Aroused and Immersed: The Psychophysiology of Presence

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Introduction:

Compared to conventional media, highly immersive mediated experiences are expected to elicit greater subjective ratings of presence and more intense physiological responses. The relationship between the two has yet to be systematically investigated. With particular reference to television and video presentations, literature related to the measurement of both presence and physiological arousal is presented together with justification for studying associations between the two. In doing so, a consideration of the possible nature of presence itself and the behavioural implications of physiological data are discussed. An experiment is presented for which preliminary results may be available at the Presence 2000 workshop and plans for future work are considered.

Measuring Presence:

Freeman, Avons, Pearson and IJsselsteijn (1999) have defined presence as "the observers subjective sensation of 'being there' in a remote environment"(p. 1). In a review of the literature Lombard and Ditton (1997) looked at different uses of the term presence and other similar concepts. They provide the following definition: Presence is "the perceptual illusion of non-mediation [it] involves continuous ('real-time') responses of the human sensory, cognitive and affective processing systems" (p.9).

The ITC Sense of Presence Inventory (SOPI) developed by Lessiter, Freeman, Keogh and Davidoff (2000) aims to include all the key components of presence that exist in the literature. A factor analysis

revealed four dimensions: (1) 'Physical Space', which relates to feeling part of and interacting with a displayed environment, (2) 'Engagement', which includes questions relating to involvement, personal relevance and the intensity of the experience, (3) 'Naturalness', which refers to the comparability of the displayed environment with the real world and (4) 'Negative Effects', which refers to adverse physiological effects of the experience. As the questionnaire includes and elaborates on critical questions asked by other researchers in the field (e.g. Slater, Usoh & Steed, 1994), it will be the main subjective measure of presence used in this project.

While analyses of presence questionnaires may elucidate the phenomenology of immersive experiences, they remain post-test measures dependent on memory for an event. Presence has, however, been measured throughout a viewing experience using a hand-held sliding scale (IJsselsteijn, Freeman, Avons, Davidoff & de Ridder, 1997; IJsselsteijn, de Ridder, Hamberg, Bouwhuis & Freeman, 1998; Freeman, Avons, Pearson & IJsselsteijn, 1999). However, it is unclear exactly what people were responding to and how responses were affected by continuously assessing one's own experience. Perhaps, a more objective method of studying continuous experience is to use physiological recordings of arousal.

Measuring Arousal:

Arousal has generally been conceived of as a drive state or a non-specific energiser of behaviour, something that describes the intensity of an experience but not it's quality (Duffy, 1962; Mandler, 1992). Descriptions of arousal go hand in hand with considerations of physiological activity. For example in Duffy's (1962) activation theory arousal is synonymous with activity in the brain reticular formation, projecting to the cortex. In comparison, theories of emotion have concentrated on activity in the autonomic nervous system (Grings & Dawson, 1978). Research has attempted to link specific behaviours or phenomena to the absence or presence of specific physiological patterns (Cacioppo & Tassinary, 1990; Levenson, 1992; Lang, Greenwald, Bradley & Hamm, 1993). A brief description of physiological measures relevant to research described later in this paper, and how they have been used previously, will now be given to help clarify the utility of taking such recordings.

Electrodermal activity (EDA) is a measure of electrical activity between two points on the skin, usually on the palm of the hand. Changes in EDA are thought to reflect dilations and secretions of eccrine sweat glands, which are innervated by the sympathetic nervous system. In general, as the intensity of stimulus increases so does EDA (Bernstein, 1969). Whilst EDA is often associated with levels of emotional arousal (Greenwald,

Cook & Lang, 1989), higher levels of EDA during learning have been linked to a variety of effects on memory (see Revelle & Loftus, 1992 for a review). Furthermore electrodermal responses occur on presentation of an unexpected stimulus (Yaremko, Blair & Leckhart, 1970), an effect known as the orienting response.

A second physiological measure of interest can be obtained from cardiovascular activity. Information about heart-rate may be obtained from an electrocardiogram (ECG) which measures electrical potential across the skin associated with electrical activity in the heart. The ECG reflects sympathetic and parasympathetic activity. As with EDA, changes in cardiac activity are not indicative of one type of behaviour. However, specific psychological functions have been linked to patterns of cardiac activity. For example, as the intensity of an emotional experience increases, so does heart-rate. Furthermore positive emotions are associated with greater ECG activity than negative emotions, thus heart-rate is sensitive to hedonic valence (Lang et al., 1993). Also, in reaction to unexpected stimuli, heart-rate decelerations have been associated with the orienting response to novelty and accelerations with defensive responses (Graham, 1992), i.e. fear and anxiety.

It is evident that taking a variety of physiological measurements during an event would be advantageous if sensible conclusions are to be drawn concerning their psychological significance. Other useful measures might include EEG recordings of cortical activity, electromyogram measurements of facial muscle tensions, respiration rate and blood pressure.

Presence and Arousal:

Televised presentations in various forms are thought to produce and moderate states of arousal. For example, surveys and other research have shown that the main reason people watch television is to produce feelings of relaxation or excitement, (Zillman, 1990). In addition, Freeman and Avons (2000) found that when video excerpts were presented in 3D, focus group participants described their experience as more 'involving', intensifying and enhancing their experiences, in comparison to 2D presentations. Research into psychophysiological responses to media form and content is, however, sparse. This is surprising given that the research that has been conducted could be useful when considering continuous measures of presence.

In general, features such as videographics, scene cuts and motion have been associated with short-term patterns of physiological activity linked to attentional processes (Thorson & Lang, 1992; Rothschild, Thorson, Reeves, Hirsch & Goldstein, 1986). Manipulations of media content, on

the other hand, have shown that subjectively rated arousing video footage can maintain both physiological arousal and behaviour patterns over longer periods of time, while unarousing stimuli produce states of 'relaxation' (Zillman, 1990). Interestingly, relative to still images, moving images produce higher levels of EDA and larger HR decelerations whilst also elevating subjective ratings of emotional intensity (Detenber, Simons & Bennet, 1998; Simons, Detenber, Roedema & Reiss, 1999). Motion has also been shown to consistently increase subjective ratings of presence (Freeman, Avons, Pearson, & IJsselsteijn, 1999; Freeman, Avons, Meddis, Pearson, & IJsselsteijn, 2000).

At first glance, it would seem that manipulations of media form are the most relevant to presence research. Indeed one study has shown that increasing screen size results in both higher levels of EDA and presence ratings, (Lombard, Reich, Grabe & Ditton, in prep). However, given the nature of the data to be expected from continuous viewing experiences it would seem sensible to consider both attention and affect when looking at the psychophysiology of presence. The fact that presence questionnaires have not only addressed how engaging an experience is but also how intense that experience is supports this view.

Unfortunately, other studies have failed to find a systematic relationship between presence and arousal. Weiderhold, Davis & Weiderhold (1998) found that although flight simulations presented through a head mounted display were rated as more relaxing and higher in presence than when presented on a computer screen, the physiological data was unclear. Salnass (1999) also failed to find a relationship between presence and physiological measurements when comparing shared virtual environments with or without haptic force feedback.

Although the lack of research limits any concrete conclusions, the literature indicates that physiological measures of presence are worth pursuing. Indeed, future research could increase the specificity and generalisability of the findings by tackling various problems such as the manipulation and measurement of presence; content effects; movement artefacts and individual differences.

Research Plan:

The initial phase of research will explore physiological concomitants of immersive experiences. It is predicted that experiences that elicit greater post-test subjective ratings of presence will also be marked by: (I) changes in overall levels of EDA and heart-rate, and (ii) a greater magnitude of responses in both measures to specific aspects of the displayed environment.

A larger number of subjects than has previously been used will be tested in order to account for some individual variation. In a counterbalanced repeated-measures design, participants will view the same video footage both with and without stereoscopic depth cues. Lessiter et al.'s (2000) ITC SOPI questionnaire will be completed after each viewing. Skin resistance and ECG recordings will be taken before and throughout each viewing.

The manipulation of stereoscopic cues is intended to create high and low immersion conditions reflected in post-test presence ratings. These cues have previously been shown to increase continuous (IJsselsteijn et al, 1998; Freeman et al, 1999) and post-test (Freeman et al 2000; Barfield & Hendrix, 1996) presence ratings. Candidates for the stimuli include a rally drive sequence or a relaxing boat ride. While the first is expected to be highly arousing and possibly high in presence, the second shows slow movement and the appearance of clearly separated objects (temporally and spatially). This may be important as physiological recordings in response to specific stimuli often have long latencies and decay. The latter sequence may thus better allow the observation of physiological responses as well as tonic levels.

Future research will examine the effects of novelty, audio information and varied content on presence and physiology. All these issues must be examined if psychophysiology is to be proposed as a continuous measure of presence. Depending on the utility of the methods, the results of early research may be applied to studies of memory and attention.

Acknowledgements:

The generous support of the Independent Television Commission enabled the completion of the research reported here.

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Last Revision 21-01-00, Jonathan Freeman