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Focus, Locus, and Sensus: The Three Dimensions of Virtual Experience

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ABSTRACT

A model of virtual/physical experience is presented, which provides a three dimensional conceptual space for virtual and augmented reality (VR and AR) comprising the dimensions of focus, locus, and sensus. Focus is most closely related to what is generally termed presence in the VR literature. When in a virtual environment, presence is typically shared between the VR and the physical world. "Breaks in presence" are actually shifts of presence away from the VR and toward the external environment. But we can also have "breaks in presence" when attention moves toward absence—when an observer is not attending to stimuli present in the virtual environment, nor to stimuli present in the surrounding physical environment—when the observer is present in neither the virtual nor the physical world. We thus have two dimensions of presence: focus of attention (between presence and absence) and the locus of attention (the virtual vs. the physical world). A third dimension is the sensus of attention—the level of arousal determining whether the observer is highly conscious or relatively unconscious while interacting with the environment. After expanding on each of these three dimensions of experience in relation to VR, we present a couple of educational examples as illustrations, and also relate our model to a suggested spectrum of evaluation methods for virtual environments.

INTRODUCTION: PRESENCE AND THE THREE DIMENSIONS OF EXPERIENCE

Humans are complex creatures. We experience, sample, and process information from reality, both consciously and unconsciously. We not only perceive the world around us directly, as do all animals; we also reflect on what we have perceived, rehearsing facts and events and trying out hypothetical scenarios in consciousness. Absence is characterized as a psychological focus on such conceptual processing, and presence as a psychological focus on direct perceptual processing (of things that are present in the current environment, whether real or virtual).

Presence is the hallmark of virtual reality[1] (VR). VR designers typically aim to create a convincing, engaging environment in which users feel present. When this feeling of "being there," immersed in a virtual world, is strong, users do not seem to have to conceptualize about the world to make sense of what is portrayed. One interpretation of this is that such virtual environments do not require mental modelling (knowledge in the head) to make sense. Rather, they contain "knowledge in the (virtual) world," which is amenable to direct

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perceptual processing. The gold standard of VR can then be seen as passing the "VR for Animals" test[2]—could the VR convince a nonhuman mammal (since such animals exceed human perceptual skills, but lack most of our conceptual capabilities)? By this view, since most other mammals do little or no conceptual processing, they are always present when conscious.

Presence is thus a psychological state, not a quality of virtual or physical environments, which is one reason that models of presence are in general somewhat underdeveloped. Slater et al.[3] suggest that presence is not the same as immersion, but that high immersion tends to yield high judgments of presence. Immersion depends on the technology used in the VR—a head-mounted display is more immersive than desktop VR. They suggest that presence, rather, is a state of consciousness, as do we. But the question of when more immersion yields greater presence, and when it does not, is left open. Other models, while more predictive, are not always plausible. Bystrom, et al.[4] present the Immersion, Presence and Performance (IPP) model. Roughly speaking, this suggests that immersion produces sensory fidelity, which directs the allocation of attention in such a way that subjective disbelief is suspended, yielding high presence and, as a result, better task performance. While this model has the advantage of explicitly relating presence to both level of immersion and the allocation of attention it seems to us to be obviously wrong. Clearly, people performed tasks before the advent of virtual worlds in which they felt present! The model of Bystrom et al.[4] also suggests that there will be no sense of presence without sensory fidelity, but this is also not borne out by the literature.

This is not to say that there is never a correlation between task performance and sense of presence but, as Welch[5] suggests, this outcome is rather exceptional. Most reported studies have tended to confound presence and performance, and the existence of a correlation does not help us determine whether better performance causes greater presence, or greater presence results in better performance, nor if some third factor is affecting both. In recent experiments[6] we found that performance was better in a hypermedia environment, in which students felt no presence, than in an equivalent virtual world where they felt highly present. The task was exactly the same. When we compared three different virtual worlds varying in vividness, we found differences in rated presence but no differences in performance. Like Welch[5] we consider it likely that presence sometimes helps performance. Sometimes presence will make no difference, and sometimes—depending on the nature of the task—it can be expected to interfere with performance.

Witmer and Singer[7] attempted to separate out the technological versus attentional aspects of the sense of presence in a slightly different way. They posit that spatial presence is a direct product of the level of technological immersion, whereas attentional presence arises from the extent to which users become involved in what the virtual environment portrays. Presence thus depends to some extent on task demands. Draper et al.[8] relate what they refer to as experimental telepresence to the way in which attentional resources are allocated.

The root of the problem with many existing models of presence is perhaps confusion between presence and suspension of disbelief. Suspension of disbelief is the result of conceptual processing which then leads to a secondary sense of involvement—as when we read a gripping novel in which we become engrossed. On the other hand, we see presence as that which arises in situations where no belief suspension is needed, because the display is immediately perceptually engaging (though not necessarily faithful to normal sensory perception). These two tend to be confused in VR studies because of the dominant method of presence assessment by subjective ratings. Sometimes subjective judgements are in conflict with physiological and physical responses. A person may say that a VR display is very unrealistic and does not fool them, but may still show physical responses (such as ducking out of the way of an approaching virtual object) and physiological correlates (decreased skin resistance, quickened pulse). The reader of a novel may become deeply engrossed in the lives of the characters and the action that is described, but they are unlikely to move their bodies unconsciously to avoid a hazard that is only described in text.

Schubert et al.[9] see presence as "embodied cognition." They suggest that presence emerges when bodily responses are conceived as possible in a VR. This is compatible with the approach of Stappers et al.[10] who adopt an ecological approach to human behavior, one where they look for objective performance correlates of subjective reports. For example, while low sensory fidelity (more abstract images) was found to result in low ratings of presence, people often behaved bodily as if they were really present in the virtual situation. They conclude that subjective reports need to be supported by performance measures of presence—such as body movements. Similarly, Zahorik and Jenison[11] see perception-action coupling as necessary to a sense of presence, or what they call (after Heidegger) "being-in-the-world."

Despite reservations about existing models of presence, it seems necessary to consider experienced presence when trying to understand how VR environments might help develop conceptual learning in students. For example, Salzman et al.[12] present a model that purports to explain this. But by failing to consider different aspects of the conscious experience of the learner, their framework comprises merely an interconnected web of situational characteristics. However, there are other significant dimensions of virtual experience to be considered.

When in a virtual environment, presence is typically shared between the VR and the physical world. "Breaks in presence"[3] are actually shifts of presence away from the VR and toward the external environment. But we can also have "breaks in presence" when attention moves towards absence—when an observer is not attending to stimuli present in the virtual environment, nor to stimuli present in the surrounding environment—when the observer is present in neither the virtual nor the physical world.

We thus have two dimensions of presence: focus of attention (between presence and absence) and the locus of attention (the virtual vs. the physical world). A third dimension is the sensus of attention—the level of arousal determining whether the observer is highly conscious or relatively unconscious (see Fig. 1). In the rest of the paper we expand on each of these three dimensions of virtual experience, and then present a couple of educational examples as illustrations. We also relate our model to a spectrum of evaluation methods for virtual environments.

PRESENCE VERSUS ABSENCE: THE MIND AS A TWO-ROOM APARTMENT

Changes in the balance between conceptual (abstract) reasoning and perceptual (concrete) processing affect the nature of our experience of the world around us.[13–15] Our model suggests that subjective duration depends on the amount of conceptual processing performed during an interval, relative to the level at which an individual habitually performs. For example, when our conscious processing load is heavy (during difficult abstract reasoning), our experience of duration is short—"time passes quickly." We pay little attention to our bodies or the world around us, we are "absent minded" and do not feel present in the world. And when our conscious processing load is

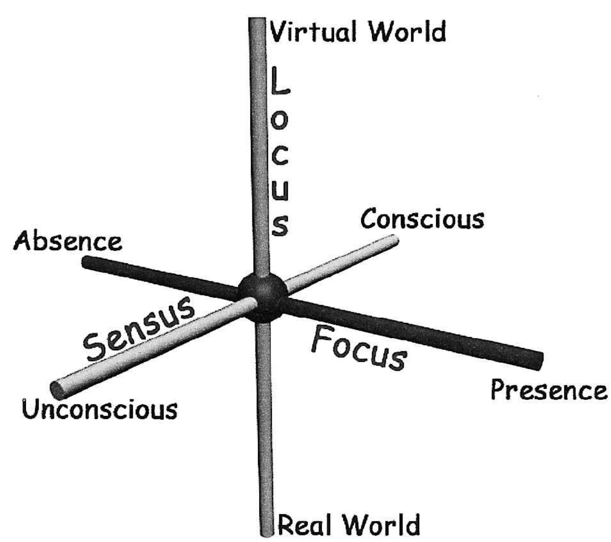

FIG. 1. The three dimensions of virtual experience.

light, duration seems long—"time passes slowly"—and we are highly present in the current situation, we frequently sample what is going on in the environment around us, whether natural or synthetic.

Presence arises when we mostly attend to the currently present environment within and around the body. The capacity we have for such attention depends on the amount of conceptual processing the situation demands. As we process more in an abstract way, we can consciously sample fewer concrete aspects of the present situation, and so our sense of presence diminishes; we become absent. Figure 2 illustrates this trade-off in more general terms, viewing the mind as a two-room apartment lit by a single light source which hangs in the doorway between the two rooms. The rooms represent concrete and abstract processing, respectively. The light is consciousness, and areas in darkness are unconscious.

If the light is angled to the left, concrete conscious processing of the present situation is emphasized, and there is a strong sense of presence. At the extreme, an observer in this state of mind has no capacity left for abstract thought. He is having a vivid experience that seems to take a long time to unfold, though he will have little recallable memory about it. VR can elicit this level of presence, just as physical reality can. If the light is angled more to the right, however, abstract conscious processing of concepts is emphasized, and there is little or no sense of presence. The individual has little awareness of what is going on around him. Time passes quickly, and the person's experience is only of the concepts with which he or she is dealing and of which he or she will have a good recallable memory. For more details, see Waterworth.[14]

Although it is often naively said that "time passes quickly when we are having fun," whether that is true depends on what we are doing cognitively to have fun. The duration of pleasures that involve low abstract processing will tend to be overestimated, whereas that of pleasures involving heavy abstract processing will tend to be underestimated. Subjective duration is thus a useful indicator of sense of presence, with the sense of time-in-passing recognized as a construction of the thinking mind—a product of conception.

Note that we consider the notion of presence to be useful only as a way of describing how an individual experiences an environment external to their mental constructions. This distinction—between an internal conceptual world and an external perceptual world—is fundamental to our view of presence and its antithesis, absence. Although dreams, daydreams, images, fantasies, and other mental experiences may be extremely vivid, they are in

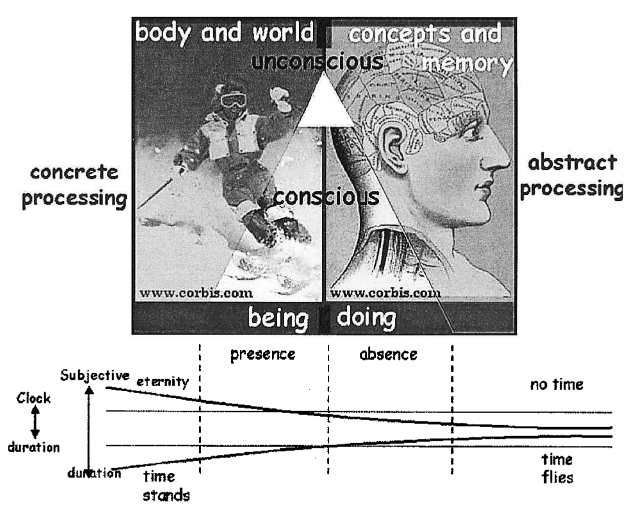

FIG. 2. The mind as a two-room apartment.

competition with the experiences underlying presence in real or virtual worlds. Put simply, you cannot feel present in a virtual world, or in the real one, while also being lost in thoughts, dreams, or fantasies. This is not, however, to assume a dualistic conception of mind along Cartesian lines, as some have suggested. Of course mind is a product of the material structure of the brain, but that is not to say that there is no difference between imagined worlds and perceived worlds—whether real or virtual. Not only is there such a difference, but the balance of attention between the two determines the nature of our experience of the world around us, whether real or virtual.

THE LOCUS OF ATTENTION: LIVING IN THE REAL OR THE VIRTUAL WORLD

Immersion in VR is in some ways like being trapped in Plato's cave. As prisoners in the cave we experience only reflections of reality. We can contrast Plato's view[16] with Galileo's revolutionary (at the time) ideas of how knowledge is acquired—through careful observation of the real world aided by appropriate technology such as the telescope. Galileo's telescope was an example of what Ihde[17] terms an embodiment relation between a person and technology. The technology is, as it were, taken into the experience and the world is perceived through the technology. The technology is between the observer and the object, and changes how reality is experienced, but it does not present a model of reality. Other examples of such embodied technology are microscopes, sunglasses, hearing aids and a blind person's stick.[18]

At first sight, it seems that augmented reality (AR) might exemplify an embodiment relation between person and technology, since the user experiences the real world, albeit augmented with additional information. VR, on the other hand, apparently displays a different kind of relation between a person and a technology. Here, the observer experiences a model of reality as the only source of knowledge, and so could be seen as an example of what Ihde[17,19] terms a hermeneutic relation—the technology provides a representation of some aspects of reality. Other examples of the hermeneutic relation between people and technology include petrol and other gauges on a car dashboard, most of the instruments in an airplane cockpit, and the familiar (in north Sweden) wall thermometer indicating the outside temperature.

But if we look again at VR and AR, this classification appears unsatisfactory. Although what is experienced in VR is a model, the model is presented as if real. The experience is directly perceptual and so more akin to the embodiment relation. And the augmentation inherent in AR generally involves conceptual interpretation, even though the real world is also perceived through the device. The necessary conceptual interpretation that AR demands of the user suggests a hermeneutic relation. In many ways, AR and VR break down the neat distinction between embodiment and hermeneutic relations suggested by Ihde.[17,19] Both are perhaps better seen as examples of a third class of relation, and we can identify a continuum for this relation ranging between the real world and a completely virtual world (similar to Milgram et al.[20] This third class of relation may be what Ihde terms alterity.[19]

The technology in an alterity relation is seen as an "other," with "a life of its own within the environment that allowed this form of life"[17] (p. 99). To interact with the technology gives the sense of interacting with something "other" than either myself or reality. The technology has a life of its own, and appears to be very unpredictable.[19] To a certain degree both VR and AR can be seen as examples of this kind of relation, particularly those applications that do not have a simple connection to the real world (for example the artistic VR installations of Char Davies).[21,22] In this kind of relation the user experiences a model (hermeneutic relation) and at the same time the experience does not have to be interpreted cognitively by the user (embodiment relation). Examples of AR demonstrating alterity relations can be found in, for example, medical applications such as ultrasound imagining.[23] Here ultrasound echography imaging, a video see-through head-mounted display and a high performance computer graphics engine are used to provide augmented views of patient anatomy. When the physician moves a probe over the abdomen of the patient, slices are sampled into the volume of interest. The human, the technology, and the reality are three separate parts in relation with each other.

Taking relative presence and absence into account, as well as the notions of embodiment, hermeneutics, and alterity from Ihde,[19] we arrive at a two-dimensional model that encompasses both the relationship of the technology to the real world, and the nature of the experience when interacting with, or through, the technology. One dimension is thus presence versus absence, and the other is the extent to which the real world is modelled as opposed to experienced directly (see Fig. 3).

THE SENSUS DIMENSION: THE IMPORTANCE OF BEING AWAKE IN CLASS

Sensus refers to the level of conscious arousal of the organism. Any living animal must process information continuously, and this is largely carried out unconsciously. Even as we sleep dreamlessly, our bodies are constantly monitored and maintained as, to some extent, is the surrounding physical environment. But our level of conscious awareness is very low, unless some internal or external crisis—stomach cramps or the sound of a window smashing—prods us into alertness. Conscious arousal is one result of a basic physiological response to novel, threatening or other biologically significant events, a response which underlies emotional affect and which we share with many animals.

Today's classroom education tends to stress abstract and logical thinking (which in our terms is to be relatively absent) and requires a high degree of attention. One problem this produces is that people are not good at applying high attention to relevant concepts over a long period, and the mind tends to wander onto other, less demanding, things. Most current VR applications, on the other hand, stress experiencing and exploring information, emphasizing presence, which makes the users feel that they are there within the created reality. The weakness of this approach is that, although it is initially very engaging, there is little evidence that the user will gain much new knowledge, even when viewing the display for a long period (this is the problem of purely experiential cognition, discussed in some detail by Norman[24]). And after a while, boredom sets in, and once again the mind starts to wander. This points out the potential benefits of every now and then breaking the absence in traditional education and of breaking the presence in VR-based learning. The opportunity to change the world that is modelled in a VR provides a focus for breaking presence, since meaningful change requires conceptual work for its planning and execution.[25] The shift of focus also provides an opportunity for relief from the burden of maintaining a continuously high level of attention.

We suggest a view of learning that follows from our model of virtual experience. This stresses the importance of breaking the sense

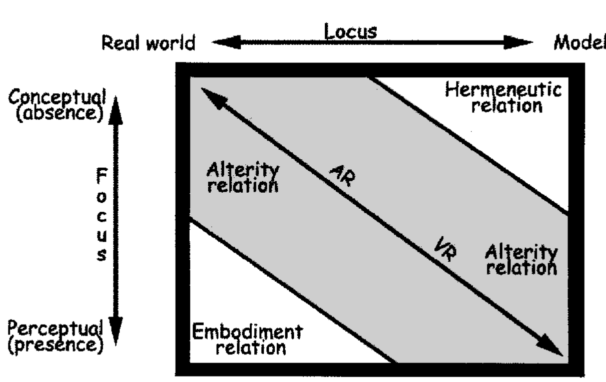

FIG. 3. Focus and locus in the relation between person and technology.

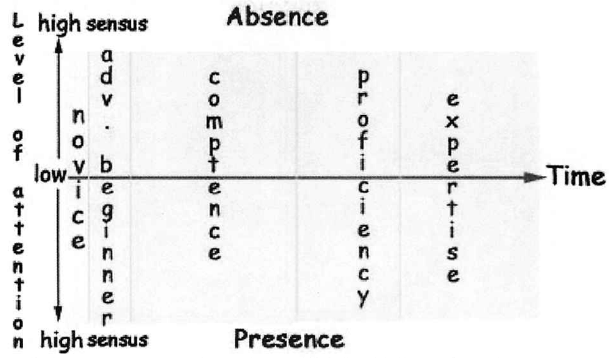

FIG. 4. A framework for understanding learning in VR.

of presence to carry the learner forward through various stages of the learning process,[26] and which also provides the necessary variation along the sensus dimension. We believe that the model could be used to understand the acquisition of conceptual knowledge as well as perceptual skills, although the learning situation differs between the two. The learning framework is shown in Fig. 4.

An example of conceptual learning is, say, when you want to learn a new language (see Fig. 5A). At first you have to learn a few single words and some simple rules to put the words together to create simple sentences. This takes all of the learner's attention and makes him or her absent—using abstract thinking. This is typical knowledge in the two first steps at the skill acquisition stages, novice and advanced beginner. These stages are very abstract and conscious. Then suddenly the learner starts to experiment (to change the world)[25] with their new learned skill and tries to speak the new language more spontaneously, which indicates that he or she has become competent and more present, but still a high level of attention (sensus) has to be used to practice the newly learned skill.

As the learner becomes more and more experienced it is possible to use less and less conscious attention in the interaction, but he or she still has to learn more words and rules which means every now and then to break the presence and return to absence. An expert does not need much attention to learn more because by that stage it is possible to learn at the same time as using the skill. This implies that the jumps between presence and absence are more or less unconscious (low sensus), but that in a situation of need the expert has the possibility to switch to high sensus absence or high sensus presence depending on the situation.

When learning a perceptual skill, on the other hand, as for example to ride a bike, the learner starts with acquiring the importance of keeping the balance of the bike and trying to practice that skill on the bike. This takes a high level of sensus and presence (Fig. 5B). After reaching the stage of preserving balance it is time to learn to steer, brake, and control the bike, which leads the learner into the next stages of skill acquisition, advanced beginner and competent learner. As the learner improves the skill he or she is able to use less attention riding the bike, and that attention could be used for other things. As in conceptual learning an expert does not need much attention to learn more because by that stage it is possible to learn at the same time one is using the skill,

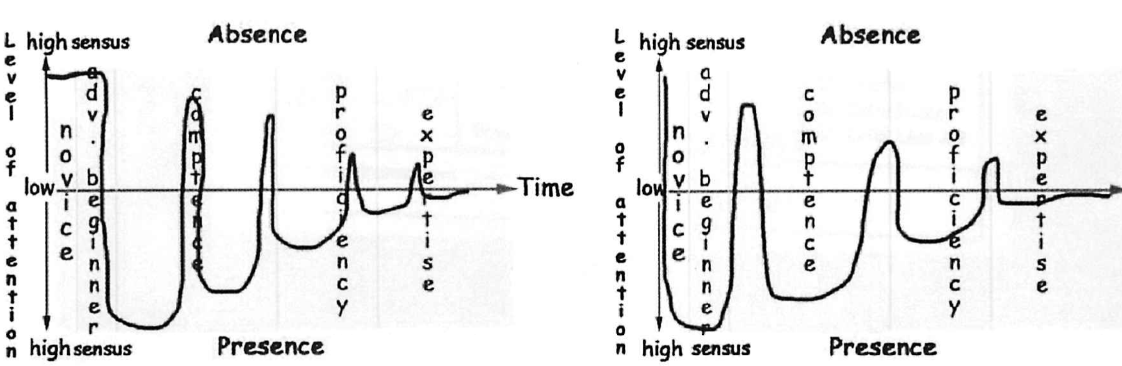

FIG. 5. (**A**) An example of conceptual learning; (**B**) An example of perceptual learning.

so this implies that by the time the learner becomes proficient or expert the curves have become the same.

Presence is a strength in educational settings because a strong experience of being present activates and motivates the learner, raising the sensus level. But it can be a weakness if attending to the present display inhibits the formation of more general, abstract concepts about the kinds of entities portrayed in the display, since in order to develop general abstract concepts one has to be conscious and process the information to store it in memory. In other words, it may be that presence stimulates initial conscious experience in a desirable way, and thus supports relevant perceptual learning, but that it tends to inhibit the kind of conceptual learning that underlies generalizable, abstract knowledge. Such knowledge depends on absence, as well as presence.

To achieve timely opportunities for the absence of mind underlying conceptual learning, it is necessary to break the sense of presence at appropriate points in the process. Fencott,[27] in a similar vein, points to the importance of both perceptual cues and surprises for conceptual learning in educational VR. Cues perceptually reinforce the unconscious expectations one has when acting within a virtual world; in other words, they engender and support a sense of presence. Surprises, on the other hand, break those expectations (and the sense of presence) and stimulate reflection. Whitelock and Jelfs,[28] report compatible experiences with a range of virtual learning environments. As Norman[28] says of purely experiential cognition: "It seduces the participant into confusing action for thought. One can have new experiences in this manner, but not new ideas, new concepts, advances in human understanding: For these, we need the effort of reflection" (p. 17).

EVALUATING VR IN RELATION TO THE MODEL

The range of applications currently addressed through VR stretches from very constrained practical tasks for dedicated professionals (such as surgeons wanting to plan a minimally invasive route for brain surgery) to artistic experiences that radically, if temporarily, change how people feel about themselves, their bodies, and the world around them. It makes little sense to try to apply the same evaluation techniques across this broad range. In human–computer interaction (HCI) studies, it has been traditional to think of evaluation as something that revolves around users' purposes in terms of the tasks they wish to perform. VR can serve as both a task-related tool and a provider of experiences, and it is often impossible to correlate the quality of the environment or tool with time, accuracy, or other traditional objective performance measures. While it might be good to explore an information space very briefly, because that means one quickly found what was wanted (the purpose of the interaction was satisfied), a long browsing session might mean that much interesting material was found, even though it was not initially being sought after. The potential value of "traveller's tales" has been suggested as a subjective measure for the evaluation of interactive experiences where a task-based approach is not appropriate.[29]

But the problem of evaluation is more than just tasks versus experiences. In artistic and some recreational applications of VR, the effect may be to render the immersant more or less incapable of giving a coherent account of his or her experience. People who have experienced emotionally very powerful installations such as Char Davies' Osmose[21] will testify to the difficulties of expressing the nature of the event. In this respect, VR is rather like a recreational drug, and the more powerful and effective it is the less likely we are to be able to give coherent subjective accounts. In these cases, internal, physiological measures have an obvious role. We suggest that assessment techniques can be arranged along a spectrum of application types, and that different parts of the spectrum can also be related to our three dimensions of virtual experience (see Fig. 6).

At the far right, the concrete-internal perspective emphasizes concrete, bodily experiences; sensus changes due to VR exposure that can be measured physiologically. An example is in interactive art works that engage the im-

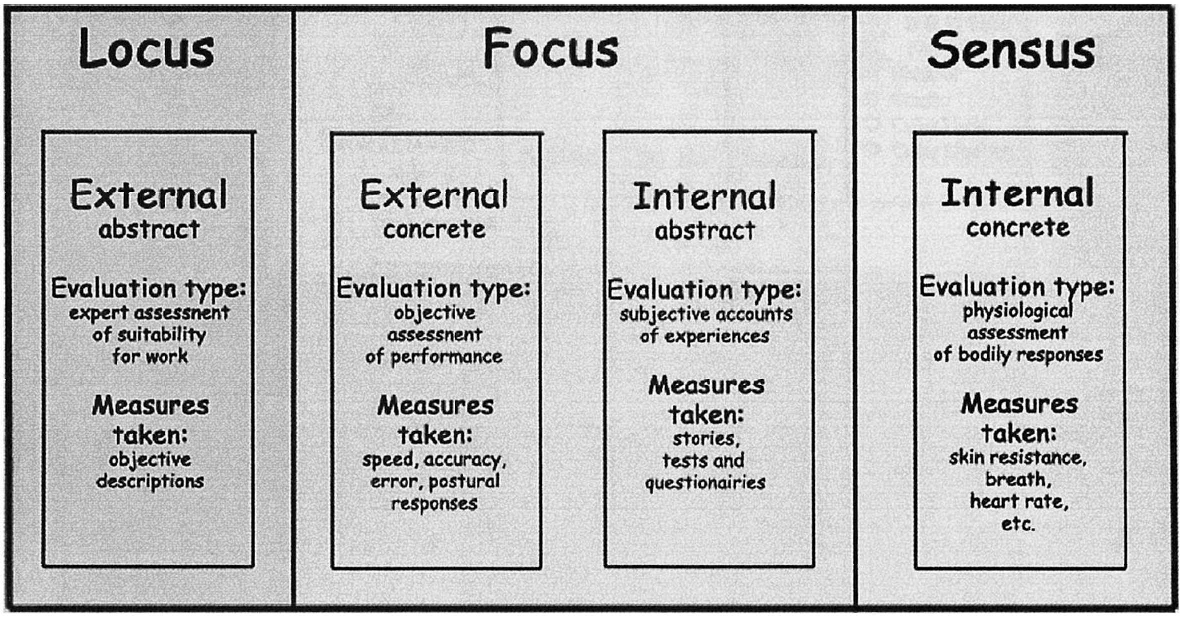

FIG. 6. A spectrum of VR evaluation methods in relation to the model.

mersant in a vivid, present reality; changes in physiological response are a strong indicator of the effectiveness of the VR (though not necessarily closely related to prevalent measures of presence).[30] Another is in the way VR can be successfully used in the treatment of anxiety disorders, such as phobias, which require a reprogramming of emotional bodily responses to certain environmental stimuli.

At the other end of the spectrum, the abstract-external perspective emphasizes expert assessments of outcomes, and reflective processing of information. Here, a sense of presence is largely incidental, and the relation of the VR to external reality—locus aspects—are of prime importance. Educational applications of VR typically fall between these two extremes, and benefit from detailed assessments of focus—of presence versus absence. Depending on the nature of targeted learning, concrete measures such as speed on tasks, postural responses[31] or abstract measures, such as subjective accounts and performance on written tests, may be more appropriate. Duration estimates can be a useful adjunct to both types of focus assessment.

In summary, part of our claim in relation to evaluation is—uncontroversially—that different types of VR application require different types of assessment. Further, we suggest that our three-dimensional model provides a useful perspective on the aspects on which to focus in evaluating VR applications of different types.

CONCLUSIONS

The sense of presence is a key aspect of experience in virtual worlds. But to understand and evaluate those experiences fully, we need to consider more than mere presence—which we characterize as a conscious emphasis on direct perception of currently present stimuli rather than on conceptual processing. We see these two types of conscious mental activity as end points of the focus dimension of our model of virtual experience. The other two dimensions are locus—that is, whether attention is directed toward the virtual or the physical world—and sensus, which is the level of attentional arousal, on a continuum from completely unconscious to fully conscious. The combination of these three provides a conceptual space in which various types of virtual experience, and virtual reality applications, can be placed. This has implications for designing and evaluating virtual worlds of various types and with varying aims. More generally, we hope the model can provide the basis for a richer understanding of the psychological realities of virtual experiences.

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