Behavioural Realism as a metric of Presence

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Summary

- **Direct Subjective Assessment of Presence is potentially unstable - dependent on prior experience and task demands due to observers not having firm understanding of construct (Freeman, Avons, Pearson, & IJsselsteijn, 1998, submitted).**
- **Objective measures of Behavioural Realism provide a potential solution to this problem, as suggested by Slater and Wilbur (1997).**
- **Reflexive responses are likely to prove the most reliable of these objective measures. Postural Sway is one such measure.**
- **Following Lee and Lishman (1975) we have made video stimuli of a simulated swinging room and have manipulated display conditions (monoscopic and stereoscopic) and magnitude of camera swing.**
- **A preliminary experiment designed to evaluate the effects of viewing condition on postural sway is reported here**
- **Work is currently in progress to evaluate the effects of viewing condition on postural sway with a view to corroborating subjective scales of presence and constructs related to presence that are currently under development.**

Introduction We have recently demonstrated that prior experience and task demands can affect direct subjective ratings of *presence* (Freeman, Avons, Pearson and IJsselsteijn, 1998, submitted). This effect was in part attributed to observers having a limited comprehension of the presence construct. Objective measures of the behavioural realism elicited by a displayed environment offer a solution to this problem. The link we draw between behavioural measures, which may range from simple reflex responses to complex interactions between observers and the environments with which they are presented, and presence is based on the premise that when observers are presented with environments or displays that make them feel present, they will respond to stimuli within the environment in the same way as they would were they presented with the same stimuli in the real world. Our view is thus similar to that presented by Slater and Wilbur (1997) who point out that the utility of presence evoking systems for applications such as psychotherapy rely on this premise. To this we would add a variety of other applications, for example training, remote handling, collaborative working environments and broadcast entertainment.

High level cognitive tasks might be susceptible to task demands. More useful and reliable measures of behavioural realism are likely to be those unavailable to consciousness, and thus immune to such problems. One promising measure for the assessment of behavioural realism is the assessment of postural responses to displayed stimuli. Whilst some behavioural measures might be confounded by higher level cognitive processing and others might generate simple binary responses, for example an observer either responding or not, proprioception during normal stance does not normally involve conscious awareness and has the potential to produce differential levels of response.

Postural Sway The importance of visual information for the control of stance has long been recognised, for example through observations that observers exhibit more postural sway in the dark. Lee and Lishman (1975) demonstrated that variations in the optic flow field at the eye are used for proprioception by placing observers within the confines of a polystyrene ‘room’. The room was moved sinusoidally through a distance of 6mm (peak to peak amplitude), with a period of 4 seconds, whilst observers’ postural responses to the room movement were measured. A significant amount of in-phase antero-posterior (AP) postural sway was measured, movement that Lee and Lishman’s observers were unaware of.

Lee and Lishman reported more body sway when observers were looking at an object 4.5m away than when they were looking at an object 0.45m away. One explanation for this is that the change in observers’ retinal images was greater for the near object. An alternative explanation rests on the increased efficacy of stereopsis at a near distance. Palmisano (1996) presented evidence that stereoscopically presented optic flow patterns produce improved forward linear vection (subjective sensation of motion). If subjective sensations of vection and postural adjustments are generated by the same mechanism then some of the reduction in body sway reported by Lee and Lishman at near distances may be attributable to the increased efficacy of the stereo cue. This idea is supported by the results of Ojima and Yano (1997) who showed that a smaller field of view (22.5deg) is required to generate relatively stable postural sway control using stereoscopic stimuli than the field of view required to generate similar sway using monoscopic stimuli (45deg). This research was done using computer generated shapes, not photo-realistic video, and it is thus possible that we will generate postural sway with a monoscopic stimulus with a FOV of 32deg.

Effects of ocularity of stimulus presentation on postural sway

This experiment was designed to test the prediction that stereoscopic stimulus presentation generates a larger postural response in observers than does monoscopic stimulus presentation.

Method Two factors were manipulated: (i) viewing condition - two levels, monoscopic or stereoscopic, and (ii) amplitude of sinusoidal camera swing contained in each sequence - three levels, 0mm, 6mm or 12mm. The frequency of the camera swing was maintained at 0.21Hz for both amplitude levels that contained camera movement.

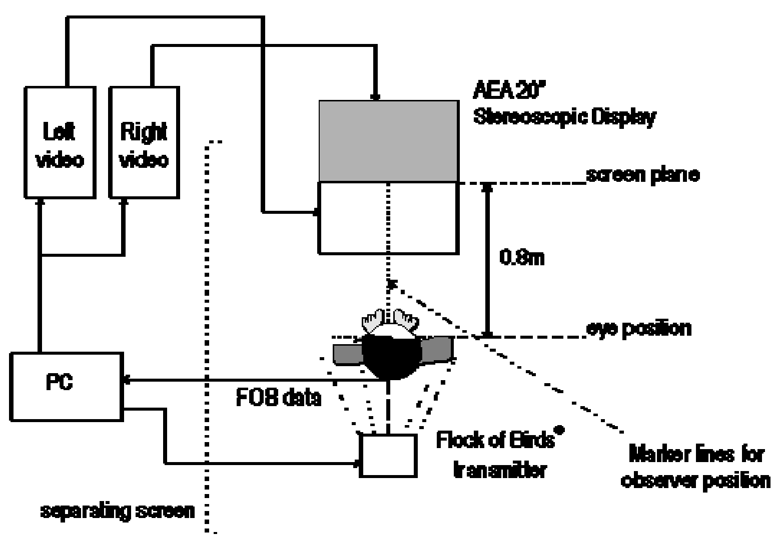
Stimuli Sequences Video sequences were taken of a room with books and videos on a stool in the foreground. For each condition two 50 second videos were produced, one for the left and one for the right eye. For stereoscopic presentation of stimuli left and right eye video streams were played, for monoscopic the left eye video stream was presented to both eyes.

Observers Twelve observers (6 m, 6 f, average age 21 years) were paid a small fee to participate. All had normal or corrected to normal vision and a stereo-acuity of 30 sec-arc or better (as tested on the RANDOT© random dot stereotest, Stereo Optical Co., Inc., Illinois).

Apparatus Observers viewed the stimulus films on an AEA Technology 20" stereoscopic display consisting of two BARCO CPM 2053 colour monitors (50 Hz PAL) with polarised filters in front of each. Observers viewed the display wearing polarised spectacles. Two synchronised Panasonic M2 (A750-B) video players provided the video input for the display. A Flock of Birds© (FOB) magnetic position tracker positioned on observers' backs (Ascension Technology Corporation, Burlington, VT, USA), was used to collect observers' x, y, z positions for each measured period. The FOB was connected to a standard PC running software that controlled both the video players and sampled x, y, z position data at 12.5Hz.

Procedure An observer stood without shoes in front of the display, aligned with the centre of the screen and the FOB axis. Observers were instructed to stand still and comfortably and look into the centre of the display (see figure 1). Half of the observers saw the stimuli in mono, half in stereo.

Figure 1 - laboratory set-up



Results

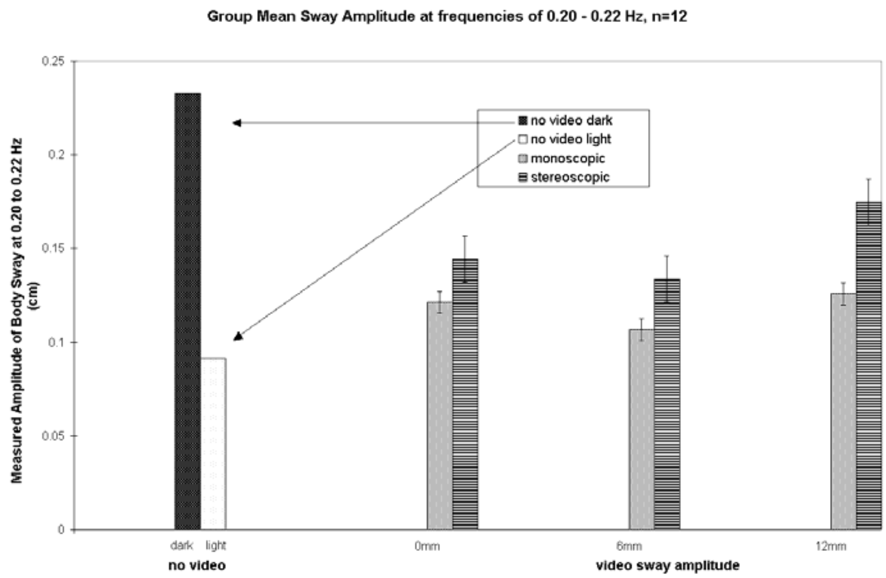
The time domain data of observers' AP position was transferred to the frequency domain using the Discrete Fourier Transform (DFT). We summed the activity in the DFT data in frequency bands 0.20Hz and 0.22 Hz for each condition by observer to obtain a measure of the sway that may have been induced by the swinging camera stimuli.

Postural Control in the Light and in the Dark: *movement in light < movement in dark*

As is clearly visible in figure 2 there was significantly more sway at these frequencies in the dark than in the light, an order of magnitude of more than double ($F_{(1,11)} = 66.394$, $p<0.0001$). This result serves to demonstrate the importance of visual proprioception in the control of stance.

Postural Control from Swinging Video: *movement in stereo > movement in mono*

Figure 2 shows the results of the group mean sway amplitudes across the 3 stimuli conditions split be viewing condition with the group mean sway amplitudes for the dark and light conditions (averaged pre- and post-video) shown for comparison.



Stereoscopic viewing was associated with higher magnitudes of postural sway at the frequency of the camera swing (0.21Hz) than was monoscopic viewing at all levels of camera swing; this result approached significance ($F_{(1,11)} = 4.709$, $p=0.053$). There was no significant effect of camera sway level ($F_{(2,22)} = 1.4893$, $p=0.247$), although there appeared to be a slight trend of higher magnitudes of camera sway being associated with higher postural responses at the frequency of interest. Finally there was also no significant interaction between viewing condition and camera sway level ($F_{(2,22)}<1$, $p=0.793$).

Discussion

These results are encouraging in that postural sway has been shown to provide differential responses based on stimulus manipulations. It is important to point out that this methodology is at an early stage and the findings presented here require replication and validation. Furthermore, issues of observer fatigue and learning are currently under investigation. In addition, in order that postural sway be useful as a display evaluation metric several levels of response need be demonstrated.

The results does suggest that stereoscopic presentation of photo-realistic visual stimuli generates a more realistic physical response in observers than does monoscopic presentation of identical stimuli. Presence has been shown to be enhanced by stereoscopic presentation of environments (Hendrix and Barfield, 1996) and photo-realistic television images (Freeman, Avons, Davidoff, & Pearson,1997; IJsselsteijn, de Ridder, Hamberg, Bouwhuis, & Freeman, 1997). The next stage of our research will be to correlate subjective ratings of presence and constructs related to presence with the objective physical measures we are currently developing.

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