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Motion Illusion Brought by Arrays of Arrowhead Patterns

Kazuhiro Otsuki, Makoto Omodani; Tokai University, Graduate School of engineering, Couse of Electro Photo Optics, 4-1-1, Kitakaname, 259-1292, Hiratsuka, Kanagawa, Japan

Abstract

We can know better about human vision as a result of revealing unknown mechanisms of various visual illusions. Motion illusions are typical illusions those mechanisms have not been clarified; why still images can be seen as if they are moving. In this study, we used arrowhead figure as a basic element of motion illusion patterns. We evaluated recognition of motion illusion on various arrowhead array patterns. We have found that a remarkable rate of observers recognized motion to the arrowhead direction on each pattern. This results suggest us that arrowhead patterns can generally cause motion illusion towards the arrowheads. This result was utilized to explain the strange bi-directional motion recognition on the Fraser-Wilcox illusion pattern.

1. Introduction

We can see rotation in the Fraser-Wilcox motion illusion (Fig. 1). A conventional explanation for the Fraser-Wilcox motion illusion is as follows. It is known that recognition speed is generally faster for higher contrast areas in our vision. The time difference of recognition between high contrast area and low contrast area in an object is supposed to bring us pseudo motion. This conventional explanation suggests us unidirectional rotation in the Fraser-Wilcox pattern[1]. However, it is also known that the Fraser-Wilcox pattern can often bring us bidirectional rotation[2], [3]. This is a defect of the conventional explanation for the Fraser-Wilcox motion illusion.

We focused on analysis of the rotating mechanism which can explain the reverse motion against the direction suggested by the conventional explanation for the Fraser-Wilcox motion illusion. The goal of our study is to find a mechanism of the bidirectional rotation in the Fraser-Wilcox motion illusion.

We have focused on another typical motion illusion pattern (Fig. 2) as a cue for the opposite rotation in the Fraser-Wilcox motion illusion. This pattern generally shows us opposite motion direction against the direction predicted by the conventional explanation for the Fraser-Wilcox motion illusion. We hope studies for this type of motion illusion (Fig. 2) must be a promising approach for getting universal explanation for the bidirectional rotation in the Fraser-Wilcox motion illusion. In this study, we used arrowhead pattern (Fig. 3) as an essential element of motion illusion patterns, which shows us opposite motion direction against the direction predicted by the conventional explanation for the Fraser-Wilcox motion illusion.

This paper reports evaluation results of motion recognition on arrow head patterns[4], [5], [6], and suggests s a new hypothesis to explain the bidirectional rotation mechanism of the Fraser-Wilcox illusion.

2. Experimental method

We evaluated recognition rate of the motion illusion on various arrowhead array patterns (liner/ circular). We used three different types (line/ black/ gradation*) of arrowhead patterns (Fig. 4). the gradation* type of arrowhead pattern has continuous density from 15% at the arrowhead side to 0% at the wide side.

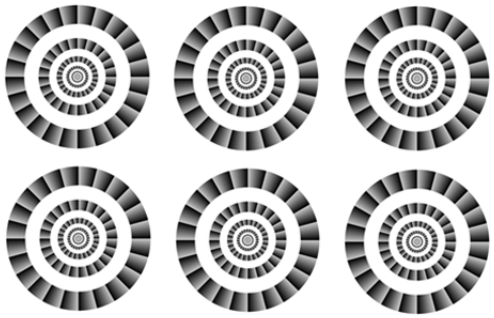


Figure 1. Fraser- Wilcox motion illusion

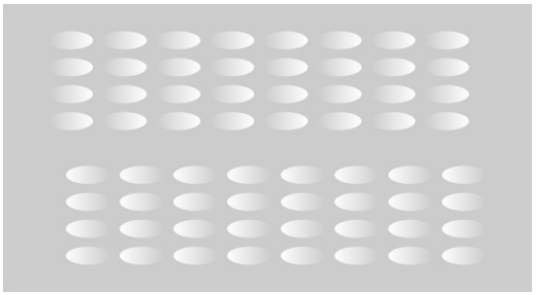


Figure 2. Motion illusion from the lower contrast side towards the higher contrast side

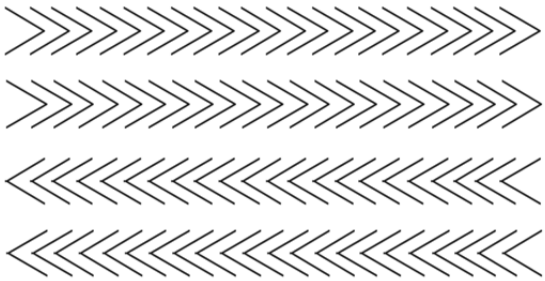


Figure 3. A typical arrowhead pattern array

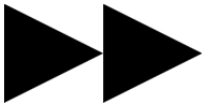
Body	*Arrowhead pattern*
Line	
Black	
Gradation	

Figure 4. Arrowhead patterns

Subjects were ordered to answer if they can recognize a motion, in each arrowhead array patterns (liner pattern (Fig. 6)/ circular pattern (Fig. 7)), and answer its motion direction. Evaluation conditions of motion recognition in each observed pattern were summarized in Table 1 and Table 2. Experimental conditions are summarized in Table 3 and illustrated in Fig. 8.

Table 1 Choices of answer for evaluation (Liner pattern)

1.	Motion to arrowhead direction
2.	Motion to wide direction
3.	No motion recognition

Table 2 Choices of answer for evaluation (Circular pattern)

1.	Motion to clockwise
2.	Motion to anticlockwise
3.	No motion recognition

Table 3 Experimental conditions

Illuminance	750 lx
Observation distance	0.75 m
Subjects	10 student
Printing paper	A4, Matte paper
Printer	Laser printer (Canon LBP7010C)

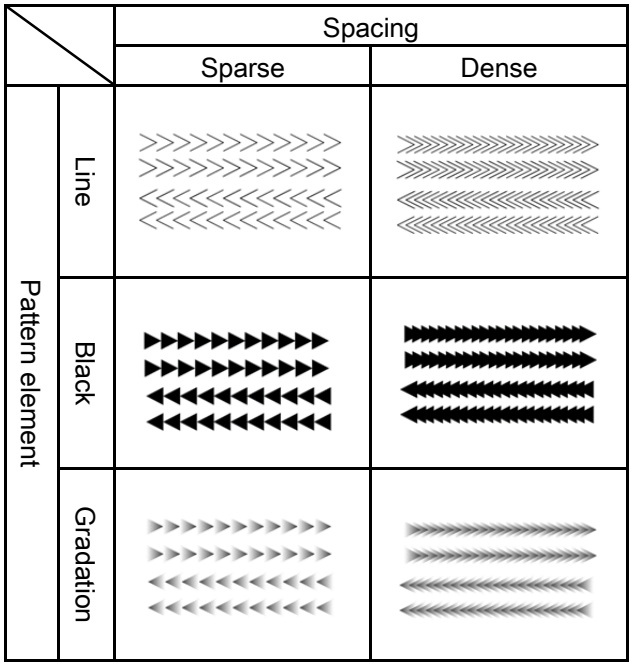


Figure 5. Liner array of the arrowhead pattern

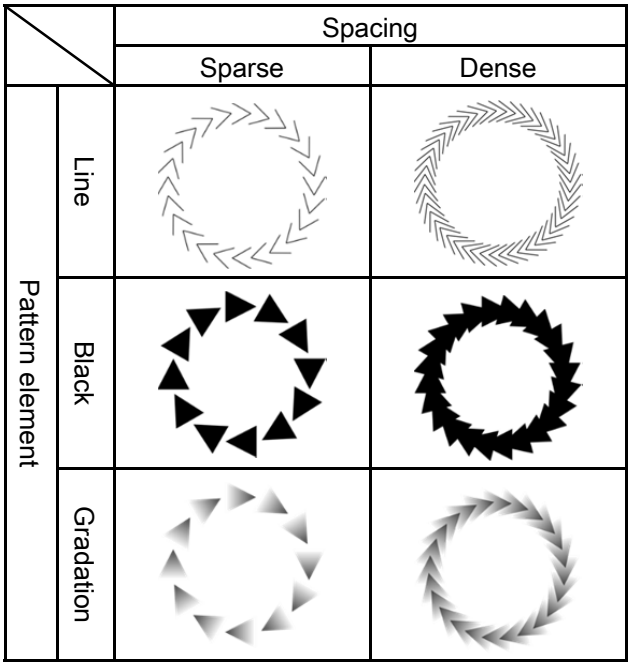


Figure 6.Circular arrowhead patterns

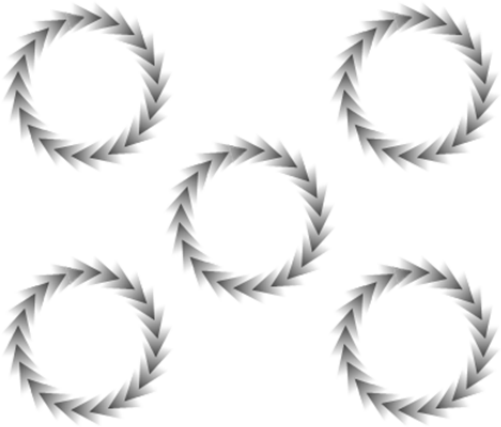


Figure 7. A typical pattern for evaluation (Gradation)

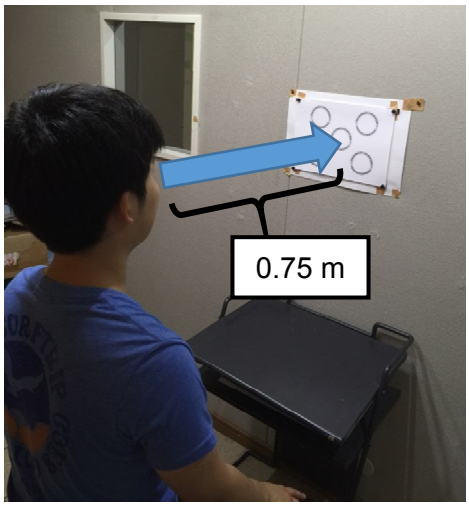


Figure 8. Evaluation scene experimental landscape

3. Results

3. 1. Motion recognition on liner pattern

Results of subjective evaluation for the liner pattern are shown in Fig. 9. Motion towards arrowhead direction was dominantly observed in all the patterns in a range of 30% - 100%. Motion towards wide-side direction was observed only in the pattern of "Gradation Dense". Especially for the pattern of "Gradation Sparse", all the observers recognized motion towards arrowhead direction. These results suggest us that arrowhead patterns can cause motion illusion of the direction dominantly towards the arrowheads in the liner array patterns.

The cause of motion observation towards the wide-side, in the "Gradation Dense" pattern, can be explained with the same mechanism of conventional explanation based on contrast effect.

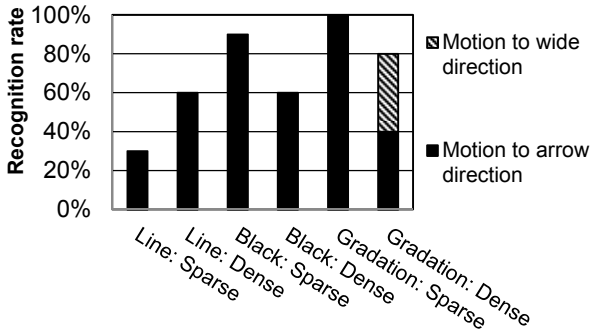


Figure 9. Motion recognition rate on each pattern (Liner)

3. 2. Motion recognition on circular pattern

Results of subjective evaluation for the circular pattern are shown in Fig. 10. Clockwise motion was dominantly observed in all the patterns in the range of 30% - 60%. Especially in the patterns of "Gradation", Anticlockwise motion was observed on the two "Gradation" patterns in the range of only 20% - 30%.

These results suggest us that arrowhead patterns can cause motion illusion dominantly towards the arrowheads also in circular patterns.

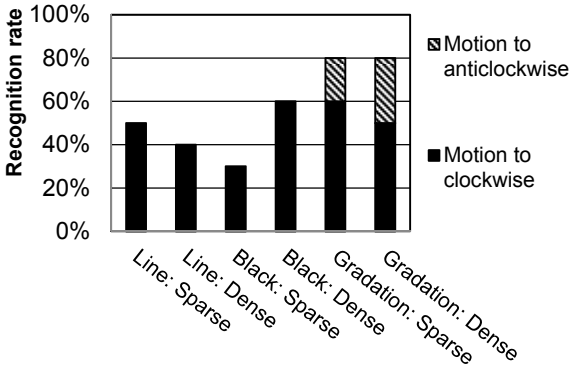


Figure 10. Motion recognition rate on each pattern (Circular)

4. Discussion

Table 4 summarizes maximum recognition rates of motion towards arrowhead side shown in each combination of arrow pattern element and its arrangement. The motion effect of arrowhead shape was confirmed as we had expected.

We noticed that the Fraser-Wilcox pattern, in fact, contains elements like arrowhead patterns (Fig. 11). The direction of rotation supposed for the quasi-arrowhead parts in the Fraser-Wilcox pattern is opposite against the motion direction explained by the conventional explanation.

Thus, these results and above finding suggest us that there should be different two motion mechanisms for explaining bi-directional motion in the Fraser-Wilcox motion illusion, one is conventional explanation based on contrast effect and the other is our new explanation based on arrowhead pattern effect.

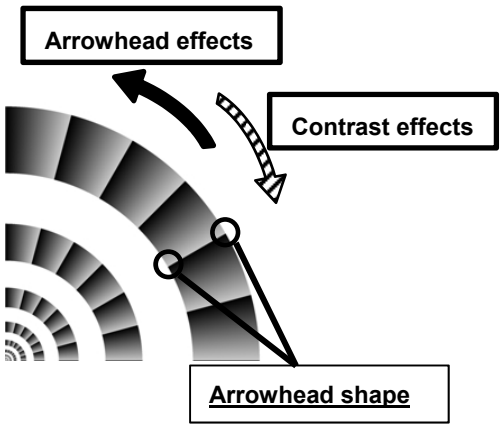


Figure 11. The Fraser-Wilcox pattern is supposed to contain arrowhead elements

5. Conclusions

1) We have found that motion recognition to the arrowhead direction dominantly on the liner array of arrowhead patterns with recognition rates up to 100%.
2) We have found that motion recognition to the arrowhead direction dominantly on the circular array of arrowhead patterns with recognition rates up to 60%.
3) These results suggest us that there should be different two rotation mechanisms for explaining bi-direction rotation in the Fraser-Wilcox motion illusion; one is conventional explanation based on contrast effect and the other is our new explanation based on arrowhead pattern effect.

Table 4 Recognition rate of motion towards the arrowheads on various combination of arrow pattern elements and their arrangements

		Pattern element		
		Line	Black	Gradation
Arrangement	Parallel	60%	90%	100%
	Circular	50%	60%	60%

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Author Biography

Kazuhiro Otsuki graduated from the Department of Optical and Imaging Science & Technology in School of Engineering of Tokai University in 2015. He is now master course student of the graduate school of Tokai University. He is now studying motion illusio