Helmholtz Square Illusion Help You Find the Most Figure-Flattening Striped Shirt

Chen Jinuo

***Abstract*—Almost everybody knows that the salesperson always advises you not to buy some horizontal striped clothes for they will look broader and shorter. On the contrary, Helmholtz square illusion explained that a square composed of many horizontal stripes seems higher and thinner than the one with vertical lines in 1867. However, common sense in the fashion field exactly contradicts this theory. Here, this study would further explore the relationship between horizontal strips and the effect of Helmholtz illusion using a graded series method (GS) and calculating the weighted average extended level of the illusion in the form of the percentage of the relative size people think from 120 participants. Specifically, the GS method was to let participants find out the most similar among a series of different graded sizes of squares with the test horizontal striped square. The result does show that the more horizontal stripes, people judged the less width. Moreover, the difference among the diminishing effect in each varying horizontal stripes duty cycle group is significant after the data analysis. Thus, at last, the relationship can be shown in a predictive curve. As a result, it is recommendable to wear clothes with more horizontal lines if people want to make themselves look even much thinner.**

***Index Terms*—Diminishing effect, duty cycle, graded series method, Helmholtz square illusion.**

I. Introduction

It is generally believed that wearing clothes with horizontal stripes will make people look fatter than their actual size, so most people choose to avoid horizontal lines as much as possible to make themselves seems slimmer. However, this "common sense" contradicts a geometric visual illusion reported by Helmholtz a long time ago: the square with horizontal stripes looks taller and thinner, and the square with vertical stripes looks broader and shorter in bare human sight [1]. Helmholtz's discovery is shown in Fig. 1.

In 2011, this postulation once interested Thompson and Mikellidou. They confirmed the truth of the Helmholtz square illusion and successfully overturned the old advice in modern fashion by continuously proving the truth of the Helmholtz square illusion on women's figures and 3D human models. (Fig. 2) "We find that a rectangle of vertical stripes needs to be extended by 7.1% vertically to match the height of a square of horizontal stripes and that a rectangle of horizontal stripes must be made 4.5% wider than a square of vertical stripes to match its perceived width." [6].

Although the Helmholtz square illusion has no convincing or definite explanation, most researchers link this illusion with another type of geometric illusion called Oppel–Kundt illusion [2] and vertical-horizontal illusion [5]. For example, in Thompson's paper, they concluded that "The Helmholtz Square and Oppel–Kundt illusions show a consistent and considerable overestimation of filled space such that horizontal lines serve to make a space appear taller." [6]. Even the behind mechanism is unknown, but the further application of Helmholtz square illusion is crucial, especially in fashion. Designer Archana Kochhar agrees that optical illusions can induce people's brains to see things that do not match reality. It gradually creates illusions on dresses by making individuals look slimmer, taller, and curvier. Creating optical illusions is a great way to strengthen, dilute, or hide certain body parts in the fashion world. That is the inspiration for this study: few research pieces focus on Helmholtz square illusion, and nobody has ever explored that the different density of horizontal stripes on the dress may lead to the different or opposite effect. Though Thompson's research mentioned the "duty cycle" (a cycle that refers to the percentage ratio of pairs of alternating white and black stripes in the square), it should be regarded more like the thickness of dark bands, still different from "cycle density" in the square.

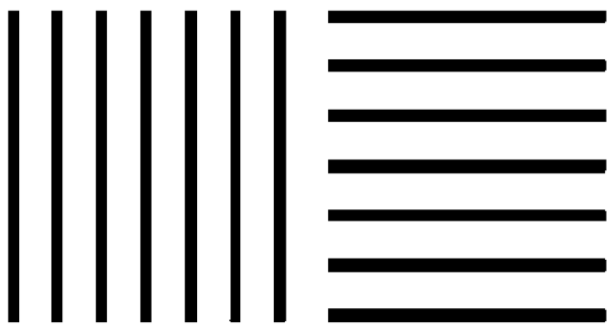

Fig. 1. Helmholtz square illusion the square of horizontal lines on the right-hand side was judged to be taller and narrower than the square of vertical lines with the same size on the left.

This research aims to find out the relationship between horizontal strips and the effect of Helmholtz illusion on judged relative width (it is known from the previous study that width and height have a negative correlation: horizontal striped squares extend the height but shrink the width, so the relationship with judged height can be approached from the results of width). The hypothesis was that the higher density of the horizontal stripes has a more significant effect on making objects look thinner than what they actually are. In the experiment, I used a graded series method (GS) to measure and compare the illusion magnitude: let the participants look over a series of different widths of blank squares until they find the comparison figure they feel is the same as the test horizontal striped square. In the end, the

Manuscript received March 13, 2022; revised May 23, 2022.

Chen Jinuo is with Wuhan Britain-China School, Wuhan, China (e-mail: melissa.jinuo@foxmail.com).

doi:10.18178/ijssh.2022.12.3.1086

postulation was confirmed experimentally.

(a) (b)

Fig. 2. Thompson and Mikellidou's research (a): the application of the 2D human figures showed the horizontal lines on the clothes make the hips appear thinner. (b): the application of the 3D human model showed that horizontal lines make the body seem slimmer.

II. Method

There are four sets of standard horizontal stripes of various cycle densities, but all with the same width of *a*. All the thickness of the dark stripe was uniform. Each standard horizontal striped square was compared with five blank squares in each set, in the form of a multiple-choice paradigm, from slightly narrower to slightly wider than the targeted striped square. The participants (120) were required to decide which of the five white squares (A/B/C/D/E) had the same width as the standard horizontal stripes and make their choice by selecting the options on the questionnaire web page (Shown in Fig. 3). The time used for each participant was not restricted, and the rules and aims were explained at the head of the questionnaire.

The deviations of the widths of blank squares were sorted from the smallest to the biggest with the same intervals: *0.95a*, *0.98a*, *a*, *1.02a*, *1.05a*. The order of the square options was randomly ranked. It was essential to note down the actual width of each width but did not show it to the participants. There were four questions in every set for repeats: #x represents how many horizontal stripes in that question; each one just had a slight difference between the order of the choices, marked as {#4-1, #4-2, #4-3, #4-4}{#6-1, #6-2, #6-3, #6-4}{#8-1, #8-2, #8-3, #8-4}{#10-1, #10-2, #10-3, #10-4}. The order of these multiple-choice questions was also random and deceived the participants that the sizes of options in one set were distinct to prevent continuous and too many exposures, leading to underestimating the illusory effect. After all the participants finished every question, the page automatically shifted to the next question. At the end of the questionnaire, the aim and deception are all well explained.

Set 1: the square with four horizontal stripes square was drawn on the left side, and another five blank squares with widths = *0.95a*, *0.98a*, *a*, *1.02a*, *1.05a* are drawn in a random position on the right side of the striped and target one and noted them with A, B, C, D, E.

Set 2: the original striped square in set 1 was substituted with a six-horizontal-striped square. Others did not change. The order of those square options in each question was consistent with set 1 for better and constant adjustment in repeated groups.

Set 3: the original striped square in set 1 was substituted with an eight-horizontal-striped square. Others did not change. The order of those square options in each question in a distinct set was consistent with that of the set (Fig. 3).

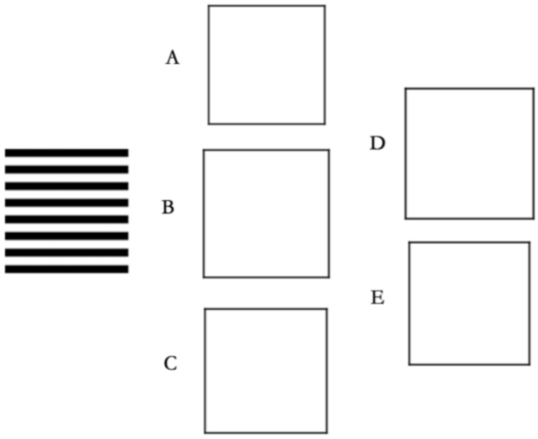

Fig. 3. Example of #8-1 drawing illustration: the square with eight horizontal stripes square was drawn on the left side, and another five blank squares with widths = *0.95a*, *0.98a*, *a*, *1.02a*, *1.05a* randomly on the right side, marked with A, B, C, D, E; the position and arrangement of blank squares on the right side is consistent through the same ordinal group in all sets, like the order of blank square is the same in #4-1, #6-1, #8-1and #10-1.

Set 4: the original striped square in set 1 was substituted with a ten-horizontal-striped square. Others did not change. The order of those square options in each question in a distinct set was consistent with that set.

III. Result

The below combo chart (Fig. 4) recorded the test results. Here I collected data from 120 participants' questionnaires online, so each horizontal lines density group has 480 repeats. According to participants' answers, the real enlargement in the vision of each striped square is weighted calculated by the width square they chose. "***#n***" refers to cycle density, the number of pairs of alternating white and black stripes. The result did show that the higher density of stripe patterns, the more effect of Helmholtz square illusion, the less width the square is shown, and the relationship between judge width (y) and n of horizontal stripes (x) is postulated to be an analogous logarithm function. Since the independent invariable ***n*** was only a few numbers, I could not obtain this relationship's effective and accurate function. But I predict it is a transformation function of the psychometric curve, which is a model always applied in signal strength and discrimination tasks.

The error bars did not even overlap, which indicated a significant difference between every set when the confidence level was 95%. So, there were significant differences among these bar charts. Moreover, it was reasonable to conclude that when the pattern density of horizontal striped in the square increases, the judged width by people actually decreases.

Relied on Thompson and Mikellidou's research, the mechanisms of our studies were the same substance; that is to say, the logic of how they transferred their 2D squared results to 3D reality could also be applied here. Though it could only be a reasonable postulation, it needs further precise confirmation by other experiments using a 3D model.

TABLE I: THE DATA COLLECTED FROM THE QUESTIONNAIRES

Judged width /%	#4	#6	#8	#10
Mean	99.581	99.472	99.372	99.322
SD	0.05	0.03	0.024	0.017

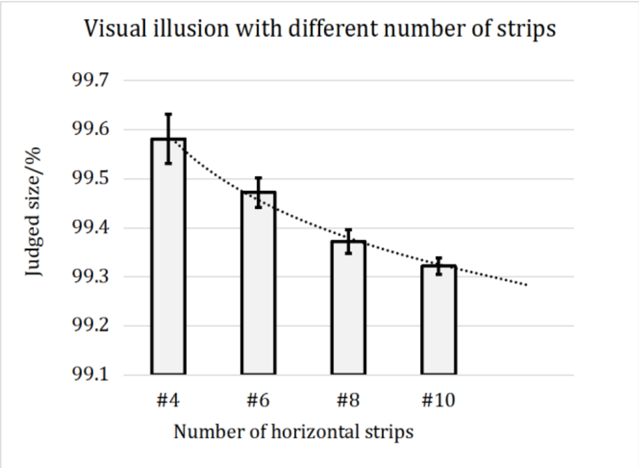

Fig. 4. Relationship between judge width (y) by bare human eyes and *n* of horizontal stripes (x)

IV. DISCUSSION

The mechanism behind this is related to the visual loop. The Helmholtz illusion is orientation-dependent, disrupting orientation-specific processing that may be expected to result in a release from the illusion and stimulation to LO1 and extrastriate regions in the brain [3].

This project has made two main contributions. First, the evidence in the experiment once evaluated part of the Helmholtz illusion truthness: the horizontal stripes in the square has a slimming effect on the size. Furthermore, the second contribution is the successful determination of the correlation between the effect of the Helmholtz square illusion and the number of horizontal stripes, other things unchanged. The result does show more horizontal stripes, and less width is shown. In this way, this research again provides statistical evidence to overturn the traditional fashion "common sense" and provide scientific evidence with another fashion theory: more horizontal stripes on the dress would have a more extensive slimming effect on people's body shape.

There are some uncertainties to consider. Firstly, the range of the participants was limited. The experiment was done online due to the epidemic, so the participants were only teenagers or adults who had access to electrical devices. Secondly, most participants used phones to answer the questions, so the resolution of drawings was small to distinguish: human eyes could not clearly and wisely make a choice. Thus the disadvantages for GS have exposed: a strict requirement on participants' distinguishable ability. As a result, most of their answers varied significantly in the repeated trials: they answered differently in the repeated questions that were identical except the order of the options, leading to the third error consideration. Thirdly, the position of the options may also provide another kind of illusion. For example, people tend to choose the closest option to the targeted striped square. Because every option looks relative the same, people tend to be influenced by a stronger irrelevant illusion in this condition.

To improve, I may first enlarge the participant range from different age and gender groups. Then, I am adding the application of projectors or other extensive resolution screens to show the participants the questions for better comparison among the sizes. Moreover, other measurement methods like analysing by comparing the "average error": let the participants freely extend or shrink the horizontal striped square to match the size of one same sized blank square.

V. CONCLUSION

The Helmholtz Square illusion on the different densities of horizontal-striped squares is experimentally tested, and the result supports the original hypothesis. This effect persists, though the function may only be correct on the 2-dimensional aspect when used on pictures of clothing and the 3D human body by reasonably using the logic rules and results in Thompson and Mikellidou's research. These results infer that more research is needed to identify the mechanisms behind this optical illusion, particularly concerning the science of visual perception, sensory processes and attention. The human visual system analyses the interactions between visible electromagnetic waves and the objects in our environment, extracts information about the world and makes visual perception possible. Hence, by studying how the brain fills in missing or ambiguous visual information, we can learn a lot about how we perceive the world. Optical illusions provide fertile ground for such study because they involve ambiguous images that force the brain to make decisions about how we perceive things. Furthermore, since optical illusions mainly share a similar origin and mechanism, this further study about the Helmholtz Square illusion could also contribute to the evaluation and improvement of the original explanation of other related illusions.

CONFLICT OF INTEREST

The author declares no conflict of interest.

ACKNOWLEDGMENT

Jinuo, Chen thanks the academic help from Prof. Brody at Princeton University, her TA, Mr Luo at Harvard University, and her instructor Mr Seswara at Johns Hopkins University. Additional thanks to her counsellor Luna, writing advisor Selena, and peer Melosa.

REFERENCES

[1] H. Helmholtz, "Treatise on physiological optics," New York: Dover vol. 3,1962.

[2] T. M. Künnapas, "An analysis of the 'vertical-horizontal illusion"' *Journal of Experimental Psychology*, vol. 49, pp. 134–140, 1995.

[3] M. Kyriaki, G. D. André, C. Hannah *et al*., "An orientation dependent size illusion is underpinned by processing in the extrastriate visual area" ,2016.

[4] B. Pinna, "Directional organisation and shape formation: new illusions and Helmholtz's square," *Frontiers in Human Neuroscience*, vol. 9, no. 92, 2015.

[5] J. O. Robinson, "The psychology of visual illusion, shrinkage in the apparent size of cylindrical objects," London: Hutchinson University Library Perception, vol. 36, pp. 3–16, 1972.

[6] P. K. Mikellidou, "Applying the Helmholtz illusion to fashion: Horizontal stripes won't make you look fatter," *I-Perception*, vol. 2, no. 1, 2011.

[7] P. Thompson and K. Mikellidou, "Applying the Helmholtz illusion to fashion: Horizontal stripes won't make you look fatter," *I-Perception*, vol. 2, no. 1, pp. 69–76, 2011.

Copyright © 2022 by the authors. This is an open-access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium provided the original work is properly cited (CC BY 4.0).

Chen Jinuo was born in Wuhan, China, in 2004, now she is a high school student studying biology in the International Baccalaureate programme in Wuhan Britain-China school. His intended major is biomedical science and neuroscience.

She attended the 2021 Johns Hopkins Biomedical Engineering summer session and graduated with a full 4.0 GPA and three credits. She also attended the 2021 Decision-making workshop held by Prof. Brody at Princeton and finished with a highly acclaimed performance. In addition, she won the first prize in the 2020 China Brainbee competition in round 1 and a gold medal in the 2020 International Genetically Engineered Machine (iGEM).