BRIEF EXPOSURE OF PICTORIAL DEPTH CUES AFFECTS PERCEIVED SIZES

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Abstract

We investigated whether perceived sizes of stimuli presented on the central vertical meridian of the visual field are modulated as pictorial depth cues are briefly exposed. In one experiment observers indicated which of two bars was bigger as they were presented for 100ms on background without depth cues (control condition); with the horizon line only; with perspective line gradient, and with horizon and perspective line gradient. In the other experiment observers compared the size of two circles presented for 150ms on a background without depth cue, with perspective line gradient and with chessboard in depth. Results of both experiments indicated that pictorial depth cues biased perceived sizes, suggesting that the visual processing of depth cues and its interaction with size perception occur very fast.

The visual system enables us to conduct estimates of size and distance from objects in our space. Size and distance are closely related because the retinal image is inversely proportional to the distance of an object. This relationship is not as straightforward and unambiguous as it may seem. When there is some kind of visual limitation, e.g., in monocular visual condition, visual system needs a cognitive mediation, drawing on the relationship between size and distance to forge a more accurate space perception.

Thus, it is possible to investigate the processes involved in size perception with pictorial depth cues, like the horizon and texture gradients. Aks and Enns (1996) indicated that perspective depth cue is more reliable and is processed faster than other depth cues.

Evidence from psychophysical (Sperandio, Savazzi, Gregory and Marzi, 2009) and neurophysiological (Murray, Boyaci and Kersten, 2006) researches indicate a quite fast time to process relative size. Nevertheless, little is still known about how time presentation of depth cues affects visual size perception.

Experiment 1

In the first experiment we examined the influence of two depth cues (perspective lines and horizon) showed briefly on size perception.

Method

24 students from the University of São Paulo (USP) participated in this experiment. The observer, with the left eye blindfolded, judged which of two vertical bars was perceived as being longer. These bars were presented simultaneously for 100 ms with four different background conditions: (1) without depth cues - C, (2) horizon - H, (3) perspective - P and (4) perspective with horizon - P+H. The participants were randomly assigned to one of these four experimental groups. The stimuli were presented by a constant method stimuli associated with

a two forced choice alternatives. There were a standard stimulus (St) of constant size in all trials and a comparison stimulus (Cs), whose size could take 11 different values (from 85% to 115% compared to the standard). There were two different blocks according to Cs position: first it was presented above fixation point (upper visual field – UVF) and second below it (lower visual field – LVF). Thus, it was presented to participants a total of 22 pairs of stimuli, 30 repetitions of each, randomly distributed and equally divided in two sessions. For each participant, two psychometric functions of size comparisons were measured based on Cs position. From these, the points of subjective equality (PSE) were calculated and submitted to an ANOVA.

Results and Discussion

In both Cs positions, the ANOVA revealed that the background condition were significant [$F(3,20)=7.035$, $p=0.002$ for Cs in LVF and $F(3,20)=12.154$, $p<0.001$ for Cs in UVF)]. In order to verify which background condition was responsible for this main effect, *post hoc* tests were performed. Hence, it was revealed that there were significant differences among perspective gradient with horizon and the others conditions: control ($p <0.001$, for Cs in LVF and $p = 0.005$, for Cs in UVF), the horizon ($p = 0.002$, for Cs in LVF and $p = 0.010$, for Cs in UVF) and the perspective ($p = 0.006$, for Cs in LVF and $p = 0.009$, for Cs in UVF). The PSE means and the standard errors are showed in the Figure 1.

Note that size distortions in trials conducted under the same background conditions are similar, regardless of the Cs position. And horizon is a pictorial depth cue that affects relative size (Rogers 1996; Torro-Alves and Fukusima 2005), as effective as the perspective lines. Beside this, larger size distortions were observed when both depth cues were showed together.

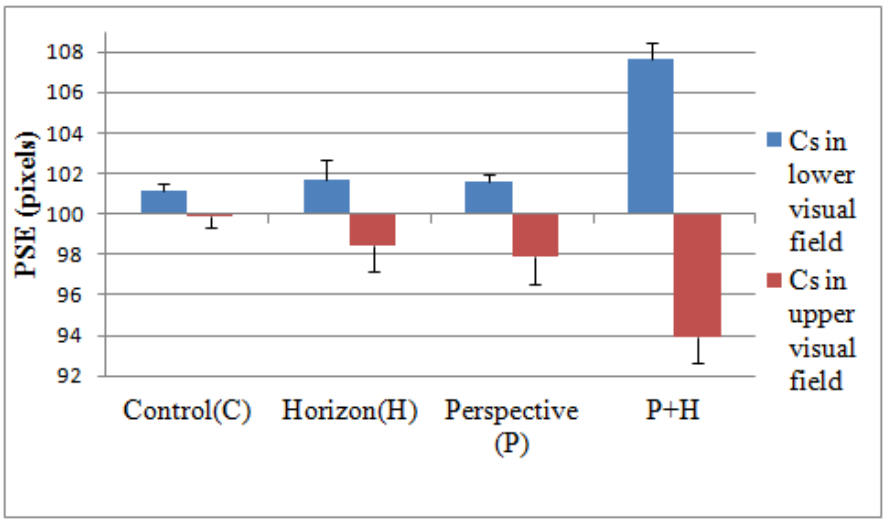

Fig. 1. Points of subjective equality (PSE) means for comparisons made with comparison stimulus (Cs) at the lower and the upper visual field. The standard stimulus (St) had a constant size (100 pixels). PSE greater than 100 indicate that the Cs was underestimated and PSE less than 100 indicate the Cs overestimation. Error bars refer to the mean standard error.

Experiment 2

It was show in experiment 1 that depth cues was effectively to inform distance, even in a short. It happened especially when perspective lines gradient and horizon were showed together. Thus, experiment 2 was designed to verify if this process is fast for a more complex background, e.g., texture gradient (chessboard in depth).

Method

30 students from the University of São Paulo (USP) were randomly assigned to one of three experimental groups. Two circles were presented simultaneously for 150 ms with the following background conditions: (1) without depth cues, (2) perspective and (3) chessboard in depth. The method was the same used in Experiment 1, the only difference was that the Cs was always presented at upper visual field. Subjects judged which of two circles was perceived as being bigger. Therefore, just one psychometric function was measured for each observer.

Results and Discussion

The ANOVA showed differences among background conditions [$F(2,27) = 8.520$, $p= 0.001$]. Through *post hoc* tests, it was found significant difference between chessboard in depth and control ($p=0.002$) and chessboard in depth and perspective ($p=0.017$). We can observe that the size distortions in the control (without depth cues) and perspective lines conditions were similar to those in the first experiment. On the other hand, like perspective lines and horizon conditions presented together, the chessboard in depth resulted in larger size distortions. It seems that even a more complex background do not requires additional time to be processed and also affect size comparisons in the same manner.

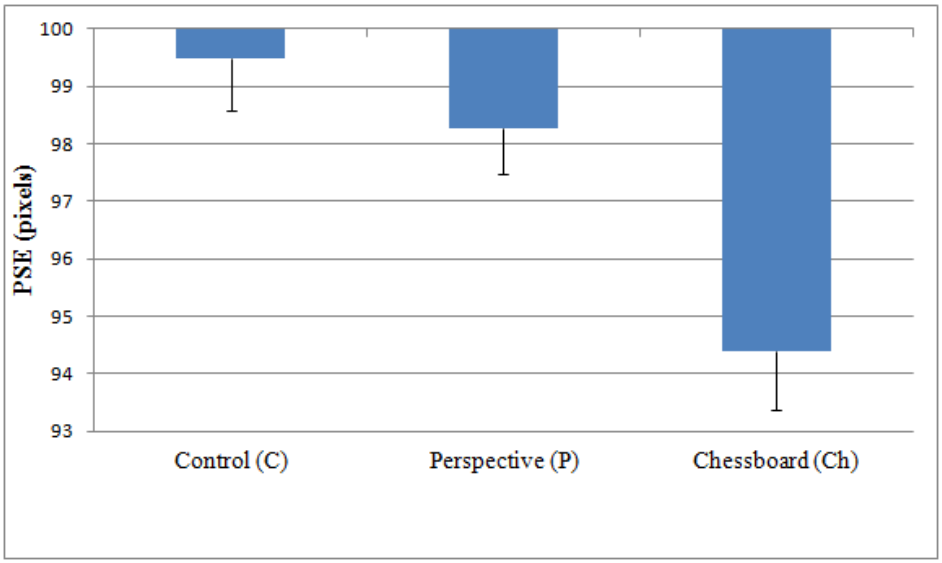

Fig. 2. Points of subjective equality (PSE) means for comparisons made with comparison stimulus (Cs) in the upper visual. The standard stimulus (St) had a constant size (100 pixels). PSE less than 100 indicate the Cs overestimation. Error bars refer to the mean standard error.

General Discussion

These findings demonstrated that the representation of size, taking distance into account provided by different depth cues, occurs even before 150 ms (Champion and Warren, 2008), i. e., depth cues integration occurs suddenly in brain processing. These are consistent with neurophysiological studies that also showed a similar exposure time to size scaling, ranging between 80 and 120 ms (DiLollo, Enns and Resink, 2000; Tong 2003). Results of these two experiments indicated that pictorial depth cues altered the perceived size, suggesting that visual processing of depth cues and its interaction with size perception occur very quickly.

Acknowledgements

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