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Measuring Presence in Virtual Environments: A Presence Questionnaire

Abstract

The effectiveness of virtual environments (VEs) has often been linked to the sense of presence reported by users of those VEs. (*Presence* is defined as the subjective experience of being in one place or environment, even when one is physically situated in another.) We believe that presence is a normal awareness phenomenon that requires directed attention and is based in the interaction between sensory stimulation, environmental factors that encourage involvement and enable immersion, and internal tendencies to become involved. Factors believed to underlie presence were described in the premier issue of *Presence: Teleoperators and Virtual Environments.* We used these factors and others as the basis for a presence questionnaire (PQ) to measure presence in VEs. In addition we developed an immersive tendencies questionnaire (ITQ) to measure differences in the tendencies of individuals to experience presence. These questionnaires are being used to evaluate relationships among reported presence and other research variables. Combined results from four experiments lead to the following conclusions:

(1) the PQ and ITQ are internally consistent measures with high reliability;
(2) there is a weak but consistent positive relation between presence and task performance in VEs;
(3) individual tendencies as measured by the ITQ predict presence as measured by the PQ; and
(4) individuals who report more simulator sickness symptoms in VE report less presence than those who report fewer symptoms.

1 Introduction

Presence is defined as the subjective experience of being in one place or environment, even when one is physically situated in another. As described by teleoperators, presence is the sensation of being at the remote worksite rather than at the operator's control station. As applied to a virtual environment (VE), presence refers to experiencing the computer-generated environment rather than the actual physical locale. This definition provides a common understanding of the concept, but it does not identify the factors influencing presence, nor does it describe the exact nature of the experience. What aspects of the VE or remote environment contribute to the experience of presence? Do individual differences affect how much presence is experienced? What role does immersion, the perception of being enveloped, play in experiencing presence? Does presence result from a simple displacement of attention from the real world to

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the VE or must one become totally involved in the VE to experience presence? (As used here, *attention* includes orienting one's senses toward information sources and selectively processing the available information.)

2 Degrees of Presence

Presence in a VE depends on one's attention shifting from the physical environment to the VE, but does not require the total displacement of attention from the physical locale. In fact, humans experience varying degrees of presence in a physical locale; typically attention is divided between this physical world and the mental world of memories, daydreams, and planned activities. The mental world may also include information portrayed in books, movies, or via a VE. Thus, individuals experiencing a VE can concurrently attend to aspects of the VE and events in their physical environment. How sharply users focus their attention on the VE partially determines the extent to which they will become involved in that environment and how much presence they will report. Whether there is a threshold for the allocation of attentional resources that must be reached before presence is experienced remains an open question, but it is reasonable to assume there is a threshold, and that the increased allocation of attentional resources beyond this threshold will result in a heightened sense of presence. That is, presence may vary across a range of values that depends *in part* on the allocation of attentional resources. It also depends upon other factors, as we discuss later in the section on immersion.

2.1 Necessary Conditions for Presence

According to Fontaine (1992), presence seems to be a matter of focus. Focus occurs when one directs attention toward something. This focus is continually shifting in everyday life, as is obvious from the amount of presence required in performing everyday tasks like commuting. Common and well-practiced tasks can often be performed while thinking about other things and may even occur without memorable consequences. When experiencing a novel environment however, people are typically more aroused and broadly focused on the tasks to be performed or the situation to be experienced. Fontaine (1992) claims that this broad focus enables the individual to be broadly aware of the entire task environment. The novelty, immediacy, and uniqueness of the experience requires the broad focusing of attention on all aspects of the environment. In contrast, a narrow attentional focus requires that most of one's attentional resources be directed toward selected aspects of the environment. Fontaine (1992) relates findings that support the wide-focus phenomena in novel environments to possible VE experiences, arguing that the broad focus is also necessary for a high level of presence in VEs.

An alternate view is that the experience of presence in a VE may have aspects similar to the concept of selective attention. *Selective attention* refers to the tendency to focus on selected information that is meaningful and of particular interest to the individual. Research has shown that attention is guided by the meaningfulness of the information presented (Triesman, 1963; Triesman & Riley, 1969). Our argument is that experiencing presence in a remote operations task or in a VE requires the ability to focus on one meaningfully coherent set of stimuli (in the VE) to the exclusion of unrelated stimuli (in the physical location). To the extent that the stimuli in the physical location fit in with the VE stimuli, they may be integrated to form a meaningful whole. Though novel aspects of the VE may attract some attention, presence depends less on their novelty than on how well they are connected within the entire VE stimulus set.

Our argument that presence depends on the ability to focus on one meaningful, coherent VE stimulus set is similar to McGreevy's (1992) concept that the experience of presence is based in attention to continuities, connectedness, and coherence of the stimulus flow. The coherence of the VE characteristics and stimuli thus enables the focusing of attention, but does not force that on the experiencer. This concept of enabling without forcing distinguishes the experience of presence from the factors that typically support the experience.

2.2 Involvement

Involvement is a psychological state experienced as a consequence of focusing one's energy and attention on a coherent set of stimuli or meaningfully related activities and events. Involvement depends on the degree of significance or meaning that the individual attaches to the stimuli, activities, or events. In general, as users focus more attention on the VE stimuli, they become more involved in the VE experience, which leads to an increased sense of presence in the VE. To the extent that users are preoccupied with personal problems or focused on activities occurring outside of the VE, they will be less involved in the VE. Similarly, if the VE user is ill or the VE head-mounted display is uncomfortable, involvement in the VE will be diminished accordingly. Involvement can occur in practically any setting or environment and with regard to a variety of activities or events; however, the amount of involvement will vary according to how well the activities and events attract and hold the observer's attention.

2.3 Immersion

Immersion is a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences. A VE that produces a greater sense of immersion will produce higher levels of presence. Factors that affect immersion include isolation from the physical environment, perception of self-inclusion in the VE, natural modes of interaction and control, and perception of self-movement. A VE that effectively isolates users from their physical environment, thus depriving them of sensations provided by that environment, will increase the degree to which they feel immersed in the VE. Typically, a helmet-mounted display (HMD) is instrumental in providing this isolation in VEs. If users perceive that they are outside of the simulated environment and looking in (e.g., while viewing the environment via a CRT display), the immersive aspect is lost, despite being involved through the presentation of a coherent and meaningful set of stimuli. For example, a standard arcade-style video game may lead to high levels of involvement, yet have poor immersive characteristics. To the extent that users find interaction with (and control of) a VE awkward, immersion in that VE is reduced. When users interact naturally with a VE, able to both affect and be affected by the VE stimuli, they become more immersed in that environment. Perceiving oneself as moving inside a simulated environment or directly interacting with other entities in that environment will also increase one's sense of being immersed. Immersing people in a simulated environment is what VEs are designed to do, and that is why VEs have the potential to produce presence. Though the VE equipment configuration is instrumental in enabling immersion, we do not agree with Slater's view that immersion is an objective description of the VE technology (Slater, Linakis, Usoh, & Cooper, 1996). In our view, immersion, like involvement and presence, is something the individual experiences.

2.4 Presence

Both involvement and immersion are necessary for experiencing presence. Involvement in a VE depends on focusing one's attention and energy on a coherent set of VE stimuli. For many people, high levels of involvement can be obtained with media other than VE, such as movies, books, and video arcade games. Immersion depends on perceiving oneself as a part of the VE stimulus flow. By stimulus flow we mean the dynamic stream of available sensory inputs and events that both influence the observer's activities and that are influenced by those activities. Fully immersed observers perceive that they are interacting directly, not indirectly or remotely, with the environment. They feel that they are part of that environment. Immersion is not common in media other than VE, though strong identification with a character in a book, movie, or video game may permit some immersion in those media. When identifying with a character in a book or movie, individuals tend to put themselves in the character's place, and in a sense, experience what that character experiences. They become immersed in that character's world much like a participant becomes immersed in the VE. A dream is another example of immersion that does not require a VE.

A valid measure of presence should address factors that influence involvement as well as those that affect immersion. Though the factors underlying involvement and immersion may differ, the levels of immersion and involvement experienced in a VE are interdependent. That is, increased levels of involvement may lead users to experience more immersion in an immersive environment and vice versa.

3 Contributing Factors

3.1 Empirical Findings

While the concept of presence has been widely discussed, only a few researchers have attempted to measure presence and relate it to possible contributing factors. Barfield and Hendrix (1995) have used measures of presence to show that update rate affects presence. Update rate is the frequency (in frames per second) at which computer-generated images change in response to user actions or to other dynamic aspects of the simulation. Prothero and Hoffman (1995) have shown that using an eye mask to limit the field of view near the eye reduces the amount of presence reported. Hoffman, Prothero, Wells, and Groen (in press) have shown that presence reported by chess players increases when chess pieces are arranged in meaningful positions as compared to random arrangements. This finding corroborates our thesis that focusing one's attention on a meaningful stimulus set supports one's sense of presence. Barfield and Weghorst (1993) surveyed people after ''fly-through'' experiences with two different VEs. Most of their questions dealt with possible immersive factors, with three questions asking directly about ''being there,'' ''inclusion'' in the VE, and ''presence.'' Responses to the ''being there'' question were correlated with comfort, presentation quality, and location information. Responses to the ''inclusion'' question were associated with general comfort, ease of interaction and movement, and the ability to introspect. The responses to the direct question about ''presence'' were associated with enjoyment, orientation, and presentation quality. In generating our questionnaires, we have independently focused on many of the same factors, although we do not rely on a simple query about presence or involvement.

3.2 Conceptual Work

Ground-breaking theoretical work by Sheridan (1992) and Held and Dulach (1992) suggested factors thought to underlie the concept of presence. In identifying factors and in developing items for measuring presence, we drew heavily on their work. Hence, the factors from which our items were derived are conceptually based, and, except as noted above, have not been tested empirically.

Based on conceptual similarities we have grouped factors into the following major categories: Control Factors, Sensory Factors, Distraction Factors, and Realism Factors. The factors within the major categories almost certainly interact with one another. Factors may also interact across the major categories. For more extensive discussion of the factors and how they may interact, see Witmer and Singer (1994).

The factors may exert their influence on presence by affecting either involvement, immersion, or both. We expect that Control Factors may affect immersion but not involvement, while Realism Factors should affect involvement but not immersion. We believe Sensory Factors and Distraction Factors should affect both immersion and involvement. While it is reasonable to hypothesize that these factors may be associated with presence, considerable empirical work is necessary before we can confidently conclude that they affect presence. Table 1 lists the factors thought to contribute to a sense of presence by major factor category.

3.3 Control Factors

Degree of control: In general, the more control a person has over the task environment or in interacting with the VE, the greater the experience of presence. This includes the ability to control the relation of sensors to the environment (Sheridan, 1992). Fontaine (1992) considers control over the situation as separate

Table I. *Factors Hypothesized to Contribute to a Sense of Presence*

Control Factors	Sensory Factors	Distraction Factors	Realism Factors
Degree of control	Sensory modality	Isolation	Scene realism
Immediacy of control	Environmental richness	Selective attention	Information consistent with objective world
Anticipation of events	Multimodal presentation	Interface awareness	Meaningfulness of experience
Mode of control	Consistency of multimodal information		Separation anxiety / disorientation
Physical environment modifiability	Degree of movement perception Active search		

from presence, but his work does show it to be positively related to presence.

Immediacy of control: When a person acts in an environment, the consequences of that action should be appropriately apparent to the actor, affording expected continuities (McGreevy, 1992). Noticeable delays between the action and the result should diminish the sense of presence in a VE (Held & Durlach, 1992).

Anticipation: Individuals probably will experience a greater sense of presence in an environment if they are able to anticipate or predict what will happen next, whether or not it is under personal control (an issue raised by Held & Durlach, 1992).

Mode of control: Presence in a situation may be enhanced if the manner in which one interacts with the environment is a natural or well-practiced method for that environment. If the mode of control is artificial, or especially if it requires learning new responses in the environment, presence may be diminished until those responses become well learned (Held & Durlach, 1992).

Physical environmental modifiability: Presence should increase as one's ability to modify physical objects in that environment increases (Sheridan, 1992). For instance, one expects to be able to open doors, move objects, and mold clay, and these experiences verify the control one has within the VE.

3.4 Sensory Factors

Sensory modality: A hierarchy of modalities may influence how much presence is experienced. Because much of our information typically comes through visual channels, visual information may strongly influence presence. Information presented via other sensory channels also contributes to the experience of presence, but perhaps to a lesser extent than visual information.

Environmental richness: The greater the extent of sensory information transmitted to appropriate sensors of the observer, the stronger the sense of presence will be (Sheridan, 1992). An environment that contains a great deal of information to stimulate the senses should generate a strong sense of presence; conversely, an environment that conveys little information to the senses may engender little presence.

Multimodal presentation: The more completely and coherently all the senses are stimulated, the greater should be the capability for experiencing presence. For example, adding normal movement, with kinesthetic motion and proprioceptive feedback, should enhance presence (Held & Durlach, 1992).

Consistency of multimodal information: The information received through all modalities should describe the same objective world (Held & Durlach, 1992). If information from one modality gives a message that differs from that experienced through a different modality, presence may be diminished.

Degree of movement perception: Presence can be enhanced if the observer perceives self-movement through the VE, and to the extent that objects appear to move relative to the observer.

Active search: An environment should enhance presence when it permits observers to control the relation of their sensors to the environment (Sheridan, 1992). To the extent that observers can modify their viewpoint to change what they see, or to reposition their head to affect binaural hearing, or to search the environment haptically, they should experience more presence.

3.5 Distraction Factors

Isolation: Devices that isolate users from their actual, physical environment may increase presence in a VE. For example, a head-mounted display that isolates users from the real world may increase presence in the VE in comparison to a standard two-dimensional, flat-screen display. Headphones that reduce local ambient noise could also increase presence even when no VE-associated auditory input is provided.

Selective attention: The observer's willingness or ability to focus on the VE stimuli and to ignore distractions that are external to the VE should increase the amount of presence experienced in that environment.

Interface awareness: Held and Durlach (1992) maintain that unnatural, clumsy, artifact-laden interface devices interfere with the direct and effortless interpretation of (and interaction with) a VE and hence diminish presence.

3.6 Realism Factors

Scene realism: Presence should increase as a function of VE scene realism (as governed by scene content, texture, resolution, light sources, field of view (FOV), dimensionality, etc.). Scene realism does not require real-world content, but refers to the connectedness and continuity of the stimuli being experienced.

Consistency of information with the objective world: The more consistent the information conveyed by a VE is with that learned through real-world experience, the more presence should be experienced in that VE (Held & Durlach, 1992).

Meaningfulness of experience: Presence should increase as the situation presented becomes more meaningful to the person. Meaningfulness is often related to many other factors, such as motivation to learn or perform, task saliency, and previous experience.

Separation anxiety / disorientation: VE users may experience disorientation or anxiety when returning from the VE to the real world. The amount of this disorientation may increase as the presence experienced in the VE increases.

4 Measuring Presence

According to Sheridan (1992), presence is a subjective sensation or mental manifestation that is not easily amenable to objective physiological definition and measurement. While Sheridan does not dismiss objective measures of presence, he indicates that ''subjective report is the essential basic measurement'' (Sheridan, 1992, p. 121). We believe that the strength of presence experienced in a VE varies both as a function of individual differences and the characteristics of the VE. Individual differences, traits, and abilities may enhance or detract from the presence experienced in a given VE. Various characteristics of the VE may also support and enhance, or detract and interfere with, the presence experience. Hence, presence measures should assess these individual differences as well as characteristics of the VE that may affect presence.

5 Presence Questionnaires

In early August of 1992 we developed our initial version of the Presence Questionnaire (PQ) and the Immersive Tendencies Questionnaire (ITQ). The ITQ was developed to measure the capability or tendency of individuals to be involved or immersed, while the PQ measures the degree to which individuals experience presence in a VE and the influence of possible contributing factors (described above) on the intensity of this experience. Many of the PQ items, but not the ITQ items, were derived directly from these factors. Both questionnaires rely exclusively on self-report information.

The PQ and ITQ use a seven-point scale format that is based on the semantic differential principle (Dyer, Matthews, Stulac, Wright, Yudowitch, 1976). Like the semantic differential, each item is anchored at the ends by opposing descriptors. Unlike the semantic differential, the scale includes a midpoint anchor. The anchors are based on the content of the question stem, and in that respect, are more like the anchors used in common rating scales. The PQ and ITQ instructions asked respondents to place an ‘‘X’’ in the appropriate box of the scale in accordance with the question content and descriptive labels. An exemplar item from the PQ is shown in Figure 1.

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18. How compelling was your sense of moving around
    inside the virtual environment?

|_______|_______|_______|_______|_______|_______|_______|

NOT                   MODERATELY         VERY
COMPELLING            COMPELLING         COMPELLING
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Figure 1. *An examplar item from the Presence Questionnaire.*

5.1 PQ Items

We investigated the utility of the PQ in conjunction with four experiments. A total of 152 students (91 men and 61 women) from colleges in the Orlando, Florida, area served as participants. Two of these experiments required participants to perform simple psychomotor tasks such as moving through doorways, traversing a figure eight, manually tracking a moving object, or placing a virtual object in a bin using a joystick or Spaceball (Lampton et al., 1994; Singer, Ehrlich, Cinq-Mars, & Papin, 1995). The VEs used were visually simple, but some of the tasks were difficult to perform. Both of these experiments used the Virtual Research Flight Helmet for displaying the VE. The other two experiments required participants to learn a complex route through a virtual representation of a complex office building (Witmer, Bailey, Knerr, & Parsons, 1996; Bailey & Witmer, 1994). The VEs used in these latter experiments were large and visually complex, requiring up to 40,000 polygons. Witmer et al. (1996) used the FAKESPACE BOOM 2C to display the VE and control movement, while Bailey and Witmer (1994) used a joystick to control movement and the Flight Helmet to display the VE. In each experiment the PQ scale was administered after participants had completed the experimental task. These experiments were not designed to investigate presence per se, but rather learning and performance in VEs. The experimental methods used in these experiments were important only in so far as they provided the task situations, the equipment interfaces, and the virtual environments. Data relating to the structure and utility of the PQ scale were analyzed both within and across these experiments. The results of these analyses, described below, lend credence to the factors that were used in generating the PQ scale and to the scale structure. The items included in the PQ version 2.0, on which our analyses were based, are listed in Table 2, along with the major factor categories from which each item was derived and the Pearson correlation coefficient relating the item score to the PQ scale total. Subscales are also shown.

5.2 PQ Item Analysis

As shown in Table 2, eleven of the twelve control factors correlated significantly with the PQ total score, as did eight of nine sensory factors. Five of seven of the realism factors and four of the six distraction factors correlated significantly with the PQ total. Because most items on the PQ scale were derived from the original factors, these results support the role of these factors in enabling the experience of presence, and suggest that the PQ items measure a single construct called presence.

Our VEs did not permit users to touch (item 17) or manipulate (item 21) virtual objects; hence, items 17 and 21 did not correlate significantly with the PQ total. All distraction items, except items 8 and 9, correlated significantly with the PQ total; thus, awareness of real-world activities appears to reduce PQ scores only when it diverts attention away from the VE tasks.

PQ items 5, 6, 10, 18, 23, and 32 were included to directly address involvement in the VE. Because involvement is considered a necessary condition for presence rather than a contributing factor, it is not among the factors listed in Table 2. All involvement items were significantly correlated with the PQ total, suggesting that involvement is an important determinant of presence.

Table 2. *Presence Questionnaire Item Stems (Version 2.0)*

Item Stems	Factors	Subscale	*ITCorr*
1. How much were you able to control events?	CF	INV/C	0.43*
2. How responsive was the environment to actions that you initiated (or performed)?	CF	INV/C	0.56*
3. How natural did your interactions with the environment seem?	CF	NATRL	0.61*
4. How completely were *all* of your senses engaged?	SF		0.39*
5. How much did the visual aspects of the environment involve you?	SF	INV/C	0.48*
6. How much did the auditory aspects of the environment involve you?	SF	AUD[a]	0.32*
7. How natural was the mechanism which controlled movement through the environment?	CF	NATRL	0.62*
8. How aware were you of events occurring in the real world around you?	DF		0.03
9. How aware were you of your display and control devices?	DF		−0.14
10. How compelling was your sense of objects moving through space?	SF	INV/C	0.51*
11. How inconsistent or disconnected was the information coming from your various senses?	RF		0.33*
12. How much did your experiences in the virtual environment seem consistent with your real-world experiences?	RF, CF	NATRL	0.62*
13. Were you able to anticipate what would happen next in response to the actions that you performed?	CF	INV/C	0.43*
14. How completely were you able to actively survey or search the environment using vision?	RF, CF, SF	INV/C	0.59*
15. How well could you identify sounds?	RF, SF	AUD[a]	0.34*
16. How well could you localize sounds?	RF, SF	AUD[a]	0.30*
17. How well could you actively survey or search the virtual environment using touch?	RF, SF	HAPTC[b]	0.15
18. How compelling was your sense of moving around inside the virtual environment?	SF	INV/C	0.62*
19. How closely were you able to examine objects?	SF	RESOL	0.55*
20. How well could you examine objects from multiple viewpoints?	SF	RESOL	0.49*
21. How well could you move or manipulate objects in the virtual environment?	CF	HAPTC[b]	0.11
22. To what degree did you feel confused or disoriented at the beginning of breaks or at the end of the experimental session?	RF		−0.06
23. How involved were you in the virtual environment experience?		INV/C	0.52*
24. How distracting was the control mechanism?	DF		0.37*
25. How much delay did you experience between your actions and expected outcomes?	CF	INV/C	0.41*
26. How quickly did you adjust to the virtual environment experience?	CF	INV/C	0.42*
27. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?	CF	INV/C	0.45*
28. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?	DF	IFQUAL	0.44*

Table 2. *(Continued)*

Item Stems	Factors	Subscale	*ITCorr*
29. How much did the control devices interfere with the performance of assigned tasks or with other activities?	DF, CF	IFQUAL	0.44*
30. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?	DF	IFQUAL	0.51*
31. Did you learn new techniques that enabled you to improve your performance?	CF		0.33*
32. Were you involved in the experimental task to the extent that you lost track of time?		INV/C	0.41*

Note. Major Factor Category: CF = Control Factors, SF = Sensory Factors, DF = Distraction Factors, RF = Realism Factors. Subscales: INV/C = Involvement/Control, NAT = Natural, AUD = Auditory, HAPTC = Haptic, RES = Resolution, IFQUAL = Interface Quality. ITCorr = Pearson correlation coefficients between PQ item scores and the PQ Total Score.

[a]No auditory stimulation was provided in our experiments.

[b]No haptic stimulation was provided in our experiments.

*$p < .001$

Item 18 measures the sense of self-motion through the VE, while item 10 measures perceived object motion. Individuals become more involved to the extent that they perceive either self-motion or object motion. When they perceive motion inside a VE, they also become more immersed. Item 22, which addresses involvement indirectly by assessing the degree to which users become disoriented when transitioning from VE to the real world, did not correlate significantly with the PQ total.

5.3 ITQ Items

Table 3 lists the ITQ items; most of these items measure involvement in common activities. As noted above, increased involvement can result in more immersion in an immersive environment. Therefore, we expect individuals who tend to become more involved will also have greater immersive tendencies. A few items (e.g., items 9, 10, and 15) measure immersive tendencies directly; others assess one's current fitness or alertness, or measure the ability to focus or redirect one's attention. Table 3 also presents the Pearson correlation coefficients between individual items and the ITQ scale total, and lists subscales.

5.4 ITQ Item Analysis

Scores on 23 of the 29 ITQ items were significantly correlated with the ITQ total score; only items 4, 11, 12, 19, 24, and 27 were not. This correlation supports our contention that most of the ITQ items measure a single construct, the tendency to experience presence. Item 12 produces categorical data, so no Pearson correlation could be computed. Item 11 asks about the number of books read for enjoyment and therefore may have been inappropriate for our survey sample, most of whom were university students; students may have little time to read materials other than textbooks. Items 4 and 24 indicate a physical and mental readiness to become involved in an activity; the usefulness of these items will ultimately depend on how much they add to the ITQ in predicting PQ scores. Item 27 inquires about avoidance of amusement park rides because they are too scary. Active avoidance of activities that generate fear or excitement may bear little relationship to the tendency become involved in an activity in which one chooses to engage. At first glance, it seems that item 19 should be correlated significantly with the ITQ total, but in fact the correlation approaches zero. Item 19 may have been

Table 3. *Immersive Tendency Questionnaire Item Stems (Version 2.0)*

Item Stems	Subscale	*ITCorr*
1. Do you ever get extremely involved in projects that are assigned to you by your boss or your instructor, to the exclusion of other tasks?		0.26*
2. How easily can you switch your attention from the task in which you are currently involved to a new task?		0.26*
3. How frequently do you get emotionally involved (angry, sad, or happy) in the news stories that you read or hear?		0.27*
4. How well do you feel today?		0.20
5. Do you easily become deeply involved in movies or TV dramas?	FOCUS	0.49**
6. Do you ever become so involved in a television program or book that people have problems getting your attention?	INVOL	0.47**
7. How mentally alert do you feel at the present time?	FOCUS	0.40**
8. Do you ever become so involved in a movie that you are not aware of things happening around you?	INVOL	0.56**
9. How frequently do you find yourself closely identifying with the characters in a story line?	INVOL	0.53**
10. Do you ever become so involved in a video game that it is as if you are inside the game rather than moving a joystick and watching the screen?	GAMES	0.55**
11. On average, how many books do you read for enjoyment in a month?		0.16
12. What kind of books do you read most frequently? (CIRCLE ONE ITEM ONLY!) Spy novels, Fantasies, Science fiction, Adventure, Romance novels, Historical novels, Westerns, Mysteries, Other fiction, Biographies, Autobiographies, Other non-fiction		—
13. How physically fit do you feel today?	FOCUS	0.30**
14. How good are you at blocking out external distractions when you are involved in something?	FOCUS	0.46**
15. When watching sports, do you ever become so involved in the game that you react as if you were one of the players?		0.43**
16. Do you ever become so involved in a daydream that you are not aware of things happening around you?	INVOL	0.56**
17. Do you ever have dreams that are so real that you feel disoriented when you awake?	INVOL	0.50**
18. When playing sports, do you become so involved in the game that you lose track of time?	FOCUS	0.46**
19. Are you easily disturbed when working on a task?		−0.03
20. How well do you concentrate on enjoyable activities?		0.49**
21. How often do you play arcade or video games? (OFTEN should be taken to mean every day or every two days, on average.)	GAMES	0.35**

Table 3 *(Continued)*

Item Stems	Subscale	*ITCorr*
22. How well do you concentrate on disagreeable tasks?		0.29**
23. Have you ever gotten excited during a chase or fight scene on TV or in the movies?	FOCUS	0.51**
24. To what extent have you dwelled on personal problems in the last 48 hours?		−0.10
25. Have you ever gotten scared by something happening on a TV show or in a movie?	INVOL	0.42**
26. Have you ever remained apprehensive or fearful long after watching a scary movie?	INVOL	0.31**
27. Do you ever avoid carnival or fairground rides because they are too scary?		−0.05
28. How frequently do you watch TV soap operas or docu-dramas?		0.28**
29. Do you ever become so involved in doing something that you lose all track of time?	FOCUS	0.49**

Note. Subscales: INVOL = Tendency to become involved in activities, FOCUS = Tendency to maintain focus on current activities, GAMES = Tendency to play video games
Note. ITCorr = Pearson correlation coefficients between ITQ item scores and the ITQ Total Score.
*$p < 0.01$
**$p < 0.001$

misinterpreted because of the use of the term ''easily disturbed''; perhaps substituting the phrase ''easily distracted'' may result in a clearer interpretation of the item.

5.5 Necessary Scale Properties

Any measure of presence must be shown to be both reliable and valid. A measurement scale is *reliable* to the extent that individual differences in scale scores are attributable to true differences in the characteristics under consideration rather than resulting from errors due to random fluctuations in individuals or in testing conditions (Anastasi, 1968). A reliable scale consistently yields replicable scores. A scale is *valid* to the extent that it measures precisely what it purports to measure and measures it well. *Content validity* refers to the coverage of the measured behavioral domain by the scale items. Items should cover a representative sample of the behavioral domain in order for a scale to have high content validity. A scale has *construct validity* to the extent to which it can be said to measure a theoretical construct or trait. If the PQ is a valid measure of the presence construct, then PQ scores should be associated in a predictable manner with other variables or constructs that in theory are related to presence.

5.6 Scale Reliability

Reliability analyses were performed on both questionnaires using the combined data from four VE experiments (Lampton et al., 1994; Witmer et al., 1996; Bailey & Witmer, 1994; Singer et al., 1995). Because the PQ and ITQ score distributions were similar across experiments, we combined the data from these experiments to form a larger sample on which to base our reliability estimates. Internal consistency measures of reliability (Cronbach's Alpha) for ITQ and PQ yielded reliabilities of 0.75 and 0.81 for the ITQ and PQ, respectively. An iterative approach was used to isolate and drop items that did not contribute to the reliability of the PQ (items 4, 8, 9, 11, 22, 24, 31, and 32) and ITQ (items 1, 2, 3, 4, 11, 19, 22, 24, 27, and 28) scales. The ITQ was reduced to 18 items (from 29) with a resultant alpha of 0.81 (Cronbach's, N = 132). Because item 12 produces categorical data, it was retained but not included in the reliability computation. The mean score on the new ITQ scale was 76.66, with a standard deviation of 13.61. The PQ was reduced to 19 items (from 32) with a resultant alpha of 0.88 (Cronbach's, N = 152). Three auditory and two haptic items were retained but not included in the computation of reliability because the data were based on VEs that provided no haptic or auditory stimulation. The mean score on the new PQ scale was 98.11, with a standard deviation of 15.78.

5.7 Content Validity

PQ items were based largely on the factors derived from a review of the presence literature. PQ items tap both aspects of presence: involvement and immersion. ITQ items were developed to identify individual differences that could affect how much presence might be experienced in any given situation. ITQ items assess the tendency of individuals to become involved in everyday activities and measure the ability to focus on a particular activity. ITQ items tap both involvement and immersion.

5.8 Construct Validity

Though our primary goal is the development of a valid presence scale, we are also interested in the factor structure of the scale. Cluster analyses were performed on data from the reduced ITQ and reduced PQ scales to determine scale structure and identify data-driven subscales. Initially, we considered performing a factor analysis, but rejected that approach for several reasons. First, our primary purpose was to build up a scale to measure a single construct, presence, from individual items that appear to contribute to this construct. To accomplish this, we selected cluster analysis, as recommended by Thorndike (1978). Second, the assignment of items to subscales is more straightforward when using cluster analysis than when using factor analysis. Third, obtaining reliable results from a factor analysis of the 32-item PQ would require a minimum of 370 subjects, and perhaps as many as 1,074 subjects (Thorndike, 1978). Finally, scales developed using cluster analysis are easier to score and make more sense to the general user than scales derived from a factor analysis because the latter procedure requires breaking up the variance of single items (Thorndike, 1978).

ITQ subscales: The cluster analysis of the ITQ data revealed three subscales: Involvement (7 items; $M = 26.51$, $Sd = 7.24$), Focus (7 items; $M = 40.33$, $Sd = 6.07$), and Games (2 items; $M = 6.21$, $Sd = 3.16$). The subscale labels are loosely based on the content of the questionnaire items in their cluster. Table 3 indicates the items that compose each subscale. Involvement items ask about the subjects' propensity to get involved passively in some activity, such as reading books, watching television, or viewing movies. Items in the Focus cluster ask about their state of mental alertness, their ability to concentrate on enjoyable activities, and their ability to block out distractions. The *Games* cluster has two items: one asking how frequently they play video games, and another asking whether they get involved to the extent that they feel like they are inside the games.

PQ subscales: Three subscales were also identified from the cluster analysis of the PQ data. The PQ subscales were labeled *Involved/Control* (11 items; $M = 57.39$, $Sd = 8.96$), *Natural* (3 items; $M = 12.36$, $Sd = 3.44$), and *Interface Quality* (3 items; $M = 14.65$, $Sd = 3.4$). These subscale labels were also chosen based on the content of the subscale items. Table 2 indicates the items that compose each subscale. The Involved/Control subscale items address perceived control of events in the VE, responsiveness of the VE to user-initiated actions, how involving were the visual aspects of the VE, and how involved in the experience the participant became. Natural items measure the extent to which the interactions felt natural, the extent to which the VE was consistent with reality, and how natural was the control of locomotion through the VE. The Interface Quality items address whether control devices or display devices interfere or distract from task performance, and the extent to which the participants felt able to concentrate on the tasks.

As revealed by Table 2, the statistically derived subscales for the PQ do not perfectly match the original factors. For example, no subscale directly corresponded to the realism factors. Nor did the items representing the sensory factor cluster as a separate subscale. Items representing the control factors split into two groups; one group was the Natural subscale, while the other combined with involvement items to become the Involved/Control subscale. The Natural subscale also includes item 12, which asks how closely the VE experiences match real-world experiences. Finally, some distraction factor items became the Interface Quality subscale. The auditory, resolution, and haptic clusters are not true subscales but rather place holders for items that were not tested because our VEs did not adequately support the experiences referred to by those items (e.g., haptics).

Expected association between presence and other constructs: A valid measure of presence should be associated in predictable ways with other variables and constructs. For example, a VE that stimulates all of the senses and allows natural modes of interaction should result in more presence than a less immersive VE. Presence should relate positively to VE task performance, increasing as individuals become more proficient in performing the tasks. Likewise, individuals who have a greater tendency to become involved in a variety of activities as measured by the ITQ should report more presence on the PQ. Conversely, individuals who experience VE simulator sickness symptoms could be expected to report less presence in the VE than those who have no symptoms, assuming that simulator sickness acts as a distraction. Other variables, such as number of collisions in the VE or measures of spatial ability, might be expected to have little impact on presence. Data related to selected aspects of construct validity are discussed below.

Simulator sickness: Across experiments we have consistently found significant negative correlations between Simulator Sickness Questionnaire (SSQ) scores (Kennedy, Lane, Berbaum, & Lilliental, 1993) and PQ scores. Combining the data from four experiments, the correlation between SSQ and PQ was $r = -0.426$, $p < 0.001$. We believe that symptoms associated with simulator sickness (e.g., nausea, disorientation) draw attention away from the VE and focus that attention inward, decreasing involvement in the VE and thereby reducing the sense of presence.

Task performance: In general, the PQ was shown to be positively related to measures of task performance in a VE. Statistically significant correlations between PQ scores and performance on simple psychomotor tasks performed in a VE were found in one experiment (Witmer & Singer, 1994), but not in a subsequent experiment involving the same tasks (Singer et al., 1995). Significant correlations were also found between PQ and performance on tests of spatial knowledge in one experiment, but not in another similar experiment (Bailey & Witmer, 1994). Given that task performance can be influenced by many different factors, including individual skills and abilities, it is not a total surprise that presence as measured by the PQ would not always be significantly associated with better performance. In each experiment, however, the association between presence and performance is consistently positive, as we should expect if higher levels of presence are associated with better performance.

Natural modes of interaction: In one experiment (Bailey & Witmer, 1994), one group of participants could change their viewpoint in the VE by either turning their heads (headtracking on) or by moving a joystick. For the other group, only the joystick controlled their viewpoint (headtracking off). Contrary to expectation, there were no significant group differences in presence as measured by the PQ. In another experiment, Singer et al. (1995) found that different displays interacted with head tracking to change the perception of presence.

Relation to ITQ: If high ITQ scores reflect a greater tendency to become involved or immersed, then individuals who score high on the ITQ should report more presence on the PQ when exposed to a particular VE. Taken individually, only two of the four experiments resulted in a significant correlation between ITQ and PQ scores. Combining the data across experiments, however, produced a significant positive correlation between ITQ and PQ scores ($r = 0.24$, $p < 0.01$).

Spatial ability tests: As expected, no significant correlations were found between tests of spatial ability and PQ scores in the VE navigation experiments. Nor did the number of collisions made in traversing a route through a building correlate significantly with PQ scores (Bailey & Witmer, 1994).

Preliminary conclusions regarding PQ construct validity: To date we have performed no research that directly compares the PQ scores of a single group of participants across vastly different VEs. Neither have we investigated presence as a function of extended practice with a particular VE configuration. Nevertheless, our preliminary results suggest that presence, as measured by the PQ, is a valid construct. Supporting evidence includes consistent positive correlations between the degree of presence and VE task performance. Also, variables that might be expected to be significantly related to presence (e.g., ITQ scores, SSQ scores) were related, while variables that might be expected to be unrelated to presence (Spatial Ability Test scores, number of collisions in VE) were not. The significant correlation of the items derived from the original factors with the PQ total and with the subscales identified through the cluster analysis also attests to the construct validity of the PQ. However, we must emphasize that these findings are preliminary and are pending further testing and analyses. When we have collected PQ data from the number of respondents necessary to obtain reliable factor analytic results (see previous discussion), a factor analysis will be performed to further investigate the structure of the scale and the factors that contribute to presence.

6 The Role of Presence in Learning and Performance

While results relating measures of presence in VE to learning and performance in the VE and in the real world have been mixed (Witmer & Singer, 1994; Bailey & Witmer, 1994), many of the factors that appear to affect presence are known to enhance learning and performance. It is well established that meaningfulness and coherence of a stimulus set promotes learning (Underwood & Schulz, 1960). Gibson (1969) has suggested that selectively focusing one's attention on certain features of the environment to the exclusion of other features can be taken as evidence that perceptual learning has occurred. Bandura (1971) also reserves a prominent role for selective attention in his social learning theory. Learning is aided by requiring responses that are natural for the learner in a given situation (Seligman, 1970). As mentioned previously, interacting with the environment in a natural manner should increase immersion and thus presence. Factors believed to increase immersion, such as minimizing outside distractions and increasing active participation through perceived control over events in the environment, may also enhance learning and performance. Because many of the factors involved in learning and performance also increase presence, it would be very surprising indeed if positive relationships between presence and performance were not found. As we continue to test and refine the PQ, one important criteria for the validity of the presence construct (as defined by the PQ) will be how well the PQ relates to learning and performance.

The dynamics of human / computer interaction have typically not included immersion; the link between humans and the computer has been from the outside in rather than from the inside out. Typically, the user sits at a terminal and communicates with the computer via interface devices (such as a mouse or keyboard) over an indirect link, much as one would communicate with someone via the telephone. The world generated by the computer and the user are separate entities that have two-way communication but do not share a common space. This limits the types of possible interactions, thereby preventing the user from directly experiencing the computer-generated world.

With VE, the user acts within a space generated by the computer. The computer's world becomes the user's world, and the user experiences presence in that world. The computer-generated world surrounds the user with ever-changing sensations, while simultaneously responding to the user's actions. Hence, users become active seekers of information who can more easily control what is experienced. Because they perceive themselves to be inside the computer-generated world, they experience that world directly, making the experience more meaningful. Assuming that learning improves when the user is an integral part of the stimulus flow, and that meaningfulness and active control over a user's experiences aids learning, then immersive environments likely are better training tools than standard computer-based training environments.

From the above discussion, we contend that manipulating factors that increase presence will increase learning and performance, but as yet we have no direct evidence to support our contention. If both presence and performance levels can be shown to vary in a predictable manner as these factors are manipulated, then a strong link between presence and performance would have been forged. Otherwise, we can only speculate about a possible link between presence and performance in VEs.

If this link can be established, then measures of presence such as the PQ might be used instead of performance measures to evaluate the training potential of various types of VEs or other simulated training environments. Interfaces (e.g., different HMDs and locomotion control devices) between these environments and the user might also be evaluated using the PQ. Similarly, the ITQ might be used to identify individuals who are likely to benefit the most from training in such environments.

7 Conceptualizing Presence

Clearly, presence is a multifaceted concept. It is not simply a matter of how involved an individual becomes in a situation or environment, though involvement is an essential component. Our research with the PQ indicates that control, which affects immersion, is essential for a strong sense of presence, and that other factors are also important. Selective attention, along with perceptual fidelity and other sensory factors, affects how much presence is reported. The naturalness of the interactions with the VE and how closely these interactions mimic real-world experiences also affect how much presence is reported. Precisely how these factors combine and interact to affect presence is not clear. By identifying PQ and ITQ subscales, we have begun the process of determining how the various factors combine. We maintain that both immersion and involvement are necessary for experiencing presence and that they interact to determine how much presence is reported. We do not claim to have identified all of the factors that affect presence, nor do we fully understand the presence construct, but we believe we have made considerable progress. We are continuing to refine the ITQ and the PQ as we learn more about the concept.[1]

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1. Copies of the PQ and the ITQ and scoring instructions are available from the authors at the Army Research Institute, 12350 Research Parkway, Orlando, FL 32826-3276 or via e-mail, Bob_Witmer@stricom.army.mil or Mike_Singer@stricom.army.mil.

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