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UM INVARIANTE NO CONTROLE DA PERCEPÇÃO E AÇÃO EM TAREFAS DE BISSECÇÃO.

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Resumo: Diversos estudos empregando ações visualmente dirigidas como indicadores da distância percebida demonstraram que as pessoas podem caminhar acuradamente para alvos distantes em até 22m. Estes resultados, somados aos relacionados com medidas perceptuais de distância percebida, demonstram que estas respostas são controladas por uma única variável interna, denominada de localização visualmente percebida. No presente estudo, comparamos os desempenhos em tarefas de bissecção, realizadas por caminhada visualmente dirigida, ou por emparelhamento perceptual. Os observadores (N=20) caminharam ou ajustaram a posição de uma ponteira ao ponto médio da distância egocêntrica de um alvo (5, 10 or 15m), sob observação binocular. Os resultados indicaram acurácia em ambas respostas, sem diferenças significativas entre elas, o que sustenta a hipótese de uma única variável interna controlando ação e percepção. Este invariante pode ser determinado por um conjunto ponderado de fontes de informação.

Palavras-chave: Percepção espacial, percepção visual, sistemas de percepção-ação, bissecção, locomoção

PERCEPTION-ACTION INTERACTION AND BISSECTION

Abstract: Several studies using visually directed actions as indicators of perceived distance showed that people could accurately walk toward targets far up to 22m. Those results, summed up to those related to perceptual measures of perceived distance, showed that those responses were controlled by a single internal variable, namely visually perceived location. In the present study, we compared performance in bisection tasks, performed by open-loop walking or by perceptual matching. Observers (N=20) walked toward or adjust a pointer to the mean point of an egocentric distance (5, 10 or 15m), under binocular viewing. Results indicated accuracy on both responses, with no reliable differences between them, supporting the hypothesis of a single internal variable controlling action and perception. This invariant may be determined by a weighted set of sources of information.

Key-words: Space perception, visual perception, perception-action systems, bisection, locomotion

Visually directed action has been seriously investigated for the past 20 years. However, findings had not been completely unequivocal. Data showing accuracy in visually directed actions, such as walking (Fukusima, Loomis, & Da Silva, 1997; Loomis, Da Silva; Fujita & Fukusima,1992; Philbeck & Loomis, 1997; Rieser, Ashmead, Talor, & Youngquist, 1990; Thomson, 1983, 1980), throwing (Thomson, 1983), or pointing (Foley & Held, 1972; Fukusima, et al., 1997) were not in agreement with other studies that presented systematic errors on walking tasks (Elliott, 1986, 1987; Matsushima, Gomes, Ribeiro-Filho, & Da Silva, 2001; Steenhuis & Goodale, 1988) and on throwing (Eby, & Loomis, 1987). Despite this controversy, the general finding was an adequate performance for providing adapted behaviors to environmental conditions. The main issue of the

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present investigation was related to the essential processing of visual information for an adequate performance in visually directed walkings. Loomis and associates (1992) described hypothetical constituent subprocesses to accomplishment of this kind of tasks: a) visual perception of target location; b) updating of current self-position based on integration of perceived self-velocity; c) imaginal updating of target location based on updated self-position; and d) executing the response to updated target position. Errors in any of these subprocesses will lead to decrements in performance. Consider a common finding in visual space perception, that the more reduced was availability and reliability of sources of information provided by a scene, the poorer will be performance on any task toward this scene. Thus, if the first subprocess, visual perception of target location, was changed to impoverished perceptual information, such as an imagined location relative to a landmark, it would impose an equally impoverished performance on any task to this scene.

Philbeck and Loomis (1997) proposed a theoretical schema to describe the relationship between sources of information and visually directed tasks. In this schema, a single internal variable, perceived distance (lately named as visually perceived location), controls visual distance perception, as assessed by perceptual tasks, such as verbal reports, and by motoric tasks, such as visually directed tasks. Evidence favoring this schema was a tight covariation of responses under those two types of tasks as cue availability varied. Results from other studies comparing the two types of tasks also provided evidence for this covariation (Matsushima, et al., 2001).

Thus, the main experimental issue can be translated into a question. Is there the need for a visually assessed object to produce an accurate open-loop walking (visually directed walking) or one could accurately walk to imagined points in space in relation to landmarks? There are some evidences for the second statement. Matsushima and associates (2001) showed that open-loop walkings toward viewed or imagined targets did not produce reliable differences. However, responses toward perceived or imagined points were all biased toward a single distance from the obstacle, about one meter from it. It seems that the imposed task, a type of collision avoidance task, led observers to employ a safe strategy, maintaining a one-meter-distance from the obstacle. Another study (Rieser, Guth, & Hill, 1986) showed that adults could imagine changes in relative positions of elements of a complex layout caused by displacement to a new viewpoint, without any physical displacement as well as with displacement to the new viewpoint.

In order to avoid task characteristics that biased Matsushima and colleagues' (2001) investigation, we compared perceptual and motoric responses to egocentric distance by means of a bisection task. Observers must walk toward an imagined point that is not close to obstacle, therefore they would not need to employ a safe strategy. Results from bisection tasks were not unequivocal as well as from visually directed tasks. Da Silva (1982) found exponents smaller than one for bisection tasks under objective instructions. Thus, distances in near space will be less underestimated than distances in far space. Rogers and Gogel (1975) found for bisection tasks perceptual constancy (exponents equal to 1.0) when observers received apparent instructions and overconstancy (exponents larger than 1.0), for objective instructions. Purdy and Gibson (1955), and Cook (1978) found perceptual constancy for fractionation tasks. Possibly those differences were related to differences in methodological features, such as instructions (apparent x objective), range of distances, and viewing conditions (Da Silva, 1982). So, no predictable outcome could be extracted from those results.

Method

Observers. 40 undergraduates and technicians, aged from 18 to 34 years old (median 21 years), participated of this study, ten observers in each level of between-subjects factors, balanced for gender. All participants were naïve about the subject of the study, had 6/6 minimum visual acuity, corrected or not, and were paid by the end of tasks.

Experimental Environment. Targets were placed at 5.0, 10.0 and 15.0m from observation point, on a 30.0m section of an asphalted street, 5.0m width, without obstacles and floor marks, as depicted in Figure 1.

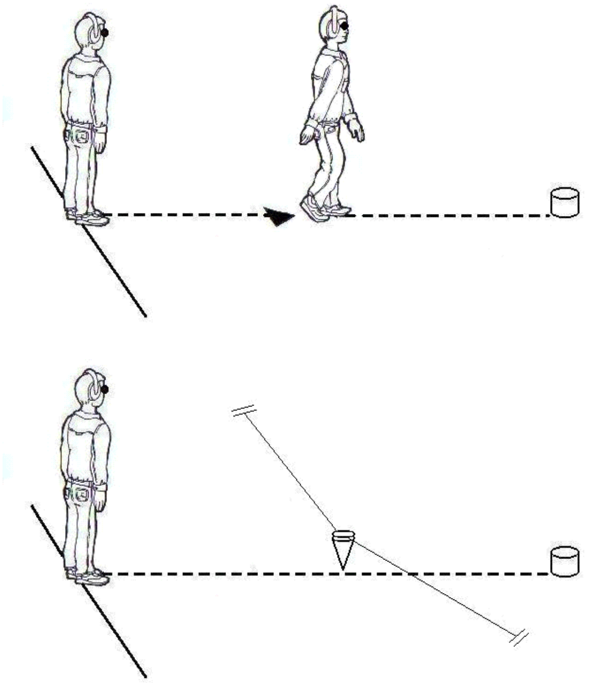

Figure 1. Representation of experimental environment. Upper panel - bisection task by open-loop walking (motoric bisection). Lower panel - bisection task by adjustment of probe location (perceptual bisection).

Stimuli and Apparatus. A yellow cylinder, 10.2cm diameter x 10.2cm height, was the target. An inverted cone, 3.6cm diameter x 11.0cm height, hung by transparent nylon wires was the probe. Monocular and binocular masks produced viewing conditions.

Design. We used a factorial design with two between-subjects factors, 2 Tasks (bisection by probe location adjustment – from now on, perceptual bisection – and bisection by open-loop walking – from now on, motoric bisection) X 2 Viewing Conditions (monocular and binocular), and with two within-subjects factors, 3 Trials x 3 Target Distances (5.0, 10.0, and 15.0m), with Cartesian coordinates of produced egocentric distances as dependent variable. The presentation order was randomized within trials.

Procedure. After visual acuity and eye dominant tests, observers were led to experimental environment, where they received objective instructions ("as measured by a tape measure"). Instructions for perceptual bisection asked observers to warn assistants that were moving the probe when it arrived at the midpoint of the target distance. Observers were allowed to correct probe position until it appeared at the correct position. The probe was moved in ascending (from observer to target) and descending (from target to observer) directions (data analysis showed no reliable differences between directions).

Instructions for motoric bisection asked observers to blind walk toward the midpoint of the previously seen target distance. They carefully observed the target position imagining the midpoint of target distance, covered their eyes with the mask, and then walked toward the imagined midpoint, indicating it by a ankle stroke and some verbal signal.

In perceptual bisection, after adjustments in both directions, observers must kept their eyes covered by masks during distance measurements and preparations for the following trial. In motoric bisection, after each walking, observers were led to a random location in experimental field where they remained seated during distance measurements and preparations for the following trial. Cartesian coordinates were measured by a method of triangulation.

Results and Discussion

Centroids calculated from individual Cartesian coordinates are depicted in Figure 2, with their respective standard deviations, in meters. The centroid was the separate mean of the three x- and y-coordinates produced for each distance. Mean absolute errors of distances produced are summarized in Figure 3, with their respective standard deviations, in meters. We applied two different statistics to these different parameters, a MANOVA (2 tasks x 2 viewing conditions x 3 target distances x 3 trials) over individual Cartesian coordinates, and an ANOVA, in the same design, over individual absolute errors.

We used the Hotelling's T^2 from MANOVA, because it is an F-like ratio which analyze simultaneously both coordinates taking into account their covariance (Philbeck, et al., 1997). Analysis of Cartesian coordinates revealed reliable difference for main factors, Task, [$F(2, 29) = 5.091$, $p < .05$], and Target Distance, [$F(4, 27) = 333.758$, $p < .05$].

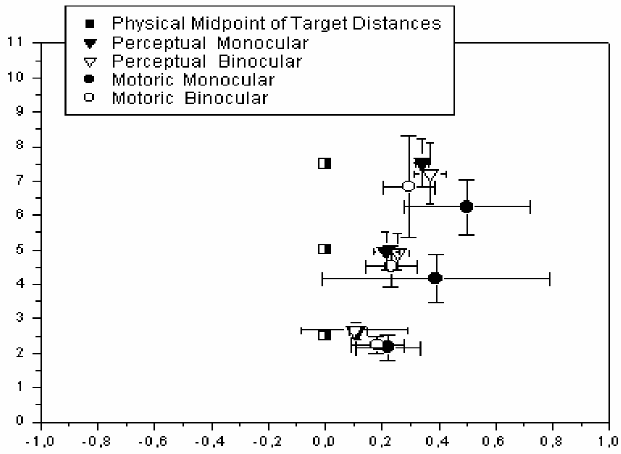

Figure 2. Mean centroids and standard deviations on x- and y-coordinates, in meters. Squares represent physical midpoints of egocentric distances. Triangles represent centroids produced in perceptual bisection, and circles, in motoric bisection. Filled symbols represent centroids produced under monocular viewing, open symbols, under binocular viewing. Larger caps represent standard deviations of centroids produced in motoric bisection.

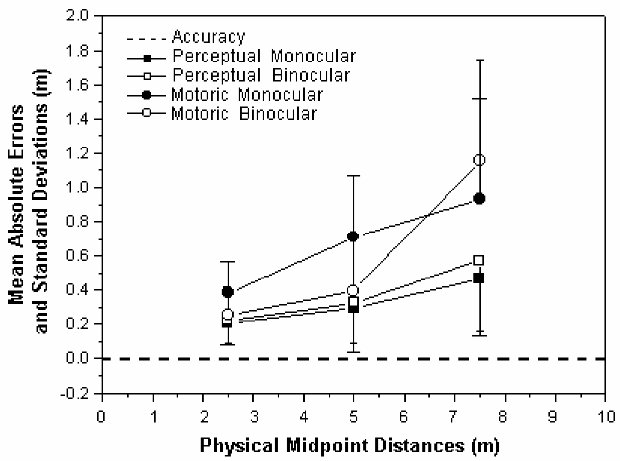

Figure 3. Mean absolute errors of produced distances and standard deviations as a function of physical egocentric distances of midpoint, in meters. Squares represent centroids produced in perceptual bisection, and circles, in motoric bisection. Filled symbols represent centroids produced under monocular viewing, open symbols, under binocular viewing. Dotted line represents accuracy line. Larger caps represent standard deviations of centroids produced in motoric bisection. Deviation bars are depicted in a single direction for improving readability.

Analysis of absolute errors revealed reliable differences for main factors, Task, [$F(1, 36) = 16.779$, $p < .05$], and for Target Distance, $F(2, 72) = 51.946$, $p < .05$], and for interaction Task X Target Distance, [$F(2, 72) = 8.636$, $p < .05$]. Those differences between tasks could be observed in Figures 2 and 3. Motoric bisections were slightly more compressed than perceptual bisections and had larger absolute errors.

Inspecting Figure 3, one may observe that motoric bisection responses presented an interesting pattern. Motoric bisections under monocular viewing presented a monotonically increase in errors as a function of target distance. This pattern is consistent with increasing perceptual errors as a function of decreasing availability and reliability of visual cues with increasing egocentric distance (Cutting & Vishton, 1995; Künnapas, 1968). However, motoric bisections under binocular viewing up to 10m of target distance presented a performance that was similar perceptual bisections. After this, the performance dropped until reaching monocular motoric bisection errors. This breakdown in performance may indicate ceasing or critical decreasing in effectiveness of a binocular source of information or another source of information that resented the absence of a binocular ancillary cue. A possible source of information responsible for this effect was angular declination (Loomis, 2001; Ooi, Wu, & He, 2001; Philbeck & Loomis, 1997). There was some evidence that this source of information is dependent on binocular information to provide useful information for egocentric distance perception (Matsushima, et al., 2001).

Do these differences between motoric and perceptual bisections represent dissociation in perceptual and action systems? We do not agree with this. Further analysis on data by a Pearson product-moment correlation between mean perceptual and motoric bisections was .896. This indicated that there is a one-to-one mapping between perceptual and motoric responses. This finding corroborated the assumption of a shared internal constraint, controlling perceptual and motoric responses. This internal variable must be visually perceived location, as proposed by Philbeck and Loomis (1997).

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