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Turning Presence Inside-Out: MetaNarratives

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Abstract

Our work explores the potential in turning the concept of presence "inside-out." We theorize a relationship between current multidimensional conceptualizations of presence, theories which utilize predictive processing and comparative models to explain the underlying cognitive structure of presence, and evidence which suggests that past experience with both the content of media and the media providing the content are influential factors in overall felt presence. We propose a conceptualization of presence not as a unified "sense of being there", but rather as a "sense of feeling real" as the result of an automatic perceptual process. We consider an emergent metanarrative for presence, or lack thereof, as an alignment of external stimuli with an internal set of schemata. Lastly, we explore possible new research questions and discuss the implications of our proposed model for both the design of virtual experiences and the measurement of presence.

1 Surfacing the Narrative on Presence

Presence is a psychological construct, generally thought of as a "sense of being there," and is of particular interest in virtual immersive experiences. Here we explore the possibilities of turning the concept "inside-out" by placing different operational definitions, conceptualizations, and theories of presence in context with each other. Interrelating these perspectives opens the possibility for creating a theoretical framework to engage how presence arises and is sustained in potentially novel use cases generated by emerging consumer VR (and AR) technology. As envisioned by promissory narratives defining these technologies, use cases include ubiquity (immersion on-demand), mobility (immersion on-the-go), sensorial augmentation beyond that which is humanly possible (multi-scale real-time feedback between sensors, inputs, actuators and data driven content), blended/mixed-reality experiences of "being there" and "being here", and extended interactive experiences of unprecedented duration [1]. It also facilitates the emergence (and exploration) of a proposed model to address the role of individual experience with both the content of a medium and the medium itself as a basis for felt presence. We theorize this is enabled by a relationship between aspects of several multidimensional conceptualizations of presence (detailed below), context, and cognitive frameworks based in predictive processing that suggest prospective mental simulation unique to individuals.

1.1 Theories, and definitions

Tracing operational definitions of presence from Marvin Minsky's concept of telepresence -- describing the affordances of advanced teleoperation technology allowing operators to feel as if they were at the actual sight of operation [2] -- much of the subsequent research has focused on developing theoretical perspectives that articulate relationships between technologies and content, and the influence of these relationships on felt presence. Co-existing with the often used definition of presence as a "sense of being there" [3] are several operational definitions of presence: a "perceptual illusion of nonmediation," [4] a "sense of being in an environment," [5] a "psychological focus on perceptual processing" [6] and the "subjective veridicality of perceptual processing" [7] to name only a few. These theoretical and conceptual frameworks all use the same term, presence, but their implications are different. We use "presence" as an umbrella term referring to multiple theoretical/conceptual views simultaneously. The variety of definitions, theories, and measures of presence revolving around similar phenomena can result in issues of generalizability and cross-compatibility, some of which are described below. Our proposed model strives to address some of these issues. In contrast, we focus on individual human factors and the context of content to articulate presence. We propose an alternative definition for presence as a "sense of feeling real," supported by multidimensional frameworks described in Section 1.2.

Following on from Minsky's telepresence, Steuer [5] presents a theory of presence centered on the degree to which one achieves a "sense of being in an environment." This theory emphasizes how attributes of the technology (vividness and interactivity) interact with the individual's immediate situational factors and ongoing personal concerns, or "background" [8], to affect the human experience of telepresence.

Lombard & Ditton [4] present the "illusion of nonmediation," a way of integrating past theories of presence which share common characteristics. In this theoretical perspective, presence cannot occur unless a person is using a medium which provides content, and arises when the medium either becomes transparent to the sensation of the content or is transformed into a social entity. Furthermore, Lombard & Ditton propose the idea that presence is a transient experience which either does or does not occur, rather than occurring in degrees, and that the subjective feeling of non-binary degrees of presence is attributable to and proportional to the frequency of instances in which presence is felt. Though this conceptualization emphasizes the role of technological attributes which cause presence, two human factors are presented as mediators for felt presence: The willingness to suspend disbelief -- to actively suppress inconsistencies and signals that suggest the experience is mediated -- which can be reconceptualized into the mediating factor of personality variables on presence [9], and knowledge of or prior experience with the medium [2, 9]. Both of these factors are dependent on the content and context of the medium and may vary between individuals.

Attention also plays a major role in felt presence by filtering the stimuli processed, changing the nature of experience with content. The term "breaks in presence" has been used to describe momentary lapses in felt presence resulting from shifts in attention from a virtual environment to the physical [10,11]. These breaks do not occur when simultaneously attending to both the physical and virtual [13]. In contrast, Waterworth and Waterworth [6] explicate virtual experience by introducing the concept of absence (separate from "breaks in presence") as the antithesis of presence, wherein an individual is focused on conceptual processing and shifts resources away from the perceptual processing that antecedes feeling present. Waterworth and Waterworth also consider consciousness, or lack thereof, as a factor in the amount of perceptual or conceptual processing available, and introduce the locus of attention on either the virtual or the physical as a component of presence in virtual environments (rather than a strictly presence inhibiting component).

Place illusion (Pi) strictly refers to the "sense of being there" and is not associated with features that have subsequently been

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added to presence such as feelings related to the self or others, whereas Plausibility illusion (Psi) refers to the "illusion that the scenario being depicted is actually occurring" even if it is cognitively known that the events depicted are not occurring [14]. Within the larger context of presence as a sense of "feeling real," plausibility illusion can be simplified into "feeling believable." In this framework, Pi arises from the successful simulation of sensorimotor contingencies (SMC) -- mental models of the correspondence between self action and its associated sensory information [14,15]. Psi then comes from "correlations between external events not directly caused by the participant and his/her own sensations (both exteroceptive and interoceptive)" [14]. Pi and Psi are mechanistically different in this context, though as we describe in Section 1.4, their underlying mechanisms may be the same and it is simply the mental models pertaining to these constructs that makes them distinguishable. Our model as presented in section 2 below speculates Psi to be highly related to the notion of narrative presence, which describes a person's affective-cognitive relationship with the story being depicted [17]. The term "illusion" in the context of Pi, Psi, and "illusion of nonmediation" has been controversial as evidence suggests that presence is processed in the same way throughout both mediated and unmediated experiences, as described in Section 1.3.

The sampling of viewpoints in this section exists within a broader range of theoretical perspectives that address presence as a multidimensional construct (presented in the sections below) with potentially interrelated domains [2,4,17,18].

1.2 Domains of human experience: physical, social, self

The content of our environment is integral to our interpretation of the world and the subsequent amount of presence that is felt. Chaffee [20] categorizes human experience into three broad domains: the environmental, the social, and the self. Many theoretical perspectives have mirrored this categorization, splitting the domains of presence into similar trichotomies. This pattern of division seems to arise because we use vastly different mental models to judge our social, self, and physical environment. How we evaluate a person existing and being sentient is different from how we evaluate the non-sentient environment and ourselves existing within the environment. In response to this assumption, many theoretical perspectives split the domains of presence in a way which parallels the three types of human experience as proposed by Chaffee, recognizing the possibility that the phenomenology of presence may still be unified. Others have developed frameworks for presence that only pertain to one of the domains.

Heeter's [3] personal, social, and environmental feelings of presence are derived by a process of validation of the virtual self and the virtual world. These types of presence rely on the sensory channels presented by the virtual environment, action and feedback being adequately represented, and the perceptual richness of the environment (which would later be called immersive factors).

Biocca [5] theorizes that presence is split into three distinguishable domains: physical presence, social presence, and self presence. Presence under Biocca's theory is the result of simulation of the structure of experience, and mental models derived from past patterns of energy in the sensory organs. This mirrors the predictive processing account of presence described in Section 1.4. Physical presence is the feeling of being located in a space, and is transient because the location of focus (i.e on the physical, virtual, or imaginary) can shift from moment-to-moment. This relates to the focus and locus concept described by Waterworth & Waterworth [6]. Social presence is said to occur when one feels as though "the form, behavior, or sensory experience indicates the presence of another intelligence." Finally, self presence is the awareness of a self-identity inside a virtual environment based on one's body schema, body image, perceived traits, and physiological and emotional states. Each of these domains of presence opens the door for felt presence to be modulated by past experience as they are enabled by pre-formed mental models in the respective domain, with a comparative norm which is not stable. These domains are further developed by Lee's [18] explanation of the phenomenological aspect of presence as a "psychological state in which virtual objects are experienced as actual objects in either sensory or nonsensory ways," clarifying that during a virtual experience, the virtuality of the experience needs to go unnoticed to some extent in order for an individual to feel present. This perspective opens the theoretical bounds of presence, meaning that presence is not only based on a mental simulation of what is real (physical reality), but also what is unreal (mediated reality).

When these perspectives are taken into consideration within the context of each other, we observe that the definition of presence can be expanded from "a sense of being there" to a broader interpretation: a "sense of feeling real" as the result of mental simulation of reality and media. Frameworks described in Section 1.4 provide a mechanistic account to this interpretation, which we expand upon throughout Section 2, in which we present a contextually influenced predictive processing oriented model for establishment and maintenance of presence. Though this definition of presence as a "sense of feeling real" is semantically similar to what has been referred to as "reality judgment" [21], "reality testing" [21,22] and "doxastic veridicality" [24], evidence supports that these constructs are phenomenologically different and psychometrically distinguishable [21].

1.3 A mediated phenomena or a structure of consciousness?

Theories that envision presence as a psychological construct often suggest that it is a phenomenon limited to mediated experiences [2,3,4,24,25,26]. In contrast, others conclude that the dimension of presence is constantly experienced regardless of mediation, but contest that its nature may change in mediated environments [4,5,27,28,29,30]. Coelho et al. [32] categorized the difference as the "media presence" perspective versus the "inner presence" perspective, dependent on the amount of mediation necessary for the concept of presence to be applicable. Seth [7], presents a notion of presence as a "structural component of consciousness" in an effort to shed light on its nature and operations in addition to the workings of the mind.

At the heart of the media presence perspective is the notion that presence is either a sensory illusion [3,4,13] or a willful suspension of disbelief [32,33,34]. Lee [18] rejects the notion of "illusion" because of its negative connotation which implies that presence is, at least somewhat, undesirable. On the other hand, the notion of willful suspension of disbelief indicates that presence is a volitional activity. As described in Section 1.4, presence is predominantly an automatic perceptual process that can be aided by elements that increase engagement and emotional involvement. The "belief" indicated by a suspension of disbelief is more in line with the idea of reality judgment, or the cognitive judgment that an experience is real [21]. "Illusion" is an adequate descriptor in many cases, but is not applicable to all instances of presence. Yet, we acknowledge that many of the components of presence described by theories that use this definition are helpful to understanding the construct in a broader sense. Because of this, we do incorporate theories which use these definitions, such as Psi, into an inner presence perspective.

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Evolutionary perspectives seeking to understand presence and why it occurs lend themselves to the "inner presence" perspective. Relevant here is the distinction between subjective veridicality, or the experience of perceptual content as real, and doxastic veridicality, or the cognitive understanding that perceptual content is real [24]. According to Reeves and Nass [33], the ability to feel present while doxastic veridicality is absent -- or in other words, while we understand what we are experiencing is not real -- comes from the simple fact that throughout nearly the entire duration of the human evolutionary timeline, subjective veridicality and doxastic veridicality were one and the same. This resulted in the human capacity to respond to mediated or simulated perceptions as if they are real even though we cognitively know they are not real. Differentiating events that occur within the self from those that occur in the external world has also been postulated as a possible evolutionary role of presence, allowing us to form rich mental simulations in the mind while understanding that they are not real [19]. Presence also plays an essential role in survivability by informing us when the environment is unfamiliar and identifying the source of this unfamiliarity so that we can commit more cognitive resources and attention to new stimuli automatically [36,37,38,39,40].

1.4 Layered frameworks of presence

Distinguishing presence into different domains dependent on the content displayed is useful, as the mental models we use to judge these types of content should be very different. However, many theoretical frameworks which attempt to outline the underlying mechanisms enabling presence view the construct as generative of layered models and processes. The predictive processing account of presence, outlined in this section, allows for a reinterpretation of theories such as Pi and Psi. This would theoretically place Pi, which is generated by SMCs, hierarchically lower than Psi, which is determined by simulation of higher level models supported by SMCs. By reinterpreting theories with layered structures, we can provide an account for presence which is supported by a broader range of theoretical views.

The perspective that presence is an "intuitive perception of intentions in action" [41], and is used as a feedback mechanism for the current condition of action, has lent itself to a forward-inverse model of presence. In this model, intention is used to make a prediction of the state of an object after intention is enacted, and then that prediction is compared to the actual state of the object after action is taken [42]. Here, the difference between the intention and the perceived status of the object after action supports the idea of proto, core, and extended presence [19], [42]. These types of presence developed out of Damsio's [43] theory which separates self-consciousness into three categories: the proto self, which neurologically maps the physical state of the self; the core self, which is transiently generated from interaction between the self and the world; and the autobiographical self, which neurologically maps properties and traits learned about the self. Proto presence occurs via the process of differentiating the self from the non-self through motor action, and the comparison of perceived sensory information to that of an internal sensory representation [19,44] -- though these representations may be better explained by SMCs [15]. Core presence is established by differentiating the self from the external world using a comparison of a world-model to its own internal logic [45], wherein two functional states are possible -- one in which the core self is 'online,' synchronized to the external world and able to make predictions about it; and the other in which the core self is 'offline' and able to model realistic scenarios from memory, which theoretically occurs when dreaming or daydreaming [46]. Extended presence pertains to anticipations of the future, long-term goals and the tracking of their achievement, memory, learned abilities, and more, playing the role of "verify[ing] the significance of the experience for the self" [19]. As described by Riva et al. [47], the Dynamic Theory of Intentions [48] aligns with proto, core, and extended presence. M-intentions, or motor intentions, describe low-level, mostly unconscious maintenance of motor guidance, supporting proto-presence. P-intentions, or present-directed intentions, describe high-level conscious guidance and maintenance of motor activities, supporting core presence. D-intentions, or future-directed intentions, describe high-level intentions which act as intra- and inter-personal coordinators of means and plans, supporting extended presence. This model suggests that there is a direct relationship between intentions, the affordances of an environment [49,50], and the nature of felt presence. By extension, this means that the nature of presence changes as media advance to afford a wider range of actions within novel use cases.

The development of general theories of cognition and brain function, namely the perspective termed "predictive processing" which states that perception and cognition are a function of utilizing past and present information to predict future events [35, 36, 37, 50, 51, 52], has spurred theories which shed light onto the possible neural underpinnings of presence. This "free energy" framework differs from classical views that postulate perception as a "bottom-up" process in which detected features accumulate into a holistic perception of objects and scenes. Predictive processing views perception as the process of "top-down" predictive signals generated by hierarchical generative models (HGM) being modulated by "bottom-up" signals which result from errors in the prediction and are sent to higher levels of HGMs. Under this framework, perception and cognition are fundamentally designed to use information to make predictions of the future [51], and perception itself requires the autonomic creation of HGMs to predict sensory signals that could originate from objects, scenes, people, and so forth [54]. These HGMs relate perception, action, and cognition, with higher-level models grounded in lower-level models neurologically stored in the area pertaining to their modalities. Abstract and contextual information is derived from high-level HGMs; while concrete, granular information is simulated in lower-level HGMs [52,54,55]. An important aspect of predictive processing is the reduction of prediction error through both the modulation of HGMs that are the source of the error (perceptual inference and learning), and action to confirm sensory predictions concerning the object that is the source of the error (active inference).

Sjolie [40] presents a framework where HGMs stored in the neocortex form a subjective mental reality which is sustained by a constant simulation of the environment [36], and formed in part by interaction with and internalization of objects [57]. Presence, in this framework, arises out of a synchronization between a person's active subjective mental reality and the current perceived environment. When a prediction does not match an input, information is then sent to higher levels of HGMs, the effect of which depends on the extent of the difference between prediction and input. This framework stresses the importance of familiarity and its role in informing a synchronization between perceived stimuli and HGMs that are used to make sense of the environment. When unfamiliar content is perceived, it puts stress on the current context of the environment and requires more resources and attention. This leads to either a shifting of the subjective mental reality, or an loss of synchronization between the subjective mental reality and the external environment. This results in a lack of presence [40]. Under this theory, presence is the maintenance of sustaining familiarity

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with reality. Following this, reality can then be defined by a predictable environment [58]. What makes virtual reality so effective under this assumption is immersive virtual content's ability to present stimuli that is familiar to preformed models, and the human mind's ability to form and change models in response to new patterns of stimuli that are similar to those recognized by past models.

Another theory that explains presence through predictive processing is Seth's [6,23] Predictive Perception account of Sensorimotor Contingencies, which integrates sensorimotor theories of perception into the model of predictive perception. This model describes perceptual presence as the subjective veridicality of experience -- or the experience of objects as real. This mirrors many of the definitions of presence provided above, including the explicit distinction between doxastic veridicality and subjective veridicality [24], and parallels the distinction between presence and reality judgment [21]. The sensorimotor account of perception is the idea that perception is dependent on the mastery of sensorimotor contingencies (SMC), which are mental models we apply to objects to simulate the wider array of possible behaviors that those objects can display in response to action [14,15,49]. The integration of these two ideas has expanded the nature of the role of HGMs in predictive processing to include the concept of counterfactually-rich generative models (CRGM). Given a repertoire of possible action yet to be executed, CRGMs encode both the values and precisions of sensory signals likely to occur, and the likely causes of those sensory signals, organized in the same fashion as HGMs [24]. This integration more closely couples action with the nature of perception (and by extension presence), lending support to the notion that a "sense of being there" comes from the ability to "do there." This is in line with the notions of presence from Gamberini & Spagnolli [13] and is inherent in establishing proto, core, and extended presence [19]. However, this does not explain how the broader scope of presence, including social and self presence among others, occurs from a sensorimotor account of perception. This may be because these constructs either stem from different levels of HGMs, or have different dependencies that are CRGMs by definition but do not stem from sensorimotor contingencies.

2. Individual experience and a predictive theory of presence

Considering these mediating variables, multiple measures, definitions, and theories of presence within the context of each other, we make the following observation: *Neither the broad set of theoretical nor conceptual frameworks take into account the role of past experience and acquired knowledge of technologies or content, the domain of the content perceived and its role in predictive processes, nor the effect of context, despite the known effects of each of these on felt presence*. A theoretical model accounting for these aspects, (when tested thoroughly) would make possible the development of enhanced experimental designs for understanding the functional components of presence in the context of the impending wave of consumer VR technologies and novel use cases. These will likely change perceptions of the technology used in experimental designs by offering consumers the possibility of repeated exposure to immersive virtual environments.

2.1 Media and reality schemata: a proposal

A common feature amongst many of the theories we have described so far is that presence is an automatic perceptual process dependent on, and generated by, cognitive simulations produced by mental models. These models are described and have impact at various levels, such as the role of body schema in the formation of social presence [25], HGM [23,39,52] and CRGM [24]. We suggest that this complexity can be productively reduced by focusing on the characteristic features of mental models and their interaction with the mechanistic components of presence while remaining agnostic to any given theory or conceptualization. Therefore we propose the concept of reality schemata (RS), theorized as the mental models comprising subjective mental reality at all levels of specificity. While a simplification, this concept retains the features of prediction precision and precision weighting that are associated with predictive processing. In regards to presence, a RS prediction must align with an attended stimuli in order for presence to be supported. "Precision," in this framework, refers to the degree of alignment required. Precision weighting describes the effect that a prediction error has on inhibiting or supporting/maintaining presence.

As supported by "the media equation" [33], perceptions of the technology enabling presence in mediated experiences may have a lesser effect on the extent of presence felt relative to RS. Yet, our perceptions of media need to be accounted for in any model of presence, as they are a mediating variable [2,3,9]. To describe the effect of interaction with media changing over time, Ijsselsteijn [59] introduced the idea of media schemata (MS) or "knowledge representations of what media are, and are capable of." In our model we suggest that MS be integrated into the predictive processing framework of presence in instances where experience is at least partially mediated. Under this proposed theoretical framework, both mental models for a subjective mental reality (RS) and mental models pertaining to media (MS) contribute to overall presence. Evidence supports that MS play an inhibitory role in felt presence [2,3,9]. Applying the principles of predictive processing to media schemata provides that the precision of MS predictions is determined by past experience with, and knowledge of, the current medium. In generating felt presence, integration of the media equation within our model suggests that the precision weighting of such predictions is less than that of predictions made from RS [32]. A possible explanation as to why MS would have less weighting than RS is that throughout human evolutionary experience, what appeared to be real was in fact real [32].

2.2 Integration: A contextually influenced predictive processing model of presence

To address observations in sections 1 and 2 regarding emerging technologies, novel use cases and the role of individual experience in felt presence we propose an integrative and contextually influenced predictive processing model of presence supported by this broad range of theoretical and conceptual perspectives.

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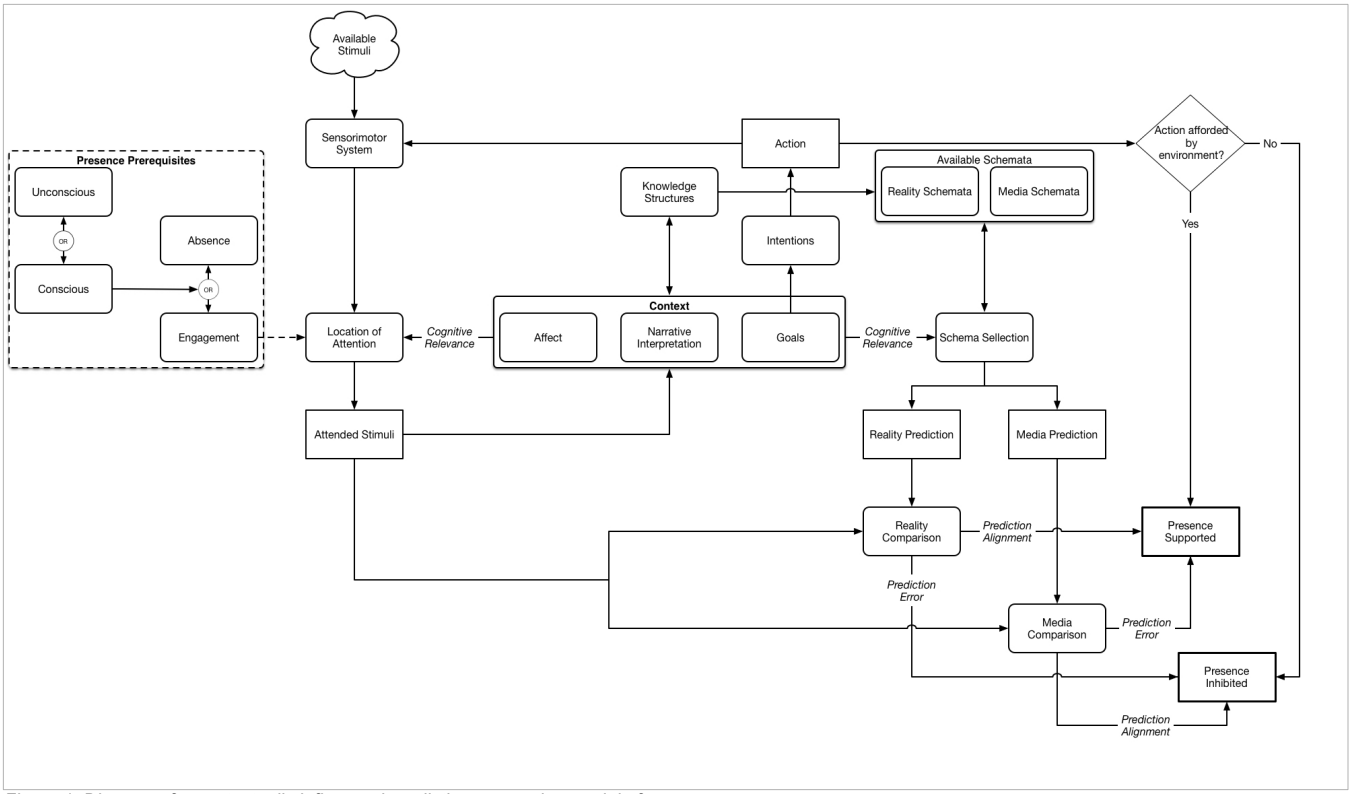

Figure 1: Diagram of a contextually influenced predictive processing model of presence

Figure 1 presents the integration of the above theories into a layered set of interrelationships within the theorized model. From left to right, we have separated the model diagram into 3 parts (as shown in Figures 2a, 2b, and 2c), in order to describe the interrelationships.

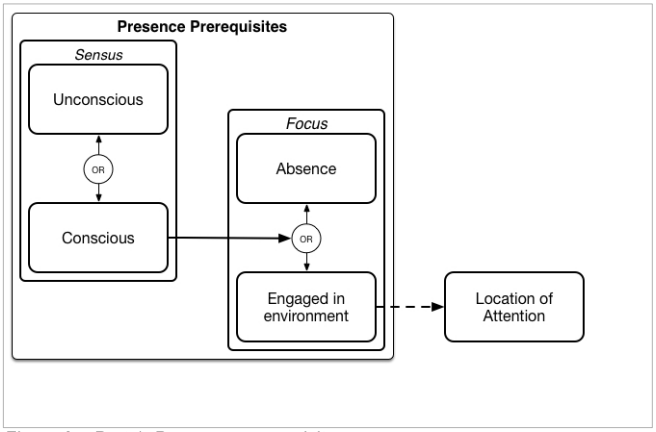

Figure 2a: Part 1, Presence prerequisites

Part 1 of our model, shown in Figure 2a, represents the relationships in Waterworth & Waterworth's [6] theories which maintain that for presence of any type to occur -- by virtue of presence being a perceptual product -- an individual must be both conscious and psychologically involved in the environment. When an individual is focused on conceptual processing and not focused on the environment, the perceptual stream of sensory information is reduced, decreasing the likelihood that the individual may feel presence. These prerequisites must be maintained for an individual to feel present within the environment; however, meeting these prerequisites does not ensure presence is felt.

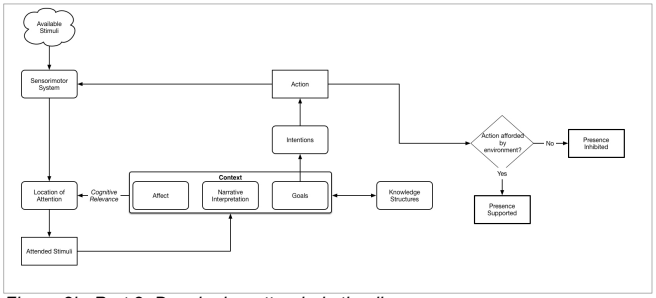

Figure 2b: Part 2, Developing attended stimuli

Part 2 of the model, shown in Figure 2b, shows the relationships between attention, context, cognitive relevance, intention, and action. The layers that comprise context (narrative, affect, and goals) influence both cognitive relevance and intention (via goals). The relationship between context and the location of attention is supported by cognitive relevance theory, which suggests that objects are prioritized for attention based on an interaction between cognitive knowledge structures and current task goals [59]. This relationship is further supported by evidence which shows that hierarchical models (i.e. knowledge structures) inform attention

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prioritization [60]. The layered structure from goal, to intention, to action is supported by Riva et al.'s [42] forward-inverse model of presence. Under this model, interaction between the environment and the autobiographical self percolates into layers of intentions and actions. Of particular interest for experiences within virtual environments is the self's interpretation of narrative. This situationally informs what actions are appropriate [16,60] -- and possible through sensorimotor contingencies (SMCs) -- when the autobiographical self is not as established. This partial detachment from autobiographical self occurs because we take on the characteristics of agents we are embodied within [62]. An individual's intended actions must then be afforded by the environment in order for presence to be supported [48,49]. The principle of "free energy" for predictive processing of attention suggests that the stimuli that do not align with cognitive knowledge structures are avoided due to their production of uncertainty, as uncertainty is naturally avoided [39,62]. When action is not afforded by the environment, presence is inhibited in varying degrees dependent on the level of intention that is not supported by the environment [47].

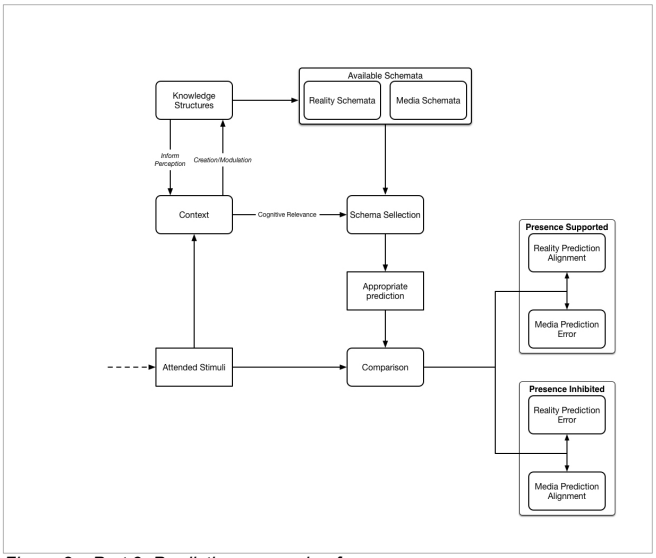

Figure 2c: Part 3, Predictive processing for presence

Part 3 of the model, shown in Figure 2c, illustrates the roles of predictive processing, reality schemata, and media schemata. Attended stimuli update the current context, which is informed by cognitive knowledge structures. When information does not fit knowledge structures available in memory, knowledge structures are either modulated, or new knowledge structures are created in order to inform and understand the current stream of sensory stimuli [37,52,62]. The model proposes that the selection of RS or MS in their utilization for prediction formation is based on the same cognitive relevance used to prioritize objects for attention. This is supported by evidence that affect [48,63], narrative [13,16] and goals [47] mediate felt presence. In other words, context informs which RS and MS are appropriate in the formation of predictions for both attention and presence. In this model, the observation that affect increases memory for goal-relevant stimuli [65] indicates that presence may also be enhanced by affect and goals coinciding, resulting in the formation of more precise RS (as well as knowledge structures) by encouraging their proliferation. This proliferation may be enhanced if affect and goals become cohesive in narrative.

As previously described, presence is supported when attended stimuli and reality predictions align or when media prediction errors occur, and inhibited when reality prediction errors occur or when attended stimuli and media predictions align. The difference in precision weighing between media errors and alignments is represented in our model through the deliberate placement of reality prediction outcomes above media prediction outcomes.

This integrative model proposes presence as the psycho-neurological process of maintaining a "sense of feeling real." This occurs when RS predictions align with the stream of attended stimuli, outweighing RS prediction error and MS prediction alignments. This process of prediction alignment takes place within a larger system of relations that includes the intention-to-action loop, contextual factors which influence the selection of RS and MS predictions, psychological prerequisites for presence to occur, attention, and cognitive relevance. The synchronization of subjective mental reality with the external environment is a result of the overall addition of prediction alignments and prediction errors (including their precision weighting) [40]. This process is constantly altered by action, attention, and context. All attended stimuli that flow through the system either reinforce or inhibit the constant establishment of presence, as a "sense of feeling real." In summary, individual differences in the formation of RS and MS and the interpretation of context lead to the possibility that individuals may experience varying degrees of presence even when exposed to the same content.

3 Discussion

In this model we have proposed a contextually influenced predictive process that results in felt presence. Through being centered on a "sense of feeling real" it offers a mechanistic relational framework for phenomenological experience and can be applied to many different theoretical and conceptual perspectives of presence. It incorporates factors which have largely been ignored in previous conceptual and theoretical frameworks by proposing how mediating variables can be integrated into a model of presence. We also highlight the importance of experience with, and knowledge of, media and its content by proposing the Reality Schemata construct, and articulating its relationships to Media Schemata. We suggest that incorporating RS and MS within a single model is relevant for addressing the changes in users' formations of MS for VR and AR technologies that were mostly novel to participants in previous research designs, but which will cease to be novel with the advent of ubiquitous consumer VR/AR, as well as a broad range of new use cases for these technologies.

The model also presents the potential value of including measurement of past experience with content and media within experimental designs that research presence. This also has implications for the design of virtual experiences. The model advocates for the importance of the target demographics' (or experimental groups') past experience with both the content of the experience and the technology enabling it. This translates to a need for understanding the media user's extent of exposure to the content, if user presence is a design goal. Future research would be required to determine the extent to which virtual environments for simulations need to be more exact in their representation of content for demographics that have had more experience with the simulated content. Or, if in the case of demographics that have had less exposure to the content more abstractions can be used in the content's representation. An additional question is if abstract

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interaction paradigms in line with the affordances of the environment can be presented, without negatively affecting presence in either case. Beyond this, the target demographic's previous experience with the enabling technology must be considered. For demographics that have more experience with a medium, either the medium needs to be plausibly integrated into the experience, or attentional cues must be implemented to pull attention away from stimuli that reveals the mediation of experience. An approach to this can be to provide an affective narrative that encourages the formation of goals which require action, that are in turn afforded by the virtual environment in order to be achieved.

Our future work includes empirical research to validate the proposed model. One task is to disambiguate how context directly influences felt presence mechanistically. Another is investigating the possibility that context drives attention, and does not directly inform the selection of RS and MS but instead primes them for prediction formation. Within the proposed model the effect of context in the precision and precision weighting for predictions in RS and MS is ambiguous. RS and MS could be selected based on the nature of the schemata alone independent of their associated precisions and precision weightings, or the precisions and precision weightings of selected schemata could be influenced by context. Future work will be required to provide the empirical evidence to reveal the detailed nature of this interaction. Not included in our model is an explanation of how attended stimuli and context can require a person to be absent due to goals that require conceptual processing and planning before action is enacted. Waterworth & Waterworth [6] provide an adequate description of how this process occurs. Additionally, the model currently does not offer an explanation as to how individuals may differ in the formation and modulation of RS and MS to fit novel environments, it only articulates how they interrelate within regulating presence.

We offer this contextually influenced predictive processing model of presence in hope of engaging the broader community developing technologies and content for virtual, augmented and mixed reality experiences in a dialogue on implementing designs that take in to account the value of individual differences in experience.

References

[1] R. West, M. J. Parola, A. R. Jaycen, and C. P. Lueg, "Embodied information behavior, mixed reality and big data," 2015, p. 93920E.

[2] M. Minsky, "Telepresence," 1980.

[3] C. Heeter, "Being There: The Subjective Experience of Presence," *Presence Teleoperators Virtual Environ.*, 1992.

[4] M. Lombard and T. Ditton, "At the Heart of It All: The Concept of Presence," *J. Comput.-Mediat. Commun.*, vol. 3, no. 2, pp. 0–0, 1997.

[5] J. Steuer, F. Biocca, M. R. Levy, and others, "Defining virtual reality: Dimensions determining telepresence," *Commun. Age Virtual Real.*, pp. 33–56, 1995.

[6] E. L. Waterworth and J. A. Waterworth, "Focus, locus, and sensus: The three dimensions of virtual experience," *Cyberpsychol. Behav.*, vol. 4, no. 2, pp. 203–213, 2001.

[7] A. K. Seth, K. Suzuki, and H. D. Critchley, "An Interoceptive Predictive Coding Model of Conscious Presence," *Front. Psychol.*, vol. 2, 2012.

[8] T. Winograd and F. Flores, *Understanding computers and cognition: A new foundation for design*. Intellect Books, 1986.

[9] S. E. Kober and C. Neuper, "Personality and Presence in Virtual Reality: Does Their Relationship Depend on the Used Presence Measure?," *Int. J. Hum.-Comput. Interact.*, vol. 29, no. 1, pp. 13–25, Jan. 2013.

[10] R. Held and N. Durlach, "Telepresence, time delay and adaptation," *Pict. Commun. Virtual Real Environ.*, pp. 232–246, 1991.

[11] M. Slater and A. Steed, "A Virtual Presence Counter," *Presence*, vol. 9, no. 5, pp. 413–434, Oct. 2000.

[12] A. Brogni, M. Slater, and A. Steed, "More breaks less presence," in *Presence 2003: The 6th Annual International Workshop on Presence*, 2003.

[13] L. Gamberini and A. Spagnolli, "An Action-Based Approach to Presence: Foundations and Methods," in *Immersed in Media*, M. Lombard, F. Biocca, J. Freeman, W. IJsselsteijn, and R. J. Schaevitz, Eds. Cham: Springer International Publishing, 2015, pp. 101–114.

[14] M. Slater, "Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments," *Philos. Trans. R. Soc. B Biol. Sci.*, vol. 364, no. 1535, pp. 3549–3557, Dec. 2009.

[15] J. K. O'Regan and A. Noë, "A sensorimotor account of vision and visual consciousness," *Behav. Brain Sci.*, vol. 24, no. 05, pp. 939–973, 2001.

[16] J. K. O'Regan and others, "What it is like to see: A sensorimotor theory of perceptual experience," *Synthese*, vol. 129, no. 1, pp. 79–103, 2001.

[17] J. P. Rowe, S. W. McQuiggan, and J. C. Lester, "Narrative presence in intelligent learning environments," in *Working notes of the 2007 AAAI fall symposium on intelligent narrative technologies*, 2007, pp. 126–133.

[18] K. M. Lee, "Presence, Explicated," *Commun. Theory*, vol. 14, no. 1, pp. 27–50, Feb. 2004.

[19] G. Riva and J. A. Waterworth, "Presence and the Self: A cognitive neuroscience approach," *Presence Connect*, vol. 3, no. 3, 2003.

[20] S. H. Chaffee, *Communication Concepts*. SAGE Publications, 1991.

[21] R. M. Baños, C. Botella, A. Garcia-Palacios, H. Villa, C. Perpiñá, and M. Alcañiz, "Presence and reality judgment in virtual environments: A unitary construct?," *Cyberpsychol. Behav.*, vol. 3, no. 3, pp. 327–335, 2000.

[22] J. Lichtenberg, "The testing of reality from the standpoint of the body self."

[23] H. J. Irwin, "Reality testing and the formation of paranormal beliefs: A constructive replication," *J.-Soc. Psych. Res.*, vol. 68, pp. 143–152, 2004.

[24] A. K. Seth, "A predictive processing theory of sensorimotor contingencies: Explaining the puzzle of perceptual presence and its absence in synesthesia," *Cogn. Neurosci.*, vol. 5, no. 2, pp. 97–118, Apr. 2014.

[25] F. Biocca, "The Cyborg's Dilemma: Progressive Embodiment in Virtual Environments [1]," *J. Comput.-Mediat. Commun.*, vol. 3, no. 2, pp. 0–0, Sep. 1997.

[26] M. Slater, "A note on presence terminology," *Presence Connect*, vol. 3, no. 3, pp. 1–5, 2003.

DOI: 10.2352/ISSN.2470-1173.2016.4.ERVR-418

[27] M. Slater, B. Lotto, M. M. Arnold, and M. V. Sánchez-Vives, "How we experience immersive virtual environments: the concept of presence and its measurement," *Anu. Psicol. 2009 Vol 40 P 193-210*, 2009.

[28] J. Loomis, "Distal Attribution and Presence," *Presence Teleoperators Virtual Environ.*, vol. 1, no. 1, 1992.

[29] P. Zahorik and R. L. Jenison, "Presence as being-in-the-world," *Presence*, vol. 7, no. 1, pp. 78–89, 1998.

[30] M. J. Schuemie, P. Van Der Straaten, M. Krijn, and C. A. Van Der Mast, "Research on presence in virtual reality: A survey," *Cyberpsychol. Behav.*, vol. 4, no. 2, pp. 183–201, 2001.

[31] J. V. Draper, D. B. Kaber, and J. M. Usher, "Speculations on the value of telepresence," *Cyberpsychol. Behav.*, vol. 2, no. 4, pp. 349–362, 1999.

[32] C. Coelho, J. G. Tichon, T. J. Hine, G. M. Wallis, and G. Riva, "Media presence and inner presence: the sense of presence in virtual reality technologies," *Commun. Presence Cogn. Emot. Cult. Ultim. Commun. Exp.*, pp. 25–45, 2006.

[33] B. Reeves and C. Nass, *How people treat computers, television, and new media like real people and places*. CSLI Publications and Cambridge university press, 1996.

[34] N. N. Holland, "The willing suspension of disbelief: A neuro-psychoanalytic view.," *PsyART*, 2003.

[35] B. Laurel, *Computers as theatre*. Addison-Wesley, 2013.

[36] K. Friston, "The free-energy principle: a unified brain theory?," *Nat. Rev. Neurosci.*, vol. 11, no. 2, p. 127+, Feb. 2010.

[37] K. J. Friston and K. E. Stephan, "Free-energy and the brain," *Synthese*, vol. 159, no. 3, pp. 417–458, 2007.

[38] G. Hesselmann, S. Sadaghiani, K. J. Friston, and A. Kleinschmidt, "Predictive coding or evidence accumulation? False inference and neuronal fluctuations," 2010.

[39] K. M. Lee, "Why presence occurs: Evolutionary psychology, media equation, and presence," *Presence Teleoperators Virtual Environ.*, vol. 13, no. 4, pp. 494–505, 2004.

[40] D. Sjölie, "Presence and general principles of brain function," *Interact. Comput.*, vol. 24, no. 4, pp. 193–202, Jul. 2012.

[41] D. Kahneman, "Maps of bounded rationality: A perspective on intuitive judgment and choice," *Nobel Prize Lect.*, vol. 8, pp. 351–401, 2002.

[42] G. Riva, F. Mantovani, E. L. Waterworth, and J. A. Waterworth, "Intention, action, self and other: An evolutionary model of presence," in *Immersed in Media*, Springer, 2015, pp. 73–99.

[43] A. Damasio and R. J. Dolan, "The feeling of what happens," *Nature*, vol. 401, no. 6756, pp. 847–847, 1999.

[44] R. R. Llinás, *I of the vortex: From neurons to self*. MIT press, 2002.

[45] R. L. Gregory, *Eye and Brain: The Psychology of Seeing: The Psychology of Seeing*. Princeton university press, 2015.

[46] I. Farber, *The world within the skull*. Nature Publishing Group, 2001.

[47] G. Riva, J. A. Waterworth, E. L. Waterworth, and F. Mantovani, "From intention to action: The role of presence," *New Ideas Psychol.*, vol. 29, no. 1, pp. 24–37, Jan. 2011.

[48] A. N. Leont′ev, *Problems of the development of the mind*. Moscow: Progress, 1981.

[49] P. Turner, "Affect, Availability and Presence," in *Immersed in Media*, M. Lombard, F. Biocca, J. Freeman, W. IJsselsteijn, and R. J. Schaevitz, Eds. Cham: Springer International Publishing, 2015, pp. 59–71.

[50] J. Grèzes and J. Decety, "Does visual perception of object afford action? Evidence from a neuroimaging study," *Neuropsychologia*, vol. 40, no. 2, pp. 212–222, 2002.

[51] D. L. Schacter, D. R. Addis, and R. L. Buckner, "Remembering the past to imagine the future: the prospective brain," *Nat. Rev. Neurosci.*, vol. 8, no. 9, pp. 657–661, 2007.

[52] M. Bar, "The proactive brain: using analogies and associations to generate predictions," *Trends Cogn. Sci.*, vol. 11, no. 7, pp. 280–289, 2007.

[53] K. Friston, "Hierarchical Models in the Brain," *PLoS Comput. Biol.*, vol. 4, no. 11, Nov. 2008.

[54] G. E. Hinton, "To recognize shapes, first learn to generate images," *Prog. Brain Res.*, vol. 165, pp. 535–547, 2007.

[55] L. W. Barsalou, "Grounded Cognition," *Annu. Rev. Psychol.*, vol. 59, no. 1, pp. 617–645, 2008.

[56] A. Postma and L. W. Barsalou, "Spatial working memory and imagery: From eye movements to grounded cognition," *Acta Psychol. (Amst.)*, vol. 132, no. 2, pp. 103–105, Oct. 2009.

[57] V. Kaptelinin and B. A. Nardi, *Acting with technology: Activity theory and interaction design*. Mit Press, 2006.

[58] J. Hawkins and S. Blakeslee, *On Intelligence*, Reprint edition. New York: St. Martin's Griffin, 2005.

[59] W. A. IJsselsteijn, "Presence in the past: what can we learn from media history?," *There Concepts Eff. Meas. User Presence Synth. Environ. G Riva F Davide WA IJsselsteijn*, vol. 5, p. 17, 2003.

[60] D. B. Walther and C. Koch, "Attention in hierarchical models of object recognition," *Prog. Brain Res.*, vol. 165, pp. 57–78, 2007.

[61] A. Gorini, C. S. Capideville, G. De Leo, F. Mantovani, and G. Riva, "The Role of Immersion and Narrative in Mediated Presence: The Virtual Hospital Experience," *Cyberpsychology Behav. Soc. Netw.*, vol. 14, no. 3, pp. 99–105, Mar. 2011.

[62] N. Yee and J. Bailenson, "The Proteus Effect: The Effect of Transformed Self-Representation on Behavior," *Hum. Commun. Res.*, vol. 33, no. 3, pp. 271–290, Jul. 2007.

[63] H. Feldman and K. J. Friston, "Attention, Uncertainty, and Free-Energy," *Front. Hum. Neurosci.*, vol. 4, 2010.

[64] G. Riva, F. Mantovani, C. S. Capideville, A. Preziosa, F. Morganti, D. Villani, A. Gaggioli, C. Botella, and M. Alcañiz, "Affective Interactions Using Virtual Reality: The Link between Presence and Emotions," *Cyberpsychol. Behav.*, vol. 10, no. 1, pp. 45–56, Feb. 2007.

[65] L. J. Levine and R. S. Edelstein, "Emotion and memory narrowing: A review and goal-relevance approach," *Cogn. Emot.*, vol. 23, no. 5, pp. 833–875, Aug. 2009.

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