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A Cognitive-Heuristics Approach to Understanding Presence in Virtual Environments

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Abstract

A strange paradox surrounds the role played by technology in inducing presence. The more sophisticated the technology, the greater the presence, which means greater invisibility of the technology. While we know that advancements in media technology, from larger screens to more interactivity, can enhance the sense of presence, the theoretical mechanisms by which this occurs are yet to be specified. We address this shortcoming by proposing that user interpretation of technology critically mediates the relationship between technological factors and a sense of presence. In particular, we adapt the MAIN model [1] to propose that technological affordances transmit cues that trigger cognitive heuristics leading to perceptions of presence. This paper identifies and describes a sample of heuristics triggered by modality, agency, interactivity, and navigability. Applications to 3D environments exemplify this approach by identifying specific cues and demonstrating the operation of the proposed heuristics en route to generating presence.

Keywords--- **Cues, Heuristics, Affordances, MAIN Model, Modality, Agency, Interactivity, Navigability, Presence, Being There, Social Presence, Telepresence**

1. Introduction

Over a decade of research on the psychological construct of presence has revealed that various media characteristics, ranging from screen size to audio fidelity, serve to influence the "perceptual illusion of non-mediation" [2]. For example, studies have shown that the feeling of presence is greater for larger screen sizes [3, 4], surround sound audio [2], and more interactive features [5].

Several concept explications have identified different types of presence experienced by users of media, games, and virtual reality devices. Studies have shown that factors like the number of sensory outputs in a mediated conversation [6], avatar behaviors [7] and haptic feedback [8] can increase social presence. Meanwhile, spatial or physical presence, or a sense of "being in the virtual place" [9], is affected by a medium's vividness or realism [10] determined by such features as screen size [11] and image quality [3]. The term "presence" is often used interchangeably with "telepresence," though telepresence, or sometimes physical presence, more specifically identifies a sense of being "at the remote site of operation" [12] while the more general "presence" has many sub-concepts such as social presence, co-presence, self presence, and others. In this paper, we adopt the more general term *presence* to indicate a general sense of non-mediation while telepresence will refer more specifically to a sense of being in the medium and social presence to existing with another being in the medium.

Clearly, presence is a multifaceted concept that is influenced by a variety of media and user characteristics. Once induced, presence can be quite useful in simulations pertaining to training, distance learning, decision-making, and enjoyment arising from suspension of disbelief [2]. As new virtual environments develop and become more pervasive in everyday life, the scope of applications for presence will only get larger.

However, it is not entirely clear how attributes of the medium induce presence. At its heart, a feeling of presence involves a psychological tendency to overlook mediation by technology [2]. That is, the environment must either become transparent or must be transformed into something other than a medium so that the person fails to perceive the medium, resulting in presence. Thus, presence is a personal experience, but ultimately a function of the mediated environment in which the person is "there." In either case, presence is dependent on the sophistication of the medium, as indicated by the degree to which it is invisible, i.e., the degree to which technological attributes facilitate users' direct interactions with content and involvement in the environment created by the technology.

Beyond this notion of technological sophistication contributing to the medium's invisibility (i.e., illusory perception of realism of content or environment), precious little is known about the theoretical mechanisms underlying the effect of technological attributes upon a psychological feeling of presence. In 1997, Lombard stated that "we know relatively little about the characteristics of a medium's form and content and the characteristics of medium users that encourage a sense of presence." Various efforts of the explication of presence continue [13, 15] though only little progress has been made in the decade since Lombard's statement on the theoretical underpinnings for its cause. Earlier theories such as social presence [6] and media richness [16] have often been invoked by presence researchers to refer to a medium's approximation

of face-to-face communication, but they stop short of specifying the mechanisms by which medium characteristics affect presence.

Witmer and Singer [17] come close to a theoretical framework in their understanding of presence in virtual environments (VE) as a balance between our physical location and our mental location. "How sharply users focus their attention on the VE partially determines the extent to which they will become involved in that environment and how much presence they will report" (p. 226). For them, presence is a combination of both immersion and involvement, thus the VE must foster these cognitive necessities. Exactly how a given technology can promote involvement, focus, and other such antecedents of presence is yet to be specified.

More recently, the Capacity Limited Cognitive Constructionist (CLCC) model of presence by Nunez [18] links presence to cognitive information processing, and demonstrates that various stages of presence (from spatial presence to true engagement) make differential use of working memory. For Nunez presence is largely a psychological construct; feelings of presence include information in the environment but are dependent on our depth of processing that information.

In the ongoing debate about *where* presence lies, the pendulum appears to have swung more toward user characteristics, even though some of the earliest work [6] tended to treat presence as a function of the medium, characterized in such global terms as warm/cold and personal/impersonal. In recent work, the focus has largely been on the state of mind engendered by presence [14]. While psychological aspects of presence have been addressed in extant research, which particular aspects of the technology trigger such a state of mind and how they do it are still largely missing from the discourse.

To address this shortcoming, we propose a theoretical framework based on cognitive heuristics for digital information processing. This framework involves three key concepts, namely affordances, cues, and heuristics. We define *affordances* as capabilities offered by the medium to facilitate a potential action [21]. *Heuristics* are mental shortcuts or judgment rules for making quick inferences. *Cues* are design features of technologies that highlight the underlying affordances and serve as triggers for heuristics.

We start with affordances present in media technology, pertaining to such aspects as modality, agency, interactivity, and navigability, and posit that these affordances contain cues which trigger heuristics (or mental shortcuts) in users about the experience, leading to a sense of presence (see Figure 1). Given that most presence research relies on self-report assessments, the role played by cognitive heuristics is particularly applicable because of the subjectivity of sense-making in a technologically mediated interaction.

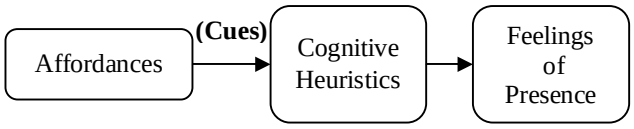

Figure 1 Cognitive heuristics triggered by cues from affordances lead to presence

The rest of the paper is organized as follows: In Section 2, we provide a background of and motivation for cognitive heuristics relevant to presence in virtual environments. Section 3 discusses the role of heuristic processing in cognition and decision-making. In Section 4, we discuss growing use of technological and interface cues in the digital medium. The MAIN model is presented in Section 5 along with definitions of terms used in this research. Finally, in Section 6, we suggest an empirical application of the theoretical advancements described in this paper in the domain of 3-D internet products and make some observations about the potential implications of this research.

2. Background

Digital media technologies have resulted in an exponential growth in information available in any given context, resulting in an overload problem with its attendant inefficiencies. It is well known that during the process of making sense of all this information, people utilize cognitive heuristics to make quick decisions about the credibility, utility, and quality of information, making them vulnerable to misjudgments if they do not systematically evaluate the underlying information [20].

The work proposed here goes beyond source and content cues to investigate cognitive heuristics triggered by four technological features that are common to all digital media: Modality, Agency, Interactivity, and Navigability (MAIN). Based on research evidence that suggests today's digital media users pay as much if not more attention to these technological aspects compared to source and content aspects, the MAIN model [1] explores ways in which modality, agency, interactivity, and navigability shape our perceptions during digital media use. These features are conceptualized as "affordances" [21] (or action possibilities) which, in media technology, inform the user how to use the particular feature [19]. These affordances suggest certain functions and/or transmit certain cues that trigger cognitive heuristics (or mental shortcuts) leading people to their impressions of the quality and credibility of the underlying information.

Thus far, the MAIN model has focused on judgments of credibility as its primary outcome, but other important cognitive aspects of the heuristics triggered by media technologies are in need of assessment. With richer digital environments and virtual worlds, presence and immersion have become cognitively consequential for our media experiences and therefore deserve greater understanding.

Thus, the current research explores the possible presence-related heuristics cued by the affordances embedded in these environments. That is, what affordances are present in interactive 3D spaces and how do they cue feelings of presence and immersion? By approaching such a question in terms of cues and heuristics, we gain a new way of understanding how presence is achieved and experienced in mediated environments.

3. Heuristic processing

Decades of research in social cognition has shown that information receivers will not effortfully assess the quality of information [20], in part because the aforementioned overload problem precludes any systematic efforts to exhaustively sample incoming information. They will instead resort to cognitive heuristics or mental shortcuts that yield quick evaluations of source credibility and quality of incoming information [22, 23]. These heuristics are said to be triggered by cues embedded in the message context [24]. For example, a long message will carry with it the length cue, which, by triggering the "length-equals-strength" heuristic, will lead users to conclude that since the incoming message is long, it must be a strong one. This is an evaluation made based on heuristics triggered by the structure rather than the content of the message. Likewise, a message attributed to an expert source will be deemed reliable and believable, not because the message itself has strong, internally consistent arguments, but because it was attributed to an influential source, the heuristic being: if it came from an expert, then it must be true. Message length and expert source are examples of cues that trigger heuristics pertaining to quality and credibility of underlying information. Heuristics are judgments rules (e.g., length equals strength; expert sources must be trusted) that aid quick decision-making with regard to information assessment and utility for the task at hand. Social psychologists have long demonstrated that human beings are innately miserly with their cognitive resources and will expend only as much of it as is minimally necessary and sufficient for drawing conclusions about the veridicality of incoming information [20]. This explains the heavy reliance on cues and heuristics in human information processing.

3.1. Dual Process Models

A general class of theories called Dual Process Models [22, 24, 25] predict that conclusions drawn by information processing based on cues and heuristics are qualitatively different from those drawn by effortfully engaging the central content of the information. The Heuristic-Systematic Model (HSM) [22], makes a clear distinction between "systematic processing" referring to a detailed analytical consideration of judgment-relevant information, and "heuristic processing" relying on mental shortcuts to judgmental rules (or "heuristics") that are already stored in memory—heuristics such as length equals strength and experts' statements can be trusted.

So, what predicts the use of heuristics such as the expertise heuristic? Researchers [27] have identified three criteria: First of all, the cue (e.g., American Red Cross as information provider making a mass appeal for blood donations) has to be cognitively available at the time of making a decision about the credibility of the content. Second, the heuristic or judgment rule (e.g., expertise implies accuracy) should be accessible (if it is a rule that is used often to judge content, then it is likely to be more easily accessed by our brain) at the time of decision-making. Third, the heuristic should be applicable or relevant to the situation at hand (i.e., judging the reputation of Red Cross is an important aspect of assessing the credibility of the shortage in blood supply).

A heuristic thus invoked can either directly lead to a snap judgment as in heuristic processing (e.g., we have an acute need for blood) or serve to frame, bias, or otherwise guide more systematic processing of content (e.g., experts such as Red Cross are making mass appeals for blood, so it must mean there is a severe shortage of blood).

It is important to note that the use of heuristics does not automatically mean heuristic processing. Heuristics are, after all, evolved generalizations stored in one's knowledge base that often get refined with experience. So, they can certainly be very helpful as analytical tools while processing systematically as well. If the perceiver is willfully applying the heuristic to arrive at a conclusion (as in the example above of estimating blood shortage), then the processing is said to be conscious or controlled [26]. More often, the perceiver is unaware of the operation of the heuristic and, thus, its role in influencing judgment, in which case the process is said to be unconscious or automatic [28]. This often results in the direct acceptance of a message (e.g., the acute need for blood) whereby users can seldom attribute the reason for their acceptance; they simply say that they feel that the message is credible.

Cues that trigger heuristics could be either embedded within a message (e.g., message length) or appear in the context of message presentation (e.g., message source). They might even be internally located within the perceiver (e.g., attitudes, mood states), according to the literature [27].

4. Technological/Interface cues

One could argue that the more fundamental source of all these types of heuristic-cue information is the technology of the medium used for communication. Each technology brings with it a set of affordances or capabilities that can shape our perception of content and guide the nature of our interaction in a given medium. In addition to constraining and shaping content, these affordances also determine the way the content is typically presented via the medium and receivers' states of mind while using it. For example, the affordance of interactivity in an online forum suggests "action possibilities" such as responding to threads or typing in the site's chat room. The mere existence of these possibilities suggests openness of

information access and the participatory nature of the forum, among other things. If this were a political candidate's website, open flow of information and invitation to participate can immediately translate into a heightened sense of involvement with the site and, by extension, the candidate. This kind of involvement is associated with a sense of social presence [29] and is likely to drive the psychological component of 'presence as immersion' [2]. Therefore, each affordance could be seen as a repository of cues, some of which may aid one's presence in the device or site by triggering heuristics about the expected or typical nature of user interaction with it.

Research overwhelmingly indicates that the current generation of digital media users is extremely reactive to cues transmitted by affordances on the interface. Several large studies have shown that they focus on "design look" or "information design/structure" of the interface rather than the central content that they produce or consume [30, 31]. For example, the presence of interactivity (a common affordance in modern digital technologies) can transmit cues that imply a greater sense of dialogue in the system, or a higher sense of determination (or contingency) on the part of the user in dictating the nature of information exchange, or simply a more robust flow of communication [32]. Depending upon which of these is salient during a given informational context in which interactivity appears, the heuristic used to guide the receiver's experience and evaluation of message content will be different. The "dialogue" cue might give users the sense that the content is mutually shaped, serving as a trigger for a variety of heuristics relating to participation, democracy, consensus, and so on. The "contingency" cue might trigger the notion of individualization of messages, leading to heuristics pertaining to customization (e.g., tailoring, own-ness, etc.). The "flow" dimension of interactivity might evoke heuristics relating to system responsiveness, such as speed, telepresence, and so on [33]. These heuristics may have either a positive or a negative connotation in users' minds in a given situation, thereby shaping both their sense of presence during the interaction and subsequent characterization of presence experienced while using the technology.

5. MAIN Model

The key question then becomes: which affordances are most likely to cue presence-related heuristics? Ten years of research at our laboratory (Penn State University's Media Effects Research Laboratory) with a variety of digital media have identified four broad affordances that have shown significant psychological effects: Modality (M), Agency (A), Interactivity (I), and Navigability (N). These affordances are present to a greater or lesser degree in most digital media and seem promising in their ability to cue cognitive heuristics pertaining to presence because they are all structural features that underlie the design aspects or surface-level characteristics associated with powerful first impressions [30, 34]. Clearly, each affordance is richly meaningful from a psychological point of view, but it is unclear what particular meanings they hold for users. Research suggests that, depending on how a particular affordance manifests itself to users, it can lead to positive or negative outcomes. For example, if the design of interactive features on an interface successfully cues the convenience aspect of interactivity, users are likely to react positively; but if it cues the need for constant navigation, then it is likely to be viewed as burdensome. In general, calls for interaction with the system have proven to be a double-edged sword, with users preferring them in market surveys but showing a generally negative tendency toward them in experimental studies—a phenomenon labeled "interactivity paradox" [35]. The dominant engineering conviction favors more and more affordances, and users, especially young users, are quite enthusiastic about new structural features in technology, but when they actually use it, the impact on their thoughts, attitudes, and behaviors is often unpredictable even under conditions of good usability. This implies the existence of a "sweet spot" in the interactivity continuum wherein an affordance can optimally lead to presence—anything lower in interactivity is insufficient to engage the user and anything higher is overbearing.

Although source and content of digital media are very important in shaping perceptions and initiating user action, the MAIN model is primarily concerned with the technological aspects of digital media that can influence actions and judgments. As such, the starting point is an *affordance* offered by the technology, which means a particular capability possessed by the medium to facilitate a certain action [19]. It is suggestive and perceived by the user. For example, a keyboard affords the possibility of typing in text, whereas the mouse suggests pointing and clicking. The user is an integral part of interpreting the affordance. A music composer might see the mouse as a tool for editing a score online with ease, whereas an avid pianist might see it as a foot pedal and proceed to operate it with her feet. A *cue* is anything in the context of digital media use that might serve as a trigger for the operation of a heuristic. The MAIN Model specifies two broad types of cues—(1) the sheer presence of an affordance (e.g., interactive message board) and (2) metrics generated by the interface (e.g., number of people currently online). A *heuristic* is simply a judgment rule (e.g., "emoticons mean this interactant is touchy-feely"; "lots of people online means an active conversation is underway in this bulletin-board") that can result in decisions to interact in a particular way or assess the interaction in a certain light.

The cues that trigger these heuristics have a number of outcomes for the user. Thus far, the model has been used to assess how users assign credibility to various digital media [1]. However, a medium's affordances can also trigger other ways of understanding and experiencing the given environment. For example, one recent study explored how cues generated by collaborative filtering technology in e-commerce sites (user ratings, number of product reviews, and sales rank) triggered the bandwagon heuristic ("everybody else thinks this is a good product, so I should, too"), which fully accounted for purchase intention and other product-related attitudes [36]. Therefore,

the MAIN affordances can cue heuristics pertaining to a wide variety of dependent variables. We focus here on one important experiential outcome in mediated environments, namely presence, or a sense of "being there" [2], as shown in Figure 2.

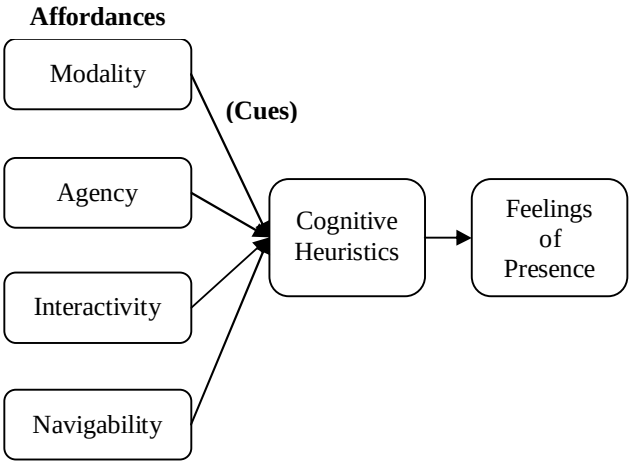

Figure 2 Affordance cues of the MAIN model lead to feelings of presence by triggering cognitive heuristics.

5.1. Modality

Modality refers to the mode of information presentation. It is often classified in terms of text, audio, video, and haptic in rough correspondence to human senses and perceptual system. We conceptualize modality more broadly to indicate different forms of information input and representation. Under this conceptualization, modality includes traditional modes of communication as well as other structural aspects related to representing data, such as animation, pop-up windows, screen size, stereoscopy, and so on. As Sundar [1] points out, each of these modalities carries psychological baggage and can therefore serve as a trigger for cognitive heuristics about the typical nature of the underlying content. For example, the cliché that "pictures tell a thousand words" is indicative of the fact that the picture modality is a richly and densely encoded representation and entails relatively little translation effort in terms of converting the symbols into meanings [37]. This kind of logic gave rise to the label "rich media" to signify modality enhancements beyond simple text. Picture is said to be richer than text, video is richer than still picture, large screen is richer than small screen, and so on.

Intuitively, enriching modality of presentation, from text to audio to video to virtual reality, is appealing in terms of approximating real, non-mediated interaction. This is perhaps why much of the empirical work on the causes of presence has manipulated modality features of the interfaces in question. Short, Williams, and Christie [6] manipulated the richness of communication between two people by varying the outputs (audio only vs. audio & visual). They found that the richer the medium, that is, the closer the communication is to face-to-face, the greater the social presence felt by study participants. More recently, Bente, Rüggenberg, Krämer and Eschenburg [38] found that when text was enhanced with audio or video modalities, a significant increase in social presence was reported.

From the perspective of the MAIN Model, this result can be explained in terms of the *realism heuristic*. The richer the modality of presentation, the more realistic the representation of data as it approximates "real life," whether that data is in the form of information or a social being at the other end—"it is so real, therefore I am present." What advanced modalities essentially attempt is a veridical rendering of the "content" that they convey. The finer (or "richer") the modality, the more realistic this rendition. If the "content" is a VR simulation, then the user will feel presence because s/he is applying the realism heuristic—if it seems real, then it must be. The greater resemblance of a mediated event (chatting in an online bulletin board) to its real-world counterpart (chatting face to face), the greater the chance of this heuristic being triggered. Technological advancements in modality have made possible the widespread application of this heuristic to experiencing presence in a wide variety of human activities, from enjoying mediated sports on wide-screen TV screens to exercising using the Nintendo Wii.

Speaking of wide screens, Reeves, . Detenber, and Steuer [3] found greater presence when they manipulated screen size. Participants who watched clips of action films on a 70-inch screen reported significantly greater presence than subjects who watched them on a 35-inch screen. Similarly, Lombard and Ditton [4] had people watch a movie either on an IMAX screen or a show on a 12" TV screen and cited specific technological features of the IMAX screen, such as high resolution images, 3D, surround sound audio, and subjective camera angles as contributing to a sense of presence. Lee and Peng [11] also looked at the effect of screen size, specifically on physical and self presence while playing a third-person point-of-view computer game. They also found that those who played on the large screen reported greater physical and self-presence. Most recently, Bracken [39] assessed the effects of new HDTV technology on a sense of presence. Participants watched a 13 minute video that was either in HD format or standard NTSC format and then completed measures of various types of presence, immersion, and realism. The HD video was found to cause greater feelings of immersion and spatial presence.

These findings may be explained by the operation of the *being-there heuristic*. Rather than make the medium feel more like real life, the bigger screens draw the user into the medium. Bigger screens afford a greater opportunity to experience motion and being telepresent in the represented space—"I am part of the action, therefore I am present." Larger and higher-resolution displays increase the "perceptual bandwidth" [40] of information transmission and can be physiologically arousing, indicating that sensory immersion has taken place. This is likely to cue the being-there heuristic—if I felt like I was there,

then I experienced presence. More formally, when users feel like they are part of the mediated universe, they will factor the authenticity and intensity of the experience into their later evaluations of the event, including those that retrospectively assess their sense of presence.

5.2. Agency

A key technological affordance of the digital age is the ability of users to assume agency or "the power to take meaningful action and see the results of our decisions and choices" [41]. As Herrera, Jordan, and Vera [42] remark, "agency is a very close concept to presence," with both sharing the notion of control over a virtual environment [17, 42, 43]. In his agency model of customization, Sundar [44] equates agency to the idea that the self serves as the source of communication.

When the user feels agentic, the assumption is one of greater presence. At least three different heuristics could be operating in the exercise of agency. If the interface focuses on its ability to offer control to users, then the agency affordance is likely to trigger the *control heuristic*, which is a shortcut assessment of the event or environment based on the degree of personal control felt by the user—"I am in control, therefore I am present."

In addition to control, the agency affordance also offers users the very real ability to create and customize content and experiences. When the users reach a point where they have created idiosyncratic artifacts (as in the case of creating islands in Second Life or profiles on Facebook), they are likely to apply the *identity heuristic*—"this is me, therefore I am present." The inherent egocentrism encouraged by the agency affordance is likely to contribute to a heightened sense of presence. In the spatial presence model proposed by Wirth, Hartmann, Böcking, Vorderer, Klimmt, Schramm, Saari, Laarni, Ravaja, Gouveia, Biocca, Sacau, Jäncke, Baumgartner, and Jäncke [45] the perceptual acknowledgment and verification of the mediated space as the primary ego reference frame is critical for fostering a sense of spatial presence.

An awareness of the agency affordance in a given technology will not only encourage users to assert their own agency but also predispose them to anticipate other-agency. This is one explanation for finding heightened social presence in mediated interactions where there is reason to believe that another being is exerting agency. The *social-presence heuristic* is basically a cognitive determination that one is interacting with a social entity, and is likely to impact one's own sense of presence in the interaction or co-presence in the environment—"I can sense the other, therefore I am present with him/her." This explains widespread self-disclosure behavior in various forums on the Web as also risky communications via technologies such as electronic mail and instant messengers without pausing to think about privacy and security implications. The widely reported case of a US congressman exchanging sexually explicit communications through these means with an intern [46] is a clear case of the social-presence heuristic driving one's presence in a mediated world to the point of neglecting real-world consequences.

Skalski and Tamborini [47] explored the social presence created by a mediated, interactive social agent as a source and the effect of the experienced social presence on attitude toward the communicator and the message. Participants viewed a health message which was given by an agent who varied in attractiveness and the level at which she interacted with the participants. Indeed, the agent who was more interactive created greater levels of social presence, regardless of her level of attractiveness.

As Nass and Moon [48] have long argued, anthropomorphism is not necessary for triggering social responses from users, but interactivity is. Their research has repeatedly demonstrated that computer users psychologically assume a social presence while interacting with a computer to the point of applying human social rules to the computer, such as granting it agency. This is true as long as there is evidence of some contingency in the interaction. This would argue for the primacy of a psychological, rather than technological, determination of social-presence heuristic. While that is true to a certain degree, research suggests that certain affordances such as voice, language, and personality [49] do indeed contribute to the activation of the social presence heuristic. These affordances, just like the interactivity manipulation in the Skalski and Tamborini study, serve as cues indicating the existence of other-agency, thereby triggering the social presence heuristic.

5.3. Interactivity

The affordance of interactivity is a major determinant of presence because of its ability to engender user engagement with the system [50]. Several interactivity-related heuristics outlined by Sundar [1] are likely to be involved in imbuing a sense of presence among users of digital media, but we shall focus on two that are most relevant.

The first is the *telepresence heuristic* and it is based on Steuer's [51] definition of interactivity as real-time modifiability of form and content. Virtual reality systems, with their head-mounted displays, strive to cue the *telepresence heuristic*, which is the feeling of being transported to a physically different location or a dynamic virtual environment. By being highly responsive to the user's location and movement, VR systems are quite effective in allowing users to modify the mediated environment in real time. This psychological realization is at the heart of the telepresence heuristic, which when triggered can lead to a heightened sense of presence. "I am moving, therefore I am present."

Somewhat related is the *flow heuristic*, which is likely to be automatically activated when user skills and system demands are in such synchrony that the user is challenged without being bored or frustrated [52]. When this happens, a user is said to be "in a zone" where she has reached an optimal level of concentration on a task and is not distracted by other stimuli. When the interactivity affordance offers options for

adjusting speed and related performance attributes of the system, it is likely to trigger the flow heuristic because it facilitates a seamless interaction characterized by a high degree of engagement with the mediated reality. "I am in a zone, therefore I am present."

More often, the flow heuristic is likely to be triggered in the negative, i.e., when there is a break in flow (e.g., herky-jerky video-conferencing interactions or voice-recognition software that requires users to eschew prosodic disfluencies). For example, when Anderson and Heulskamp [5] compared an interactive and a non-interactive website for a fictitious product (sunglasses with a built-in MP3 player), they found that the interactive site with flash intros and mouse roll-overs presented a level of challenge that was too high to stay in a state of flow. Therefore, presence was not heightened by interactivity in this case.

Most major websites offer numerous entry-points for users, thus triggering a *browsing heuristic*, which is a general sense that there is a lot to browse and "check out," with information being open-ended and free-flowing. A portal with several RSS feeds, a blog with a rich archive, a Flickr contact's recently updated photostream, or a Facebook profile with numerous applications and wall-postings will all trigger this heuristic. There's plenty here to "browse," but no one can reasonably be expected to peruse all the information. To the extent the interface encourages users to browse in search of "something interesting" [53], then users are likely to be in a surfing mode, which carries with it its own sense of presence—"I am exploring, therefore I am present."

Affordance	Heuristic Triggered	Mechanism for Presence Outcome
Modality	*Realism heuristic*	It is so real, therefore I am present
	Being-there heuristic	I am part of the action, therefore I am present
Agency	*Control heuristic*	I am in control, therefore I am present
	Social-presence heuristic	I can sense the other, therefore I am present with him/her
	Identity heuristic	This is me, therefore I am present
Interactivity	*Telepresence heuristic*	I am moving, therefore I am present
	Flow heuristic	I am in a zone, therefore I am present
Navigability	*Browsing heuristic*	I am exploring, therefore I am present
	Play heuristic	I am playing, therefore I am present

Table 1 Heuristics of the MAIN model as they induce presence

5.4. Navigability

Given the space-based metaphors assigned to digital media (site, cyberspace, information superhighway), the affordance of navigability (i.e., the interface's ability to facilitate user navigation or movement through the site or device) is particularly critical for imbuing a sense of spatial presence among users. The importance of good navigational design for spatial presence in VR applications cannot be overstated.

Work on navigability as a cause of feelings of presence has focused largely on physical navigability through virtual reality environments. For example, Eckmann, Yu, Boult, and Kessler [54] varied the level of navigability of their training task by having participants find their way through a building via a virtual environment and compared their presence with that of participants reading a blueprint of the building. In addition to better conveying the space, the former condition probably triggers the *play heuristic* whereby users experience both enjoyment and escapism while performing the task. This is what Shneiderman [55] calls "fun-in-doing." Play is clearly a central element of a lot of media use these days, from iPods to handheld games to poking a friend on Facebook. They simultaneously provide a sense of leisure and psychological immersion. Perceived play during online search tasks has been

associated with positive attitudinal outcomes [56]. In fact, the main draw of videogames and virtual worlds is the play heuristic that they trigger. Recent efforts to build serious applications for games (e.g., health games) and virtual worlds (interventions in Second Life) are really designed to capitalize on this play heuristic. Once this heuristic is successfully triggered, a sense of presence will be naturally realized—"I am playing, therefore I am present."

6. Empirical application and impact

In summary, each of the four affordances reviewed above can trigger cognitive heuristics relevant to the formation of a sense of presence. While the modality affordance cues realism and being-there heuristics, the agency affordance triggers the control, social presence, and identity heuristics, the interactivity affordance cues the telepresence and flow heuristic, and navigability cues browsing and play heuristics (see Table 1).

This list of heuristics is by no means exhaustive, but is presented here for illustrative purposes, as a starting point for examining the theoretical mechanisms underlying the role of technological variables upon the psychological realization of presence.

Recent advances in 3D internet offer many avenues for investigating how these affordances cue heuristics that lead to a sense of presence in virtual environments. A very popular 3D environment is Second Life (http://www.secondlife.com) where people quite literally create a virtual world in which they live, buy, sell, and learn. Second Life has the advantage of being one of the most well-known virtual worlds with an established community and user base. Other similar virtual worlds include There (http://www.there.com/), and Worlds (http://www.worlds.com), and many more that are aimed at specific targets such as teens, "techies," and designers. Researchers can even create their own virtual worlds to test specific affordance cues using software such as Active Worlds (http://www.activeworlds.com/). The researchers can identify the cues (functions and/or metrics) that are likely to trigger the operation of the hypothesized heuristics. These cues are then used as independent variables (or causal predictors) in experimental studies in which users interact with the given interface. The resultant cognitions, such as that of presence, will constitute the dependent variables, which may range from simple behaviors on the interface as well as higher-order processes such as sense-making.

The primary difference between traditional presence research and one informed by the MAIN model lies in (1) sourcing independent factors in specific cues embedded in or transmitted by specific technological affordances, and (2) directly measuring the operation of a given cognitive heuristic in order to statistically assess its mediating role. This approach captures the true meaning of the Gibsonian notion of affordances by allowing mutual shaping of meaning by technological as well as perceptual factors. There are plenty of examples in the literature where so-called rich media did not perform any better than poorer media on psychological outcome variables. Several studies have found that audio is as good as, if not better than, video for inducing a sense of presence even though audio is considered poorer than video. The key to such counter-intuitive findings may lie in the cognitive heuristics triggered in the minds of perceivers. Technological features alone are insufficient to predict presence outcomes. Theoretical attention must be paid to user interpretation of those features (cues), the meanings attributed to that interpretation (heuristic) and the relevance of that interpretation to judgments of presence.

Aside from theoretically enriching our understanding of presence formation in technologically mediated contexts, this research would extend the MAIN model by not only expanding the scope of outcome variables (from content quality to content experience) but also by bringing new heuristics to the fore. And, since presence can be a peculiar mix of automatically and consciously generated cognitions, findings of such future research have the very real potential to inform additivity, sufficiency, and related mechanisms in the social psychological literature on dual process models.

Practical implications of such research include better design of presence-inducing technologies and better efforts to scaffold users on their way to achieving or, if a situation warrants, avoiding presence. This research will motivate design innovations by providing ideas for new functionalities and metrics on digital interfaces that are driven by user psychology rather than simply dictated by engineering considerations. The work undertaken here is likely to have a lasting impact in the area of presence as it provides a new understanding of its psychological mechanisms and offers new methods for measuring it.

Perhaps most importantly, this research will seek to empirically ascertain the mediating role played by presence in the growing list of psychological outcomes—from motivation to persuasion to empowerment to sense of community--attributed to recent media and communication technologies.

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