THE INTERACTION OF FOCUSED ATTENTION WITH FLOW-FIELD SENSITIVITY

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ABSTRACT

Two studies were performed to determine whether a subject's response to naturalistic optical flow specifying egomotion would be affected by a concurrent attention task. In the first study subjects stood in a 'moving room' in which various areas of the optical flow generated by room movement were visible. Subjects responded to room motion with strong compensatory sway when the entire room was visible. When the side walls of the room were completely obscured by stationary screens, leaving only the front wall visible, sway was significantly reduced, though it remained greater than in an eyes-closed control. In Exp. 2 subjects were presented with either the full room (large sway response) or the room with only the front wall visible (moderate response), each in combination with either a hard or easy verbal addition task. Preliminary results show that swaying in the fully visible room and in the room with only the front wall visible increased when combined with either the hard or easy tasks. These preliminary results suggest that at the least the pick-up of optical flow specifying egomotion is not affected by concurrent attentional activity, supporting the notion of dual visual systems, and of the direct, non-attentional nature of the pick-up of optical flow.

INTRODUCTION

In recent years a growing amount of work has investigated the role of optical information in the control of both postural stability and guidance of actions, such as standing, running, and flying. Generally these studies have dealt with automatic pick-up of flow information, and have tacitly assumed that active attentional processes are unimportant in these areas. In fact the role of active, exploratory attentional pick-up during egomotion has hardly been addressed at all. One of the few studies related to this issue was carried out by Fischer, Haines and Price (1981) who investigated pilots performance in simulators with Head-Up Display (HUD) instrumentation. The tasks involved this study were quite complex, and while subjects typically showed no decrement in simulator performance while reading HUD, there were some cases in which flight-critical information went completely undetected. The present paper reports the results of the first two experiments in a series devoted to the basic question "What is the role of attention during locomotion?" To what extent, if any, must we actively attend to the optical information accompanying motion in order to successfully get around? Can we pick up information for our own motion through the environment while at the same time attending to some task?

For an initial look at this issue it was decided to use a situation for which something is already known about the usefulness of optical flow. In a series of experiments with the well-known 'swinging room' Lee (Lee & Lishman 1975, Lee & Aronson, 1974) has shown that large scale optical flow is naturally used in the control of standing posture. Subjects in the swinging room sway in response to exclusively optical room motion; the effect is robust, and the sensation of egomotion very compelling. Such a paradigm could easily be augmented by a variety of attention tasks.

If attention does have an effect on concurrent pick-up of flow field information, we would expect that such effects would be to some extent a function of the difficulty of the attention task. Similarly, a given level of attention task difficulty could have differential effects on the use of flow information depending on the ease with which the latter could be picked up; pick-up of restricted or otherwise impoverished flow could be less efficient while active attention was being used than otherwise. Experiment 1 sought to determine conditions under which optical flow specifying egomotion might be rendered less effective in controling posture.

EXPERIMENT 1

Method A moving room was constructed for use in these experiments. The 'room' is a large cubical box, 2.5m on a side, mounted on four wheels such that it can be rolled along the floor. The walls have reinforced wooden frames, faced on the inside with rigid cardboard, which is itself covered with a semi-random visual texture. The room has no floor, such that a subject inside it stands on the floor of the laboratory as the room moves around them. One wall of the room is left open; subjects stand with their backs to this open wall, facing into the room.

Postural adjustments in response to room motion were registered by a potentiometer. A grooved wheel was fixed to the axle of the potentiometer, and a string passed over the wheel and around the subject's neck, such that anterior/posterior movements caused the wheel to turn, generating a position-specific voltage which could be recorded. A second potentiometer registered motion of the room; data from the two could be correlated as time series to determine the effect of room motion on stance.

Stationary cardboard screens could be placed in the room in order to restrict the optical motion available to subjects. The screens could be placed so as to occlude the three vertical walls of the room. Subjects wore a hat with a wide bill which prevented their seeing the ceiling.

The room was moved sinusoidally along an axis parallel with the subject's line of sight. The total magnitude of the movements was 2.5cm, with a period of 12 seconds per cycle. Each one minute trial consisted of a continuous series of five of these cycles. Subjects were instructed to look straight ahead, keeping their gaze within a small square outlined on the front wall. They were not given any task to do, and were not informed about room movements in advance, but were simply told to stand still and look at the wall.

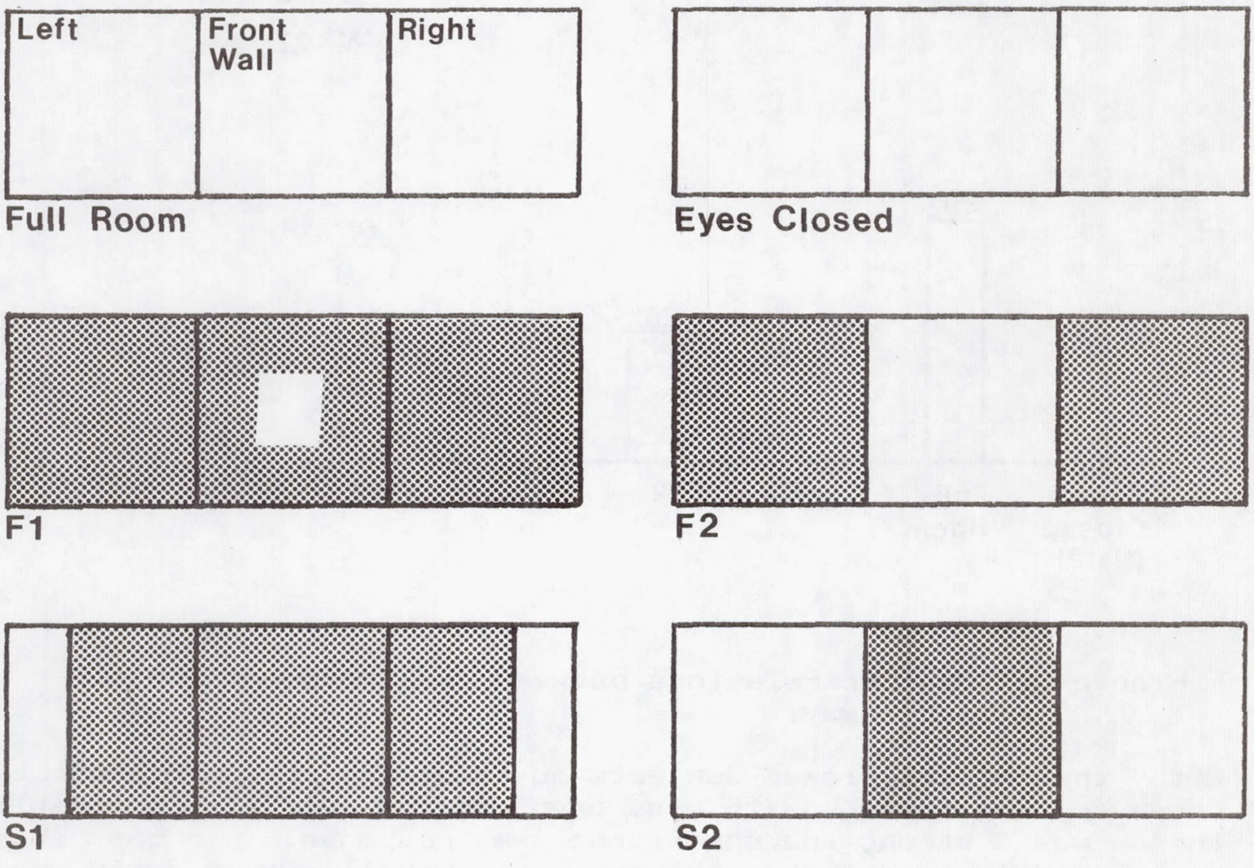

Figure 1. Experimental conditions. Dotted areas were blocked by stationary screens. The ceiling was always blocked. The floor was visible but did not move.

Conditions Conditions are illustrated schematically in figure 1. The Full Room condition served as a baseline to establish the magnitude of the basic sway response. In the control condition subjects stood as normal in the room, but kept their eyes closed throughout the trial. In the four experimental conditions the side and front walls of the room were blocked off by the stationary cardboard screens, leaving flow available to either the retinal center or periphery. Each of 27 subjects participated in the five experimental conditions, and 12 of these also were in the eyes closed control.

Results The data shown in figure 2 are the mean correlations (across subjects) between room motion and subject motion for each condition.

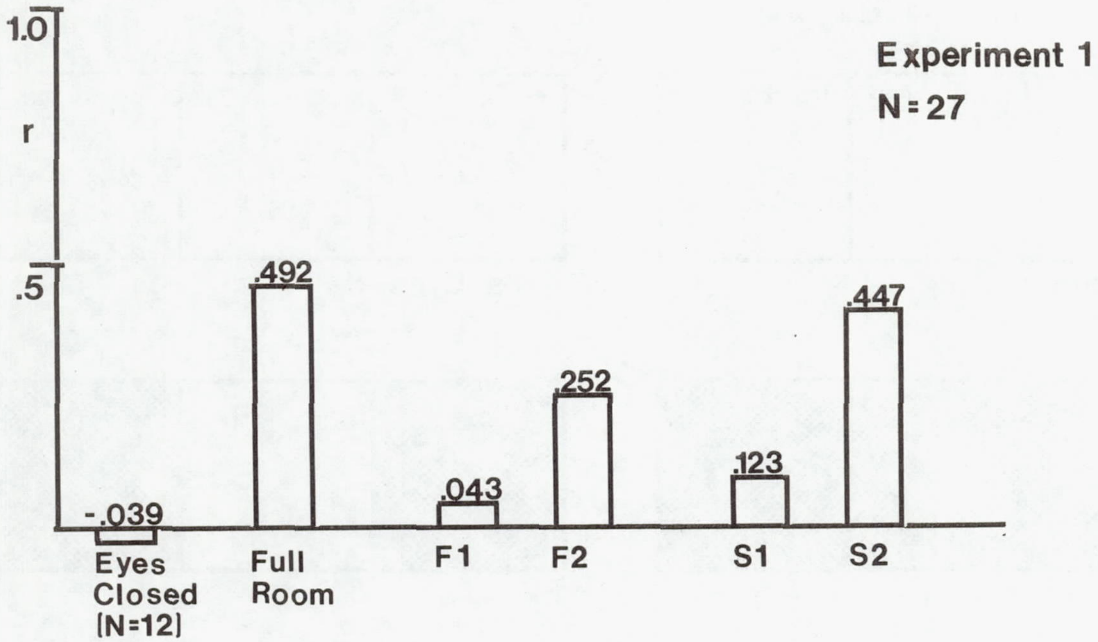

Figure 2. Mean correlations between room movement and subject sway.

With their eyes closed subjects movements were unrelated to those of the room. With eyes open and the entire room visible there was a strong and consistent sway response. In the four experimental conditions the greatest overall sway came in response to the larger peripheral exposure, such that for this condition subjects swayed nearly as much as when the whole room was visible. By contrast, the larger front wall exposure produced only half as much sway as its peripheral counterpart, and significantly less than the full room. Neither of the smaller exposures produced any more sway than in the eyes closed control.

<u>Discussion</u> Experiment 1 showed that by limiting optical flow to the front wall of the experimental room (and thereby blocking off flow from the far retinal periphery), compensatory sway could be significantly reduced, though the larger front wall exposure still produced significantly more sway than the eyes closed control. These results suggest a peripheral dominance for the pick-up of flow information for postural stability, and are consistent with the findings of Brandt, Dichgans and Koening (1973), who found a similar peripheral dominance for sensations of egomotion induced by rotatory optical stimulation. With respect to the goals of this project, the major result is the finding that exposing the entire front wall of the room results in a significant but reduced sway response; the difference between Full Room and Front Wall conditions could be used in the next experiment.

EXPERIMENT 2

The second experiment combined the two levels of sway response established in experiment 1 with two levels of difficulty in a verbal addition task as a preliminary test of the interaction between attention and flow pick-up. Subjects were presented with both the full room and with the room with the side walls completely occluded by the stationary screens. Each of these exposures was paired with both the hard and easy verbal tasks. In the easy task the subject was presented with a three digit number at the beginning of a trial, which they would increment by 2 continuously over the course of the trial, announcing the sums in time with the beating of a metronome (50 beats/minute). The hard task was identical, except that subjects added 3 instead of two. Nine subjects were run.

<u>Results</u> Since this was a preliminary study only sway data were analyzed; task performance as a function of flow exposures will be evaluated in future studies. Results are presented in figure 3. As can be seen from the figure, the addition of either the hard or the easy task produced no decrement in sway in either full room or front wall conditions. On the contrary, the presence of either of the verbal tasks produced an <u>increase</u> in induced sway. Multiple comparisons done with the Tukey test showed no significant differences between the full room by itself and in combination with either of the tasks, or between the partially blocked room by itself and in combination with either of the tasks.

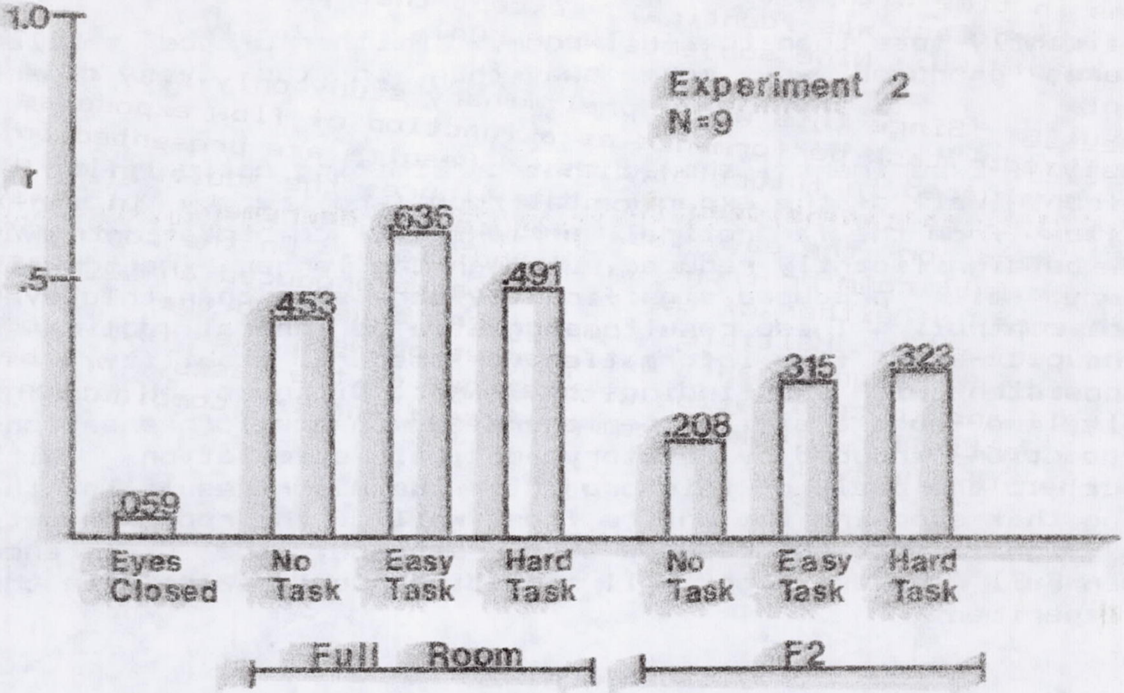

Figure 3. Mean correlations between room movement and subject sway.

<u>Discussion</u> These results, though preliminary, indicate that in the present experiment the presence of an ongoing attention task did not diminish adaptive responding to large scale optical flow specifying egomotion. This is consistent with the notion that optical information used for maintaining postural stability is picked up 'automatically'. The suggestion in these data that a concurrent verbal task may increase sway would be more difficult to interpret.

Future studies in this series will again investigate the effects of attention tasks on response to visual motion, but also the reverse; the effects, if any, of flow pick-up on performance of an attention task. They will also examine the interaction of flow pick-up with visual attention tasks (such as might be found in flight situations), and will extend the requirements on flow pick-up by having subjects execute an active movement task which is dependent on the pick-up of flow information.

REFERENCES

Brandt, T., Dichgans, J. and Koenig, E., "Differential Effects of Central Versus Peripheral Vision on Egocentric and Exocentric Motion Perception", 1973, Experimental Brain Research, 16, 476-491.

Fischer, E., Haines, R. and Price, T., "Cognitive Issues in Head-Up Displays", 1980, NASA Technical Paper 1711.

Lee, D. and Aronson, E., "Visual Proprioceptive Control of Standing in Human Infants", 1974, Perception and Psychophysics, 15(3), 529-532.

Lee, D. and Lishman, R., "Visual Proprioceptive Control of Stance", 1975, Journal of Human Movement Studies, 1, 87-95.