Cognitive Factors Associated with Immersion in Virtual Environments

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Immersion into the dataspace provided by a computer, and the feeling of really being there or "presence", are commonly acknowledged as the uniquely important features of virtual reality environments. How immersed one feels appears to be determined by a complex set of physical components and affordances of the environment, and as yet poorly understood psychological processes. Pimentel and Teixeira (1993; p. 15) say that the experience of being immersed in a computer-generated world involves the same mental shift of "suspending your disbelief for a period of time" as "when you get wrapped up in a good novel or become absorbed in playing a computer game." That sounds as if it could be right, but it would be good to get some evidence for these important conclusions. It might be even better to try to connect these statements with theoretical positions that try to do justice to complex cognitive processes. The basic precondition for understanding Virtual Reality (VR) is understanding the spatial representation systems that localize our bodies or egocenters in space (Franklin, 1992). The effort to understand these cognitive processes is being driven with new energy by the pragmatic demands of successful virtual reality environments, but the literature is largely sparse and anecdotal (cf. Benedikt, 1991; Ellis, 1992; Furness, 1992; Laurel, 1992; Pimentel and Teixeira , 1993; Witmer and Singer, In Preparation).

Although the VR literature pays a great deal of lip service to the perceptual psychology of J. J. Gibson, there is little in the ecological perception framework that might suggest sources of individual differences in the quality of immersion. Yet, anecdotally, there appear to be wide differences in how well people react to these exotic environments.

In a first step to gather more information, a very short set of questions were compiled and sent to users of virtual reality environments over the internet on the virtu-l listserv. The questions were carefully designed to cover cognitive factors that have been raised in the literature on virtual reality environments. By and large, the literature has not raised a very detailed or analytic set of questions, so many questions we developed deal with issues that have some face value only. For instance, Pimentel and Teixeira (1993; p. 105) offer the following set of factors as instrumental for deep immersion: interactivity, fast update rate, high image complexity, engaging, 3D sound, head-mounted display; stereoscopic; large field of view, and head tracking. None of these are cognitive factors, although they admit that a "holistic technique might be necessary because the experience of immersion is more than just the mere sum of its parts."

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DESIGN

Stimuli

The factors we considered were grouped into two categories:
A. Susceptibility to immersion; and B. Quality of immersion.

A. Susceptibility to immersion:
- I. Imagination
  - Strength of visual imagination
  - Dreaming
  - Self-consciousness
  - Daydreaming
  - Ability to willingly suspend disbelief
  - Depth of involvement in books, theater, etc.
- II. Vivid Imagery
  - Dreaming
  - Prior expectations about the virtual reality environments
  - Claustrophobia
- III. Concentration and Attention
  - Attentional filtering
  - Cognitive conflict in holding two recursive immersions
  - Spatial Navigation
  - Claustrophobia
- IV. Self-control
  - Self-control
  - Active participation and catharsis

B. Quality of immersion.:
- I. Affordances of the VR Environment for Immersion:
  - Object Persistence
  - Sensory Completeness
  - Interactivity
  - Realism of the environment
  - Amount of lag or delay
  - Size of field of view
  - Accuracy of egocenter or body image location
  - Pleasure and exhilaration from the novelty of the experience
- II. Distractions from the Real Environment:
  - Presence of others; sounds, tactile
  - Fatigue and irritation by bulky equipment
  - Restrictiveness of the equipment
  - Similarity of Real World to VR World
- III. Physiological effects
  - Simulator sickness
  - Disorientation after immersion
- IV. Other Effects
  - Prefer immersion alone
  - Surprise when HMD removed

Many other factors could be assessed, but for the first effort it was important to keep the questionnaire as short as possible to elicit as many voluntary responses as possible, and to begin winnowing these factors in a sensible way.

The constructed questionnaire used 12 questions for the susceptibility component (that might also be used as a pretest in any experimental setting) and 11 questions to measure the quality of immersion. All questions were constructed on a five point categorical (Likert) scale for responses. The questionnaire is included in the appendix A, with some changes and new questions that have been added through the preliminary analysis reported here. The questions were asked so that roughly half of them were constructed to relate positively with depth of immersion and hal, negatively. A key was constructed to convert all questions to positive relationships.

Subjects

Fifteen respondents whose gender is unknown had some experience in a variety of virtual reality environments ranging from homebred PC systems to state of the art centers at UNC, BBN, Chicago, and the HIT Lab at U. Washington. The modal virtual reality environment was the W. Industries' Virtuality arcade with 7 respondents. Most of the respondents had less than one hour of experience in the virtual reality environments. In addition 8 responses came from individuals with no virtual reality environment experience, who only answered the questionnaire dealing with susceptibility.

These are very small numbers of respondents for the factor analyses used in this exploratory study. The results must be viewed as provisional, reflecting some of our biases as well as true relationships between cognitive components and depth of immersion. Ideally, 100 respondents for each group would be welcome. This would even begin to allow comparisons among the different VR environments used by the respondents. We urge you all to complete the questionnaires in Appendix A, or have your students complete them, and send them to us for further analysis.

RESULTS

PreTest

On the susceptibility to immersion questionnaire, no significant differences were found in the scores of the group with no VR experience and the group with some VR experience, using a standard analysis of variance ($F = 0.45$, 1,21 df; $p = 0.51$). The two groups' scores correlated significantly ($R = .63$; 9 d.f.; $p < .05$). On the whole, they often dream in color; think that the quality of VR is like TV; occasionally feel claustrophobic or uneasy in small spaces; feel somewhat self conscious speaking in public; have sometimes cried watching a good, sad movie; find a good book very engrossing; have sometimes stayed up late to finish a good book; daydream often; are often able to read in a moving car, boat, or plane; can often tell where they are when some one else is driving; feel it is somewhat important to be completely in control; and have occasionally been told that their name was called when watching TV or reading a book, but have not recollection of hearing it.

PostTest

On the actual experience of virtual environments, the critical question that asked how completely people believed they were part of the virtual environment, yielded only a modest "somewhat". However, on the whole, they felt "very" exhilarated by the experience. More than half the respondents reported they were "very" or "totally" exhilarated. The difference may be that more than half of them felt a little or more woozy or nauseous from the experience. Given their short stays in these virtual environments, that may be a reason for concern.

Most of them felt somewhat surprised by the direction they were facing when they removed the HMD. On the whole, this left no aftereffect, and they reported that they were only a little disoriented by the experience. They continued on the whole to be somewhat aware of the direction they faced in the real world during the VR experience. They occasionally or sometimes thought about the other person(s) in the real world with them there. Most of them felt that other person(s) made no difference to their enjoyment of the experience.

Almost all of the respondents complained that the VR devices restricted their movements somewhat or a lot. The bulkiness of current equipment should make that a surprise to no one.

Most of them reported that when they turned their back on an object in the VR environment, it was still there (although some commented that they might not easily find it again). This is a cognitive skill called "object permanence" or _existence constancy" by psychologists. It is part of a Piagetian test of maturation for children, and may be a good index of the maturity of VR environments too.

There was considerable variability in how flat and missing in depth the VR world appeared, as might be expected from the range of equipment, but on the whole it was only a little missing in depth.

Correlations

Many significant correlations were found ($r = .47$, $df = 13$; $P = .05$). Two sets of correlations might be interpreted. One set looks at the questions within each of the two questionnaires for common factors of importance. The other looks at the correlations between the two questionnaires to try to guess at causal or dynamic connections among susceptibility and the quality of immersion. Principal components factor analysis was used with oblique varimax transformations to select the factors reported below.

Causal or dynamic connections between susceptibility and the quality of immersion: The results were examined for each question that asked about the quality of the experience for a correlation that significantly affected it. These correlations are reported in terms of rules below.

Overview: Immersion was most affected by how claustrophobic someone is. The more claustrophobic you are the more often you think about the other person(s) in the real world with you there; the more you complained that the VR devices restricted your movements; the less often you felt objects were still there when you turned your back on them; the less exhilarated by the experience you were; and the more nauseous or woozy you felt. Clearly this is a danger signal for arcade makers of VR environments. Rather than providing access to a wide open cyberspace, current equipment is still evoking claustrophobic feelings of enclosure and restriction. While almost half of the respondents reported no wooziness or nausea after the experience, this is a pretty extreme response, and arcade makers should flag the fact that more than half reported a "little" or "some" wooziness or nausea. Apparently, those who are somewhat susceptible to claustrophobia, and in this small sample 9 of the 15 reported some sensitivity, have this fear triggered by current equipment.

Depth of immersion was most strongly predicted by whether or not you dream in color, by how often you cry at good, sad movies, and by how effectively you filter out other distractions while reading a book or watching TV. You are more deeply immersed if you dream often in color and you ignore others when they call you while reading or watching TV. You also are more deeply immersed if you are more exhilarated by the experience. There appear to be two psychological factors dominant in predicting depth of immersion. One is the willingness to accept another reality and the willingness to make the effort it takes to participate in it fully and satisfactorily. This factor is dominated by crying at movies, staying up late, and being engrossed by a book. It suggests that childhood pretend play and make believe were a significant part of a person's experience. The other factor depends on the ability to shut out the distracting effects of the real world. This factor is implicated in ignoring others when they call you while you are watching TV, and being able to shut out the real world when you wake up dreaming. This factor may be seriously tested as more complex VR systems become available, that integrate virtual worlds with reality into a new augmented reality.

Exhilaration and enjoyment of the experience is also increased if you are not claustrophobic, and you do not think self control is very important. Two individuals were strongly claustrophobic, and their exhilaration scores were markedly lower than the others'. Exhilaration is also increased if you believed you were deeply immersed and that objects behind your back continued to exist.

Summary of Susceptibility for Immersion

Relationships among the questions are given as rules in Appendix B.
Several clusters are revealed by these intercorrelations.

Cluster A (35% of the Variance) Imagination: Questions 4, 6, 7 and 8 intercorrelated. These all deal with self - consciousness, daydreaming, and how engrossing a book is, even staying up late to finish reading it. Attentional control and ignoring distractions may be the dominant factors. Especially in arcades, wearing the gear required for VR experiences may make some people feel foolish and disturb their immersion. Being willing and able to use your imagination seems to be a common thread.

Cluster B (29 % of Variance) Vividness of Imagery and Claustrophobia: Questions 1, 2, 3, and 9 intercorrelated. 1 and 2 deal with how often you dream in color and how realistic you think the VR world will be visually, while 3 and 9 relate to motion sickness and claustrophobia. The link between those two is unknown. Perhaps there is an unknown relationship between being able to remember dreams in sufficient detail to remember color, (since we all dream every night, probably in color) and our ability to deal with motion sickness and claustrophobia. Our favorite explanation, derived from discussions with our colleague Peter Legree, postulates that the common thread is an ability to shut out or exclude the unwanted effects of the environment. Obviously this is important for claustrophobics when they try to control their claustrophobia in small spaces.

Shutting out reality is also important for those who want to remember their dreams. Most dream memories are only accessible in the first few moments of waking, a special twilight period when both realities are accessible to people. If you can shut out the world during this brief period, you will remember your dreams more clearly, including the fact that they are in color. Most of us who have tried to recall our dreams over an extended period have found that our ability to hold on to this twilight period when dreams are accessible increases with practice, but some of us continue to find it easier than others. It appears that parts of this ability are a skill that can be learned, but other parts may be controlled by psychological processes that are more difficult to change. It appears that they may also affect the depth of immersion in today's crude VR environments.

Why this factor contains expectations of the photorealism of the VR world is also not immediately explicable. Again, our favorite story is that the expected realism of the VR world depends on the vibrancy of dream worlds compared to the real world. Those who can remember their dreams in vivacious detail may be expected to have higher and similar expectations for the VR experience. These expectations also seem to influence the depth of the immersion experience, since those who expect too much appear to be disappointed.

Cluster D (19% of Variance) Self Control: Questions 5 and 11 intercorrelated. These both deal with some components of self control and attentional control. Crying at movies deals with issues of immersion that are under voluntary and imaginative control, rather than the involuntary and ecological or environmental imposition of immersion that we normally experience in our day to day interaction with the environment. Crying at movies also demands the willingness and skill to be able to achieve catharsis (Laurel, 1992) from the fantasy experience of the VR world. Crying at the movies is a pleasurable experience, not an unhappy one. It does not come easily, but demands that viewers participate actively in the movie, and engage its themes and personal events in a powerful way that releases emotions safely, and without fear of personal injury. It demands involvement and participation in an interactive way, and may be related to how satisfying childhood pretend play and make-believe were. Movies and VR experiences are thrilling and emotionally satisfying because they are safe and they are fantasy. If you did not know that it was a fantasy, the events would be horrifying and deeply unsatisfying; yet, because they are fantasy the experience can be deep and meaningful, but quite pleasurable too. Unlike dreaming, where it is important to shut out the distractions of the real world, cathartic release in movies depends on actively engaging and participating in the movie, and actively suspending your disbelief about its illusion. It is interesting that this skill appears to be more positive and affirming than the negative act of shutting out distractions, that appeared in the first factor.

Cluster C (17% of the Variance): Questions 10 and 12 intercorrelated. These both deal with being able to do two things at the same time: pay attention to where you are going when someone else is driving; and listening for others who call you while watching TV. This factor may hinge on the skill of holding two or more realities in mind at the same time. Being able to concentrate and disregard the opinion of others seems to be a common thread.

Table 1. Intercorrelations of each of the PreTest Subscales with the Total PreTest Score

	Pre-A	Pre-B	Pre-C	Pre-D
Pre-A	1			
Pre-B	.093	1		
Pre-C	.064	.263	1	
Pre-D	.657 *	-.087	-.36	1
PreTest Total	.38	.736 *	.473 *	.234

* $p < .05$

Summary of Depth of Immersion Responses:

The responses and intercorrelations for each question are given in Appendix C.

Several clusters are revealed by these intercorrelations.

Cluster A (32% of Variance) Distractibility: Questions 2, 3, 5, and 8 intercorrelated. They all deal with potential distractors outside of the VR environment that could diminish the depth of immersion and the feeling of presence. The direction you face in the real world, how often you think of others in the real world, how restricted your movement is, how flat and missing in depth the world appears, all potentially distract you from the immersion experience. The flatness or lack of depth question was intended to pertain to the VR world, but perhaps people took it to apply to the real world after coming out of the VR experience.

Cluster B (26% of Variance) Willingness to Suspend Disbelief: Questions 6, 7 and 10 intercorrelated. These all deal with those components of the automatic or ecological affordances of the environment that control the depth of immersion, and since they include the prime measure of depth of belief in being part of the environment, they must be more central to the whole immersion experience: sense of object permanence, exhilaration in the experience: these are all involuntary effects of deep immersion. This is perhaps why they all correlate with dreaming in color, since that too is an involuntary immersion and acceptance of another reality, the reality of unconscious imagery and dreams. If one can accept the reality of these still crude cartoons and interactive computer displays, then it may not take an act of self control and will power, but a state of mind that is open and susceptible to altered states of consciousness, like dreams. Notice that dreams are not like daydreams, a meandering of conscious ideas, and it is instructive that daydreaming does not correlate with any of these measures of ecological immersion. It is only the basic involuntary and biological but complex act of dreaming, a total immersion in a hallucinogenic other reality that provides the best measure of immersion into VR environments.

Cluster C (24% of Variance) Concentration: Questions 1 and 4 intercorrelated. They ask how much more enjoyable the experience would have been without anyone else around, and how surprised you were when the HMD was removed. Apparently this did not affect the depth of immersion of people who were distracted by the presence of others, nor make them think of others, so it is not related to their distractibility. However, some people must find fantasy in an immersion environment more enjoyable when they are alone, perhaps because they are self-conscious and cannot concentrate on the experience. Surprise on removing the HMD gives a measure of the concentration on the task of immersion.

Cluster D (19% of the Variance) Simulation Sickness Effects: Questions 9 and 11 intercorrelated. These both deal with how disoriented and how woozy or nauseous you feel. These side effects of immersion also have a strong influence on the depth of the immersion experience. Surprisingly, we did not ask about the effects of lag or apparent body position, so dizziness and nausea were only related to being aware of the direction you faced in the real world.

Table 2. Intercorrelations of each of the PostTest Subscales with the Total PostTest Score.

	Post-A	Post-B	Post-C	Post-D
Post-A	1			
Post-B	.542	1		
Post-C	.479	.34	1	
Post-D	.587	.295	.549	1
Post Total	.815	.792	.761	.686

Overall Correlations between PreTest and PostTest

The correlation between the Susceptibility measure and the Total Immersion scale was .82 (13 d.f.; $p < .01$). This significant correlation suggests that our measure of immersion susceptibility offers the minimal requirement for prediction: significant correlation of the intended measure.

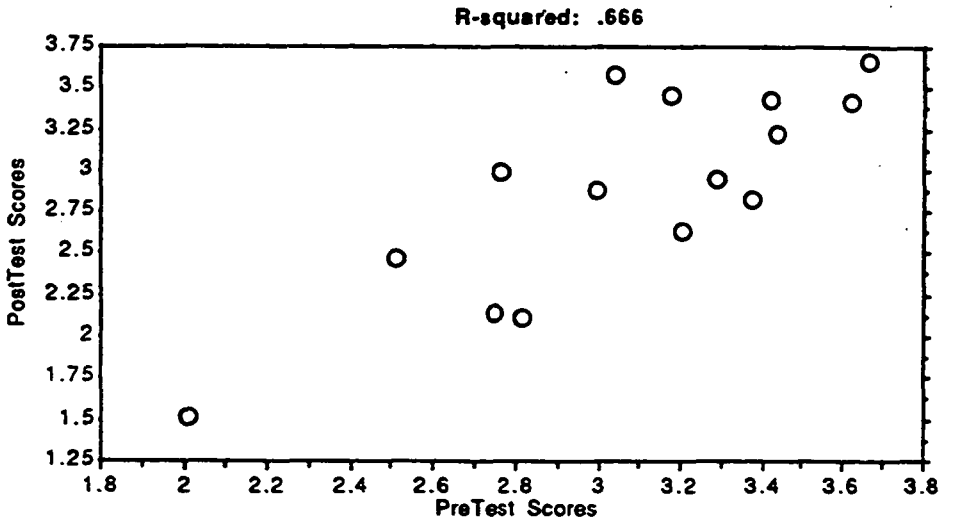

Figure 1. Scattergram showing correlation between PreTest and PostTest Scores

DISCUSSION

The most interesting component of these results is that immersion can be seen as a dual phenomenon: on the one hand dependent on implicit or subconscious biological processes and skills that invoke our cognitive machinery only when the affordances of the ecological setting is suitable; and on the other hand dependent on voluntary attentional skills that depend on self control, self-consciousness, distractibility, attention, expectations, and will power. These two factors (implicit versus conscious control of immersion) are captured in one correlation: Immersion is most complete if you dream in color. How these two components interact is a powerful mystery. The two implicit and conscious components appear to do different things and may not be capable of affecting each other directly. These factors come out so strongly that they are visible in all three sets of correlations: in the susceptibility factors, in the immersion factors, and in their intercorrelations. The fact that they are so strong in the susceptibility factors may indicate that people were interpreting these questions in a very special way, since they had already experienced VR immersion. A larger sample may introduce differences between those who are and are not experienced in VR, on the responses to the susceptibility questionnaire. It must be remembered that these results came from people who answered both questionnaires at the same time, not in the way they were inteded to be used: before and after experiencing immersion. However, this standardization group is still important for the kinds of intercorrelations it demonstrates.

Implicit factors have a kind of dominance. It may not be possible to overlook certain ecological preconditions for immersion if they are violated, no matter how intent one may be to have a deep immersive experience. For example, if the lag between intention and visual feedback of perceived hand movement in the VR world is very large, no amount of mental filtering of the image is likely to reduce that lag; and it may lead to varying degrees of simulator sickness. Or, as another example, if your visual system tells you that your egocenter or body image is in one location, but your kinaesthetic senses locate it somewhere else, there may be no way to override or integrate these two positions by cognition alone. Longer term processes of learning and adaptation that change the cognitive machinery may be required.

From these results, it appears that immersion in a VR world is not like being immersed in a book or a good movie. It appears to be more like remembering your dreams. Unlike a book or a movie there are strong visual affordances for immersion in your dreams. There you are almost always the agent of action and interaction, and there is only one world in which you are immersed. When you look at a picture or build up a representation of the space described in a book (Tversky, Franklin, and Coon, 1992) that fact that you are sitting or standing in another (real) space never quite gets forgotten, so there must always still be some sort of conflict between the two representations of your egocenter.

This conflict is most evident when you look at a picture, either a photograph or a painting. Particularly in paintings, the viewpoint of the painting is often quite controlled and striking (Kubovy, 1986). In Davinci's famous painting of the last supper, for instance, the viewpoint is elevated some 5 meters above the floor of the room where most people stand to view it. Art critics have suggested that this is to give one the feeling of elevation and levitation as one views the painting. Most viewers are unaware of the conflict between their egocenter as people in the room and their apparent egocenter as viewers in the painting. The space of the painting and the space of the room are shared easily. This is unlike VR immersion where entering the VR world depends on blocking out the real world almost completely. This happens in the real world when someone holds a mask in front of their face too. Holding a picture in froont of your face has a disturbing effect a maks does not, because the space of the picture and the space of your face are so different that it is not really possible to reconcile them. Surely conflicts between visual and kinesthetic egocenters are being resolved continuously in the real world, since all of our systems are slightly in error in our interactions with the world.

It is very important to proceed with the categorization of the cognitive and perceptual components of immersion, and continue this analysis. Take for instance the primary cognitive process of specifying an egocenter within a cognitive spatial representation system. Clearly the location of the egocenter is computed from many visual cues, derived from the structure of the optic array. In a VR system many differences between an ecologically mimetic representation and the real world could yield either less presence, or inaccurate immersion, or both. For instance, a narrower field of view could destroy the experience of immersion as others have suggested, not in and of itself, but because it also created a displaced egocenter, or created the illusion of viewing the world through a porthole or goggles from outside the world.

Entering the VR world appears to require the full and complete use of psychological spatial representation processes that normally appear to be able to allocate only one spatial egocenter at a time. Franklin, N., Tversky, B., and Coon, V. (1992) report that readers will try to encompass only one described scene at a time, and cannot easily integrate two different locations and scenes. Holding on to reality in a VR experience appears to be equally difficult, and so the distractibility of the environment and the equipment used for the VR representation become critical factors in the depth of the VR experience.

Fleshing out the cognitive and perceptual components of immersion promises to be a long but rewarding task. It is particularly rewarding for training and educational purposes because we already know that so much of cognitive representation is in the form of mental models for understanding complex systems. Vr promises to turn knowledge into experience and make education and training much more direct and effective.

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APPENDIX A: Two Questionnaires

Please answer these questions. They are intended to provide us some insight into the process of "immersion" and the nature of "presence". If you have already had some VR experience, please answer the second part too, but first indicate what kind of equipment you used and how often you have had direct experience of VR:
Equipment: _____
Frequency of Experiencing VR: #times_____#hours:_____
Purpose of Vr Experience: Recreation; Research; Training

PRETEST: A questionnaire to try to measure someone's susceptibility to experiencing a pleasurable immersion into VR.

1. Do you dream in color?
Never Seldom Sometimes Often Always

2. How realistic do you think this experience will be visually?
PhotoReal LikeMovies LikeTV LikeComics Blurred

3. Do you feel claustrophobic or uneasy in small spaces?
Never Seldom Sometimes Often Always

4. When you speak in public, how self-conscious do you feel?
Totally Very Somewhat A Little Not At All

5. How often have you cried watching a good, sad movie?
Never Seldom Sometimes Often Always

6. How engrossing is a good book?
Totally Very Somewhat A Little Not At All

7. How often have you stayed up late to finish a good book?
Never Seldom Sometimes Often Always

8. How often do you daydream?
Never Seldom Sometimes Often Always

9. Can you read in a moving car, boat, or plane?
Never Seldom Sometimes Often Always

10. Do you keep track of where you are when some one else is driving?
Never Seldom Sometimes Often Always

11. How important is it to be completely in control?
Totally Very Somewhat A Little Not At All

12. How often have people told you they called your name and you have no recollection of hearing them while watching TV, or reading a book?
Never Seldom Sometimes Often Always

Additional Questions:

13. How realistic and detailed are your usual visual images, such as of your car or of a good friend?
Totally Very Somewhat A Little Not At All

14. How much do you prefer improvisation and exploration over following directions?
Totally Very Somewhat A Little Not At All

15. How often as a child did you play pretend or make - believe?
Never Seldom Sometimes Often Always

POSTTEST: A questionnaire to try to measure the depth of someone's immersion into VR.
1. When you removed the Head mounted display, how surprised were you at the direction you were facing?
Totally Very Somewhat A Little Not At All

2. During the immersion how aware were you of the direction you faced in the real world?
Totally Very Somewhat A Little Not At All

3. How often did you think of the other person(s) in the real world with you?
Never Seldom Sometimes Often Always

4. How much more enjoyable would it have been to have the immersion experience with no one else in the room?
Totally Very Somewhat A Little Not At All

5. How restricted was your movement by the VR devices?
Totally Very Somewhat A Little Not At All

6. How completely did you believe you were part of the virtual environment?
Totally Very Somewhat A Little Not At All

7. When you turned your back on an object in the virtual environment, was it still there?
Never Seldom Sometimes Often Always

8. How flat and missing in depth did the VR world appear?
Totally Very Somewhat A Little Not At All

9. How woozy or nauseous did you feel after the experience?
Totally Very Somewhat A Little Not At All

10. How exhilarated did you feel after the experience?
Totally Very Somewhat A Little Not At All

11. How disoriented did you feel after the experience?
Totally Very Somewhat A Little Not At All
Additional Questions:

12. How disturbing was the lag or delay between your movements in the real world and the VR world?
Totally Very Somewhat A Little Not At All

13. How often did you feel your body image was in the wrong place in the VR world?
Never Seldom Sometimes Often Always

14. How responsive was the environment to your movements?
Totally Very Somewhat A Little Not At All

15. How natural and realistic was any object motion?
Totally Very Somewhat A Little Not At All

16. How much narrower was the field of view than normally?
Totally Very Somewhat A Little Not At All

17. How completely could you survey or search the environment visually?
Totally Very Somewhat A Little Not At All

18. How realistic was this experience visually?
PhotoReal LikeMovies LikeTV LikeComics Blurred

19. How completely did you adapt to the VR world and its special characteristics?
Totally Very Somewhat A Little Not At All

20. How completely were all your senses engaged by the VR world?
Totally Very Somewhat A Little Not At All

21. How often did images of the VR world intrude in your daily life or your dreams after the experience?
Never Seldom Sometimes Often Always

APPENDIX B

Summary of Susceptibility for Immersion Responses:

Question 1. If you tend to dream in color you believe the VR world will be more photorealistic, and you seldom feel claustrophobic.

Question 2. If you expect the VR world to be more cartoon - like and blurred you tend not to dream in color, and you tend not to be able to read in a moving car.

Question 3. If you tend to be claustrophobic you rarely dream in color.

Question 4. If you are self-conscious you find a good book engrossing and you seldom daydream.

Question 5. If you often cry at a good, sad movie you stay up late to finish a good book, you can read in a moving car, and you find it important to be in control.

Question 6. If you tend to find a good book engrossing you tend to stay up late to finish a good book, you cry more often at good, sad movies, and you find it important to be in control.

Question 7. If you tend to stay up late to finish a good book you tend to find a good book engrossing, you cry more often at good, sad movies, and you find it important to be in control.

Question 8. If you tend to daydream more often you are not self conscious and you find a good book engrossing.

Question 9. If you tend to be able to read in a moving car you tend to dream in color, you believe the VR world will be more photorealistic, and you seldom feel claustrophobic

Question 10. No significant correlations.

Question 11. The more important you feel it is to be completely in control. the more you tend to cry at good, sad movies, the more engrossing a good book is, and the more often you stay up late to finish a good book.

APPENDIX C

Summary of Depth of Immersion Responses:

Question 1. If you are more surprised by the direction you are facing when the HMD is removed, you become disoriented by the experience, and when object constancy is accepted in the virtual environment.

Question 2. If you tend to be more aware of the direction you are facing in the real world, while you are immersed, you think of other people in the real world, you tend to feel that the VR devices are restrictive, and you tend to become woozy or nauseous.

Question 3. If you tend to think about the other person(s) in the real world with you there you tend to be more aware of the direction you are facing in the real world, you tend to feel that the VR devices are restrictive, and the world tends to feel flat and missing in depth.

Question 4. No significant correlations.

Question 5. If you find the VR devices restrictive you tend to be more aware of the direction you are facing in the real world, you tend to think about the other person(s) in the real world with you there, and the world tends to be less flat and missing in depth

Question 6. If you tend to believe completely that you were a part of the VR world, your object constancy is strong in the VR environment, and the experience tends to be very exhilarating.

Question 7. If your object constancy is strong in the VR environment you are more surprised by the direction you are facing when the HMD is removed, you tend to believe completely that you were a part of the VR world, and the experience tends to be very exhilarating.

Question 8. If the world tends to be less flat and missing in depth you tend to be more aware of the direction you are facing in the real world, while you are immersed, you tend to think about the other person(s) in the real world with you there, and you find the VR devices restrictive.

Question 9. If you become more woozy and nauseous you tend to be more aware of the direction you are facing in the real world, while you are immersed.

Question 10. If the experience tends to be very exhilarating you tend to believe completely that you were a part of the VR world and your object constancy is strong in the VR environment.

Question 11. If you are more disoriented you are more surprised by the direction you are facing when the HMD is removed.

APPENDIX D

Summary of Depth of Immersion Related to Susceptibility for Immersion:

Question 1. You are more surprised by the direction you are facing when you remove the HMD if you tend to dream in color. This also happens when you become disoriented by the experience, and when object constancy is accepted in the virtual environment.

Question 2. You tend to be more aware of the direction you are facing in the real world , while you are immersed, if you are claustrophobic and tend to stay up late reading books. This also happens when you think of other people in the real world, if the VR devices are restrictive, and if you become woozy or nauseous.

Question 3. You tend to think about the other person(s) in the real world with you there if you are claustrophobic, if you daydream, and if you lose your sense of location when others drive you.

Question 4. You would find the VR experience more enjoyable alone if you are self-conscious, and feel an need for self-control.

Question 5. You find the VR devices restrictive if you are claustrophobic and self-conscious.

Question 6. Immersion is most complete if you dream in color and are not distractible.

Question 7. Your object constancy is strong in the VR environment when you are not claustrophobic, and you do not need to be in control.

Question 8. The VR world tends to be less flat and missing in depth when you expect it to be more cartoon like and blurred.

Question 9. You become more woozy and nauseous when you rarely dream in color, when you are more claustrophobic, and it is important to be in control.

Question 10. The experience is more exhilarating when you are less claustrophobic and less distractible.

Question 11. You are more disoriented when you often cry at a good, sad movie; and the more important it is to be completely in control.