humans or animals selecting improper reference or basing on perceptual experience when they observe objects. It reflects perceived ability and mechanism of visual system from a unique perspective. Therefore, it is of great significance to study illusion theory, establish proper mathematical models, and simulate natural scenes in computer for the development of psychology, physiology and computer vision. Illusions that can be quantitatively measured and quantitatively analyzed, is desired. In this paper, we utilize a new quantitative technique developed by our laboratory to measure a new blind illusion. The results can be expected to the elucidation of the mechanism of visual illusions, as well as leading to the understanding of perceptual features and intelligence.**

Index Terms—**Visual illusion, blind illusion, quantitatively measure, the mechanism of visual illusions.**

I. INTRODUCTION

Elucidation of human intelligence is one of the greatest challenges to mankind in the 21st century. And the perceived ability to recognize the environment is one of the typical aspects of intelligence. It is the phenomenon which disturbs this perceived ability, features on the perception in an extreme form, appeared as the dare leads to the understanding of the fundamental features of perception, has recently been considered as an important method to study the neural mechanisms of visual perception and so as to human intelligence [1]-[3].

Many illusions have been observed and studied for a long time. One of the most famous illusions is 'wagon wheel illusion' [4] that is the apparent backwards rotation of a wheel that is in fact rotating forwards.

Fraser and Wilcox presented a motion illusion called an 'escalator illusion' that the luminance gradient reverses within a small region in many places produced an illusory motion [5]. Faubert, J. and Herbert presented an illusion related to the 'escalator illusion'. They proposed that the reversals in the luminance gradient result in changes in the direction of illusory motion, such that both clockwise and counterclockwise rotation can be observed in the same figure [6].

The complexity of visual perception has made people's elucidation different from each other, which is visual illusion.

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There are many kinds of visual illusion, such as Edgar Rubin & Harrower, Lateral Inhibition, Muller's illusion, Illusion of Depth, Afterimage, Fill up illusion, Perspective illusion, Camouflage illusion, Illusion of Contour, Apparent Motion Perception [7]-[9].

But most of them were discussed qualitatively and therefore their mechanisms have not been elucidated. A new illusion that can be quantitatively measured and quantitatively analyzed is desired. In this paper, we report a new speed illusion that falling speed of descent of snowflakes seen from the partially blinds window looks quite quicker than that of snowflakes seen from the window without a blind. We call it 'Blind Illusion (BI)' that is found by one of authors who looked outside through a window in a snow day. We reappear the nature phenomenon in a computer, shown in Fig. 1, and confirm the new type speed illusion. In this figure, the white spots indicate snowflakes and dark red long rectangles indicate many blind strips.

Furthermore, we simulate various conditions in nature, such as falling speed of snowflakes, falling direction, width and number of blind strips, and so on, to measured illusion amount of BI quantitatively. Before our research in this paper, Miyajima *et* al. discussed the topic of apparent movement and pursuit eye movement in BI [10], Jinye *et* al. discussed the effect of luminance difference on BI [11]. We study the number and width of blind strips sequentially. The results can be expected to the elucidation of the mechanism of visual illusions, as well as leading to the understanding of perceptual features and intelligence.

II. EXPERIMENT I

A. Introduction to Experiment

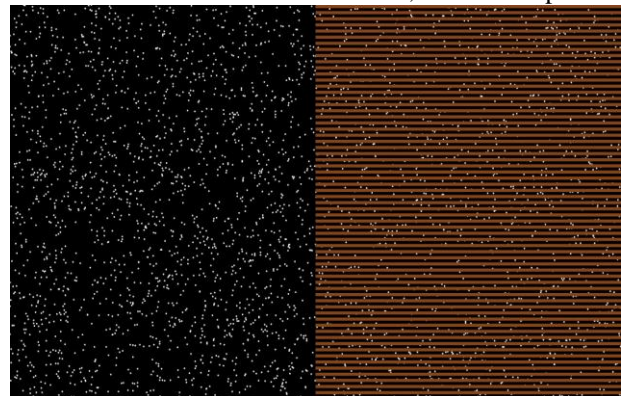When we observed natural snowfalls, we found a phenom-
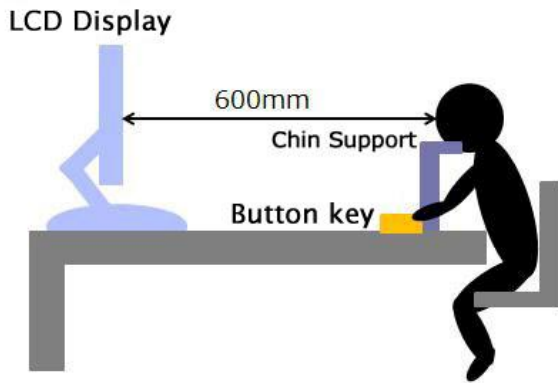

Fig. 1: Blind illusion model.

Fig. 2: Experimental equipment.

enon of visual illusion called BI and simulated it in computers. This experiment is based on those previous ones and further simulates all kinds of real situations, then abstracts a model beyond reality in order to test some new research requirements and goals.

In the experiment, we design two windows in which simulating falling of snowflakes to contrast, the left one is called a normal window, and the right is called BI one with some blind strips. We plan to utilize a variety of different data, including the falling speed of snowflakes, the width of blind strips, and the number of blind strips, to test the experimental participants.

We will make quantitative analysis of BI phenomena, detect the key information about the occurrence and change of BI, and speculate the conditions of promoting and inhibiting BI phenomena.

B. Equipment

The experiment will be carried out in a darkroom which prevents light outside from interfering. The experimental equipment is shown in Fig. 2. A liquid crystal display (LCD), whose parameters are shown in Table 1, is placed on an experimental table, 600 mm far from a tester sitting on a chair. The head of the tester is fixed with a chin support. The answer device is put near the tester's hand. Ten students aged between 20 and 30 years old of the University of Toyama will take part in this experiment. They are healthy and of good eyesight.

C. Stimuli

There are two kinds of stimulus scenes in this experiment. One is standard stimulus. The screen background is black. There are about 2000 white dots with a diameter of 0.1deg randomly distributed on the picture. These light spots are used to simulate snowflakes with a falling speed of 0.5deg/s.

The other is comparison stimulus. The screen background is also black and the number, size and location of snowflakes are exactly the same as those in standard stimulus. Some dark red rectangular strips are evenly distributed in the picture to simulate the effect of the blinds, shown in Fig. 3. The dark red

Table 1: Parameters of LCD.

Type	LCD-AD172SEB
Size	17 inch
Maximum range	338mm×270 mm
Resolution	1280pixel×1024 pixel
Maximum refresh frequency	75 Hz

Fig. 3: An example of stimuli.

Table 2: Parameters of Comparison Stimulus.

n	1	2	3	…	9	10
Number of blind strips	1	2	4	…	256	512
Width between two strips (deg)	128	64	32	…	0.5	0.25

area is an area where snowflakes cannot be seen, indicating the part that is covered by blind strips. The black area between two blind strips is the visible part of snowflakes, indicating the gap between the two strips. The width of a blind strip is the same as that of the gap between the two strips. The number of blind strips increases by 2n-1, and the width between two strips decreases consequently. The parameters are listed in Table 2.

D. Methods and procedure

Each participant in the experiment will be tested independently. The tester sits in the chair and adjusts to darkness, and then begins to observe the display screen and presses the button to answer. The display screen is divided vertically into two blocks, the left is standard stimulus area, and the right is comparison stimulus area. Each participant experiences by the given ten pictures, listed in Fig. 4, in which there are more and more blind strips.

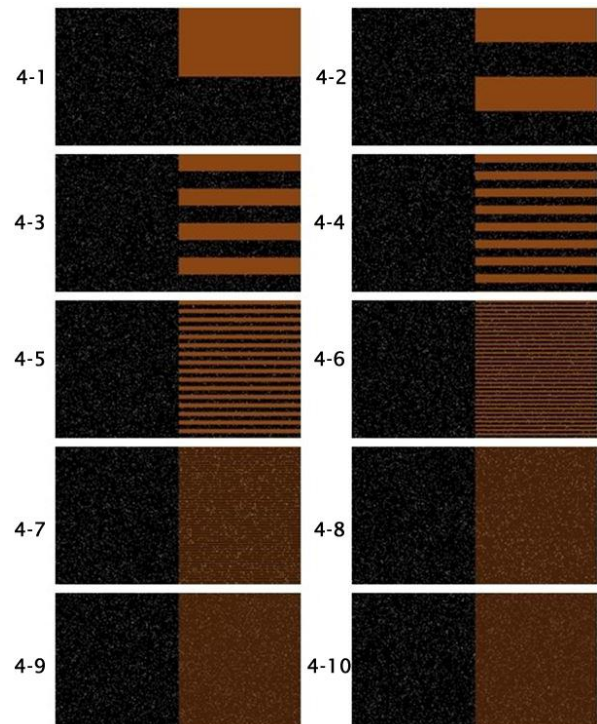The experimental procedure is described as follows:
S1: n=1;

Fig. 4: Stimuli.

S2: If n < 11 then Fig. 4-n appears, else jump to S5;

S3: The tester presses the left button if he feels that the snowflakes in the stimulus area fall faster than the ones in the standard stimulus area;

S4: The test system slows down the falling speed of snowflakes in the comparison stimulus area, then jump to S2;

S5: The tester presses the right button if he feels that the snowflakes in the stimulus area fall as fast as the ones in the standard stimulus area;

S6: n+1 => n, jump to S2;

S7: End.

E. Results and analysis

We record all the testers' responses and the corresponding system data, then analyze them. Fig. 5 depicts the changes of illusion amount of each tester in different stimuli, in which the horizontal axis indicates the number of blind strips and the vertical axis indicates the illusion amount. In Fig. 5-1, when the number of blind strips is 1, the first person (P1) judges that the falling speed of snowflakes in comparison stimulus area is the same as that in standard stimulus area. That is a correct judgment, so the illusion amount is 0 at point 1 of horizontal axis and the number of blind strips increases to 2. When the number increases from 2 to 16, the illusion amount of P1 remains at 0.1. Subsequently the errors of P1's judgement become more and more with the number varying from 16 to 128. And the illusion amount reaches a peak value 1.7

eventually when the number reaches 128, that is to say, the diameter of a grain of snow is the same as the width of two blind strips. P1's judgements return to be correct when the diameter of a grain of snow is bigger than the width of two blind strips. We can understand the other 9 pictures in the same way.

Considering the ten figures together, we can see that the illusion amount reaches a maximum value generally when the number of blind strip is 64 or 128. Of the ten participants, six have the maximum illusion amount when the number of blind strips is 64, and two keep the maximum values from 64 to 128, and the other two reach the peak at 128.

We synthesize all the data of 10 participants, and then obtain the mean curve, shown in Fig. 6. It can be seen from the figure, all the participants almost have no errors when the value of horizontal axis is 1; when the value increases to 2-8 a few errors appear on these participants and we can infer there do exist visual illusion phenomena; and when the value increases from 8 to 64 the illusion amount rises up sharply, then reaches the highest value at 64; while the value continues to increase to 64-512, the illusion amount falls down sharply.

Before this experiment we predicted the changes of illusion amount and the conclusion which is that illusion amount will first increase to a peak value and then fall down with the increasing of the number of blind strips has been verified. Furthermore we get a critical value 64 at which the illusion amount reaches the maximum value.
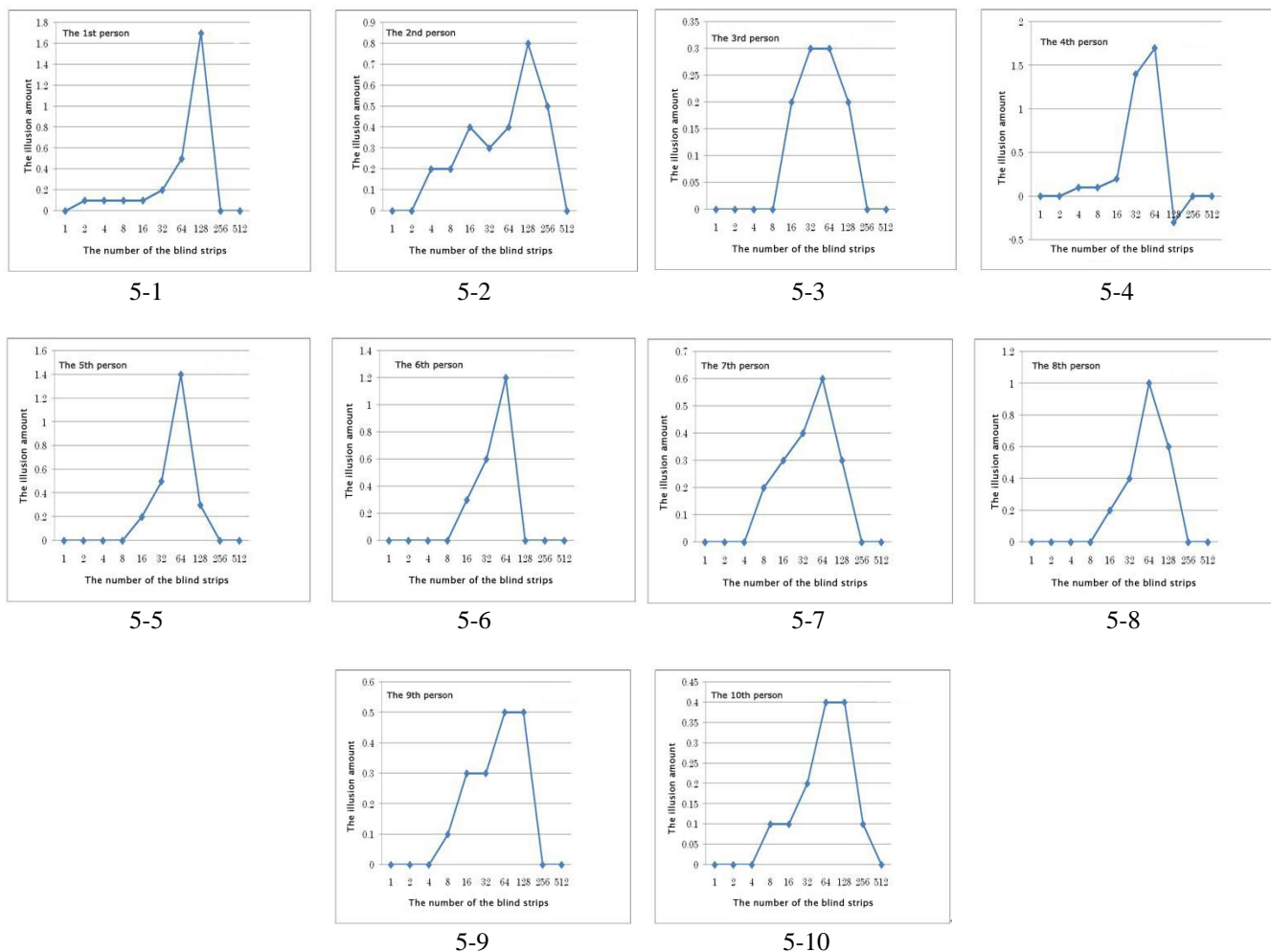

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5-5   5-6   5-7   5-8

5-9   5-10

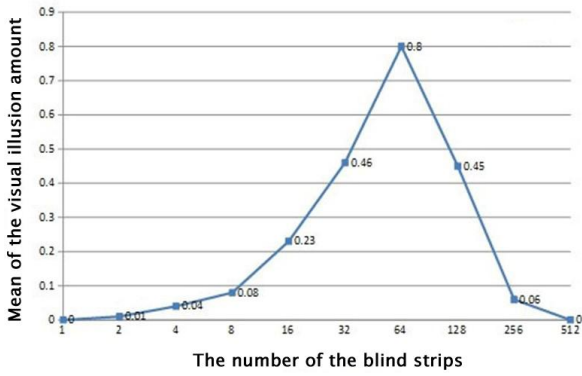Fig. 5: Personal illusion amount (ten participants).

Fig. 6: Mean illusion amount of ten participants.

III. EXPERIMENT II

A. Introduction to Experiment

From experiment I, we can see that almost the illusion all experimenters have the highest illusion amount when the number of blind strips is 64. Therefore, in experiment II, we focus on adjusting the interval width between blind strips while fixing the number of blind strips to be 64. We observe what changes occur to illusion amount.

B. Equipment

This experiment will be conducted in a darkroom which is the same as that in Experiment I. And the others are the same as those in the former experiment.

C. Stimuli

There are also two kinds of stimulus scenes in this experiment. One is standard stimulus. There are about 2000 white dots with a diameter of 0.1deg randomly distributed on the picture. These light spots are used to simulate snowflakes with a falling speed of 0.5deg/s.

The other is comparison stimulus. The screen background is also black and the number, size and location of snowflakes are exactly the same as those in standard stimulus. Some dark red rectangular strips are evenly distributed in the picture to simulate the effect of the blinds. It must be pointed out that the number of blinds is fixed to be 64. However, the interval width between any two blinds are changing from 0.25deg to 3.75deg.
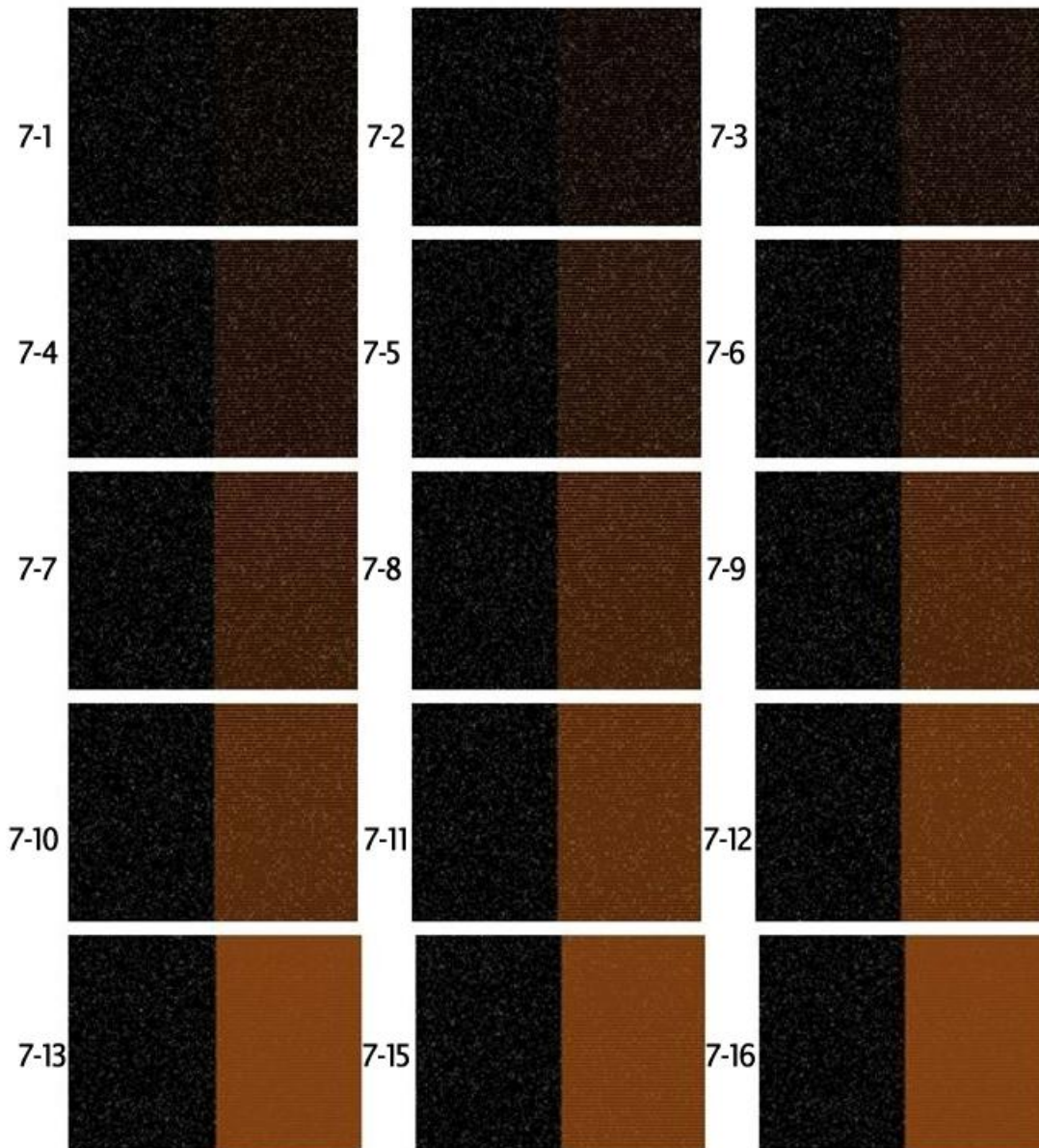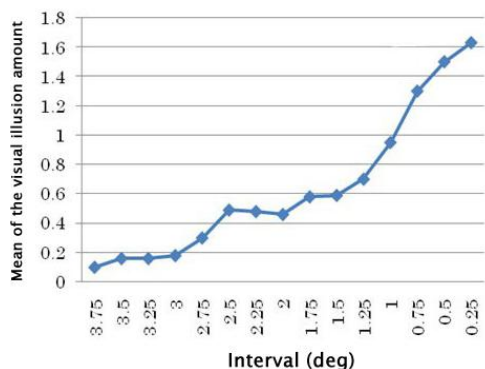

Fig.7: The change of intervals.

Fig. 8: Mean illusion amount of ten participants of
Experiment II.

The participants observe the standard and comparison stimulus area at the same time. The falling speed of snowflakes in both areas keeps the same. We will adjust the interval between blind strips in comparison stimulus until the participants feel the falling speed of snowflake in the standard stimulus is the same as that in the comparison.

D. Methods and procedure

According to the results of Experiment I, the illusion amount reaches the maximum value when the number of blind strips is 64. Thus in this experiment, we will adjust the interval between blind strips. Due to the limitation of the display screen, the interval will change from 15 pixels to 1 pixel. And then we will examine how the illusion amount changes. The participants are tested separately. The initial intervals are set to 15 pixels and the first person (P1) begin to judge whether the speed in the left is the same as that in the right or not. If the judgement is correct, the intervals will be decrease to 14 pixels and then P1 is asked to judge the two speeds. If the judgement of P1 is wrong, we will adjust the falling speed of snowflakes in the right until P1 feel the two speed are the same. We record the data produced in the experiment. The experiment is carried out in such a way, and the intervals are gradually reduced. When the interval is down to 1 pixel, the experiment ends. The change of intervals is shown in Fig. 7.

E. Results and analysis

From the mean illusion amount of ten participants in Fig. 8, we can see that there is almost no visual illusion produced when the intervals between blind strips are reduced from 3.75deg to 3deg, and even if there is, there is almost no change in illusion amount. When the intervals decrease from 3deg to 2.5deg, the illusion amount increases gradually. However, the illusion amount decreases when the intervals are reduced from 2.5deg to 2 deg. And then it gradually decreases with the decreasing of the intervals.

IV. CONCLUSION

The rapid development of computer science and technology provides a new technology for the study of visual illusion. Specially, it can simulate natural phenomena and even some scenes that does not exist in nature. The study of visual illusion gradually shifts from theoretical mechanism to social life, such as the applications in road sign, interior dec-

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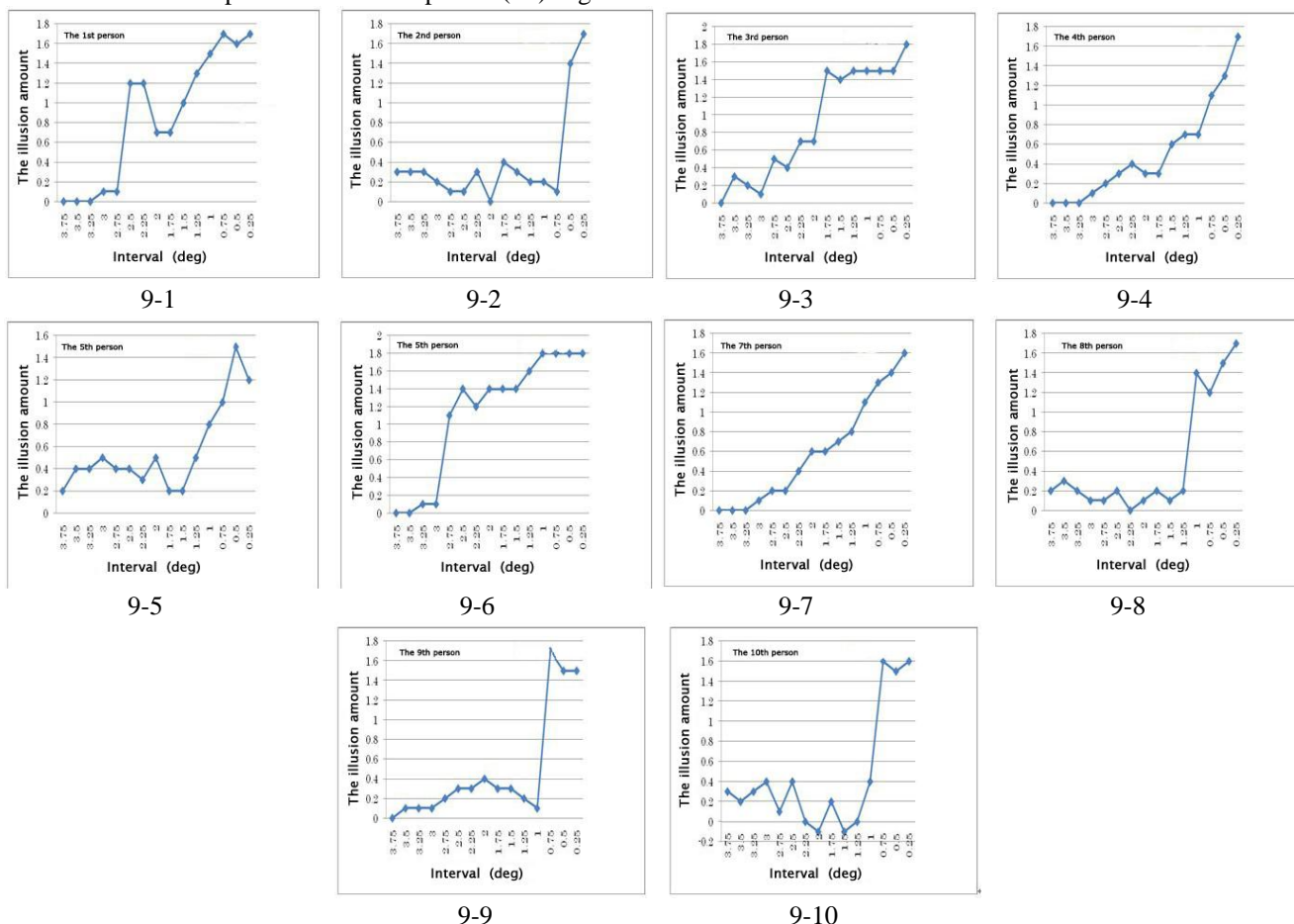

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Fig. 9 Personal illusion amount (ten participants) of Experiment II.

oration, plastic art, film stunt and so on which can introduce people to make full of visual illusion to improve their life.

The study in this paper is based on a newly discovered speed illusion which is called BI. We reappear the realistic and unrealistic scenes in a computer. We adjust the simulated scenes, and record the answers of the experimental participants about whether the falling speed of snowflakes in the standard stimulus is the same as that in the comparison stimulus or not, and then calculate the illusion amounts. Through this study, we can conclude that how the number of blind strips, the interval of blind strips, and the falling speed of snowflakes affect the illusion amount, and furthermore analyze the specific critical values at which the BI happens and the illusion amount reaches the peak, respectively. We also can construct mathematical models, utilize computers to simulate all kinds of scenes, understand the theories of visual illusion better, and master some methods of analyzing BI.

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