

# An Experimental Analysis on the Characteristics of Muller-Lyer Illusion About Young People

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**Abstract:** The purpose of this paper is to find the variation of Muller-Lyer illusion and analyze the characteristics of the individuals. We carry on the experiment by an illusion instrument which produced by Beijing Jade Bird Tianqiao Instrument & Equipment Co., Ltd. and Muller lyer illusion test software which developed based on the illusion instrument by us. Then 474 samples are got through the illusion instrument and the test software totally. The statistical analysis shows that the illusion quantity increases while the angle decreases with the test order of 30°, 45°, 60° or 60°, 30°, 45°. But the illusion quantity of 45° is greater than 30° and the illusion quantity of 60° is less than 30° with the test order of 45°, 30°, 60°, which shows that the order of test has an effect on the experimental results and the adaptability is conducive to reduce the amount of illusion in this test group. At the same time the statistical analysis also shows that the illusion of females' is higher than that of males', and the female in the group of whose illusion quantity of 45° is the biggest were almost the students who achieved outstanding academic performance.

**Keywords:** Muller Lyer Illusion, Test Tool, Test Order, Adaptability

## 1. Introduction

This paper aims to observe the changes of Muller lyer illusion of 30°, 45°, 60°, and analyzes how the experimental order, gender, learning ability affects the illusion quantity, which provides the basis of the scientific use of visual illusion.

Visual illusion refers to a person in a particular situation not randomly distort external visual stimulation and lead to perceived images which are not the original state of the graphics in the world [1, 2]. Illusion of the psychological activities of people is almost inevitable, and does not change from the will of the people. Even though people have realized

this, they are still very difficult to get rid of illusion. When there are conditions for illusion, everyone will have illusion which has individual differences on size. So illusion is not a psychology defect.

There are many types of illusion, but the most widely used are the geometric graphics illusion. Muller Lyer illusion is a kind of typical geometry visual illusion which was presented by F. C. Muller-Lyer in 1889. This illusion has strong illusion effects and get widespread attention. It refers to two lines of equal length. Because one is with two arrows and another with two nocks, it looks like the former is shorter than the latter, which is shown in Figure 1.

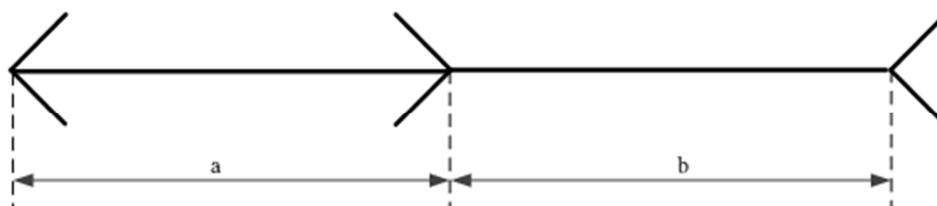


Figure 1. Muller-Lyer illusion.

Application of visual illusion of road traffics safety and architectural design is very meaningful. Road designs has formed a relatively complete system in theory, but in practice, there is still hidden safety problems in road designed according to the driving characteristics, and often caused traffic accidents because of the sight problems [3]. Visual illusion is always a subjective judgment error the driver tried to avoid, and reasonable use of visual illusion can also be beneficial to driving safety. It can avoid potential safety hazard and unreasonable design of road signs and lines caused by the illusion [4]. The road landscape design need to consider various factors, such as driving range, operating speed and driving illusion which has influence on the alignment design [5] "Devil's highway" examples of USA showed the harm to traffic safety of road alignment and roadside landscape, and effective use of visual illusion technique can improve the traffic safety [6, 7].

Through long-term practice, people have realized that the illusion is unavoidable, and accumulated a lot of experience to overcome and correct the visual illusion. The designer must understand and dialectical treat various kinds of visual illusion phenomenon, and apply them flexibly in the design according to different construction and decoration requirements [8, 9]. The use of visual illusion of architectural design can not only expand the space, but also bring the different artistic effect on the building, so as to maximize realizes the construction of social value and economic value, and give people the enjoyment of beauty. From the perspective of architectural decoration design, in-depth analysis of building structures,

### 2.1. BD-II-113 Illusion Instrument

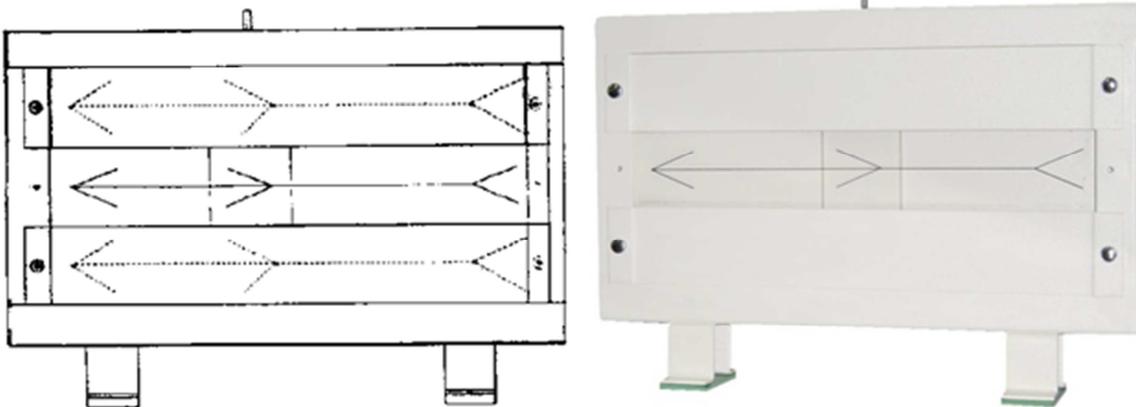


Figure 2. BD-II-113 illusion instrument.

Method of use:

- (1) There are three lines of different angles, when chose one for a test, baffle the rest two;
- (2) The instrument must be upright on the desktop and the participants looks at the front of the instrument horizontally in a meter far. The main test mobile the deflector rod until the participants thinks the left line is equal to the right one. It can verify length illusion phenomena and read error value;

surface, rhythm, texture and other aspects of how to use visual illusion can make the building more harmonious and beautiful [10, 11].

The experiments show that the average Muller-lyer illusion is inversely proportional to the angle, namely with the increasing angle, average illusion is gradually reduced [12]. Systematic experimental study and careful analysis on the structure of Muller-Lyer illusion graphics and visual illusion rules showed that the Muller-Lyer illusion is mainly caused by the angle between oblique and horizontal lines and length of oblique line. 32 samples' analysis proved illusion was inversely proportional to the angle between and standard stimulus pattern. Illusion is proportional to the length of oblique line. The findings were consistent with Heymans's results (1896): "the illusion size is in direct proportions to the cosine of the angle" [13].

## 2. Material and Methods

Two kinds of measuring tools are used in this research which is hardware and software system. The hardware is produced by Beijing Jade Bird Tianqiao Instrument & Equipment Co., Ltd (the original Peking University instrument factory), namely BD-II-113 illusion experimented instrument, as shown in Figure 2. In view of the hardware operation is time consuming; we developed the Muller-lyer illusion instrument software system in order to collect samples, as shown in Figure 3.

- (3) Select another line of different angle and repeat step 2. Compare effects on the illusion of different angles.

### 2.2. Muller-Lyer Illusion Test System

Development tools: Microsoft Visual Basic 60.

Application environment: Windows operating system.

Angle between the oblique lines: 30°, 45°, 60°.

Method of use:

- (1) By double clicking the file, enter the testing main

interface, as shown in Figure 3;

- (2) Put in the age and gender information; click the angle 30°, 45° and 60° button into the interface; adjust the slider stop at the left line equal with the right line, click

the back button to the main interface;

- (3) Subjects must look at the front horizontally in 0.5 meters away; the myopic ones must with glasses.

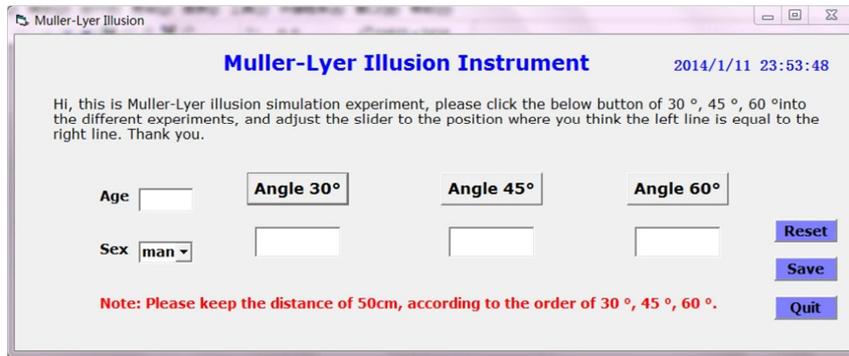


Figure 3. Main form of Muller-Lyer Illusion test system.

2.3. Information of Participants

(1) Participants of BD-II-113 illusion instrument

They are 30 college students participant in the experiment, and they were divided into three groups, each group of 10 people with three different sequences of measurement. The first group is by the order for 45°, 30°, 60°; the second group are by the order for 60°, 30°, 45°; the third group are by the order for 30°, 45°, 60°.

(2) Participants of Muller-lyer illusion test system

They are 158 college students and workers with Bachelor degree and Master degree who are the author’s classmates, students and friends participant in the experiment, and they were divided into two groups. The first group is 120 people according to the test sequence of 30°, 45°, 60°; the second group are 38

people according to the test sequence of 45°, 30°, 60°.

3. Results

3.1. Results of BD-II-113 Illusion Instrument

Illusion quantity units of this study were mm and the statistical analysis of experimental results is shown in Table 1, Table 2 and Figure 4. The descriptive statistics analysis of different sequence measurement results is shown in Table 1; average illusion quantity comparative analysis of different gender is shown in Table 2; average illusion quantity comparative analysis of different testing orders is shown in Figure 4.

Table 1. Descriptive statistics of BD-II-113 Illusion Instrument.

	N	Min	Max	Average SE	SD	Variance	Median
Illusion Quantity of 30°	30	-3.00	21.00	0.93	5.09	25.93	11.0
Illusion Quantity of 45°	30	-6.00	20.00	0.90	4.95	24.53	13.5
Illusion Quantity of 60°	30	-6.00	16.00	0.94	5.16	26.64	10.5
Effective N (list status)	30						

From Table 1, the minimum has negative value of the 30 samples and the average and median of the illusion shows 45°>30°>60°. The SEs are more than or equal to 0.9 and less than 1, which indicates this measurement is reliable; standard deviation of the three angles are not too much difference, which indicates the gap is small between each angle illusion; variance difference of the three angles are not too much

difference, which indicates the data fluctuation is small.

We can see from Table 2, the average and median of females is greater than males in the illusion of 45°, while smaller than males in the illusion of 30° and 60°; the variance in 45° of males is maximum, while the females is minimum.

Table 2. Average comparison between males and females of BD-II-113 Illusion Instrument.

Sex		Illusion Quantity of 30°	Illusion Quantity of 45°	Illusion Quantity of 60°
Male	Average	10.38	11.81	9.81
	N	16	16	16
	SD	4.73	6.02	5.65
	Variance	22.38	36.30	31.90
	Median	11.5	12.5	11.0
Female	Average	9.71	13.29	9.50
	N	14	14	14
	SD	5.64	3.41	4.75
	Variance	31.76	11.60	22.58
	Median	10.0	14.5	9.5

As you can see from Figure 4, different test order has obvious influence on the results. The illusion of 30° and 60° shows increasing trend respectively, while the illusion of 45° decreases first and then increases.

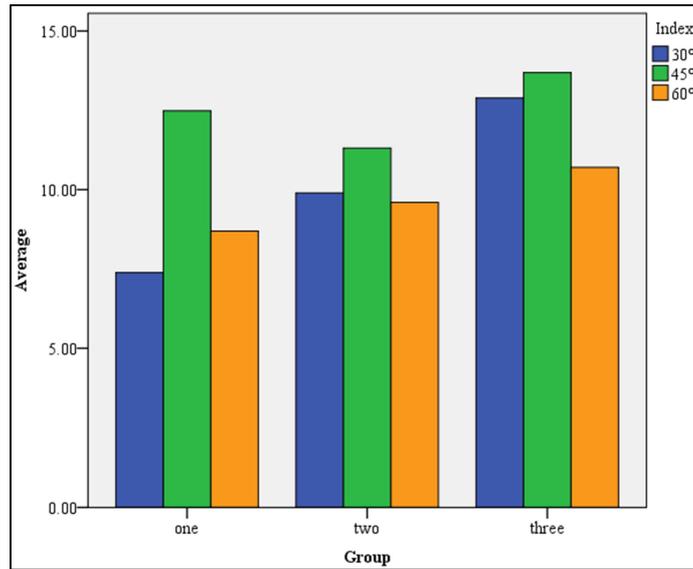


Figure 4. Illusions comparison of different order.

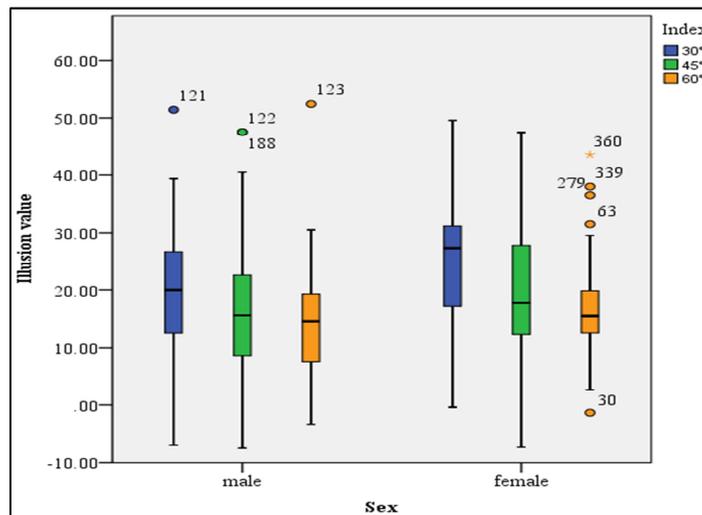


Figure 5. Box-plot between men and women.

3.2. Results of Muller-Lyer Illusion Test System

- (1) The descriptive statistics analysis according to the order for 30°, 45°, and 60° is shown in Table 3; the average comparison of different gender are shown in Table 4; illusion quantity box diagram analysis of different gender is shown in Figure 5.

Table 3. Descriptive statistics of illusion test system (Group 1).

Item	N	Min	Max	Average SE	SD	Variance
Illusion Quantity of 30°	120	-6.97	51.43	1.01	11.05	122.10
Illusion Quantity of 45°	120	-7.47	47.51	1.11	12.21	149.04
Illusion Quantity of 60°	120	-3.39	52.45	.83	9.12	83.16
Effective N(List Status)	120					

From Table 3, there is negative value of the minimum of 120 samples and the average satisfies with the illusion phenomenon of 30°>45°>60°; The SE is about 1 and the average SE of 60° is reliable relatively while the 45° is

unreliable. The SD of three angles has no much difference which indicates that the gap between each angle is not big. The variances between three angles have much difference which indicates a big data fluctuation.

**Table 4.** Average comparison between males and females of illusion test system (Group 1).

Sex		Illusion Quantity of 30°	Illusion Quantity of 45°	Illusion Quantity of 60°
Male	Average	19.37	15.38	13.73
	N	77	77	77
	SD	11.01	11.79	8.91
	Variance	121.27	139.05	79.32
Female	Average	24.98	20.95	16.85
	N	43	43	43
	SD	10.29	12.26	9.26
	Variance	105.86	150.32	85.66

We can see from Table 4 that the average of three angles of females is higher than males and the variance in 45° is maximum which shows a big data fluctuation.

From Figure 5 we can see, there are 8 outliers and the abnormal rate was 2.22%; the median showed the trend of 30°>45°>60° and the females is higher than the males. The data distribution of females is right skewed.

(2) The descriptive statistics analysis according to the order

for 45°, 30° and 60° is shown in Table 5; the average comparison of different gender is shown in Table 6; illusion quantity boxes diagram analysis of different gender is shown in Figure 6. Box-plot comparison between two groups is shown in Figure 7. Bar charts of mean illusion comparison between two groups is shown in Figure 8.

**Table 5.** Descriptive statistics of illusion test system (Group 2).

Items	N	Min	Max\	Average SE	SD	Variance
Illusion Quantity of 30°	38	-2.33	50.48	2.08	12.84	164.90
Illusion Quantity of 45°	38	-4.11	65.29	2.46	15.19	230.84
Illusion Quantity of 60°	38	-2.0	49.45	1.83	11.28	127.34
Effective N(List Status)	38					

From table 5, there is negative value of the minimum of 38 samples and the average satisfies with the illusion phenomenon of 45°>30°>60°; The SE is about 2 and the average of 60° is reliable relatively while the 45° is unreliable. The SD of 45° is the biggest which explains that the gap between this angle is larger. The variances in three angles have much difference which indicates a big data fluctuation.

We can see from Table 6 that the average of three angles of females is higher than males and the variance in 45° is maximum which shows a big data fluctuation.

From Figure 6 we can see there are 6 outliers and the

abnormal rate was 6.1%. The median of 45° and 60° is not located in the central of upper and lower four percentile which explains that their data does not meet the standard normal distribution. The median shows the trend of 45°>30°>60° and the females are higher than the males.

Figure 7 and Figure 8 shows that the order has impact on the experimental results and the median of 30° in the second group is lower than that of the first group, while the 45° and 60° is higher than the first group. The average of group 2 is higher than group 1. The data basically meets the standard normal distribution.

**Table 6.** Average comparison between males and females of illusion test system (Group 2).

Sex		Illusion Quantity of 30°	Illusion Quantity of 45°	Illusion Quantity of 60°
Male	Average	23.04	27.06	19.65
	N	27	27	27
	SD	11.33	13.32	9.94
	Variance	128.32	177.41	98.78
Female	Average	24.52	27.74	21.49
	N	11	11	11
	SD	16.58	19.81	14.55
	Variance	274.79	392.50	211.69

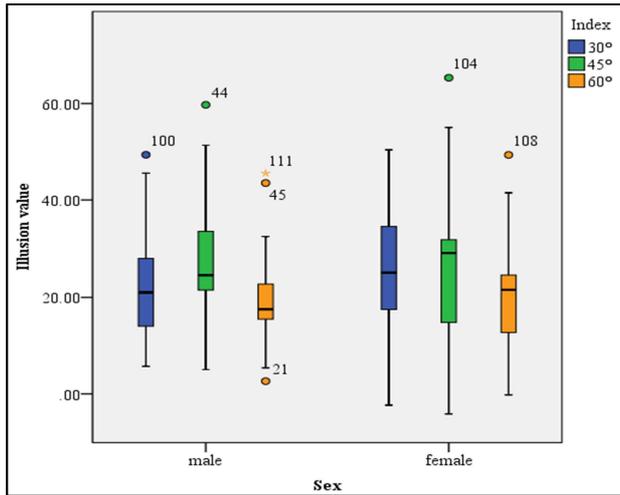


Figure 6. Box-plot of illusion between males and females.

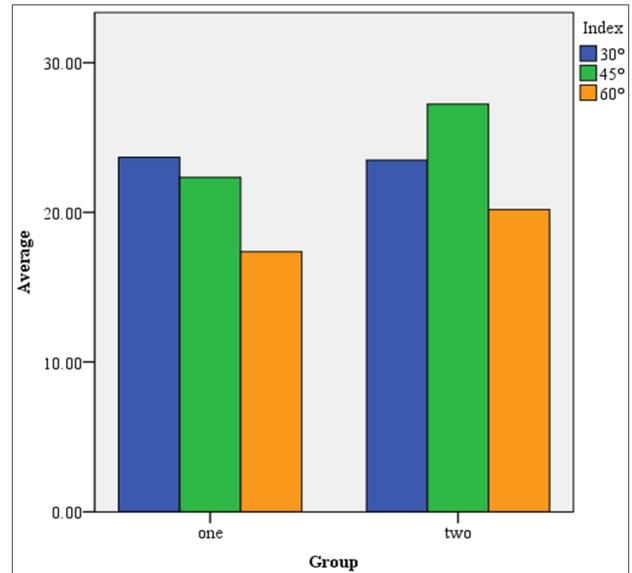


Figure 8. Bar chart comparison between two groups.

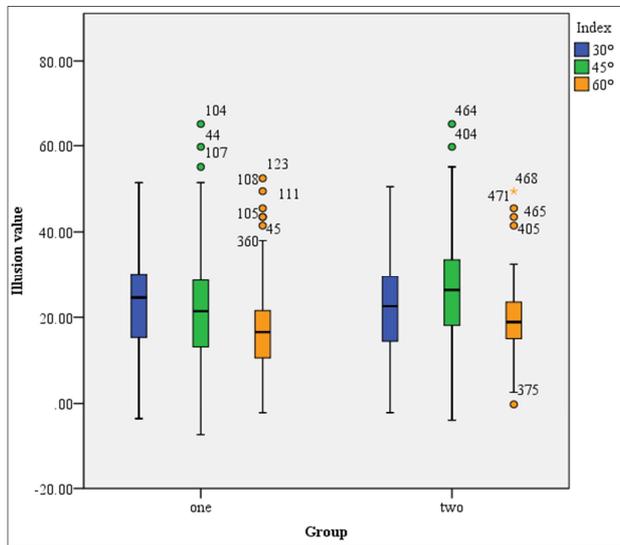


Figure 7. Box-plot between two groups.

## 4. Discussions

### 4.1. Variance Analysis Under Different Test Order

Variance analysis of the 90 samples which are from three groups (45°, 30°, 60°; 60°, 30°, 45°; 30°, 45°, 60°) collected by BD-II-113 illusion instrument is shown in Table 7. We can see from table 7 that significant values are bigger than 0.05, so the test sequence has no significant effect on the illusion.

Variance analysis of the 474 samples which are from two groups (45°, 30°, 60°; 30°, 45°, 60°) collected by Muller-lyer illusion test system is shown in Table 8. We can see from table 8 that significant value is 0.058 which are slightly bigger than 0.05, so the test order has influence on the illusion [14].

Table 7. ANOVA of the first measurement results.

Items		Quadratic Sum	df	mean square	F	Significant
Between groups	(Combination)	13.64	2	6.82	1.99	.22
	linear term	12.61	1	12.61	3.69	.10
	Deviation	1.03	1	1.03	.30	.60
Within group		20.52	6	3.42		
Total		34.16	8			

Table 8. ANOVA of the second measurement results.

Items		Quadratic Sum	df	mean square	F	Significant	
Between groups	(Combination)	704.527	1	704.527	3.651	.058	
	linear term	Unweighted	704.527	1	704.527	3.651	.058
		weighted	704.527	1	704.527	3.651	.058
Within group		30100.542	156	192.952			
Total		30805.069	157				

### 4.2. Results Analysis of BD-II-113 Illusion Instrument

The negative value of this experiment is because the subjects carried out its own psychological hint before the test

and do not objectively for reading. Therefore, psychological suggestion has important influence on cognitive ability. The sample of age 29 is abnormal because the subject is lack of psychological resources and does not have the patience to

finish a complete experiment.

The average and median showed the phenomenon of  $45^\circ > 30^\circ > 60^\circ$  which does not meet the Muller-Lyer illusion rules. Therefore, the adaptability may have a positive impact on the subjects. The  $45^\circ$  angle is very special, the females average and median of  $45^\circ$  angle is greater than males. And data fluctuation of females is minimal, but a fluctuation of  $45^\circ$  angle is maximal for males. In addition, in the part of repeated experiments, the illusion change of  $45^\circ$  angle is more obvious than  $30^\circ$  and  $60^\circ$ . Therefore, illusion quantity of angle  $45^\circ$  is worthy of attention.

#### 4.3. Results Analysis of Muller-Lyer Illusion Test System

The negative value of this test is objective and the subjects are engineering workers mostly. The females whose illusion of  $45^\circ$  angle is the biggest were very good students with high scores. The illusion average of test order  $30^\circ$ ,  $45^\circ$ ,  $60^\circ$  meets the illusion law of  $30^\circ > 45^\circ > 60^\circ$  angle which indicates that the amount of last sample is not enough. But the test order for  $45^\circ$ ,  $30^\circ$ ,  $60^\circ$  meets the rules of  $45^\circ > 30^\circ > 60^\circ$  which indicates that adaptation has a positive effect on subjects.

The  $45^\circ$  angle is very special and SE, standard deviation and variance are biggest. Also has the maximum data fluctuation. Females' illusion values are higher than males'.

Gender has no obvious correlation between illusion.

## 5. Conclusions

Illusion has important significance of the field of cognitive and it especially has a very good reference to the security of traffic safety [15]. The experiments show that the average of Muller-Lyer illusion quantity gradually reduces with the increased angle of  $30^\circ$ ,  $45^\circ$  and  $60^\circ$ ; but the different order influences the results, that is adaptive or learning ability are helpful for us to improve the cognitive ability of illusion [16,17,18]. The females' illusion is universal higher than males, and the  $45^\circ$  angle is interesting in the sex and illusion. Because the experimental conditions are not perfect and the sample capacity is not large enough and other reasons, the illusion factors such as experimental sequence, time analysis is still to be improved and the special angle of  $45^\circ$  also need further study. At the same time how to improve the adaptability of people and improve cognitive ability also needs to further to explore.

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