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A New Conception of Spatial Presence: Once Again, with Feeling

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Recent theories of telepresence or spatial presence in a virtual environment argue that it is a subjective experience of being in the virtual environment, and that it is the outcome of constructing a mental model of the self as being located in the virtual environment. However, current theories fail to explain how the subjective experience of spatial presence emerges from the unconscious spatial cognition processes. To fill this gap, spatial presence is conceptualized here as a cognitive feeling. From this perspective, spatial presence is a feedback from unconscious cognitive processes that informs conscious thought about the state of the spatial cognitive system. Current theorizing on the origins and properties of cognitive feelings is reviewed and applied to spatial presence. This new conception of presence draws attention to the functionality of spatial presence for judgments, decisions, and behavior. By highlighting the distinction between spatial cognitive processes and the subjective feeling of spatial presence, the use of questionnaires is theoretically grounded and legitimized as a method of presence research. Finally, embodied cognition theories are reviewed to identify cues that give rise to spatial presence.

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Users of virtual environments typically report that they experience a sense of *being there in* the virtual environment. This experience has been termed *telepresence* (Held & Durlach, 1992; Minsky, 1980; Sheridan, 1992), *presence* (Heeter, 2003; Slater, 1999), *spatial presence* (Lessiter, Freeman, Keogh, & Davidoff, 2001; Schubert, Friedmann, & Regenbrecht, 2001), or *physical presence* (Lee, 2004). The first decade of presence research during the late 1990s and early 2000s was dominated by a thorough debate on the definition of this phenomenon. One strong position that has developed during this debate is that spatial presence is a psychological phenomenon that is experienced or *felt* (for overviews, see Lee, 2004; Lombard & Ditton, 1997; Lombard & Jones, in press). Characterizing spatial presence as being experienced indicates that people are conscious of it. This distinguishes the experience of spatial presence sharply from automatic and uncontrollable responses to virtual environments such as startle reflex,

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body sway, physiological reactions, or social responses, which have sometimes been discussed as alternative, objective measures of presence (Bailenson, Blascovich, Beall, & Loomis, 2003; Freeman, Avons, Meddis, Pearson, & IJsselsteijn, 2000; IJsselsteijn, de Ridder, Freeman, Avons, & Bouwhuis, 2001; Meehan, Razzaque, & Brooks, 2005; Nichols, Haldane, & Wilson, 2000; Slater et al., 2006).

Recently, research on presence has entered a new phase. In this new phase, researchers are recognizing that cognitive theories of spatial presence are needed, or, in the words of Lee (2004), that "one of the most important issues" is to explain the "mental mechanism that enables humans to feel presence when they use media or simulated technologies" (p. 47). Theories are now being developed that try to explain which cognitive processes are involved in the perception and interaction with virtual environments, and how these processes lead to presence. In doing so, these theories largely assume that unconscious spatial cognitive processes underlie the construction of a mental model of the virtual environment, which then evokes presence (Biocca, 1997; IJsselsteijn, 2002; Nunez, 2007; Regenbrecht & Schubert, 2002; Sanchez-Vives & Slater, 2005; Wirth et al., 2007). These attempts profit enormously from the definition debate (see above), but also from earlier research on determinants and measurements of presence (Slater, Linakis, Usoh, & Kooper, 1996; Slater & Usoh, 1993; Slater & Wilbur, 1997). Importantly, the theories of presence that are now being developed go beyond the earlier work because they are more concerned with the cognitive processes, which were rather a black box in the earlier work on presence. One can also hope that the theoretical efforts provide new input to the definition debate.

In the following, I will argue that the new task to develop a cognitive theory of spatial presence poses an important challenge that is largely ignored by current approaches. The challenge lies in the fact that they need to explain the following: While the cognitive processes underlying presence are unconscious spatial cognitive processes, the experience itself is conscious. There seems to be a consensus in the literature on both claims, yet it is unresolved how the conscious experience emerges from unconscious processes. After reviewing the recently proposed cognitive theories of presence in order to explicate the problem in more detail, I will propose a solution to it.

However, first the terms used in this paper should be explicated. As already stated above, many different terms have been used in the literature to refer to the phenomenon of having the sense of being there in a virtual environment. Some researchers have argued for a distinction that is based on the type of environment one feels in and thus for using the term "virtual presence" for virtual environments and "telepresence" for remote real environments (Sheridan, 1992). Other researchers have distinguished between different components of presence, especially attentional and spatial-cognitive components, and termed them as involvement and spatial presence (see below). Because the goal of the present paper is to develop a general model for the *sense of being there* that applies to the experiences of spatial presence in virtual and real environments as well as to the experiences emerging from reading and remembering, I will use the term *spatial presence* to refer precisely to this experience irrespective of whether technology mediated the experience, or which technology was involved

(cf. Lee, 2004). Thus, the experience of this feeling in virtual environments, mediated real (remote) environments, or real environments is referred to as spatial presence.

Current theoretical models of spatial presence

Several studies have investigated subjective measures of presence, and tried to develop internally consistent and focused scales for different aspects of the experience in virtual environments. The remarkably consensual outcome (cf. Freeman, 2003; Nunez, 2007) of several independent approaches to measuring presence is that at least two components seem to be distinguishable: (a) spatial presence or the sense of being in a place, and (b) involvement in the sense of focusing attention on the virtual environment (Lessiter et al., 2001; Schubert et al., 2001; Witmer, Jerome, & Singer, 2005). In addition, two of these three studies have also consensually identified a third component, judgments of realness. The difference between the experience of spatial presence and the experience of involvement has led to one theoretical approach to presence proposed by Regenbrecht and Schubert (2002; see also Schubert, Regenbrecht, & Friedmann, 1998). This approach is based on an embodied view of spatial cognition, especially Glenberg's (1997) theory, and argues that two processes work in conjunction. One process constructs a coherent spatial mental model of the virtual environment and one's possible actions in it. The other process is attentional, and focuses attention on the virtual environment and compatible information from the real environment, while suppressing incompatible information from the real environment. These two cognitive processes are assumed to give rise to spatial presence and involvement, respectively.

A more recent, comprehensive, and integrative attempt at a cognitive theory of presence was presented by Wirth et al. (2007). Their theory concentrates on spatial presence and argues for the distinction of two different cognitive steps in its formation. Roughly sketched, it assumes two steps. In a first step, after allocating attention to the stimuli presented by the virtual environments, users of virtual environments build a mental model of the simulated space, a so-called *spatial situation model*. In a second step, users accept, in a hypothesis-testing process, this spatial situation model as their own egocentric viewpoint, or, in the terms of the theory, as their *primary egocentric reference frame*. If they do, spatial presence is assumed to emerge. If they do not, the mental model of the real world remains their primary egocentric reference frame. Although the theory is not explicit about this, it strongly suggests that both construction and acceptance as the primary reference frame are unconscious processes of spatial cognition.

Wirth et al.'s theory demonstrates its virtues by successfully placing two concepts within its framework that have often been confused before with presence: Involvement and suspension of disbelief. Involvement is conceptualized as the active processing of the virtual environment. It favors the virtual environment's acceptance as the primary egocentric reference frame because it adds more and more stimuli to focus on, and leads attention away from stimuli favoring the real environment as the

primary frame. Suspension of disbelief is conceptualized as the intended lack of attention for information that contradicts the acceptance of the virtual environment as the primary egocentric reference frame.

A second field where Wirth et al.'s theory excels is the integration of media- and person-related factors. Both kinds of factors can influence both the construction of a spatial situation model and its acceptance as the primary egocentric frame of reference. For instance, media richness and vividness and domain-specific interest are identified as determinants of attention allocation during the construction of the spatial situation model. Persistence and interactivity are identified as media factors influencing the acceptance of the model as the primary frame. This specification provides interesting hypotheses for empirical tests.

However, Regenbrecht and Schubert's theory (Regenbrecht & Schubert, 2002; Schubert, 2003; Schubert et al., 1998) and Wirth et al.'s (2007) theory share a white spot with all current models of spatial presence (for an excellent overview, see Nunez, 2007). The question concerns the emergence of spatial presence. Wirth et al. assume that "spatial presence occurs when the medium-as-[primary egocentric viewpoint]-hypothesis is confirmed repeatedly through processed information and is thus stabilized over time" (p. 508). Similarly, Regenbrecht and Schubert simply assume that spatial presence "emerges" from spatial cognition. Note that the theories agree with the majority of previous definitions of spatial presence in understanding presence as a *subjective experience*. The cognitive processes of constructing the spatial situation model and the choice of a primary egocentric reference frame from the available reference frames are themselves unconscious and not available to conscious experience. There is a gap between unconscious spatial cognition and conscious experience that is unexplained. What can be done to bridge it? How exactly can we understand the emergence of a subjective experience from these unconscious cognitive processes?

Feelings as feedback from unconscious processes

Fortunately, extensive research and theorizing on the emergence of subjective experience from unconscious cognitive processes has been conducted in other fields of psychology. Most of this research terms such emerging subjective experiences simply as *feelings*, and distinguishes them from *knowledge* (Neumann & Strack, 2000). Feelings and knowledge are distinguished by a variety of properties, which I will describe in detail below. The most important distinction is the quality of the experience. Feelings have a perceptual quality to them, just like percepts of the environment (Kahneman, 2003; Koriat, 2007). For example, compare two situations: You either watch a child taking chocolate out of a drawer, or you infer, after finding an empty drawer, that the child has taken the chocolate. The insight that the child has the chocolate has a different quality in the two situations: It is either a percept or an inference. Feelings are like perceiving, not inferring. They are immediate, given, and not consciously inferred in a deliberate process.

In a nutshell, I will argue that theorizing and research on feelings can help us to understand the gap between unconscious and conscious processes in two ways: First, by focusing on the function of feelings, and second, by providing detailed process assumptions. In the following, I will review the current understanding of feelings, and then apply this perspective to spatial presence. The literature describes both affective and nonaffective, or *cognitive*, feelings. Since the notion of a cognitive feeling might seem contradictory at first, I begin with affective feelings.

Affective feelings

Prototypical examples of feelings are affective feelings—positive and negative feelings about a person, an object, a situation, or the self, which can be short-lived or enduring (i.e., moods). Affective feelings provide a good example to briefly sketch the idea underlying current theories of experiences. *First*, it is almost trivial to say that affective feelings are determined by positive and negative events in our lives. *Second*, these positive and negative events, in addition to causing affective feelings, have many direct consequences that are not mediated by the feelings. That is, the events that are causing feelings have direct, automatic, unconscious effects on cognition and behavior. For example, exposure to affectively laden stimuli can cause spontaneous facial expressions of emotions and physiological changes (Dimberg, Thunberg, & Grunedal, 2002). Positive events also change the way one perceives elements of the environment (Forgas, 1999). All these effects very likely occur independently of conscious feelings. *Third*, the precise processes leading to an affective feeling that we have at a given moment are not available to conscious introspection. We simply have no clue how our multitude of experiences in the last minutes, on a given day, week, or year, add up or how they are weighted before we feel a mood in any one moment. However, we are sure that we know how we feel when we are asked (although we may not always answer truthfully). *Fourth*, we usually attribute our feelings to a specific aspect of a situation, our own thoughts, or a person. For instance, when we are asked how satisfied we are with our life, we will use the affect we are feeling at that moment to determine our satisfaction, and we do this because we attribute our affect to our life. That it may not be our life that is causing the depressed mood, but just the weather that day, is usually ignored. However, if we are reminded of the weather's influence, we tend to attribute our current affect to it and not to our life (Schwarz & Clore, 1983).

In sum, the general model underlying this research is basically a dual process model: Unconscious processes following perception lead automatically to a number of likewise unconscious, and largely unintended, consequences in cognition and behavior. However, in addition, these unconscious processes also cause feelings that become available to conscious processes, which then use them for further monitoring, regulation, and judgment. In other words, becoming aware of an evaluative reaction of the own mind to environmental stimuli opens up a second layer of regulation through conscious processes. Feelings can thus be understood as signals or feedback from unconscious processes made available to conscious cognition (Koriat, 2007).

This feedback allows conscious, controlled processes to plan and initiate further regulatory behavior that goes beyond the primary unconscious processes. For instance, positive and negative feelings (i.e., affect) inform the individual about the result of an automatic and instantaneous evaluation of the environment. This information then allows cognitive tuning of cognition and behavior (Schwarz, 2002; Schwarz & Clore, 2003).

Cognitive feelings

In addition to affective feelings, researchers have also explored the field of cognitive feelings, or, as some have called them, cognitive experiences, or nonaffective feelings (Schwarz & Clore, 1996, 2007; Wegner, 2005). Cognitive feelings are experiences that arise from perceptual and cognitive processes that are not specifically concerned with evaluations. A primary example is the feeling of knowing (Koriat, 2000, 2007). The feeling of knowing comes into play when we attempt to retrieve information from memory. Imagine you meet a former colleague at a conference. You recognize him, without remembering the name immediately. But you might have a feeling of knowing that tells you it is worth it to try a bit harder to remember the name, since you are likely to know it. And indeed, after some time you remember the name. On the other hand, it could also have happened that you recognize the face, but after a short attempt to remember the name you sense that you do not know it, and that it is better to call off the search and start looking for an excuse. The feeling of knowing informs about how accessible an item is in memory, and how easy it is to generate. Remembering is not an evaluative process, even though the remembered content might have affective value. This is why the label cognitive feeling is appropriate.

In addition to the *feeling of knowing*, Clore (1992) discussed the feelings of *uncertainty, familiarity*, and *distraction* as further cognitive feelings. Recently, Schwarz and Clore (2007) added *surprise* and *boredom* to the list, and Wegner (2005) proposed to frame the *feeling of doing*, or *sense of agency*, as a cognitive feeling. Wegner argues that we have a feeling of doing if we think about the intended outcomes of our actions before we actually observe ourselves doing them. Otherwise, we feel that we have not really done something ourselves.

Recently, a great deal of research has focused on *processing fluency* and its subjective experience. Fluency is experienced during perception, for instance, of clear patterns, symmetric figures, or rhyming phrases (perceptual fluency), but also during identification and categorization of stimuli (conceptual fluency). However, how exactly different fluency experiences, familiarity, or ease experiences are interrelated is still an open question.

In sum, the basic model behind research on cognitive feelings is identical to the dual process models underlying affective feeling: Cognitive feelings are thought to arise from nonconscious processes (during recollection, attention, or behavior) and inform the conscious mind about these processes. They are then used for further regulation. A great deal of research in cognitive and social-cognitive psychology has

focused on the use of feelings in judgments (Reber, Schwarz, & Winkielman, 2004; Winkielman, Schwarz, Fazendeiro, & Reber, 2003).

Characteristics of feelings

Several properties of these experiential states have been pointed out in the literature from the fields of cognition and especially social cognition (Clore, 1992; Koriat, 2000; Neumann & Strack, 2000; Wegner & Gilbert, 2000). In the following, I will discuss each of them in turn and later apply them to spatial presence.

Feelings are caused by unconscious processes

During the past few years, more and more theory and evidence became available that investigates the bases of cognitive feelings, their components, and their outcomes. Research on feelings has primarily focused on their consequences; however, a good deal is also known about their origins. For instance, it is typical that feelings emerge not only from one but from a number of cues. Affective feelings can result from the perception and subsequent evaluation of external events or objects, but they may also arise as the result of feedback from proprioceptive cues, for instance, from smiling versus frowning (Strack, Martin, & Stepper, 1988; Strack & Neumann, 2000). Similarly, several mnemonic cues have been proposed to lead to the feeling of knowing: Fluency of processing of the target cue is assumed to become available early on in the process, while accessibility of the memory trace is assumed to be available later. Both contribute jointly to the resultant feeling of knowing, which is experienced as one unified feeling (Koriat & Levy-Sadot, 2001). Neither the development of these cues themselves nor their weighing in the feeling formation is available to conscious control. Instead, nonanalytic unconscious processes combine the cues and produce a unified judgment. In more detail, the currently advanced models propose to understand the development of feelings as the outcome of unconscious, automatized inferential processes, or unconscious heuristics (Kelley & Jacoby, 1998; Koriat & Levy-Sadot, 2000; Koriat, 2000). The heuristics operate on the available cues (e.g., familiarity and accessibility for the feeling of knowing), and their result is then known without knowing its source, precisely because the heuristics operate below the level of conscious awareness. This is an elegant yet precise explanation of how the gap between unconscious and conscious processes can be bridged: Automatized inferential processes result in a judgment that becomes conscious. By itself, it does not differ from judgments that result from conscious judgmental processes, but because it was produced by an automatic process, it appears to have no source, and is therefore just *felt*. Note, however, that the literature is currently mute on the question of how this automatic inference develops. This question needs to be addressed in future investigations.

Feelings are immediate

As already noted, feelings are ''immediately given,'' just as a percept of an object in the environment. It is not necessary to consciously and/or deliberately infer them

from something else. Consider mood: It is not necessary to judge on the basis of other information what mood you are in, or, in other words, to consciously *infer* it from something else. One just feels one's mood. Similarly for the feeling of knowing: You simply experience during recall whether you are likely to know what you try to remember. It is not necessary to consciously infer it from, say the time it takes to remember, or from the face you make while you try to remember, and it is not necessary to apply knowledge one has about the relation between time, facial expression, and knowing in order to make the inference. Feelings are directly accessible and experienced. In fact, Koriat (2007) argues "that the nonanalytic, unconscious basis . . . is responsible for the phenomenal quality of the feelings of knowing as representing an immediate, unexplained intuition. . . . According to this view, sheer subjective experience, which lies at the core of conscious awareness, is in fact, the end product of processes that lie below awareness" (p. 19). The opposite of this sheer experiencing of feelings is the cognitive effort and time we have to put into judgments and conscious inferences that follow propositional knowledge and rules.

Feelings are always true

Feelings differ from propositional representations (things we know) in that they have no truth value; they cannot be true or false. One could also say that they are always true to the person who has the feeling. Believing that Rome is the capital of the United States can be marked as false simply by learning that it is not, but feeling that Rome is the nicest town on earth cannot simply be negated by the person feeling it—it can only be disputed by others, and slowly changed by acquiring additional evaluative information.

Feelings get attributed

Feelings are typically spontaneously attributed to a temporally close external or internal event (e.g., Wegner, 2002). Usually, this attribution is quite valid and captures the actual source of the feeling. However, the attribution process can be influenced or misled, leading to misattribution. Experimental research has shown that the attribution of feelings can be easily manipulated. For instance, Schwarz et al. (1991) informed their participants that music played during the experiment would influence their recall of certain life events. As a result, participants did not use their experienced ease of recall (a feeling) anymore when they had to form judgments. Apparently, they attributed their ease of recall to the music and not to their own memory anymore, and thus discounted the feeling's diagnosticity.

Feelings have informative value

Feelings are used as information in judgments (Clore, 1992; Schwarz & Clore, 1996) and to control behavior. Under most circumstances, they are indeed valid cues. For instance, the feeling of knowing successfully predicts later recognition of a target when a first attempt to retrieve it from memory failed (Schwartz & Metcalfe, 1992). In a seminal study on this topic, it has been found that the feeling that something

is hard to retrieve influences subsequent judgments more than the actual content of the retrieval (Schwarz et al., 1991). Only a strong discounting of the feeling's diagnosticity lowered its influence on judgments. Using feelings as information is basically a heuristic process (Kahneman, 2003). Thus, feelings are by no means just an epiphenomenon or symptom of unconscious processes, but an immensely valuable cue used for complex monitoring and control. It is this metacognitive ability humans have developed that makes human cognition much more flexible (Koriat, 2007).

Feelings vary in intensity

We all know that affective feelings can vary in intensity. Similarly, cognitive feelings like familiarity and the feeling of knowing vary in intensity. Stronger feelings are more likely to be used as the basis for judgment. In the ''tip of the tongue'' phenomenon, the feeling that one knows a name is often particularly strong even though one is unable to actually retrieve the name (Brown & McNeill, 1966).

Feelings (often) have valence

It has recently been argued that even nonaffective feelings often have a hedonic tone associated with them. For instance, the feeling of fluency during cognitive processing elicits positive affect (Winkielman & Cacioppo, 2001). The affect accompanying a cognitive feeling is typically an indicator of its adaptive value. Fluent processing is a signal that the processed information is well-known, and therefore likely to be easily processed and recognized (Reber et al., 2004), benign (Zajonc, 1998), and known and thus likely to be controllable (Garcia-Marques & Mackie, 2000). Note that acknowledging that cognitive feelings have an associated hedonic tone, or affect, does not make them themselves affective feelings—they are still outcomes of cognitive processes, not evaluations of the environment. Nevertheless, the insight of an associated affect makes the term nonaffective feeling (Clore, 1992) somewhat awkward; I have adopted the term cognitive feeling here instead.

Summary

In sum, cognitive feelings are subjective experiences that are a feedback from unconscious cognitive processes. They are functional in the sense of allowing monitoring and control of cognitive functioning by conscious, deliberate processes. These ''messages within'' (Bless & Forgas, 2000) are immediately given, seem indisputable just as percepts of the environment, and inform judgments, decisions, and behavior after being attributed and interpreted.

Spatial presence as feeling

When we turn to spatial presence, a remarkable majority of definitions underscore its experiential nature, describing it as a sense, a (subjective) experience, subjective perception, phenomenal sense, or a subjective feeling (for overviews, see Lee, 2004; Lombard & Ditton, 1997; Lombard & Jones, in press). In contrast, I know of no

definitions framing spatial presence as knowledge, such as "knowledge that one is in the virtual environment." In fact, in factor analyses of questionnaires, items that capture such a knowledge aspect typically do not load on presence factors, but on a factor termed realism (Lessiter et al., 2001; Schubert et al., 2001).

For these reasons, it appears promising to *conceptualize spatial presence as a cognitive feeling*. In a nutshell, I suggest that spatial presence is a feedback of unconscious processes of spatial perception that try to locate the human body in relation to its environment, and to determine possible interactions with it. If the spatial cognition processes are successfully able to locate the body in relation to the perceived environment, and construct possible actions in it, the feeling of spatial presence is fed back and becomes available for conscious processes.

The characteristics of spatial presence as a feeling

With this idea in mind, let us now go through the list of properties found to characterize other cognitive feelings, and examine how plausible they are for spatial presence.

Spatial presence is caused by unconscious spatial cognition: Cues for presence

Which cues give rise to the feeling of spatial presence? The literature on the feeling of knowing suggests that a pool of several cues is likely to be responsible. For an answer, we can look at the most successful manipulations of spatial presence (for an overview, see Sanchez-Vives & Slater, 2005). The most likely cue is the representation of possible actions in the virtual environment. There is good evidence that the possibility to move the virtual body in the environment, to interact with virtual objects and agents, and even the mere illusion of interactivity lead to an enhanced feeling of spatial presence (Regenbrecht & Schubert, 2002). Furthermore, the manner of interaction seems to be important: Presence is enhanced when body movements in interaction effects are not just arbitrarily coupled (a mouse-click moves the virtual body forward), but coupled in a way that fits the experiences one has with one's body (Slater, Usoh, & Steed, 1995).

These findings are in line with current embodied theories of cognition (Barsalou, 2008), which assume that the activation of potential motor responses is a common feature of perceptual processes (Dourish, 2001; Glenberg, 1997). There seems to be at least two sources of such codings: Bottom-up activations from affordances, and top-down activations from goals. Concerning the first aspect, numerous studies on grasping confirm that affordances of objects in the environment activate motor codings in a bottom-up fashion. For instance, neurological studies found that the monkey's premotor cortex contains so-called canonical neurons that become active when an object congruent with a certain type of grip is perceived (Murata et al., 1997). In other words, these motor neurons code potential actions (Rizzolatti, 2005). In humans, experimental evidence shows that the perception of common objects (e.g., tools, kitchenware) automatically involves the activation of motor programs of how to handle these objects. This has been shown for real objects (Pavese & Buxbaum,

2002), pictures of real objects (Ellis & Tucker, 2000; Symes, Ellis, & Tucker, 2005; Tucker & Ellis, 1998, 2001), computer-generated renderings of virtual objects (Ellis, Tucker, Symes, & Vainio, 2007; Symes, Ellis, & Tucker, 2007), and even remembered objects (Derbyshire, Ellis, & Tucker, 2006). Motor programs are activated irrespective of the medium. The majority of this research has focused on showing that the effect exists; recent research also explored its boundary conditions. For instance, distraction from bodily interactions with an object in the form of producing verbal semantic associations to its name has been shown to reduce affordance effects (Creem & Proffitt, 2001).

In addition to this bottom-up activation, goals seem to provide a second way to activate motor responses in the coding of the environment. The theory of event coding (Hommel, Müsseler, Aschersleben, & Prinz, 2001) proposes that actions are coded in terms of their sensory consequences. In a classic study, Van den Bergh, Vrana, and Eelen (1990) showed that skilled typists, but not nontypists, evaluated letter combinations more positively when they had to be typed with different instead of the same fingers. The letter combinations were shown as prints of a typewriter. Apparently, this display automatically activated motor programs that led to the production of the display—the letters are coded in terms of how to produce them, and the simulated ease of the movements determines evaluation of the letter combinations (Winkielman et al., 2003)—moving two fingers is easier and faster than moving one finger twice. Recently, it has been shown that coding in terms of production movements is reduced when the respective body parts are busy with doing something else (Beilock & Holt, 2007).

Similarly, the understanding of language seems to involve the activation of motor programs; this has been shown both on behavioral (Glenberg & Kaschak, 2003) and neural levels (Hauk, Johnsrude, & Pulvermüller, 2004). Motor actions penetrate cognitions during language comprehension on many levels, from phonological processing, to lexical access, and from sentence comprehension, to discourse comprehension (Fischer & Zwaan, 2008; Zwaan & Taylor, 2006).

In this brief review, I have concentrated on possible interactions with objects in an environment. However, locomotion of the own viewpoint (i.e., the virtual body) in the environment (Slater et al., 1995) and interaction with other agents in the environment (Regenbrecht & Schubert, 2002) will be important as well. Regarding locomotion, similar but less evidence is available (e.g., Presson & Montello, 1994; Richardson, Montello, & Hegarty, 1999). Regarding interaction with other agents, the growing literature on mirror neurons suggests a complex interplay of imitation and coordination in the activation of motor responses (Fischer & Zwaan, 2008; Iacoboni et al., 1999; Knoblich & Sebanz, 2006).

Taken together, evidence on the influence of motor coding during perception and language comprehension suggests that coding in terms of bodily interactions is common to many cognitive tasks. Activating representations of potential motor actions can be either bottom-up, provoked by the environment, or top-down, fostered by goals and intentions. In both cases, cognitive and bodily states of the perceiver,

both transient and chronic ones, are likely to modulate the activation of motor programs. The remarkable consistency of these effects in different media allows me to formulate the parsimonious hypothesis that spatial presence in all types of environments (real environments, virtual environments, pictures, movies, books, and even imagination) is caused by the same cue, namely, the representation of potential interactions with the environment and its objects. In all cases, the interaction has to be mentally represented as an action of *the own body* in the virtual environment. If, for instance, locomotion is instead mentally conceptualized as moving a virtual camera, it should *not* lead to enhanced spatial presence.

In their theory of spatial presence, Wirth et al. (2007) argued that accepting the egocentric viewpoint on the virtual environment as the primary egocentric viewpoint leads to the development of spatial presence. As the underlying process, they propose the testing of perceptual hypotheses (e.g., Gregory, 1980). It seems likely that the testing process Wirth et al. assumed differs from the coding of motor responses referred to above. The best way to integrate the two proposals is to assume that the testing process that Wirth et al. proposed provides a second cue, in addition to the motor coding. Wirth et al. hypothesized that the "strength of the [spatial situation model] varies by its internal consistency (the more plausible the spatial scenery, the stronger the [spatial situation model]) and its richness (the more objects entailed, the stronger the [spatial situation model]). A strong [spatial situation model] adds to the relative strength of the medium-as-[primary egocentric reference frame]-hypothesis: The more plausible and richer the [spatial situation model], the more plausible and stronger the resulting medium-as-[primary egocentric reference frame]-hypothesis" (p. 509). This directly provides a testable hypothesis. If internal consistency/richness of a virtual environment and its potential for coding of motor responses are manipulated independently, a combination of both approaches would predict two main effects on spatial presence.

Regardless of the question whether internal consistency and richness of a spatial situation model provide a unique contribution to spatial presence, the process assumptions derived from theorizing on cognitive feelings are applicable. As for the feeling of knowing, I argue that spatial presence is the outcome of an unconscious, automatized heuristic that infers from aspects of the current coding of the environment whether it provides the current environment of the body or not. If yes, then this judgment becomes conscious, and because the processes leading to it are unconscious, it is experienced as an immediate, sheer feeling, unmediated by conscious deliberations.

In addition to discussing possible cues for the spatial presence feeling, it is also instructive to explore which cognitive processes are unlikely to feed into it. One that should certainly be discussed is attention. While attention plays an important role during the selection of aspects of an environment and determines the construction of a situated model (Glenberg, 1997), it does not provide useful information on whether the construction was successful, or whether the own body is actually located in the virtual environment. Consequently, items that tap experiences of attention

allocation do not load together with items on spatial presence in factor analyses, but on a separate factor usually termed involvement (Lessiter et al., 2001; Schubert et al., 2001). This understanding of involvement is in line with Wirth et al. (2007), and also with most of the various conceptualizations of involvement in the literature (Wirth, 2006). In other words, attending to the virtual environment is no cue for being present in it. Nevertheless, attending to the virtual environment is a prerequisite for presence to the extent that attention is necessary to construct a situation model.

However, it is of course conceivable that deliberately focusing attention on aspects of the virtual environment and suppressing contradicting information from the real environment helps in constructing potential interactions and thus building up presence. The current framework proposes that effects of a deliberate effort to be present in a mediated environment (a form of a suspension of disbelief) would be mediated by focusing attention on possible interactions, and their successful coding.

To sum up: Proposing that spatial presence is a cognitive feeling explains how the spatial cognitive processes during the perception of an environment produce spatial presence. In terms of Wirth et al. (2007), constructing a spatial situation model that includes motor responses to the virtual environment, its objects, and its characters, and perhaps the richness and consistency of this spatial situation model, are registered by unconscious inferential processes and result in a conscious experience of being there. Thus, the current proposal is fully compatible with Wirth et al.'s theory, while shedding more light on a key step in the model.

Spatial presence is immediate

Spatial presence seems indeed to be given immediately. For users of virtual environments, it is not necessary to deliberately review what evidence there is indicating that they feel being present in the environment. The feeling is so clearly available that it is typically very easy to remember it afterward and describe it in a questionnaire. Consider the alternative: It could be that after standing in front of a visual cliff, participants in a study might think: Well, I was really afraid when I perceived the visual cliff, so I must have felt present. In numerous interviews with participants in studies on virtual environments, I have never encountered such an inferential process, and there seems to be no data in the literature suggesting such a reasoning process. (Incidentally, the immediacy of the spatial presence feeling might explain why previous theories have seen no need to explain its actual emergence from unconscious processes.)

Spatial presence is always true

The comparison suggests further that spatial presence cannot be assigned a truth value. Indeed, this might be one of the reasons why it is so fascinating: It is possible to say that feeling spatial presence *should* be wrong because the virtual environment is not real, after all. However, the feeling itself is not deniable and cannot be simply negated as false. Note, though, that if somebody *believed* the virtual environment is actually the real environment, it would be possible to assign a truth value (to say that person is wrong). This would be a statement about knowledge, not about a feeling.

Spatial presence gets attributed

Furthermore, I propose that the feeling of spatial presence undergoes an attribution process. This idea suggests that the feeling arises out of unconscious processes and becomes available for conscious thought, but that it has no ''tag'' telling its source. This would mean that a person first has to figure out where he or she feels present, and thus, attribute the feeling to a possible source. Attribution processes are very quick and effortless, and governed by certain rules (Wegner, 2002). In most cases, of course, the environment that caused the feeling will still be available when the feeling has arisen, so it will be interpreted as the cause. However, it seems possible that misattribution can occur. It might be possible to persuade participants that a feeling of spatial presence is actually not due to the virtual environment itself, but to another source (music, drugs, etc.). The prediction is that the feeling would then not be used for judgments anymore.

Spatial presence has an informative value

Next, let us consider to what extent the feeling of spatial presence may be a valid source of information. It may seem a bit odd to discuss this in relation to virtual environments, where the conscious knowledge that the environment is virtual seemingly falsifies the validity of the feeling. However, consider the possibility that the feeling of spatial presence is in fact a usual and common feeling in response to real environments. Similar to the feeling of knowing, we just do not pay much attention to it. It is often taken for granted, and its attribution and interpretation is simply part of the flow of consciousness. We consciously register the absence of the feeling of knowing when we expect to actually have it, for instance, when we try to remember the name of an acquaintance. We also focus attention on it when the feeling contradicts other information, for instance, when we have it, but still cannot retrieve the information from memory—the tip of the tongue phenomenon. Similarly, the absence of any spatial presence at all will be very likely registered and taken as very informative and alerting. Very low spatial presence can, for instance, occur while wearing a head-mounted display that disconnects one from the real environment, but does not provide a sufficiently immersing virtual environment either. In these cases, no visual information is available to build a spatial situation model. Furthermore, if we feel present, but other information contradicts this feeling, attention will be drawn to it. This may happen to the first-time users of virtual environments who often become aware of their spatial presence feeling because it surprises them. Frequent users adapt and become less aware of the feeling.

Spatial presence varies in intensity

A conception of spatial presence as a feeling would suggest that the experience varies in intensity. This seems to contradict previous reasoning by Slater (2002) and Wirth et al. (2007), who argue that spatial presence is binary (on/off). However, this contradiction might be more apparent than real. First, both Slater and Wirth et al. argue that the binary character results from a perceptual gestalt effect. This

is similar to well-known gestalt effects such as the pictures in which interpretation switches between an old woman and a young woman or between a duck and a rabbit (see Slater & Steed, 2000). It might well be that such a process leads to a rather dichotomous pattern of spatial presence, which then flips between the real and the virtual environment (see also the explication of presence by the ISPR, 2008). Second, this does not contradict the possibility that within a period of interaction with a virtual environment, spatial presence might vary in intensity. Note also that both questionnaires (Lessiter et al., 2001; Schubert et al., 2001; Witmer et al., 2005) and online measures of the experience of spatial presence (IJsselsteijn, Freeman, Davidoff, de Ridder, & Hamberg, 1997) rely on this assumption by providing a continuous scale instead of a dichotomous decision. Participants are typically happy to use the full continuum of the scale instead of only its endpoints (Slater & Garau, 2007).

Spatial presence has a valence

The last point in the list introduces the new idea that the feeling of spatial presence might have an affective tone or quality to it. Indeed, considering its proposed source in the successful location of the body in an environment and the determination of possible action, it seems plausible that feeling present is inherently positive. Note, however, that it is necessary to ask what the comparison standard is. If the alternative to feeling present in the virtual environment is feeling present in the real environment, there is no reason *concerning the feeling alone* why one should be more positive than the other one. However, if the alternative to feeling present in the virtual environment is not feeling present in any environment, the affective consequences of feeling present are clearer. Feeling not present amounts to feeling disoriented, an inherently negative state (Kozlowski & Bryant, 1977; Lawton, 1994).

However, acknowledging the fact that presence might lead to affective consequences, we immediately have to ask ourselves: Can people who experience a virtual environment tell presence and affect apart? Or is it possible that they are confused, and that perhaps the fear in front of a virtual cliff, or the enjoyment of the content of an environment, are mistaken for presence? Within the current framework of feelings, this could be understood as a misattribution of affect onto presence. I would like to argue that we can expect users of virtual environments to be able to tell affect and spatial presence apart. The available literature suggests for both fear and enjoyment that simple correlations between these affects and spatial presence are low (e.g., Lin, Duh, Parker, Abi-Rached, & Furness, 2002; Regenbrecht, Schubert, & Friedmann, 1998). Importantly, the available methodology from studies on feelings, especially manipulations of misattribution with question orders, allows stringent tests of this hypothesis (Schwarz & Clore, 1983). Note further that the positive affect resulting from spatial presence is independent from, and will add to, affect resulting from the content of the environment (Winkielman et al., 2003).

Summary

In sum, the properties listed in the literature on cognitive feelings seem at the very least plausible properties of spatial presence. Research on the embodied understanding of

environments shows that coding environments in terms of affordances is a common process, and suggests that this cue might underlie the development of spatial presence.

Notes on augmented reality and social presence

The discussion so far focused on the feeling of spatial presence in an environment, but the presented approach can easily be extended to the experienced spatial presence of virtual objects rendered by augmented reality systems. The difference is one of quantity, not quality: It is not the whole environment in which I feel present, it is one virtual object that I feel is present. The unconscious spatial cognition processes are probably again those that check for potential interactions with the object. If the affordances of a virtual object activate potential actions, the feeling of spatial presence is fed back. The possibility of misattribution might be of special interest for augmented reality. It seems possible that some of the feeling of spatial presence of real objects is misattributed to virtual objects. This could be a reason why virtual objects in augmented reality displays often feel surprisingly "here."

Likewise, it seems possible to extend the current conceptualization to social presence. Such an extension would certainly have to focus on the difference between social presence in the sense of interacting with simulated others as if they are real social actors (Lee, 2004) and copresence in the sense of feeling one is together with others in the same space (Slater, Pertaub, & Steed, 1999). An extension to social copresence in a shared (virtual) space would be straightforward and be informed by the above-mentioned literature on imitation, mirror-neurons, and activation of motor areas through perception. However, this is beyond the scope of the current article.

Applying the new conceptualization: Implications and new hypotheses

Three aspects of the conceptualization of spatial presence as a cognitive feeling are particularly important. The three aspects concern the *what, why,* and *how* of spatial presence: First, understanding spatial presence as a feeling draws a distinction between spatial-cognitive processes underlying the sense of presence and the feeling of presence itself. This allows the investigation of their relation and also grounds and legitimizes the use of questionnaires and verbal report to measure presence. Second, the notion of spatial presence as feeling draws our attention to the functionality of presence. Finally, it provides a heuristic in the search for the multiple cues in the coding of an environment that lead to the feeling. These insights extend and qualify earlier propositions and also lead to new questions and hypotheses that have not been addressed in previous research. In the following, I will briefly outline theoretical implications and possible avenues for future research that are directly suggested by this perspective.

Spatial cognition, spatial presence, and questionnaires

From the beginning of research on presence, it has been debated whether questionnaires were only second best and inferior to "objective" measures (Held

& Durlach, 1992; Schloerb, 1995), or whether, in the words of Sheridan (1992), "subjective report is the essential basic measurement" to assess the phenomenon, precisely because "presence is a subjective sensation, . . . not so amenable to objective physiological definition and measurement" (p. 121). Over time, it seems, researchers came to agree in principle more with the first view while in practice accepting questionnaires because they are easier to apply, more versatile, and because the objective measures were actually not available yet. In sum, it seems that questionnaires have been distrusted but tolerated (Slater & Garau, 2007).

Based on the current proposal, I would like to argue that the view of questionnaires as inferior is based on a flawed assumption, namely, the assumption that verbal reports of the sense of spatial presence measure the same concept as objective measures of the cognitive, behavioral, or psychophysiological processes taken during or after the experiencing of a virtual environment. Instead, the current proposal suggests that the feeling of spatial presence is an outcome, but by no means identical to, the spatial-cognitive processes taking place during the experience. At the same time, the current proposal also shows that acknowledging the subjective nature of spatial presence does not make it less scientific, or less amenable to theoretical grounding, or less valuable. Instead, the current theory connects research on the feeling of spatial presence to other fields in psychology concerned with feelings and subjective experiences, and points toward sophisticated and rigorous theorizing about them.

Thus, the current proposal grounds and legitimizes the most important, yet distrusted method of presence research, the questionnaire. Ironically, precisely by acknowledging its subjective nature, presence scholars can make spatial presence more amenable to rigorous empirical research. In contrast, insisting on the need for objective measures of a subjective experience will only confuse the debate further.

I hasten to add, however, that this acceptance of subjective measurement cannot mean that measures of cognitive, behavioral, or psychophysiological phenomena are obsolete. On the contrary, because the current theory aims precisely at the relation between spatial cognition and subjective feeling, it is all the more important to assess them (Slater, 2004) instead of treating them as alternatives for measuring the same thing. Assessments of body sway in response to rotation of a virtual environment (Freeman et al., 2000; IJsselsteijn et al., 2001) or changes to the body image (Biocca & Rolland, 1998), for instance, are probably tapping directly into spatial constructive processes that serve as the source of the feeling of spatial presence. Studies of the relation of such behavioral and cognitive phenomena to the sense of spatial presence are very important for the current proposal, as are studies that test whether moderators of one phenomenon also affect the other one.

I would also like to add that in principle it is of course imaginable that an objective measure of the subjective sense of presence could be developed. Subjective experiences are states of the brain, and by observing the brain's functioning, we may one day be able to locate its development. There is nothing immaterial or mystical about subjective experiences. For the time, however, verbal report remains the best assessment method.

Finally, the comparison of questionnaires used to assess spatial presence and methods used to assess other feelings may provide new inspirations for presence questionnaires. For instance, the current state of the art favors multi-item scales applied once after the experience of a virtual environment. However, studies assessing the feeling of knowing (e.g., Koriat, 1993) often measure it repeatedly with only one item in within-subject designs that vary subtle aspects of the stimulus material. It seems promising to apply this methodology to spatial presence as well, especially because there are very good single items measuring general spatial presence available (Schubert et al., 2001).

Spatial presence is functional

Previous discussions of spatial presence have often been fascinated by the fact that it contradicts the artificiality of the virtual environment. In other words, spatial presence is so intriguing because it seems irrational. Thus, it has been understood as something that is wrong, essentially inadequate, or an illusion. As Lombard and Ditton (1997) discuss in their conceptualization of presence as the illusion of nonmediation, an intriguing aspect of this perspective is that users of a virtual environment can at the same time have the illusion (i.e., feel spatially present) and know it is an illusion (i.e., know that they are experiencing a simulation)—similar to optical illusions. Conceiving of spatial presence as a feeling helps to understand this phenomenon. Because feelings do not have a truth value and thus equal percepts, they can occur independently and in addition to consciously held propositional knowledge that what one perceives is in fact just a simulation. If someone would not only feel present, but also believe that he actually is in the mediated environment, he would not only suffer from an illusion, but also from a delusion (Gregory, 2003).

However, the new conceptualization changes the focus away from the apparent accusation of wrongness to a quite different aspect, namely, the *functional aspects* of spatial presence. If spatial presence is a feeling fed back to conscious thought from unconscious processes, there must be an adaptive advantage to it. Its presence, its absence, and perhaps also its intensity have a value for guiding thoughts and actions of an agent in an environment. Originally, this must have been a real environment (Riva, Waterworth, & Waterworth, 2004). If there is no feeling of spatial presence at all, but the agent has motives and goals that need to be fulfilled in an environment, an orientation reaction and exploration is required. If a strong feeling of spatial presence is available, satisfactory orientation is indicated. This perspective shows that spatial presence helps in the monitoring of one's relation to the environment. Orientation in the service of navigation is a capability that all moving creatures had to develop. Humans have developed the ability to cognize consciously about their own cognition, feeling, and behavior, all in the service of exerting additional control over it. It is thus just plausible that they also have developed an easy way to monitor consciously the workings of their lower-level orientation and way-finding machinery. Spatial presence is a way to do just that. If spatial presence is felt, one is assured that potential actions in the environment are identified, the information about potential

locomotion of the own body is secured, and action can be undertaken. If no spatial presence is felt, no action should be taken; instead, orientation is necessary first. In fact, weak feelings of spatial presence for the real environment may come from distraction by imagined other environments, signaling that spatial cognition is used for other purposes than orientation in the real environment. Thus, spatial presence has a function in monitoring and, ultimately, for behavior—in real and virtual environments.

Therefore, one research question derived from the new conceptualizations is: In which judgments and behaviors is the feeling of spatial presence used? Do people change their orientation behavior or goal-directed behavior depending on how present they feel in an environment? One interesting possibility is that attention and explorative behavior in a virtual environment are influenced by felt spatial presence. However, such effects will depend on goals active in the situation. If spatial presence is low, but motivation to do well in the task is high, people might actively strive for an understanding of the environment, and a high feeling. If spatial presence is already high, and motivation to further explore the environment is also high, people might also explore more, try to interact, and code even more elements of the environment in terms of motor responses. In sum, decisions based on spatial presence could influence further developments of it, just as decisions based on the feeling of knowing influence continuation versus termination of memory retrieval.[1] Riva et al. (2004) (see also Waterworth & Waterworth, 2001) proposed another judgment that may be based on experienced spatial presence, namely, the decision whether an environment is real or imagined. This idea would presuppose that imagined environments provide systematically lower spatial presence than real environments; otherwise, spatial presence would not be diagnostic. If we extend this idea to virtual environments, it would entail solid correlations of spatial presence and realness judgments, effects of spatial presence manipulations on realness judgments, and a mediation of those effects by spatial presence feelings. The empirical evidence on this topic is mixed. While spatial presence does correlate with realness judgments (Lessiter et al., 2001; Schubert et al., 2001), effects of spatial presence manipulations on judged realness are unstable (Regenbrecht & Schubert, 2002). Nevertheless, this idea certainly warrants further tests.

Closely connected to the function of spatial presence is the idea that it has an affective value. If spatial presence is functional for a part of human behavior and existence in environments, it is likely that spatial presence is affectively marked. Quite likely, we do not like not feeling present in the environment we are currently experiencing. Not feeling present might mean that we cannot act in this environment, that we cannot control it or be effective (White, 1959). Thus, a hypothesis resulting from the current conceptualization is that feeling present in a virtual environment, or any environment, will be marked positively. Sophisticated methodologies with subtle, unobtrusive measures of affect are available to test this idea (Reber et al., 2004; Winkielman et al., 2003).

Affordances determine spatial presence

Gibson's (1979) notion of affordances has been a very influential concept in previous treatments of spatial presence (Carassa, Morganti, & Tirassa, 2005; Mantovani & Riva, 1999; Zahorik & Jenison, 1998). Recent accounts of affordances have gone beyond Gibson's dismissal of the topic of mental representations (Glenberg, 1997), and started to investigate how bodily states, goal states, and features of the environment jointly lead to an embodied conceptualization based on activated motor representations (see review above). I would like to argue that the time is ripe to incorporate these experimental advances into the study of spatial presence. In more detail, the following two hypotheses can be directly deduced. First, manipulations that change the activation of motor representations during the perception of an environment (e.g., through manipulations of the body, or changes of the cognitive focus) should also affect the sense of spatial presence. Second, indices of activated motor representations (e.g., interference measures from reaction time paradigms) should predict the sense of spatial presence felt in an environment.

Summary of potential gains, new hypothesis, and further directions

The current new conceptualization of spatial presence theoretically grounds the use of questionnaires (and other verbal report methods) as assessments of spatial presence, distinguishes from and causally connects spatial presence to the underlying spatial cognitive processes, and orients research toward a functional view of it. The new view provides a host of new hypotheses, the most salient of which are that (a) low versus high levels of spatial presence are used as information and influence exploratory behavior and interaction in a virtual environment, (b) low levels of spatial presence have a negative valence, and (c) spatial cognitive processes that code possible interactions in an environment should provide the cues for spatial presence.

If the current view holds, and the proposed hypothesis receives evidence, research on spatial presence could profit from it because (a) its currently prominent research tool, the questionnaire, is legitimized, (b) because the questionnaire is freed from the burden of being validated by an objective measure, but at the same time theoretically linked to behavioral and cognitive phenomena, (c) because rigorous theorizing and methodology from research on other subjective experiences becomes applicable, (d) because the determinants of spatial presence can be searched not just in technological variables like screen size and update rate, but in spatial cognitive processes, for which the fast-growing field of embodied cognition provides elegant manipulations and measures, and (e) because spatial presence becomes not just the dependent variable on the left-hand side of an equation, but a predictor of cognition and behavior by looking at its functional value.

The research on embodied understanding of environments reviewed above suggested a remarkable similarity of processes in very different media, ranging from real environments to imagined ones. Research on virtual environments achieved the identification of spatial presence as a remarkable phenomenon that has importance for our understanding of human cognition and consciousness (Sanchez-Vives &

Slater, 2005). Given the parallels in cognitive processes, it now seems time to extend work on spatial presence beyond virtual environments, and to compare its determinants and outcomes across different kinds of environments. Spatial presence can be felt and measured in real environments as well (Heeter, 2003; Riva et al., 2004; Usoh, Catena, Arman, & Slater, 2000), and the same is certainly true of books and texts (Green & Brock, 2000; Towell & Towell, 1997) and even memories. The step to process theories of spatial presence should also be a step out of the virtual sandbox, and toward a more comprehensive analysis.

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Notes

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