Duration Estimation and Presence

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Abstract

In this paper we report on a first attempt at investigating the relation between presence and duration estimation, and explore the possibility of using duration estimation as a corroborative measure of presence. Duration estimation refers to the human ability to indicate how much time has elapsed and has been shown to be influenced by factors such as interest or attention. These factors are also theorised to be important in establishing a sense of presence, thus suggesting a relation between duration estimation and presence. An experiment was performed that employed a wayfinding task in a desktop virtual environment, using different types of wayfinding aids. Presence was measured using a short questionnaire. After the experiment, participants were asked whether they thought they had completed the wayfinding tasks in a short time. In addition, after each task they were asked to estimate the elapsed time interval in mm:ss. Results showed a significant positive correlation between the subjectively judged speed of task completion and the sense of presence, indicating that higher presence is associated with shorter experienced duration. No significant correlation was found between duration estimation (in mm:ss) and presence. These results are interpreted in terms of the potential underlying mechanisms, and suggestions for improving the experimental design will be discussed.

Introduction

The experience of presence, or the sense of 'being there' in an environment other than where one is physically located, is a subjective experience that has proven to be relevant for the design and evaluation of various interactive and non-interactive media systems, including virtual environments, telerobotics, cinema, videoconferencing and television. Although current media environments will seldomly, if ever, be mistaken for a real environment, users may nevertheless report a compelling perception of 'being in' the mediated environment. In particular through immersive, interactive and perceptually realistic media, user responses are provoked that are similar to those in nonmediated environments (see e.g. Lombard, 1995; Freeman, Avons, Meddis, Pearson & IJsselsteijn, 2000; IJsselsteijn, de Ridder, Freeman, Avons & Bouwhuis, 2001).

There is consensus that the experience of presence is a complex, multidimensional perception, formed through an interplay of raw sensory data and various cognitive processes – an experience in which attentional factors play a crucial role as well (Draper, Kaber & Usher, 1998; Witmer & Singer, 1998). Factor analytic studies are starting to shed light on the multidimensional structure of presence. In particular, studies by Schubert, Friedman, and Regenbrecht (1999) and Lessiter, Freeman, Keogh, and Davidoff (2000) reveal very similar factor structures. Schubert et al. (1999) arrived at a 3-factor solution for the presence construct, which they termed 'spatial presence', 'involvement', and 'realness'. Similarly, Lessiter et al. (2000) reported a 4-factor solution for presence, with three factors almost identical to the ones identified by Schubert et al.: 'physical space', 'engagement', and 'naturalness', and a fourth attenuating factor they termed 'negative effects'.

A measure of presence that is reliable, valid and robust is an essential tool in designing and evaluating media from a user-centred perspective. It will allow engineers and media developers to identify the factors (and trade-offs between them) needed to optimise the level of presence for the media user. Moreover, a good presence measure will allow the research community to further develop its understanding and systematic investigation of the construct, which will in turn enable further refinement of measurement methodologies, and so on.

To date, a variety of presence measures have either been proposed or used which can generally be classified into subjective and objective corroborative approaches. The former is by far the most common approach taken and is usually questionnaire-based. The latter approach may involve the measurement of various behavioural and psychophysiological responses, which are thought to be sensibly related to the medium manipulation under study. Importantly, both approaches present complementary ways of measuring presence, and should ideally be used together to overcome limitations of either approach alone (for review and discussion see IJsselsteijn, de Ridder, Freeman & Avons, 2000). Despite considerable progress in investigating several candidate measurement methodologies, measuring presence in a reliable, valid and robust way still remains one of the main research challenges of the field (Stanney & Salvendy, 1998; IJsselsteijn, Freeman & de Ridder, 2001).

Time perception, duration estimation and presence

In this paper we report on a first attempt at investigating the relation between presence and duration estimation, and explore the possibility of using duration estimation as a corroborative measure of presence. Duration estimation refers to the human ability to indicate how much time has elapsed. It can be expressed in conventional time units (i.e. minutes and seconds), but can also be judged in a unit-free manner, through magnitude estimation (i.e. assigning a number or category label corresponding to the perceived duration). Although we do not perceive time as such, that is to say time perception is not associated with any independent sense organ, we are able to integrate successive *events* in memory. The subjective flow of time appears to be influenced by the number of events that are processed. For duration estimation, a mechanism that integrates or summates these events has to be assumed (Pöppel and Schill, 1995).

Perceived duration has been shown to be affected by several factors, including attention and amount of information processing, arousal, and affective valence (Angrilli, Cherubini, Pavese & Manfredi, 1997). This is what makes duration estimation a potentially useful measurement tool to corroborate presence measures, since factors assumed to affect presence (such as interest or attention) also influence duration estimation in a predictable way. For instance, attentional models of time perception predict that attentional resources dedicated to processing a stimulus are subtracted from the attention individuals devote to the processing of time. Thus, an interesting stimulus will require more attentional resources, which will allow for fewer time units to be processed, resulting in the participant's *underestimation* of the temporal interval. Differences in results have been found however when using a retrospective (remembered duration) rather than a prospective (experienced duration) paradigm. In the latter case, participants have advance knowledge that they will be asked to make a duration judgement, whereas in the former case they do not (Block & Zakay, 2000).

Time perception has been suggested as a potential measure of presence, most notably by Waterworth & Waterworth (2001). In their paper, they describe a model of virtual experience consisting of three dimensions which they term 'focus' (the balance between conceptual, abstract reasoning or 'absence' and direct perceptual processing or 'presence'), 'locus' (the locus of attention which can either be directed towards the virtual world, or the real, physical world), and

'sensus' (the level of conscious arousal of the organism). When dealing with experienced duration, the 'focus' dimension is of particular relevance. Waterworth and Waterworth state that subjective duration of an experience is affected by the level of processing such that when conscious processing load is heavy (during difficult abstract reasoning for instance) our experience of duration is short, in line with the attentional model of time perception described earlier (see also e.g. Thomas & Weaver, 1975). Based on the premise that presence is characterised as a 'psychological focus on direct perceptual processing', rather than on conceptual processing (which defines 'absence' in their model), it follows that higher presence (i.e. less abstract processing) should be associated with longer experienced duration. This prediction is critically dependent on the conceptualisation of presence used by the authors, and the role of attention (aspects of which seem to be intertwined with all three dimensions of the model) in the 'direct perceptual processing' of the environment.

Most existing presence questionnaires, such as the ITC Sense of Presence Inventory (Lessiter, Freeman, Keogh & Davidoff, 2000), the Television Questionnaire (Lombard, Ditton, Crane, Davis, Gil-Egui, Horvath & Rossman, 2000), and the Presence Questionnaire (Witmer & Singer, 1998) include an item on temporal perception, mainly to investigate to what extent participants "lost track of time." Here the assumption is that a higher sense of presence is associated with people losing track of time more often. This is reminiscent of the concept of 'flow' (Csikszentmihalyi, 1991; see also Draper et al.,1998), a state of optimal concentration during which participants are often unaware of the passage of time. The pool of presence-related questionnaire items listed at http://nimbus.temple.edu/~mlombard/Presence/measure.htm also includes an item on duration judgement: "How long did your [viewing/interactive] experience last?" (1 = very short time; 7 = very long time), with the prediction that an "experience with greater immersion should be perceived as having been of shorter duration" (Lombard, 2000).

Next, we present a first investigation into the relation between the experience of presence, measured subjectively, and duration estimation. This relation was investigated in the context of an experiment aimed at investigating the efficiency of different navigational aids during a wayfinding task in a 3D virtual maze. We will limit our report here to the results pertaining to the duration estimation task and presence judgements. Other results of the experiment are reported in full elsewhere (Bierhoff, 2001).

Method

Participants

Forty-four students (32 male/ 12 female; age range 20-26) of the Eindhoven University of Technology volunteered to participate in the experiment for which they were paid 7.50 NLG. All students were naïve with respect to the hypothesis that was being tested.

Task and Material

Participants were asked to navigate through a computer-generated 3D maze (see figure 1), using the cursor keys for moving forwards, backwards, left or right. For wayfinding through the environment they were required to use a route navigation system which offered real-time directional information on-screen, either as text or as a map. The experiment was performed on a standard desktop PC (Intel Pentium-II) using a 17" screen, with participants positioned at a comfortable viewing distance (approximately 60 cm). The 3D environment and navigational aids were custom built and presented via Sense8 WorldUp (release 4).

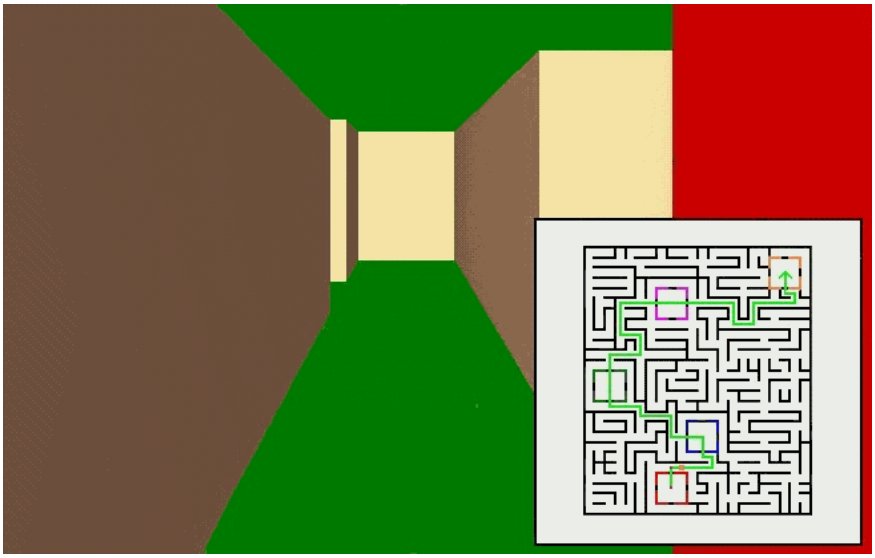

Figure 1. A typical screen-shot of the 3D maze and the navigation information system.

Design

The experiment had a 2x3 mixed design. The type of information offered (map or text) was varied as a between-subjects factor, and the range of information (complete route, per subgoal, or per decision point) was varied as a within-subjects factor. Each participant was thus required to complete three sessions, with a total experimental duration of at most 30 minutes. The different within-subject conditions were offered in counterbalanced order to compensate for any potential learning effect. It is important to note that the 3D environment itself was identical across all conditions, and that we expected no significant effects of manipulating the navigational aid on the participants' sense of presence.

Measurement

Time taken to successfully complete each task (by having reached the goal) was recorded on the PC. After each session the participant was asked to estimate the duration of the time interval they needed to complete the task (in minutes and seconds). In addition, after completing the three experimental sessions they were asked to judge whether or not they thought they had completed the wayfinding tasks in a short time (6 point 'strongly disagree' – 'strongly agree' scale). Additionally, participants were asked to rate the extent to which they agreed with number of statements related to presence, each with a 6 point 'strongly disagree' – 'strongly agree' scale:

1. 'I feel that navigating through the displayed environment is comparable to navigating through a real environment'
2. 'My body was in the physical environment, but my mind was in the displayed environment'
3. 'During the wayfinding task I had the feeling of being present inside the displayed environment'
4. 'I remember the environment as a place I visited, rather than as a picture I looked at'

Results

The coherence between the 4 presence items was determined using a factor analysis, the results of which are presented in table 1. As the table indicates, all 4 items correlate fairly well with a one-factor solution, so that for further analysis and discussion we will regard the 4 items to jointly reflect the participant's sense of presence.

Table 1. Factor analysis for the presence-related items

Item no.	factor loading
1	**.52**
2	**.86**
3	**.87**
4	**.82**
Cronbach's α	**.78**

Presence was not significantly affected by the type of information offered (map or text). Results showed a significant positive correlation between the subjectively judged speed of task completion and the sense of presence (Pearson's r=0.355; p≤ 0.05, two-sided), indicating that higher presence is associated with shorter experienced duration. This relation is illustrated in figure 2. Note that none of the participants *disagreed* with the statement regarding the speed of task completion.

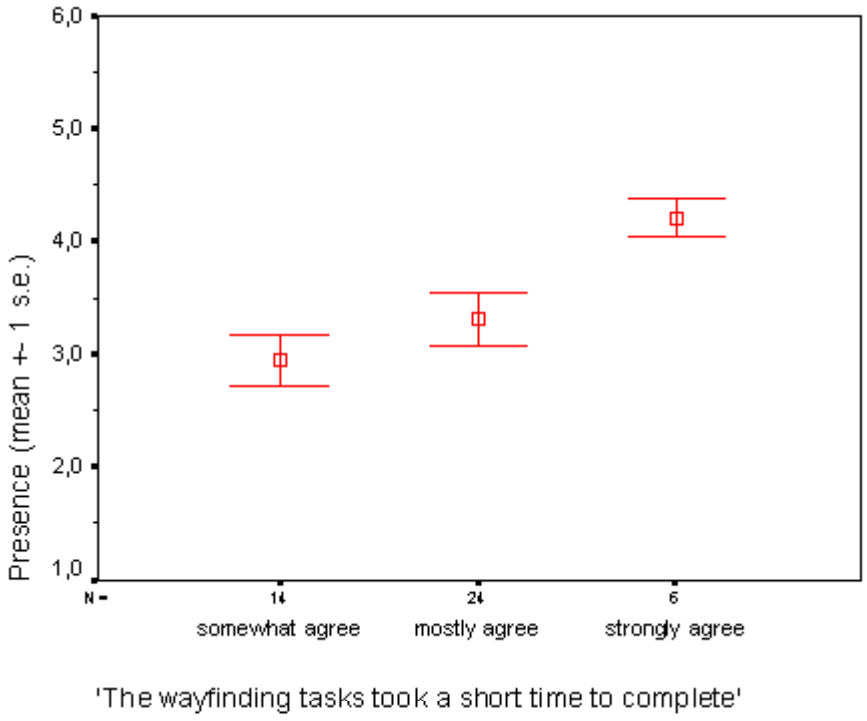

Figure 2. Relation between judgement of speed and presence.

To get an impression of the relation between duration estimation and presence we first needed to correct the duration estimations for differences in the actual time spent on a task. Thus, a difference measure Δ t was calculated such that $\Delta t = t_{estimated} - t_{measured}$. Figure 3 illustrates the relationship between Δ t and presence. Overall, participants tended to overestimate time they spent on a task, in particular when presence judgements were somewhat higher. However, no significant correlation was found between duration estimation (in mm:ss) and presence. There was considerable spread in the data, both in presence measurements and in time estimations (mean Δ t = 79.2 sec; standard deviation Δ t = 85.6 sec), with some subjects showing a near-perfect accuracy whereas others overestimated the duration by as much as 200-300s (see figure 3). Time estimates nevertheless had a significant positive correlation with the actual time needed to complete a task (Pearson's r= 0.309; $p \leq 0.05$). Speed judgements also correlated significantly with actual time needed (Pearson's r= -0.372; $p \leq 0.05$), such that a higher level of agreement with the statement that the wayfinding tasks took a short time was associated with less time actually needed to complete the task.

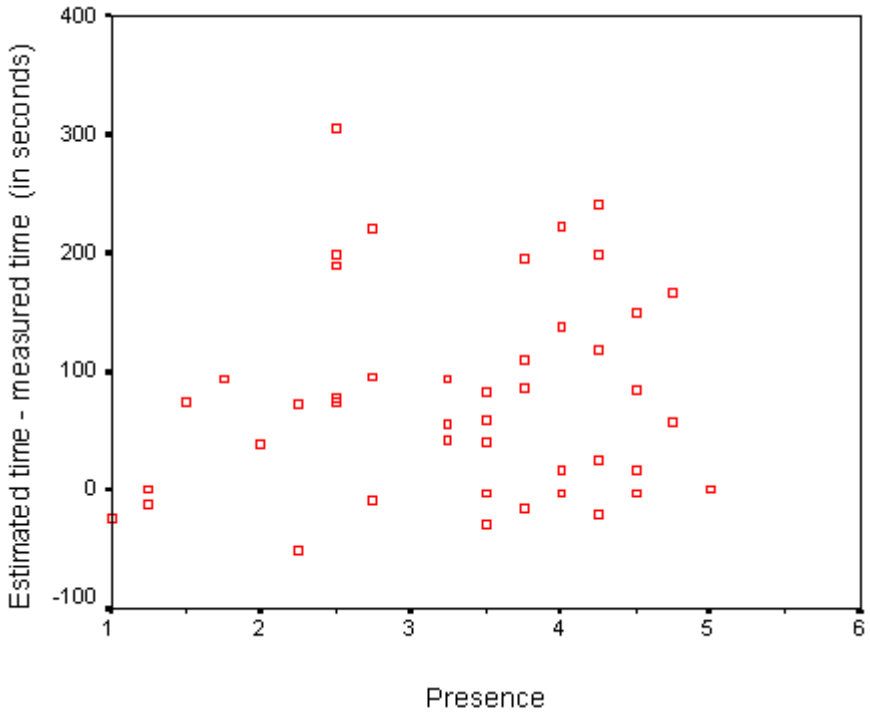

Figure 3. Scatterplot of presence scores in relation to Δ t.

Discussion

The results indicate an interesting, yet somewhat complex relation between time perception and the experience of presence. The significant positive correlation between subjectively judged speed of task completion and presence seems to confirm the hypothesis that a higher sense of presence would be associated with shorter perceived duration, in line with Lombard's (2000) prediction. This result is at variance with the prediction following from the Waterworth & Waterworth (2001) model, that higher presence should be associated with longer experienced

duration. However, in defence of their model it may be argued that the 3D desktop environment employed in our experiment may not have had the required level of immersivity, interactivity and perceptual realism to engender a high level of presence.

When comparing the results of duration estimation (in minutes and seconds) with the actual time spent on each task, we find that participants tended to overestimate the duration of the temporal interval. From an attentional resource perspective it may be argued that this would indicate that the task was neither very interesting nor demanding. One would expect that a more engaging media environment would demand more attention and the temporal interval would therefore be underestimated rather than overestimated. An issue of concern is that the current experiment effectively combined both retrospective and prospective paradigms of duration estimation. Although participants were not instructed to pay attention to the temporal interval, once a participant had been asked a single retrospective judgement, he/she could reasonably expect being asked the same question again, making his/her subsequent judgements effectively prospective. Prospective judgements tend to be larger in magnitude and smaller in variability than retrospective judgements (Block & Zakay, 2000), however in our experiment this was not entirely the case. Although variability in Δ t decreased over sessions, the average decreased slightly as well. This small, non-significant effect may be attributable to a better calibration of participants' time estimations across sessions.

In sum, the significant correlation between judged speed and presence (see figure 2) suggests that temporal judgements may be of value as a corroborative measure of presence. However, the results of this first investigation of the relation between presence and duration estimation are still somewhat inconclusive. Further experimentation is called for using (i) a clear presence manipulation, with high-presence vs. low-presence conditions, and without other potentially confounding task variations, and (ii) a duration estimation paradigm that is consistently used throughout the experiment. We hope to be able to report results of further experiments in this area at the time of the conference.

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