PERCENT ERRORS IN STANDARD MULLER-LYER AND RIGHT-ANGLED ILLUSIONS

Aurel Ion CLINCIU*, **Ruxandra Maria CLINCIU****

*"Transilvania" University of Brasov, Romania
**University of Essex, Department of Psychology, Colcester, UK

***Abstract**: This within-subjects experiment focuses on the possible causes and origins of the Müller-Lyer illusion by introducing two theories (the confusion theory and the perceptive theory) that investigate the effect of the placement of wings on judging the mid-point of the shaft. The assumption that was made was that when judging the mid-point of a line, one estimates the end points and then bisects the distance. The Independent variable consisted of a shaft with either two wings or with a right angle figure. The Independent variable had six conditions, depending on the two types of figures: the standard Müller-Lyer illusion or the right-angled illusion. The Standard Müller-Lyer illusion had greater effects of distortion than the one with the right-angled extensions, where the effect of perspective could not be invoked.*

***Keywords**: Müller-Lyer illusion, size scaling effect, acute/obtuse or right-angled wings.*

1. INTRODUCTION

Although it is one of the oldest and most well known geometrical illusions, the Müller-Lyer illusion [1] is still very far from a unitary psychological explanation. Though the studies regarding this illusion are numerous, the mechanisms of producing the perceptive distortion have not been discovered yet.

Among the explicative theories that are often cited, Gregory's perspective theory [2] is one of the most relevant. However, as appealing as it is, it still does not explain the illusion in a satisfactory manner, thus confirming the point of view expressed by Eysenck and Keane: "In all probability, more than one factor contribute to the Müller-Lyer illusion" [3]. According to this perspective theory, the knowledge, which derived from a previous perceptual activity of the three-dimensional objects, is inappropriately transferred to an actual perception of a two-dimensional object. It is taken into account, therefore, the apparent distance in order to conserve the constancy of the shape and though measures concerning the depth are taken, they are of a two-dimensional figure. Although it is sustained by multiple evidence, there are still a couple of important counter arguments: firstly, the illusion works perfectly even in the absence of the shaft and the wings alone can create the impression of expansion or compression of the space between them [2]. Secondly, the illusion can also be obtained when "the fins of the two figures are replaced by other attachment such as circles and squares" [3] . Thirdly, the illusion "can appear in the three-dimensional space as well" [4].

On the other hand, the confusion theory draws attention upon the fact that the decisive elements in the judgment of the shaft length are the wings that are placed at its extremities. Thus, the obtuse wings (pointing outwards) tend to move perceptually the end of the shaft in the same way, towards the exterior, whereas the acute wings (pointing inwards) produce the opposite effect. In other words, while the obtuse wings produce an effect of expansion, the acute wings produce an effect of compression on the shaft length. This theory also states that these effects of expansion and compression of the length are localized towards the extremity with the respective wings. Thus, the name of the local distortion: the distortion in length arises close to the wings, not all along the length of the shaft.

There are a lot of theories of vision, offered as explanations for the classic Müller-Lyer illusion, like direct size scaling [5], perceptual assimilation of the length of the shaft toward the length of the contextual elements [6] (or visual scene interpretation) [7], framing effects [8].

In order to verify this effect, [9] eliminated the wings from one of the ends in an experiment based on the task of subjective appreciation of the centre of the shaft. They reported a stronger effect of expansion for the obtuse wings than for the acute wings. Furthermore, the effect of perceptual compression seems to be localised more towards the end with the acute wings rather than towards the end with the obtuse wings. As a replicate, Predebon's study [8] reported similar effects regarding the intensity and the location for both types of wings, namely "acute and obtuse-angle forms yelded similar pattern of bisection errors" [8]. These discoveries seem consistent with the local distortion theory because the mid-point errors are in the underlying region of the shaft, therefore being negligent in the spare space of the shaft.

Specifically, Gregory's perspective theory has generated the challenge to verify the effect of the Müller-Lyer illusion through other types of approaches, different from the acute/obtuse wings, for example through the extensions with circles and squares. The local distortion theory has produced diverse models of research that could verify the different types of distortions by the category of the extension (inwards or outwards), as well as the uniformity of its distribution on the length of the shaft. This process is called bisection and scaling of the effect because it implies the judging of the centre of the shaft by reducing the conventional figures to the one-wing version.

The present investigation approaches matters that have resulted from both of the theories and tries to answer the question whether the effects are as strong and as clear for the conventional extensions as for the right angles. This could contradict Gregory's theory of perspective. In the same time, the present study investigates the judging of the distortion depending on the different type of extension.

The ***hypothesis*** that have been outlined are the following:

1. The study aims to verify the validity of the local distortion theory by using one wing shaft with acute and obtuse wings (standard Müler-Lyer illusion) or inward/outward extensions in a right angle. It is expectable that the errors occurred in the judging of the mid-point of the shaft to be negative or positive only in the segment with the wings, regardless of the type of extension, classic or in a right angle.

2. In the judging of the mid-point of the shaft we estimate where the ends points are, and then bisect the distance. In the standard Müler-Lyer illusion, the error of estimation appears as a consequence of the subjective movement either inwards or outwards of the ends of the shaft. In this experiment, the extensions in right angle fall perpendicularly on one of the shaft's end. By having the ends of the shaft, it is expectable for the error of estimation to be substantially lower than in the standard illusion. Also, it is expectable for the local distortion, generated by the type of extension used, to persist, regarding its inwards or outwards orientation. In other words, the effects of the illusion in modified conditions (right angle) will be similar to those with standard extensions (acute wings or obtuse wings).

3. Another new element in this study is the fact that the extensions that are attached to the shaft do not have opposite directions. They are combined so that different extensions are in the same direction. It is anticipated that in this experimental condition, the effects of local distortion will be the biggest.

4. Last/finally similar effects are anticipated for the same type of extension (outwards or inwards), regardless the category of which the wings are in (standard Müller-Lyer or right angled).

If hypothesis one is true, the local distortion theory could find a strong experimental support. Similar, if hypothesis two is confirmed, it will be in agreement with Eysenck and Keane's point of view, according to which the Müller-Lyer illusion can be explained through more types of mechanisms.

In the end, the last hypothesis will confirm whether or not our data are consistent with the results Predebon or Warren & Bashford arrived at.

2. METHOD

Participants: 105 undergraduate students from the University of Essex participated in the experiment as a compulsory module requirement.

Apparatus: Each participant used a Macintosh computer to determine the mid-point of the shafts that were presented.

Materials: The original Müller-Lyer illusion consists of two figures (see appendix). They have in common a horizontal line of the same length, called “shaft” or “axis”, and a pair of symmetrical oblique lines, called “wings” or “fins”, attached at *the* both ends of the axis. In one figure the wings form an obtuse angle with the axis by extending outwards from the shaft and in the other figure the wings form an acute angle with the shafts, by pointing inwards to the centre of the figure.

In this experiment the participants had to examine two types of figures: one was based on the standard Müller-Lyer illusion and it involved both acute and obtuse angles, whereas the other type of figure was made up of right angles only. For both types of figure a computerised programme was used to display the stimuli. In each figure the shaft measured 16 cm in length and 1mm in thickness and the wings measured 4 cm in length and 1mm in thickness each. However, for the standard illusions, the obtuse angle measured 90 degrees and the acute angle 45 degrees. In the right-angled figures, the wings resembled a square with one missing side.

Design: This study was a within-subjects experiment. The order in which all the participants had to judge the figures was randomised but in the end all of them were presented the same figures.

In this experiment, the Independent variable consisted of a shaft with either two wings or with a right angle figure. The Independent variable had six conditions, depending on the two types of figures: for the Standard Müller-Lyer, condition 1 was obtuse wing on one end; condition 2 was acute wing on one end; condition 3 was obtuse wing on one end, acute on the other (like an arrow). For the second type of figures, the right-angled ones, condition 4 was wing extends outwards; condition 5 was wing extends inwards; condition 6 consisted of wings at both ends. All the participants were presented 4 figures of each type and for the asymmetrical figures, on half the trials the figures were left-right reversed.

The Dependent variable was the percent error. In other words, the score obtained on each trial by all the participants was the mid-point error divided by the length of the shaft.

Procedure: The procedure was the same on each trial. Firstly, a box appeared either on the left or on the right hand side and it had the function to prevent the effect of perceptual setting. The participants had to click the mouse in that box and the cursor and box would disappear. Following a short delay, the figure which had to be judged was shown and the participants were instructed to look closely at the figure and try to determine the mid-point of the shaft by eye. In order to record the mid-point they had to simply click the mouse where they believed to be the mid-point of the axis. After two seconds, another box would appear and the same process would restart. The participants were instructed to look closely at the figure and decide where the mid-point was without placing the cursor on the line because they would violate the estimation by judging the figure and the cursor as one composite.

The participants were also asked to be silent during the presentation as they might disrupt other participants in the experiment.

3. RESULTS

For each of the six experimental conditions previously presented, the computer generated the percent error (normalized deviation score), noted by each of the 105 participants, as no data were discarded. The data that were obtained were processed for each experimental condition. The mean and standard deviation, as well as the types of illusions are represented in the table below.

Table 1 Descriptive statistics for the Standard Müller-Lyer extensions (obtuse, acute, combined and total) and for the extensions in right angle (outward, inward, combined and total)

Category	Müller-Lyer standard (acute, obtuse)				Right-angled			
Condition	1	2	3	1_2_3	4	5	6	4_5_6
N	105	105	105	105	105	105	105	105
Mean	2.11	-2.05	-4.57	-4.51	0.88	0.68	-1.33	-0.23
SD	1.85	1.40	1.56	4.16	1.49	1.25	1.35	2.93

The first four columns from Table 1 above represent a veritable confirmation of the fact that the orientation of the arrows towards the exterior or the interior dilates or comprises the underlying segment from the shaft. The sign of the distortion is in agreement with the specific hypothesis.

Also, the third column shows that the distortion produced by combining the two types of extensions is greater than the simple addition of the average percent error of the first two experimental conditions, thus providing a reliable explanation for the effect of synergy of the effects of distortion.

The last four columns of Table 1 are similar to the ones analyzed previously with two mentions. Firstly, the absolute size of these average percent errors is much smaller. Secondly, the results from condition 5 are opposite to those in condition 2, contradicting one of our expectations. Or, if the allegation of Eysenck and Keane or Goldstein is true (Müller-Lyer illusion occurs with other types of extensions than conventional ones), the fact that was previously pointed out should not occur. Therefore it would have to be considered a critical incident and an indirect confirmation of Gregory's theory of perspective.

A one-sample t-test was conducted in order to investigate whether the means for each of the six conditions are significantly different from the test value of 0. The results confirm the fact that all the values are statistically significant ($p < 0.001$). The t-values are greater for the Standard Müller-Lyer.

The critical incident regarding the positive score for the fifth condition $t(104) = 5.60$, $p < 0.001$ is opposite to the one in the second condition and it clearly indicates that the mechanism of the illusion is not the same, regardless the different types of extension used. Eysenck and Keane's supposition with concern to the multiple mechanisms (possibly different) of producing this illusion seems to be well supported by these results. Similarly, if the local distortion theory had been correct, then the second, third, fifth and sixth conditions would have had to give negative values.

In order to test the second specific hypothesis, a t-test was conducted and the significance of the difference between the percent errors from columns 4 and 8 in Table 1 was determined. The result was the following: $t(104) = 12.35$, $p < 0.001$, which means that the difference of 4.28 produces a t-value extremely significant. This means that the illusion has greater distortion effects in the Standard illusion rather than in the right-angled one.

The type of extension outwards-inwards does not produce more outlined effects for expansion, as Warren and Bashford claimed.

The t-test supports this argument: $t(104) = 0.33$, $p < 0.05$ for the Standard illusions and $t(104) = 1.50$, $p < 0.05$ for the right-angled illusions.

In conclusion, the local effects are fully comparable in size for the inward-outward orientation, which is in disagreement with Warren and Bashford's findings.

4. DISCUSSION

The present study produced results that were consistent with the initial assumptions. Thus, for five out of six experimental conditions, the local distortion theory was correct (hypothesis one). However, there was one critical incident, because in the fifth experimental condition the value was positive, rather than negative, as it was expected.

The main hypothesis of this experiment (that the types of extension used would generate similar distortion effects) can be confirmed only partially, because the inwards extension in right angle produced opposite effects to the one in acute angle. Nevertheless, the assumption that the magnitude of these effects of distortion (error percent) of the centre was greater in conventional illusion was fully confirmed, because the bisection was facilitated when the ends of the shaft were indicated by perpendicular lines, as in the case of the right angles. The fact that there were no differences of distortion effects between the extensions outwards and inwards, indicated that the mechanism of generating distortions was similar.

There was a great agreement between the results of this study and Predebon's, because the effect of the illusion had the same intensity, regardless the type of angle. In addition, the local distortion theory was correct in five out of six experimental conditions.

The fifth condition can be considered a critical incident that requires the taking into account of other explanatory mechanisms, such as the Gestaltist model, which states that we perceive the whole before perceiving the parts and that the synthesis precedes the analysis.

Gregory's perspective theory was partially confirmed because the Standard Müller-Lyer illusion had greater effects of distortion than the one with the right-angled extensions, where the effect of perspective could not be invoked.

There are also some intriguind aspects, resulting from our experiment. Unlike the finding of Christie [10] (1992) or Predebon [8] of greater length illusion magnitudes for the obtuse-angle Müller-Lyer figures, in our research the magnitudes of the percent bisection errors for acute angle wings were similar or greater those corresponding to obtuse-angle conditions.

There are a couple of questions that remain unanswered, for example the incompatibility of the fifth condition which suggests that Eysenck and Keane might be right when affirming that in the Müller-Lyer illusion there may be more than just one explicative mechanism.

The present study clearly demonstrated the effect of synergy but leaves unsolved the problem of possible experiments with other types of extensions (circle, oval, square, complete, incomplete, angular may closed or open, etc.) or the approach in three-dimensional space, as suggested by Goldstein [4].

REFERENCES

1. Müller-Lyer, F.C., *Archiv für Anatomie & Physiologie Abteilung*, Optische-Urteilstäuschungen, 2(Suppl.), 263-270, 1889;
2. Gregory, R.L., *Eye and Brain. The Psychology of Seeing*, London, World University Library, 1966;
3. Eysenck, M.W. & Keane, M.T., *Cognitive Psychology. A Student's Handbook*, 3rd Edition, Hove, Est Sussex: Psychology Press, 1995, p. 76;
4. Goldstein, E.B., *Sensation and Perception*, Sixth Edition, Pacific Grove: Wadsworth – Thomson Learning, 2002, p. 256;
5. Gillam, B., *Illusions at century's end*, In J. Hochberg, (Ed.), Perception and cognition at century's end (95-136), San Diego, Academic Press, 1998;
6. Brigell, M., Uhlarik, J., & Goldhorn, P., *Conceptual influences on judgements of linear extent*, Journal of Experimental Psychology: Human Perception and Performance, 3, 105-118, 1977;
7. Redding, G.M., & Howley, E., *Length illusion in fractional Müller-Lyer stimuli: An object-perception approach*, Perception, 22, 819-828, 1993;
8. Predebon, J., *Framing effects in and the reversed Müller-Lyer illusion*, Perception & Psychophysics, 52, 307-314, 1992;
9. Warren, R.M., Bashford, J.A., *Müller-Lyer illusions: their origin in process facilitating object recognition*, Perception, 6, 615-626, 1977;
10. Cristie, P., *Assymetry in Müller-Lyer illusion: Artefact or genuine effect?*, Perception, 4, 453-457, 1975.

APPENDIX

The six experimental conditions and The start point screen for experiment Müller-Lyer conventional and with right angles.