Conceptual Priming as a Determinant of Presence in Virtual Environments

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ABSTRACT
Many presence studies show the importance of display variables in determining presence. However, very little empirical evidence exists to support the notion of "the suspension of disbelief" or other psychological determinants of presence. We argue from a cognitive presence perspective that presence can be considered as an extension of perception, a process which is known to be significantly affected by the perceiver's mental state. We support our argument by presenting the results of a large study (n=103) in which users were conceptually primed by reading a booklet either related to or unrelated to a VE and then were left to explore that VE with either a high quality or low quality display. We found a significant interaction effect between display quality and priming, showing that the mental state of the user sets a context which affects their experience of presence as measured using two scales. We conclude that, like perception, presence does not simply occur as a consequence of sensory input only, but that it is a constructive process in which the VE user creates an experience using both sensory and psychological inputs.

CR Categories: I.3.7. [**Computer Graphics**]: Virtual Reality

General Terms: Experimentation, Human Factors, Theory

Keywords: Presence, Priming, Virtual Environments

1. INTRODUCTION
Presence has been identified as one of the defining features which set virtual environments apart from other real time visualization systems [1]. Presence has been associated with a wide range of effects on users of virtual reality systems, ranging from an improvement in task performance [2] to a sense of being in the virtual environment rather than in the experimental site [3]. Various authors such as Slater *et al* [4] and Sheridan [5] have suggested that an understanding of the causes and consequences of presence could form a valuable tool in the armamentarium of the virtual environment engineer, as this could provide a means to improve the effectiveness of virtual environment experiences.

1.1 Theoretical basis of presence
The presence literature contains several models which attempt to explain the relationships between variables which have been empirically shown to affect presence. The models vary greatly in complexity and theoretical basis. For example, Steuer [6] presents a simple two-level hierarchy based on human factors theory, while Schubert, Friedmann & Regenbrecht [7] use a complex path model to categorize variables into causes and effects, based on a data-driven, mostly atheroretical approach. This diversity in theoretical basis creates some serious problems for presence theorists. Because models use quite different theoretical bases, there is often little common ground for comparisons or discussion between authors. Recently, there has been a move towards using cognitive psychology and perception theory as a basis for presence research (see [8] and [9] for examples of this trend). Our work follows this trend by beginning from the concept of cognitive presence [9] which emphasizes the role of perception and the subsequent selection of environmentally appropriate behaviours in virtual environments. Following the cognitive presence approach, we consider perceptual processes to be at the heart of presence. This paper presents some of our work in exploring the relationship between higher-level perceptual processes and presence.

1.2 Constructive perception and schemata
Cognitive psychology contains a large body of work which explains the interface between perception and higher-level cognition. This perspective, which is sometimes referred to as the constructive perception school [10], promotes the idea that the sensory organs do not provide sufficient information for a person to behave successfully. The information is seen to arise from two sources. The first is sensory, which allows for behaviours to be selected which are relevant to the current state of the environment. The second source of information is conceptual; the state of the environment is inferred from the person's previous experiences in similar situations. This allows for associations between behaviours to be explored, so that novel but adaptive responses can be found to fit the environmental state [11]. The constructionist school opposes the view of the older ecological perception school (made famous by J.J. Gibson), which argues

that *all* of the information necessary for perception can be derived by the senses directly from the environment [12].

If perception is based in part on information stored in the perceiver, then it is important to consider how that information is encoded and stored. Rumelhart & Ortony [13] proposed a cognitive structure, the *schema*, which encodes complex concepts by means of associations between simpler ideas. Schemata are held in long term memory, and they become active (i.e. they begin to affect cognitive processing) when one or more of the simple concepts which constitute them presents itself either in thought or via the sensory organs [13]. For example, a simple percept such as a line is encoded as a single unit in memory, but a building is best encoded as a set of associations between lines. The *building* schema (which stores a generic form of "building" rather than any specific exemplar) can also associate the basic shape of the building with the materials with which it is constructed, and a host of other information. If a building is ever perceived in such a way that sensory information is missing, the schema provides the missing information [13]. So for instance, if a black and white photo of a brick building were shown to a person, the BUILDING schema would become active, and that person would be able to deduce the colour of the bricks, even if that information is not actually available from the senses (although, of course, the inference might be incorrect). Schemata do not simply associate objects; they also encode functional relationships together. For instance, *building* might associate to *person* via LIVES IN and LARGER THAN. This provides information not only about the physical properties of an object, but also encodes the actions which can be carried out with an object, or how objects can be combined. This feature makes schemata more general-purpose that Gibson's similar notion of affordances [12]. Schemata are widely used in cognitive psychology at present, as a good deal of evidence exists to support them. The reader is directed to [10], [13] and [14] for reviews of this concept and summaries of the evidence which support it.

1.3 Conceptual and sensory variables in presence

Presence research currently available seems to suggest that presence, like perception, is affected by both sensory and conceptual factors. Research has already identified a variety of both conceptual and sensory variables which affect the presence experience. For example, Steuer [6] identifies five categories of variables which affect presence: Breadth, Depth, Speed, Range and Mapping. Breadth is the capacity of the system to stimulate several sensory modalities simultaneously; depth is the amount of information which is conveyed to each sensory modality; Speed refers to the rate at which the VR system is able to respond to user inputs; Range is the number of avenues of change which are open to the user at any time, and Mapping refers to the ability of the system to respond to user input in a natural and predictable manner. Of these, breadth, depth and speed can be considered to be sensory variables, as they are related to the sensory stimuli presented to the user. Range and mapping however, relate to the plans and knowledge of the user in the virtual environment, and can thus be regarded as conceptual variables. Slater & Usoh [15] and more recently Bystrom, Barfield and Hendrix [16] have emphasized the importance of the role of display technology in presence, presenting both theoretical as well as empirical arguments; however, a large body of empirically unsupported, theoretical work exists which argues that presence cannot occur simply as a function of display parameters, but must also be affected by what can be loosely called "the suspension of disbelief". For instance, Zeltzer [17] and Steuer [6] include the concept of *interactivity* in their conceptualizations of presence. This can be considered as an example of a narrow view of constructionism in presence, as it implies that the user's cognitive processing of the environment affects their choice of interaction and consequently their experience of presence. There also exist far broader notions of the user's contribution to their own presence experience. For example, IJsselsteijn, de Ridder, Freeman & Avons [18] consider a category of variables they term "user characteristics" which includes variables ranging from previous experience with VR to motor ability. Also included in their "user characteristics" category is the notion of "willing suspension of disbelief", which is also used by others such as Thie & van Wijk [19], Bystrom, Barfield & Hendrix [16] and many others. Notions such as these illustrate that the field recognizes the importance of the role played by the user's mental state and suggests strongly that presence occurs not simply as a product of the sensory stimuli provided to the user. Based on this theory, we believe that presence is constructed, like perception, by the user from a combination of the available sensory and conceptual inputs.

1.4 Aims of this paper

The presence literature currently contains very little empirical evidence on the effects of conceptual variables on presence. This paper presents our investigation into the effects of conceptual variables on presence, to determine if presence is constructed by the user, or if it arises as a result of sensory stimulation only. We conducted an experiment to investigate the effects of higher-level cognitive processes (by means of schemata activation) on presence, and how these conceptual variables interact with the fidelity of sensory stimuli. Based on the reasoning presented in 1.2 above, and on the definition of cognitive presence [9] we assume that schemata are involved in the cognitive processing of environments, and therefore in presence. Our aim was to test the following two hypotheses and the associated interaction effect:

I. If a user has active schemata *which are related* to the virtual environment which the user is experiencing, then the user will experience more presence

II. If the virtual environment is rendered on a higher fidelity display system, the user will experience more presence

2. EXPERIMENT

Our design was a 2x2 factorial ANOVA design. The factors in our design were *Stimulus quality of VE display* x *Conceptual priming.* We used 2 levels of each variable. The first factor (stimulus quality) represented a manipulation of the fidelity of the sensory stimuli (see 2.4 below for details). The second factor (priming) represented the manipulation of the user's active schemata upon entering the experiment (see 2.5 below for details). The dependent variable was presence (see 2.6 below for the measures used). To increase the amount of available data, we had each participant take part in two experiment sessions (that is, explore two environments, and complete two sets of presence questionnaires).

2.1 Participants

Demographic details of the participants were not recorded. All were paid volunteers, and all were undergraduate students (from various faculties). The group included both men and women, with a much higher proportion of men, and included various ethnic groups. Almost all participants were in their early twenties. A total of 55 volunteers took part in the experiment.

2.2 Hardware

Our experiment used non-immersive, desktop-based systems. We used three independent workstations to allow for the collection of data from three participants simultaneously. Each of the three workstations had the same hardware specification. This was an AMD Athlon (700 MHz), GeForce 2 MX graphics card, a 17" monitor displaying a 640x480x16 graphical stream at an average of 15Hz, and stereo sound played on headphones. The computers were not connected to a network during the experiment.

2.3 Software

We used out own VE exploration tool, DAVE, for this experiment. DAVE has some advanced rendering features (texture mapping, soft-edged shadows, radiosity and portal based occlusion culling) as well as 3D sound which allow for the creation of high-fidelity virtual environments at interactive frame-rates (typically between 10Hz and 20Hz). DAVE allows the users to move around the world by means of the *quake keys* navigation method [27]. In this method, the mouse is used to change the camera yaw and pitch, while the keyboard is used to simulate a walking motion in relation to the camera's view vector.

2.4 Virtual Environments

As we had each participant taking part in two sessions, it was necessary to create two virtual environments so as to offset any learning effects which may have occurred from exploring the same environment twice. A third virtual environment was created to train the participants in the use of the system. The training environment consisted of 12 rooms spread over three levels, and represented a simple building, with no particular theme.

The two environments used during the experiment itself were created to be consistent with a set theme, so that they would activate a limited set of schemata only. To this end we created one environment as a medieval European monastery, and the other as a contemporary hospital. Each of these environments was created in two forms; a high stimulus quality form and a low stimulus quality form. The high quality versions (abbreviated as H) included textures, radiosity and 3D sound. The low quality versions (abbreviated as L) used flat shaded polygons and no sound. A comparison of the high and low quality forms of the monastery environment can be seen in Figure 1 and Figure 2 respectively; similarly, a comparison of the quality manipulation of the hospital environment can be seen in Figure 3 and Figure 4. The monastery environment consisted of 16 rooms distributed on 3 levels. The hospital consisted of 15 rooms distributed on 4 levels.

2.5 Priming materials

To activate the relevant schemata in our participants, we made use of printed booklets. Each participant was asked to read one of two booklets before immersion in the VE – either one related to the theme of the virtual environment (i.e. related to monasteries or hospitals, depending on which environment they would be visiting), and another not related in theme to either environment. We call these conditions 'VE relevant priming' (abbreviated as P) and 'VE irrelevant priming' (abbreviated as N).

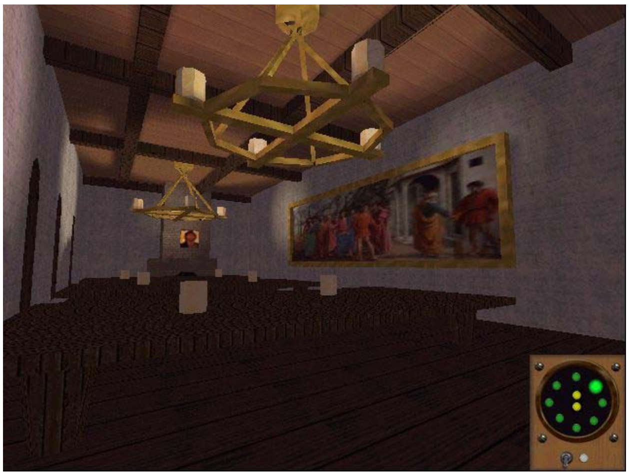

Figure 1: Monastery VE - dining hall in high stimulus quality

Each of the booklets consisted of approximately 1000 words and 4 colour pictures. The monastery related booklet provided a brief history of the monastic movement in Britain, and was presented in a gothic script. The hospital related booklet provided a description of the emergency room triage system, and described some medical tests. For the 'VE irrelevant priming' (N) condition, participants were asked to read a booklet describing the experience of driving a steam train (a theme which we felt was sufficiently removed from both hospitals and monasteries to be considered neutral).

Figure 2: Monastery VE - dining hall in low stimulus quality

2.6 Variables and measures

This study made use of three variables – stimulus quality (abbreviated as QUAL), conceptual priming (abbreviated as

PRIME) and presence. The first two variables (stimulus quality and conceptual priming) were independent variables, and each was manipulated into two levels. Stimulus quality was manipulated into a low (L) and high (H) condition by the use of the high quality and low quality forms of the virtual environments described in 2.4 above, while conceptual priming was manipulated into a VE-relevant (P) and VE-irrelevant (N) condition by means of the priming materials described in 2.5 above. The dependent variable (presence) was measured by means of existing presence questionnaires. Although several presence scales are available in the literature, the choice of which to use is far from trivial (see the recent published debated between Slater [20] and Singer & Witmer [21] which illustrates some of the intricacies of such a decision). Among the most used and most understood are the presence scale of Slater, Usoh & Steed [4], and the Presence Questionnaire of Witmer & Singer [22]. Examples of the use of these scales can be found in [15], [23] and [24]. We decided to use both of these scales to increase the generality of our findings. We abbreviate the Slater, Usoh & Steed scale as SUS, and the Presence Questionnaire as PQ.

Figure 3: Hospital VE - ward room in high stimulus quality

2.7 Procedure

2.7.1 Instruction and Training stage

The experiment was run in a dedicated room so that lighting and noise could be controlled to reduce distractions. The room contained three computers with partitions between each, to prevent participants from viewing each other's displays. The participants were told that the experiment was investigating thought processes in virtual environments. They were then given a basic instruction of their task; namely, that they were to be tourists in the virtual environment, and that they should explore and take in the sights and sounds of the VE. The DAVE tool was then started with the training VE and its use was explained to the participants. They were then allowed to practice interacting with the tool until the experimenter felt satisfied that all participants were proficient in its use. The DAVE tool was then shut down.

Figure 4: Hospital VE - ward room in high stimulus quality

2.7.2 Priming stage

The participants were told that the training was over and that the experiment was about to begin. The basic procedure was explained to them; namely, that they would be given a booklet to read, followed by their exploring a virtual environment, followed by filling out of questionnaires. Before they were given the priming materials, it was emphasized that it was not important to finish the entire booklet, but rather that they should read slowly, carefully examining the pictures and thinking about the things written in the text. The door of the room was closed, and the participants were then given the priming materials. After 5 minutes, the priming materials were taken away.

2.7.3 Exploration stage

The room's lights were turned off, and the DAVE tool started with one of the four environments (monastery or hospital in high or low quality form). The participants were instructed to begin exploring the virtual environment. The experimenter remained in the room, but observed the participants from a covert position so that the participants were not distracted. After a period of 15 minutes, the exploration stage was concluded.

2.7.4 Questionnaire stage

The room's lights were turned on, the DAVE tool shut down, and the participants were handed the first series of questionnaires (SUS and PQ) to complete. The participants were given as much time as they required to complete the entire set. This usually took between 10 and 15 minutes.

2.7.5 Second iteration

Once the questionnaires were complete, the participants were told that they were to explore one more virtual environment. The same basic procedure as above was repeated, from the priming stage till the questionnaire stage. At the beginning of this second priming stage, the participants were again reminded of the importance of not rushing through the booklet, but rather reading carefully, and of the importance of carefully exploring the virtual environment.

3. RESULTS

The results from the SUS and PQ were analyzed separately, but we combined the data from the hospital and monastery environments (by using a repeated measures design) once it was determined that no significant differences existed in either PQ or SUS scores between the monastery and hospital environments.

From our 55 participants, we collected a total of 103 complete sets of observations (a complete set constitutes two completed SUS and two completed PQ questionnaires). The observations were effectively assigned to one of the four cells of the study's design by means of random assignment. The number of observations in each of the design's cells is summarized in Table 1. The data were analyzed using the factorial analysis of variance (ANOVA) technique.

	PRIME	
QUAL	*VE relevant*	*VE irrelevant*
Low	24	28
High	27	24

Table 1: Observations in each condition (N=103)

3.1 ANOVA results: SUS

This variable presented a significant interaction between stimulus quality and priming (F(1, 99) = 10.18 $p < 0.0019$). The means plot of this effect is shown in Figure 5. There was also a significant main effect on stimulus quality (F(1,99) = 9.64 $p < 0.002$). There was, however, no significant main effect on priming (F(1,99) = 0.17, $p > 0.65$).

3.2 ANOVA results: PQ

This variable behaves in a similar way to SUS. The interaction between stimulus quality and priming (shown in) was significant (F(1,99) = 4.23 p < 0.05), as was the main effect of stimulus quality (F(1,99) = 5.99 $p < 0.02$). The main effect of priming on PQ was not significant (F(1,99) = 0.23 p > 0.63). The means plot can be seen in Figure 6.

3.3 Post-hoc analyses: SUS and PQ

Post-hoc analyses confirm that there is a difference between the *QUAL* levels at the *VE relevant* level of *PRIME* and no difference between *QUAL* levels at the *VE irrelevant* level of *PRIME*. The results of those tests, for both PQ and SUS, are presented in Table 2.

PRIME level	Df	t	*p*
SUS:VE relevant	**49**	**3.99**	**0.0002**
SUS: VE irrelevant	50	0.069	0.944
PQ:VE relevant	**49**	**3.422**	**0.0012**
PQ: VE irrelevant	50	0.26	0.795

Table 2: Post-hoc tests between QUAL levels (H vs. L). Significant tests (*p* < 0.05) in bold

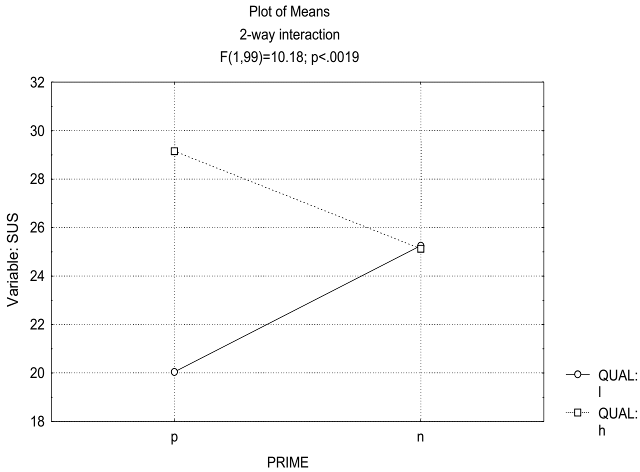

Figure 5: Means plot for interaction effect on SUS. The dashed line indicates high stimulus quality, and the solid line low stimulus quality.

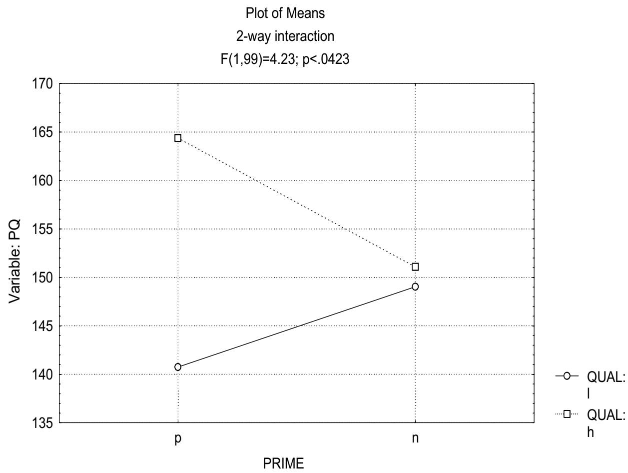

Figure 6: Means plot for interaction effect on PQ. The dashed line indicates high stimulus quality, and the solid line low stimulus quality.

3.4 Summary of results

The main effect of stimulus quality on presence in both the SUS and PQ suggest that for any two users with the same priming state, the one experiencing the higher quality display will experience more presence. The lack of main effect of priming suggests that priming does not directly affect presence. However, the interaction effect shows that priming does affect presence by acting as a context in which the stimulus quality effect can occur. This strongly suggests that priming is a mediator variable in presence. This means that at if two users are viewing a virtual environment at different levels of stimulus quality, the difference will be maximized if they have been primed, and at most nullified if they have not been primed.

4. CONCLUSION

The results from our experiment strongly suggest that the mental state with which a user enters a VE plays an important role in the production of presence. Our data suggest that it is unlikely that presence could be adequately predicted by a simple scaled sum of sensory components. The interaction we identified suggests that presence occurs as a *product* of the user's mental state and the stimulus set, and it is thus necessary to know the user's own contribution to presence before the degree of presence they will experience can be adequately predicted. We think that this finding strongly supports a constructive concept of presence, in which the users themselves construct the presence experience based partly on perceptual inputs, and partly on the mental context in which they are processed. This is in opposition to the more Gibsonian view which sees presence as occurring almost exclusively as a consequence of the perceptual stimulus set, as if it were an optical illusion. The notion that users somehow contribute to her own experience of presence has existed for some time in the literature, although only in a theoretical form. Our contribution in this effort is to offer an operationalization of "the suspension of disbelief" and provide empirical findings to support its importance by means of examining a large sample of participants.

4.1 Critique of our approach

It would be imprudent of us, however, to make such claims without taking a moment to critique our approach. We were concerned that the effect we were observing may have occurred due to artifacts arising either from the scales or from the environments to which the participants were exposed. We were able to allay our concerns thanks to our decision to use two virtual environments and two measures of presence. We re-computed our statistics separately for each virtual environment. In each case, the same patterns described in 3 above emerged, accompanied by the same pattern of statistical significance. This convinced us that the findings were not a product of our method, but rather point to an actual phenomenon.

There were, however, more troubling weaknesses in our study. The principle area which concerned us was measurement. We provide measures neither of our stimulus quality levels nor of the intensity of priming; rather, our differences are created by means of manipulation. Such a move obviously poses the question of whether the manipulations were effective in creating true differences. Unfortunately, such measures do not yet exist, and without them we cannot ensure the reader that the manipulations were effective. We can, however, present a statistical argument to support our strategy. If the stimulus quality manipulation had not succeeded in creating a real difference, then it is extremely unlikely that the ANOVAs would have shown statistical significance, because an ineffective manipulation in the context of random group assignment would have resulted in an even distribution of scores within each group, and therefore no statistical significance. Of course, this argument is somewhat circular, but until a measure of stimulus quality and priming are devised, it is necessary to resort to the manipulation of variables into gross extremes.

Another area of measurement which weakens our conclusions is that of presence measurement. Indeed, the lack of an effective measure of presence is a familiar source of frustration to those in the presence research field (see [25] for a review of some of the problems with current measures). Although we chose two popular and reasonably well-understood measures, the quality of each is known to be questionable (see [20] and [21] for a discussion of the relative merits and failings of these scales). Having inaccurate scales leads to a weakening of the conclusion both in the statistical sense (due to the increase in noise) and in the conceptual sense (due to vagueness in conceptualization of the variable in the scale).

A final criticism of our study is also related to measurement, although in a more oblique way. Our findings have all been derived via pen-and-paper questionnaires. One may rightfully ask if the findings would have been different if a different presence measuring approach had been used. Because our priming was made by means of reading, and the questionnaires are also based on written text, it is possible that the interaction we observed is limited to the verbal processing apparatus, and that the effect we observed is not related to presence at all, but only to the completion of the questionnaires. Because we did not use any non-verbal measures of presence, we are unable to address this issue directly. However, we could find no significant theoretical support for this criticism either in the presence literature, or in the cognitive psychology literature.

4.2 Explaining the results

If we consider our findings to be a real phenomenon as opposed to a methodological artifact, then it is necessary to explain their occurrence. Explaining the interaction effect is by no means a simple task. If one considers presence as being associated not only with perception of the virtual environment, but also with the selection of actions appropriate to the virtual environment (as is done in the cognitive presence approach [9]), then it is possible to explain the interaction effect in terms of schemata activation. Our priming manipulation activated a particular set of schemata, which were either relevant or not relevant to the virtual environment. The activation of schemata will pre-allocate processing resources, facilitating the processing of related perceptions. Simultaneously, the processing of unrelated perceptions will occur with more difficulty, due to the reduction in cognitive resources available [13]. Consider then a user who has been primed with materials not relevant to the virtual environment. Upon first viewing the environment, the lack of fit between the environmental stimuli and the primed schemata will lead the user to first experience confusion and difficulty in processing the environment. However, as there is very little fit between the environmental stimuli and the activated schemata, these schemata become de-activated and replaced by more appropriate ones by the user's cognitive apparatus [14]. Thus, after a brief exposure to the virtual environment, all traces of the primed schemata have been erased. The same basic principles apply in the case where the primed schemata are relevant to the virtual environment. In the case of the high stimulus quality environment, there is a large degree of fit between the environmental stimuli and the primed schemata, so an enhanced processing of the environment occurs. This in turn leads to the schemata "smoothing over" any slight inconsistencies and rendering artifacts which may be present (leading to, according to the presence understanding of presence, an increased sense of presence). In the case of the low stimulus quality environment, there exists a *slight* degree of fit between the environmental stimuli and the activated schemata (e.g., the hospital looks *almost* like a hospital, but not quite). Consider then the situation. The degree of fit is not sufficient to allow enhanced processing, but the fit is enough to prevent the schemata from being de-activated and replaced by another. The user is then left in a continual state of attempting to reconcile the active schemata with the perceptual input. This uses up cognitive resources, which in turn prevents optimal processing of the virtual environment (and, theoretically, a decrease in the sense of presence).

4.3 Applications and future work

Our findings have consequences from a theoretical and an applications perspective. On the theoretical front, our research suggests that there is considerable advantage to be gained from combining advances in cognitive psychology and presence research. Specifically, our findings suggest that the user's mental state should be considered, if not as a cause, then at least as a mediating variable in presence. Even if the reader does not consider priming to be a variable which should be included as a cause in presence research, there is a methodological imperative to its consideration in presence studies. Because we have demonstrated that the user's mental state *can* affect presence in a predictable way, priming must therefore be considered at the very least as a third variable to be controlled for in experiments.

From a practical perspective, our research suggests that the presence experience can be maximized through the use of priming. Steed *et al* [26] comment that it is a common practice for theme parks to create an expectation in their customers of what they are about to experience by means of posters or other decorations placed where the customers wait in line for the ride. Our research supports this practice, provided that the virtual environment is displayed at a high quality level (although we do not yet have an measurable notion of what "high quality" means). Because the priming process itself is quite simple (text alone can be used), the practice of priming can be applied to a wide variety of situations. Some manufacturers of immersive games already use this technique by, for instance, including music or speech audio tracks related to the game content which play during the game's installation period (for examples, see Codemaster's *Operation: Flashpoint*, Westwood Studio's *Command and Conquer: Renegade*, or Bethesda Softworks' *The Elder Scrolls III: Morrowind*). This trend is certainly in the right direction, although it seems likely that in order to take advantage of the priming effect, the manipulation would have to be repeated before each game session. This practice also exists in commercial applications, although to a far lesser extent. An example can be found in Electronic Arts' submarine simulator *Sub Command.* Each time the game is started, the player is shown a montage of real video footage of submarine operations played over a suitably martial soundtrack. This type of addition to a game or other VR application is simple to implement, and can be done quite cost effectively.

Clearly, the findings presented in this paper represent only the beginning of a fertile area of research. Before conceptual priming can be applied beyond research programs, several difficulties need to be overcome. Chief among these, we believe, is the issue of measurement. It is necessary to discover measures of stimulus quality and priming effectiveness which will allow system engineers to determine the degree to which a particular priming manipulation will contribute to or detract from the presence experienced on a particular system. Also, different modes of priming (visual, textual, aural, etc) need to be investigated to determine if differences exist, and if so, which mode is appropriate under which conditions.

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