Effects of the T-Junction Position and its Spatial Orientation on Perceived Length

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Abstract. Two perpendicular lines forming variations of T configuration were counter-clockwise rotated to investigate the effect of the orientation on perceived lengths. In each set of lines the dividing line could divide the other from one extreme to the other at nine positions. The task was to adjust the dividing line as to be perceived as the same size of the entire divided line. Results indicated that orientation of the configuration and the T-junction position affected systematic and interactively the perceived lengths of the lines.

Keywords: Visually Perceived Length, Horizontal-Vertical Illusion, Size Perception.

This work contributes to investigate the anisotropy found in visually perceived length mainly noticed in size illusions. A simple and well known distortion of perceived size is the horizontal-vertical illusion, which is described as a perceived length overestimation of a vertical line relative to a horizontal line of the same physical length [Coren & Girgus, (1978)]. This illusion was firstly cited in literature in the midlle of the nineteenth century, and although there are some explanations considering the shape of visual field [Künnapas, (1957), Prinzmetal & Gettleman, (1993)], retinotopic mapping [Pearce & Taylor, (1962); Pearce & Matin, (1969)], pictorial depth cues [Willians & Enns, (1996)] and even effect of brain hemispheres [Fukusima, (1997)], still unclear how all these variables interact to provide such anisotropic effect in visual perception.

Because of the horizontal-vertical illusion seems stronger as the vertical line is located at the center of the horizontal line, Künnapas (1955) pointed out that the distortion of perceived length, mainly in the upside down T configuration, is a combination of the vertical and horizontal orientation with the position of the dividing line (vertical line) at the divided one (horizontal line). He found that the error to adjust the dividing line located at the divided line from positions varying from one extreme to the other decreases linearly from the central position to the extremes of the divided line.

Another source of distortion of perceived length by itself is the orientation of a line relative to a horizontal one. This is pointed out in some works [Shipley, Nann, & Penfield, (1949); Morinaga, Noguchi & Ohishi, (1962), Pollock & Chapanis, (1952), Cormack & Cormack, (1974); Dick & Hochstein, (1988); Fukusima, (1996)], and they suggest that the horizontal-vertical illusion is a specific case in which the line is placed at 90deg inclination relative to a horizontal line. Errors of comparing lengths in the other inclinations are also very robust, mainly for obsuse angle about 120deg relative to a horizontal line.

However, an aspect of the effect of orientation in distorting perceived length, and not well explored, is the spatial orientation of the whole line configuration, keeping the T-junction of the lines always invariant. Works on effect of the rotated configuration of lines generally are done by steps of 90 deg, keeping the two perpendicular lines always in the horizontal and vertical orientation [Künnapas, (1955); Thompson and Schiffman, (1974)]. Only Avery and Day (1969) (Exp.3) pointed out that errors for adjusting the dividing line change as a function of the rotation of the configuration of two perpedicular lines in L shape. This configuration was rotated clockwise from 0 to 90deg by steps of 15deg, and he found that the error varies linearly in function of the rotated angle.

In order to explore more about the effect of the rotation of the whole line configuration and also the effect of the position of the dividing line at divided line the following experiment was planned. It considers configurations of two perpendicular lines, similar to the configurations of the horizontal-vertical illusion in which the dividing line is placed at different positions of the divided line.

Method

Participants . Ten adults (6M , 4F) from the Campus of the Universtity of São Paulo at Ribeirão Preto participated as volunteers. Their age varied from 20 to 36 year old, and all had normal binocular vision and visual accuity equal to 20/20 or above, with or without corrective lenses.

Material and Equipament. In an illuminated room a microcomputer 486DX2-50MHz, 4MbRAM, with a Diamond SpeedStar24 videoboard, 1MbVRAM, connected to a 15” NEC monitor, model 4FG, at resolution of 1024 x 768 pixels was used to generate and to present the stimuli, and to collect the data responses in this experiment. The monitor was set up at 50cm far way from the observer and the stimuli were configurations of two perpedicular lines connected to each other, (one the dividing line and the other the divided line). The lines were black, 1 pixel thick (.0286 deg), and drawn on a gray background (59.10 cd/m2). The entire length of the divided lines was 400 pixels (11.31 deg) and the length of the dividing line could vary initially from 280 to 520 pixels (7.97 and 14.57 deg respectively). The dividing line could be at one of the nine positions situated in the divided line (see Fig.1A).

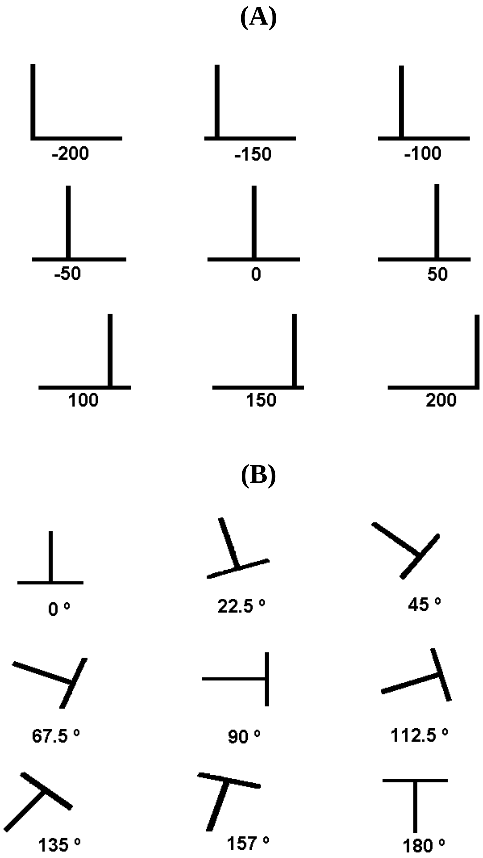


Figure 1. (A) Examples of configurations of two perpendicular lines at orientation of 0 deg in which the dividing line (vertical line) is located at nine positions in the divided line, and (B) examples of configurations in which the dividing line is at the center of the divided line and rotated counter-clockwise from 0 to 180 deg by steps of 22.5 deg.

The positions were situated from one extreme to the other and equally spaced from one to the next. Each configuration in Fig.1A was also presented rotated counter-clockwise in nine orientations, from 0 to 180deg by step of 22.5 deg. As example of this rotation, in Fig.1B is shown one of these nine orientations for rotation of the configuration where the dividing line is at the central position of the divided line.

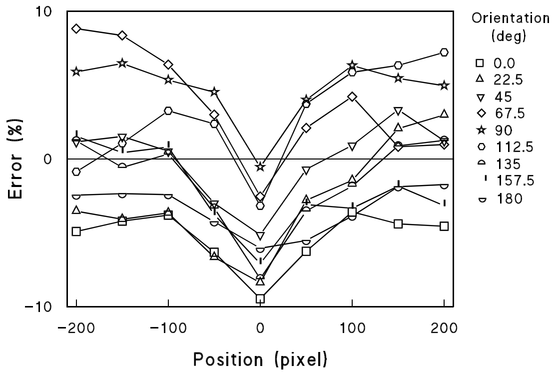
Procedure. Before starting the session, participants were instructed to run a few trials. The task was to adjust the dividing line to be perceived as the same size of the entire length of the divided line in each trial. They had to press the key “q” and “a” to increase 1 and 3 pixels respectively, or to press “e” and “d” to decrease the line length by the same steps respectively. Each combination of position and orientation was presented in 5 trials in totally random order. In each presentation the dividing line was randomly setup with an initial length that varied from 280 to 520 pixels. The relative errors to adjust the dividing line to the length of the divided line were calculated. Negative errors indicated that the dividing line was adjusted smaller than the divided line, and positive ones indicates that the dividing line was adjusted bigger than it.

Results

Relative errors were averaged in function of each combination of position and orientation for each observer, and then a two-way ANOVA for repeated measurement (9 positions x 9 orientations) was applied to the data. It indicated that there is a significant effect for position [$F(7,72)=8.83$, $p<.0001$]. As we can notice in Fig.2A this effect should be caused by the tendency of the means of relative errors for adjusting the dividing line increase from the center to the extremes of the divided line. In addition, these curves fall in three groups. The first is a group for symmetric curves for configurations rotated to 0, 45, 90, 135 and 180 deg from the initial position (0 deg). The second is a group of curves asymmetric which indicated the reduction of the superestimation of the dividing line as it is at the right side from the central position of the divided line, as shown for the rotation to 22.5 and 112.5 deg. And the third is one for asymmetric curves which indicate the reduction of the superestimation of the dividing line at the left side of the divided line, as shown for rotation to 67.5 and 157.5 deg.

The ANOVA also indicated significant effect of the orientation of the line configuration [$F(8,72)=35.93$, $p<.0001$]. This effect can be noticed in Fig.2B, in which the relative errors were plotted as a function of the orientation of the configuration. For most curves the maximun relative error trend to happen as the line configuration is rotated by 90deg, and the errors decrease toward the orientation 0 and 180deg. But they decrease asymmetrically in two ways. In one way, this decreament is almost linear from 90 to 0 deg and followed by a down inflexion near 112.5 and 135 deg from 90 to 180 deg. This had happened for configurations in which the dividing line was situated at positions -200, -150, -100, -50, 0, 50, and 100. In the other way, this decreament is almost linear from 90 to 180deg, and followed by a down inflexion at 67.5 deg from 90 to 0 deg.

(A)



(B)

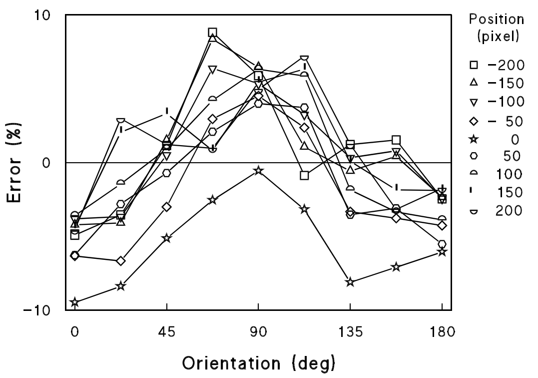


Figure 2. (A) Relative errors for adjusting the length of the dividing line to the length of the divided line in function of its position at the divided line, and (B) the same relative errors in function of the orientation of the line configuration.

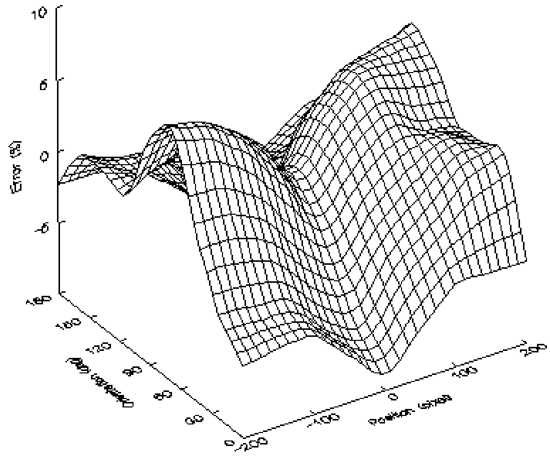


Figure 3. 3D surface of the relative errors in function of the position of the dividing line and the orientation of the line configuration.

The ANOVA also had indicated that the interaction between position and orientation was significant [$F(64,576)=3.87$, $p<.0001$]. However, this interaction was expected because of the previous analysis of the asymmetry of the curves of the relative errors as a function of the position and the orientation. In order to facilitate the visualization of this interaction, an interpolation technique for surface [McLain, (1974)] implemented in SYGRAPH program [Wilkinson, (1990)] was applied to the relative errors. This program provided the 3D surface in Fig. 3.

Discussion

The analysis showed that the T-junction position between the dividing line and the divided line, the orientation of the line configuration and the interaction between them affect perceived length sistematically.

Rotation of the line configuration counter-clockwise from 0 (dividing line vertical and upward) to 180 deg (dividing line vertical and downward) provided more evidence that there is interaction of size perception with orientation detectors, which have evidence for neural mechanism [Hubel & Wisel, (1979)]. Also it is evident that there is an asymmetry between errors if the dividing line has an inclination upward or if it has an inclination downward. A hypothesis for this asymmetry is that there is difference between processing information from upper and lower visual field [Previc (1990)]. It is supposed that a similar asymmetry involving lateral visual fields could affect the length perception too. But to check this an additional experiment to measure the error of adjusting the dividing line from orientations varying from 0 to 360deg rotation of the line configuration is required. In addition, configurations rotated by 0, 90 and 180 deg provided an analysis of the horizontal-vertical illusion in combination of the location of the dividing line similarly as done by Künnapas (1955). The results indicate that the error is maximum at the center of the divided line and decrease as the dividing line is shifted toward the extremes of the divided line, however, they partially confirm his analysis. While Kunnapas' analysis indicated linear variation of the error from the center to the extremes of the divided line, the results here did not show this linear trend, pointing out a down inflexion of the curve at positions -100 and 100. The explanation of this inflexion is unclear, but we try to work on the hypothesis that it is a genuine perceptual phenomenon. If so, the investigation about it would be worth for finding out what perceptual mechanism is involved. At first glance, it seems that the T-junction position of two lines and its orientation are important visual features that have a role in length perception; such as they have in some theories for shape and object perception [Biederman, (1987)].

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