INTRODUCTION

Humans and animals alike possess capacity for path integration. This capacity allows them to navigate the world around them by perceiving how their body is moving relative to the environment [1]. Path integration can underwrite basic adaptive behaviors such as foraging for food and the capacity to return to one’s home location.

Path integration is based upon the use of sensory information to perceive the angles turned and distances traversed by the body as it moves through the world [1]. Perception of the distances traveled during navigation is known to depend upon sources of visual and non-visual information. Non-visual information has been shown to principally rely upon information derived from the movements of the limbs during locomotion (i.e. kinesthetic perception)[2]. In the absence of visible landmarks, vision and kinesthetic perception have been shown to have an approximately equal impact on human path integration [3].

Investigations of kinesthetic distance perception have shown that perception of distance traveled while blindfolded depends upon the way in which the legs are coordinated [2]. In this research, manipulating the gait patterns employed by participants across the outbound and return phases of a simple homing task was found to result in systematic biases in task performance. The two principal gait patterns employed in this research were a walk and a gallop-walk. The gallop-walk involves stepping forward with the right foot, bringing the feet together to parallel, and then repeating this process. While performing a simple homing task, participants who used a gallop-walk as the outbound gait in the homing task, followed by walking in the return phase of the homing task, produced a systematic underestimation bias. Alternatively, either walking or running outbound followed by walking in the return phase produced no bias [1].

We hypothesized that visual information specifying distance traveled, unlike kinesthetic information for distance traveled, would not depend upon the gait patterns used by participants to complete the task.

METHODS

Eleven subjects, who are healthy individuals between the ages of 19 and 36, were recruited. Participants performed variants of a simple distance matching task consisting of a study phase and a test phase. In the study phase participants either walked or gallop-walked a set distance, and were instructed to get a sense of the distance they had traversed. In the test phase participants were asked to reproduce the studied distance from the study phase by walking a matching distance.

The potential contribution of kinesthetic and visual information in the distance matching task was investigated by manipulating the distances traversed in the study phase (6.5, 13, or 19.5m), the gait pattern employed in the study phase (walk, gallop-walk), and the availability of visual information in both study and test phases (complete blindfold, partial blindfold). The complete blindfold occluded all vision. The partial blindfold, similar to a visor, allowed the subjects to see only the immediate ground surface in front of them (about 2m). The partial blindfold prevented the subjects from getting any distance cues from visual landmarks. Experimental trials consisted of randomly presented combinations of the 3 independent variables (2
vision x 3 study phase distances x 2 study phase gait patterns).

On each experimental trial subjects put the blindfold on. They were instructed which gait pattern to employ in the study phase, which was either a walk or a gallop-walk. Participants then walked or gallop-walked a straight-line path until instructed to stop by the experimenter. While leaving the same blindfold on, subjects were then given instructions to walk a matching distance to that traversed in the study phase by continuing to walk in the same direction until they perceived a matching distance had been traversed.

RESULTS and DISCUSSION

A systematic bias in reports was observed as a function of manipulating the study phase gait $(F(1,10) = 26.91, p < 0.001)$. Although a main effect of vision was observed in the distance-matching task $(F(1,10) = 15.00, p < 0.01)$, the presence or absence of vision did not diminish the systematic bias resulting from the manipulation of study phase gait patterns $(Fs<1)$. These results are not consistent with our original hypothesis that the availability of visual information across the study and test phases would attenuate the bias resulting from manipulating study phase gait patterns.

CONCLUSIONS

In attempting to interpret these findings, we noted particular characteristics of the results we obtained. We observed that the magnitude of bias resulting from manipulation of the study phase gait was significantly greater than what has previously been observed in the investigation of kinesthetic homing tasks [2]. Additionally, a general bias towards underestimation of all distances was observed in our data that again is not observed in previous studies. Given these differences, a possible interpretation of our results is that participants in our experiment did not perceive distance in the same way as in previous homing task research. One possibility is that their reports may be biased by other variables such as effort. Effort is known to affect distance perception in some task contexts but not others [4]. Specifically, this research shows that effort affects attempts to reproduce the distance traveled along a recently traveled route (i.e. a distance matching task), but does not affect the ability to return to a fixed location in the environment (i.e. a homing task). In light of recently observed differences in the cost of transport for walking and gallop-walking [5], our results are consistent with the participants matching the following relation [6]:

$$\text{Study} \left( \frac{\text{Metabolic Effort}}{\text{Specified Distance}} \right) = \text{Test} \left( \frac{\text{Metabolic Effort}}{\text{Specified Distance}} \right)$$

We are planning to run a second experiment identical in design to our first experiment with the exception that participants will be asked to perform a homing task rather than a distance matching task.

REFERENCES


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