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The sense of presence: lessons from virtual reality

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ABSTRACT
The sense of presence—or the sense of "being there"—is a poorly understood phenomenon, especially in the case of "unseen others," e.g., God. We used the tools of virtual reality (VR) to explore the effects of active imagination in creating a sense of presence of an ambiguously real other. We found that adding a visual representation was more effective than verbal language alone in evoking a sense of social presence in a ten-minute intervention, that a proclivity for absorption enhanced the sense of social and environmental presence, and that a sense of social presence was associated with a sense of responsive interaction. We present our data together with a critical analysis of the literature on perceptual presence and conclude by suggesting that presence is best understood as the product of a collaboration between a perceiving subject and the environment within which they are embedded. This study serves as an example of a novel approach that bridges different scientific literatures, methods, and disciplines to study religious experience.

Sensible objects have always a greater influence on the fancy than any other; and this influence they readily convey to those ideas to which they are related, and which they resemble. (Hume's Enquiry (Section V, Part II))

1. Introduction

One of the great puzzles of faith is what we might term, following the anthropologist Matthew Engelke (2007), the problem of presence. God is often invisible and immaterial. Yet those of faith often report that at times they feel God near at hand. They do not necessarily feel what they call God with their senses. In the case of Christianity, people of faith often report that they neither sense God with their skin, nor hear him with their ears, nor see him with their eyes, and yet they know that he is there—and that sometimes, he is not (Luhrmann, 2012).

These themes run throughout Christian literature. Thomas Merton remarks, in *No Man is an Island*: "God, Who is everywhere, never leaves us. Yet He seems sometimes to be present, sometimes to be absent." The Hebrew Bible promises that humans will have God's presence: "And God said, 'My presence shall go with you, and I will give you rest.'" [Exodus 33:14].

Christians say complex, paradoxical things about God's presence that suggest a phenomenological awareness that is and is not sensory, as these American evangelical Christians do here:

> It feels like a presence. You know how like if you're sitting here at the desk and somebody very quietly comes into the room.

> It's like, particularly in sadness, almost like someone put a shawl on you or a heavy cape or something, yeah. My mother-in-law passed away in April, and after feeling just absolutely exhausted with tears and grief and sadness [long pause], I remember laying in bed and just feeling like there was [emotion in her voice]—like God had put a blanket on me or something and just let me sleep. it was definitely a physical sensation of I guess feeling like an invisible blanket, like a real blanket actual layer of padding or something that just rested on me. … it's just awful and then just like, "Lord, Lord, where are you?" And just feeling, I remember this feeling like there was someone had just laid a blanket on me again—like a real blanket.

> I have really felt him sometimes. Like walking. This one place on the trail, yeah, I do remember where I was. Underneath this really big oak tree. I felt that I was with him. It's more of a sense so I would—there's a fine line between the sense and the physical. I-I wouldn't say physical though. I would not describe it as a physical sense. [Yet it was] almost tangibly, as almost you can kind of reach out.[1]

When Christians report the presence of God, they often describe a quasi-sensory awareness that another person is there. Such experiences sound impossible; they ought to be rare. Yet they are not. Among US churchgoers who attend services weekly, 44% say that they experience God's presence every week, with another 28% who experience his presence every month (Barna Group, 2012).

Nor, of course, are these experiences confined to Christians. Rabbinic literature describes the "shekhinah," a term used to describe a sense of the dwelling or settling of divine presence (Unterman, 2007). In Tibetan Buddhism, Vajrayana visualization practices are used to experience alternate realities with vivid sensory correlates (McMahan, 2013). The Orokaiva of Papua New Guinea report encounters with spirits during periods of sensory deprivation associated with initiation rituals (Bloch & Bloch, 1992). People hear buried parents and missing dogs. More than half of those bereaved report that they have felt, heard, or seen their lost loved ones in the months after the death (Kamp and Due, 2018).

The experience of presence implies a felt sense of 'realness'—the being is really *over there*, within reach. In media and communication studies, where much of the work on perceptual presence has been done, presence is divided into three distinct subcategories: telepresence (spatial presence or environmental presence), self-presence, and social presence (Lee, 2004). Telepresence, or environmental presence, refers to the ways in which the user experiences the environmental and spatial properties of the mediated environment; self-presence is the extent to which the perceiver feels connected to her or his (virtual) body, emotions or identity. Social presence or "co-presence," refers to the "sense of being with another" (Biocca et al., 2003, p. 456) within the same environment, whether that other is other real humans or human-like artificial intelligences (Oh et al., 2018). Social presence is an essential component of sociality and well-being, the sensation of being in the presence of a familiar, flesh-and-blood loved one; the sense of presence that accompanies being with others. Those who lose it report feelings of de-realization and dissociation from the world and others (Ratcliffe, 2008). When people speak of the presence of spirit of God, it is the social presence to which they refer.

The current work set out to explore what factors might contribute to a sense of presence of ambiguous others, with the aim of thinking about how invisible others like God come to feel present. We began with a puzzle. We know from history and anthropological studies of religious presence that the deliberate use of the imagination—purposefully hearing, seeing, feeling, and even smelling with the mind's inner senses; or inner sense cultivation, as Luhrmann (2012) calls it—is associated with the experience of the presence of God. Many spiritual practices use inner imagination explicitly: Tibetan monks with mandalas and explicit creative visualization procedures (Beyer, 1978), orthodox Jews who chant specific words as they imagine moving along and up the sephiroth of the kabbalistic tree of life (Garb, 2011), young shamans in trance with older shamans sitting by them, encouraging them to see certain images and do certain things in their mind (Reichel-

Dolmatoff, 1975). In a survey of religious practices around the world (but focusing on shamanism), Richard Noll et al. (1985) concludes that mental imagery cultivation was found in a wide variety of societies as a means to make inner imagery more vivid and more controlled, and that as practitioners' skill increased, so did their sense of the degree of presence of supernatural beings. Work with those who pray with inner sense cultivation has shown that these individuals are indeed more likely to report that they experience God as more person-like and more present (Luhrmann et al., 2013; Luhrmann & Morgain, 2012).

Studies also found that people with a proclivity to become "absorbed" or immersed in inner imagery were also more likely to report that they more often experience God as person-like and as present (Lifshiz et al., 2019; Luhrmann et al., 2010). Absorption is a construct which seems to capture the experience of being caught up in one's sensory experience in a way that is often imagined. The 34 item scale includes items about feeling the way one did as a child, about being able to imagine things so vividly they hold the attention the way a good movie does, and so forth.

Yet common sense (and reality monitoring accounts (Johnson & Raye, 1981)) suggest that real perception is richer, more detailed and more stable than that which is imagined. Perhaps a vivid imagination and inner sense cultivation are powerful in generating spiritual experience merely because a spiritual being cannot be perceived directly.

Virtual reality (VR) has introduced a remarkable new technology that appears to enhance the ability to experience presence. The technology seems in effect to fulfill the role of imagination for the individual. People using VR technology do not have to imagine an earthquake—they see the tables shaking. They do not have to imagine the impact of environmental damage to trees in the production of paper towels—they can see the trees coming down. VR studies have shown that people feel higher levels of social presence when there is a visual representation of virtual others compared to when the virtual others are visually absent (Choi et al., 2001; Croes et al., 2016; Xu, 2014) although this is not entirely consistent in the literature (e.g., Bailenson et al., 2001; Bente et al., 2008; Nowak & Biocca, 2003). It thus provides a unique tool for studying religious experience (Andersen et al., 2019; Maij et al., 2019). In particular, by allowing the standardization and control of diverse set of sensory contexts, VR allows one to examine the roles played by particular sensory cues as well as participant practices and proclivities in contributing to something as complex as a sense of presence of an ambiguous other.

Given these observations, the present work set out to explore whether a visually-rendered virtual other could provoke stronger feelings of social presence compared to the use of one's inner senses to imagine that other in the material absence of that being. To approach the question of how the generation of private images compares to the immersive imagery of virtual reality in generating a sense of social presence, we manipulated visual representation of an avatar in a brief, guided imagination practice not unlike the guided imagination practice one finds in certain forms of prayer. In particular, we asked:

1. How participants' experience of presence, or responsiveness to a virtual other and environment, is affected by visual representation (in terms of the appearance and identity of a virtual other);
2. How proclivity for absorption affects this responsiveness;
3. Whether this responsiveness has lasting effects, in terms of experiencing the avatar in the days following the intervention.

Here we put aside metaphysical claims regarding what is real in order to investigate how human practices and proclivities shape a sense of social presence when the other is not present in an ordinary way (see also Snodgrass et al. 2011). In this paper, we report our data and discuss it alongside a critical analysis of the literature on presence across several disciplines (media studies, neurosciences, and cultural anthropology) in order to understand the experience of presence more deeply. In doing so, this project serves as an example of a kind of interdisciplinary work that embraces both empiricism and critical analyses using multi-disciplinary methods. It also serves as an example of how VR technology might be utilized to study religious experience.

2. Materials and methods

We tested several different VR presentations of a virtual other among college students to determine the effects of representation and baseline proclivity of absorption on the reported degree of "presence" of the virtual other. We utilized a 3 × 2 study with 3 conditions and 2 avatar identities. The conditions consisted of (1) opaque avatar, (2) translucent avatar, or (3) absent avatar. In the "opaque" condition, a fully opaque, more photorealistic avatar appeared. In the "translucent" condition the avatar was rendered to appear silver and semi-translucent. Finally, in the "absent" condition, no avatar appeared within the virtual environment, and participants had de facto to use their imagination alone, following the spoken instructions.

The avatar was based on a deformable mesh model representing a Caucasian male that was rendered to resemble either Leland Stanford Jr., the son of the founding family of Stanford University (a 16-year-old boy who died in 1884), or John Hennessy, the then-president of Stanford University. The Leland avatar was rendered in a virtual environment of a clearing within a forest; the Hennessy avatar in a virtual environment that consisted of a familiar portion of the campus (the main quadrangle).

While the study was motivated by an interest in the experience of God, we chose not to use an image of God in the virtual reality environment because the undergraduate students were likely to have a wide range of prior expectations of and ideas about such images. Instead, we first chose figures we thought would interest them but about which they had few expectations: Leland Stanford Junior, the young man in whose honor their university had been founded and whose life is commemorated on campus, and John Hennessy, the University president at the time of the study. We knew that all students knew that John Hennessy existed and that most had seen images of him, but also that few would have had personal one-on-one meetings with him.

Participants were randomly assigned into one of the three conditions of representation. Avatar identity was not intended to be a theoretical variable but instead was changed halfway through the study (from Leland to Hennessey) to add generalizability via multiple stimuli.

2.1. Study population

We recruited a convenience sample from the Stanford student population. All participants were enrolled in a class on virtual reality, and students were offered course credit for their participation. None were told about the nature of the study before enrolling. The total sample ($n = 115$) consisted of 35 men and 80 women who generally ranged in age from 18 to 25 years (with the exception of one student who was 51 years old; median age 20.00y). Twenty neglected to complete the second portion of the study, in which they were asked to return a survey on their experience five days after their laboratory encounter with the avatar, and they were dropped from that portion of the analysis.

2.2. Procedure

The experiment consisted of two parts: the first portion occurred in the lab, where the participant completed questionnaires and underwent the virtual immersion experience. The second part occurred five days after the lab visit, in which the participant completed an online questionnaire.

The lab component of the study took place at the Virtual Human Interaction Lab at Stanford University. Upon arrival, each participant met with a research assistant (NC), who obtained their informed consent and administered the first questionnaire, a modified Tellegen absorption scale "absorption" questionnaire] (Tellegen & Atkinson, 1974). The original scale has 34 items that one marks as "true" or "false." A participant gets a point for every item marked as "true." The questions tap participants' willingness to be caught up in their imaginative and sensory experience. We used a subset of 7 items from the original scale, based on pretest data collected from 58 undergraduates not enrolled in the current study. The pretest was designed to find a small subset of

questions that captured the essence of the survey to save time during data collection. The subscale was highly correlated with the original: $r(58) = .888$, $p < .001$.

Participants were then led into a separate room, fitted with the VR headset and underwent the simulation, which lasted approximately 10 minutes. See supplementary information for copy of scales used and transcript of 10 minute audio track. The simulation was guided by the audio track that oriented the participant to the virtual environment. Each condition had the same audio track. Participants were encouraged to see the virtual other—whether or not he was shown—and invited to trust him; they were then invited to have an imagined conversation in which they shared "something that has been bothering you" with the other, and then to listen to the advice the other gave in return. At this point in the audio track, there was a pause so that the participants could listen to the imagined voice of the avatar. At no time did the participant in any of the three conditions hear actual speech from the avatar.

Immediately after the audio clip finished the participant took off the VR heads-set and completed questionnaires assessing their experience [the standard Social Presence questionnaire used by Biocca & Harms, 2002; Nowak & Biocca, 2003, and the Environmental Presence questionnaire used by Yee & Bailenson, 2007; Ahn, 2011; Nowak & Biocca, 2003 with some additional questions]. Participants were also asked to rate their willingness (yes, maybe, or no) to follow any advice they received from the virtual other, as an indicator of their responsiveness to that other and the virtual environment [Behavioral Intention measure].

Five days later, participants were asked to complete an online questionnaire about their experiences during the days following their visit to the lab [Post Lab Experience scale]. They were also asked if they followed that advice (yes or no) as an indicator of whether the experience was compelling enough not only to stay with them but to affect their behavior [Behavioral Intention measure].

2.3. Apparatus

The immersive virtual environment was created with a Python OpenGL software toolkit called Vizard (Worldviz), which was rendered in real-time by a high-performance Dell Precision T7500 running Windows 7 with 12GB of memory and a NVIDIA GTX 680 graphics card with 1.5GB of video memory. The head-mounted display was a nVisor SX111 HMD (NVIS, Reston, VA) with a resolution of 2056×1024 and a refresh rate of 60 frames per second in each eye. An orientation sensor (Intersense3 Cube accelerometer) mounted to the HMD operating at 180 Hz with a 4 ms latency rate was used to track participants' physical head movements (pitch, roll, and yaw) and update their rendered first-person perspective viewpoint in the immersive environment.

Participants were placed in the virtual environment with the room setup illustrated in Figure 1. They donned a head-mounted display (HMD) through which they were able to view the stimulus. Sensing equipment tracked the motion of the head of the participant so that a realistic visual depiction of the environment could be updated constantly based on the direction of the participant's view. The participant's view of the immersive environments is shown in Figure 2, the panels depicting the three different conditions for both the Leland and Hennessy environments. The virtual agent always faced the participant's starting position, and the participant's eye height was matched to the 1.65 m eye height of the agent. In both studies, the avatar exhibited no behaviors other than blinking and head nodding (queued after the participant was instructed to communicate with the avatar).

2.4. Data analysis

We note that this is an exploratory study. Our research questions were: (1) whether visual representation would be associated with a higher degrees of presence of an ambiguously real other than no visual representation, in a context in which participants were asked to actively imagine the other; (2) whether a proclivity for absorption would increase this responsiveness; and (3) whether this responsiveness had lasting effects in terms of either (3a) experiencing the avatar in the days following

Figure 1. Participants were placed in a fully immersive virtual environment with the setup illustrated above. They donned a head-mounted display (HMD) through which they were able to view the stimulus. Sensing equipment tracked users' head motion so that a realistic visual depiction of the environment could be updated constantly based on the direction of the participant's view. The accompanying acoustic track was played through headphones, as pictured.

the intervention (post-lab experience) or (3b) behavioral change (willingness to follow advice received and whether they followed that advice). To address questions 1 and 2 we ran multiple linear regression models testing for effects of condition, avatar identity and Tellegen score on presence reported (social and environmental presence scores). To examine question 3a we ran multiple linear regression models testing for effects of condition, avatar identity, Tellegen score, social presence and environmental presence scores on post laboratory experience score. To examine question 3b we ran ordinal (cumulative link) and logistic regression models testing for effects of condition, avatar identity, Tellegen score, social presence and environmental presence scores on post laboratory experience score on intention to follow advice (response options: *no, maybe, yes*) and whether that advice was followed score (response options: *no, yes*). All statistical analyses were conducted using Stata- 14 software (StataCorp LP, College Station, Texas) or R version 4.0.0 R (R Core Team, 2020). Our threshold for statistical significance was $p < 0.05$; we note in the text whenever results that were significant at this threshold would be considered non-significant after Bonferroni correction (adjusted threshold: $p < 0.0016$). We include these data in our results and discussion as this is a novel, proof-of-concept exploratory study. Data are available on the Open Science Framework (OSF) https://osf.io/8pmqj/.

3. Results

A total of 115 participants (mean age 20.84, 70% female) participated in an initial VR laboratory session in which they experienced some version of either the Leland or Hennessey avatar (Table 1).

Most participants did experience a sense of presence and reported that the avatar and the environment felt real. On average participants felt "moderately strongly" that they were present in the virtual environment (to use the Leland example, that they were really inside the forest, surrounded by the trees; that they actually visited the forest; that the forest seemed to be the real world and they could reach out and touch the objects there) (mean environmental presence reported in Leland environment: 10.20 (sd: 4.76), Hennessy: 9.94 (5.06), out of 20 possible points indicating strongest presence). Likewise, participants generally reported that Leland and Hennessy were present and felt real (mean social presence reported with Leland avatar: 8.39 (4.82), Hennessy: 7.40 (4.83), out of 20 possible points indicating strongest presence) (Table 2).

Figure 2. The participant's view of the immersive environments is shown in Figure 2, the panels depicting the opaque, transparent and absent conditions (top, middle and bottom), for both the Leland (right) and Hennessy (left) environments.

3.1. Visual representation and presence

Social presence scores were significantly higher when the avatar was presented visually than with the absent figure, statistically controlling for avatar type (Leland versus Hennessy) and baseline absorption score (Table 3, left; Figure 3, left). That is, participants in conditions with a visual rendering of the figure—opaque or translucent—reported higher degrees of social presence than

Table 1. Participant characteristics (percentages, or means and standard deviations).

Variable	Avatar identity	Absent (Leland: $n = 17$, Hennessy: $n = 11$)	Transparent (Leland: $n = 22$, Hennessy: $n = 27$)	Opaque (Leland: $n = 23$, Hennessy: $n = 15$)
			Condition	
Gender	Leland	18% men, 82% women	27% men, 73% women	35% men, 65% women
	Hennessy	45% men, 55% women	33% men, 67% women	27% men, 73% women
Age	Leland	20.71 (1.49)	20.26 (1.48)	22.00 (7.36)
	Hennessy	20.73 (1.27)	20.87 (1.58)	20.17 (1.34)
Race	Leland	35% [White], 12% [Black], 12% [Latinx/Hispanic], 12% [Asian], 18% [other], 12% no response	50% [White], 5% [Black], 5% [Latinx/Hispanic], 14% [Asian], 5% [other], 23% no response	57% [White], 22% [Black], 13% [Latinx/Hispanic], 4% [Asian], 0% [other], 4% no response
	Hennessy	27% [1], 0% [2], 18% [3], 18% [4], 0% [5], 36% no response	56% [1], 0% [2], 4% [3], 19% [4], 4% [5], 19% no response	33% [1], 13% [2], 7% [3], 3% [4], 7% [5], 27% no response
Socioeconomic ladder	Leland	6.93 (1.39)	6.94 (1.52)	7.14 (1.88)
	Hennessy	7.57 (1.72)	7.68 (1.62)	7.27 (2.53)
Religious	Leland	3.40 (1.96)	3.00 (1.62)	3.50 (1.92)
	Hennessy	2.29 (1.11)	2.91 (1.80)	3.09 (1.76)
Religious attendance	Leland	1.67 (1.35)	2.00 (1.32)	2.00 (1.51)
	Hennessy	1.71 (1.60)	1.32 (1.21)	1.82 (1.54)
Social politics	Leland	2.80 (1.61)	3.35 (2.00)	2.64 (1.43)
	Hennessy	1.50 (0.84)	2.77 (1.34)	2.64 (1.50)
Economic politics	Leland	4.60 (2.20)	4.65 (1.90)	3.91 (1.80)
	Hennessy	3.17 (1.60)	4.32 (1.52)	3.55 (1.44)
Belonging	Leland	4.47 (1.51)	4.65 (1.22)	5.05 (1.59)
	Hennessy	4.43 (1.13)	4.73 (1.52)	5.20 (1.23)
Empathy	Leland	3.73 (0.70)	3.94 (0.75)	4.00 (0.87)
	Hennessy	4.29 (0.49)	3.73 (0.83)	3.80 (0.79)
VR experience	Leland	65% yes, 24% no, 12% no response	55% yes, 23% no, 23% no response	61% yes, 35% no, 4% no response
	Hennessy	55% yes, 9% no, 36% no response	63% yes, 19% no, 19% no response	53% yes, 13% no, 33% no response
VR dizzy	Leland	6% yes, 82% no, 12% no response	5% yes, 73% no, 23% no response	9% yes, 87% no, 4% no response
	Hennessy	0% yes, 55% no, 45% no response	0% yes, 63% no, 37% no response	0% yes, 53% no, 47% no response
Motion sick	Leland	2.80 (1.70)	2.59 (1.50)	2.77 (1.85)
	Hennessy	2.71 (1.38)	2.50 (1.74)	1.90 (0.99)
Motion sick conditions	Leland	0% yes, 88% no, 12% no response	0% yes, 77% no, 23% no response	4% yes, 91% no, 4% no response
	Hennessy	0% yes, 64% no, 36% no response	4% yes, 78% no, 19% no response	0% yes, 67% no, 33% no response

"Socioeconomic Ladder" responses could range from "worst off" (coded as 1) to "best off" (coded as 10). "Religious" responses could range from "not at all religious" (coded as 1) to "extremely religious" (coded as 10). "Religious attendance" responses could range from "never" (coded as 1) to "greater than one time per week" (coded as 5). "Social politics" responses could range from "extremely conservative" (coded as 1) to "other/can't say" (coded as 8). "Economic politics" responses could range from "extremely conservative" (coded as 1) to "other/can't say" (coded as 8). "Belonging" responses could range from "strongly disagree" (coded as 1) to "strongly agree" (coded as 7). "Empathy" responses could range from "not at all true of me" (coded as 1) to "completely true of me" (coded as 5). "Motion sick" responses could range from "I don't easily get motion sickness or car sickness" (coded as 1) to "I very easily get motion sickness or car sickness" (coded as 7). None of the demographic variables assessed differed significantly by avatar identity or by condition.

participants who were asked to imagine the figure ($b = 1.21$, $t = 3.69$, $p < 0.001$). The two visual conditions did not differ (opaque vs transparent: $b = 0.15$, $t = 0.31$, $p = 0.758$). With a ten-minute intervention, in participants who were unlikely to have been passionately motivated to experience these specific invisible others, the VR sensory cueing was more effective in producing social presence than deliberate imagination without visual cueing.

Table 2. Descriptive statistics (means and standard deviations) on our primary variables of interest for the three conditions (avatar absent, avatar transparent, and avatar opaque) and the two avatar identities (Leland Stanford Jr., and President John Hennessy).

Variable	Avatar identity	Condition		
		Absent (Leland: $n = 17$, Hennessy: $n = 11$)	Transparent (Leland: $n = 22$, Hennessy: $n = 27$)	Opaque (Leland: $n = 23$, Hennessy: $n = 15$)
Social presence	Leland	6.35 (5.02)	8.82 (3.91)	9.48 (5.19)
	Hennessy	3.18 (4.79)	8.48 (4.48)	8.53 (3.93)
Environmental presence	Leland	10.18 (5.13)	10.00 (4.35)	10.39 (5.05)
	Hennessy	9.82 (3.34)	9.93 (4.95)	10.07 (6.43)
Post lab experience	Leland	8.07 (1.49)	9.06 (3.15)	8.91 (1.86)
	Hennessy	7.71 (1.25)	8.55 (2.84)	7.45 (0.69)
Willingness to follow advice	Leland	2.06 (0.83)	1.77 (0.81)	1.91 (0.73)
	Hennessy	2.00 (0.77)	2.15 (0.82)	2.00 (0.65)
Whether they followed advice	Leland	1.60 (0.51)	1.41 (0.51)	1.43 (0.51)
	Hennessy	1.29 (0.49)	1.55 (0.51)	1.36 (0.50)
Tellegen absorption	Leland	5.12 (1.45)	5.18 (1.37)	5.43 (1.27)
	Hennessy	4.27 (1.85)	5.00 (1.54)	4.67 (1.91)

To calculate social presence, responses were summed across the questions with greater values indicating stronger social presence, with maximum total of 20 points. For environmental presence, responses were summed across the questions with greater values indicating stronger social environmental presence, with maximum total of 20 points. For Post-Lab Experience, responses were summed across the questions with greater values indicating a greater number of experiences of Leland/Hennessy in the five day period following the intervention, with maximum total of 30 points. For willingness to follow: Participants responded 2 = yes, 1 = maybe, 0 = no. For whether they followed: Participants responded 1 = yes, 0 = no. For Tellegen Absorption, Responses were summed across the questions with greater values indicating stronger proclivity for absorption, with maximum total of seven points. Social presence was the only variable to differ significantly across the three conditions (one-way ANOVA: F (2, 112) = 7.11, $p = 0.001$); none of these variables differed significant across the two avatars.

The condition had no significant effect on environmental presence (Table 3, right; Figure 3, right).

3.2. Absorption and presence

An individual's absorption level, as measured by a shortened version of the Tellegen Absorption scale, had small but significant effects on response to the virtual environment: After statistically controlling for condition and avatar type, participants higher in absorption reported higher degrees of both social and environmental presence (Social Presence: $b = 0.51$, $t = 2.18$, $p = 0.031$; Environmental Presence: $b = 0.64$, $t = 2.13$, $p = 0.035$; see Table 3 and Figure 4). (We note, however, that a conservative Bonferroni correction for all of the p-values reported in this paper would render this finding no longer significant.)

Table 3. Results from multiple linear regression models testing for effects of condition, absorption and avatar identity on social presence and environmental presence ($n = 115$).

	Social presence					Environmental presence				
	b	SE	95% CI	t	p	b	SE	95% CI	t	p
Intercept	7.58	0.43	[6.73, 8.44]	17.52	<0.001	10.11	0.47	[9.18, 11.04]	21.59	<0.001
Condition (A): visible vs invis.	**1.21**	**0.33**	**[0.56, 1.86]**	**3.69**	**<0.001**	−0.05	0.36	[−0.75, 0.66]	−0.13	0.895
Condition (B): opaque vs transp.	0.15	0.49	[−0.82, 1.12]	0.31	0.758	0.15	0.53	[−0.91, 1.20]	0.27	0.785
Tellegen absorption	**0.61**	**0.28**	**[0.06, 1.16]**	**2.18**	**0.031**	**0.64**	**0.30**	**[0.05, 1.24]**	**2.13**	**0.035**
Avatar: Leland vs grand mean	0.45	0.43	[−0.41, 1.30]	1.03	0.305	−0.06	0.47	[−0.99, 0.87]	−0.13	0.899

Condition was coded with orthogonal contrasts (Contrast A: "visible" conditions (opaque and transparent avatars) vs "invisible" condition (avatar absent); Contrast B: opaque vs transparent conditions); avatar was effect-coded; and Tellegen absorption was centered at the observed mean. Significant predictors of presence are in bold; note, however, that Bonferroni correction for all p-values included in this paper renders p-values ≥ 0.0016 non-significant.
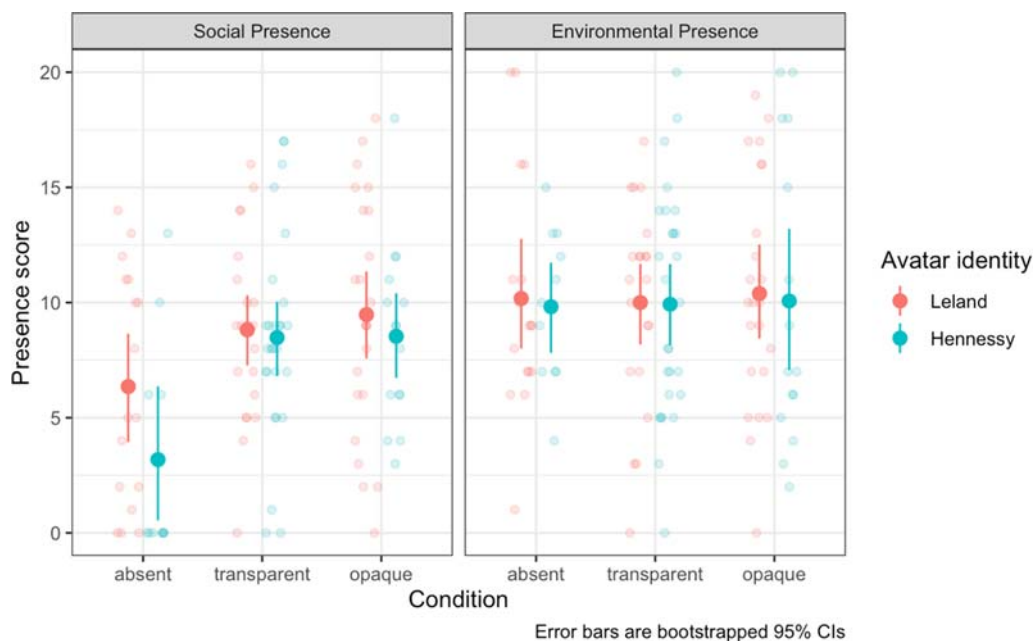
Figure 3. Mean Social and Environmental Presence scores by condition and avatar identity. Error bars are bootstrapped 95% confidence intervals.

3.3. Post-intervention experience

An initial regression analysis of the effects of condition, absorption, avatar identity, social presence, and environmental presence on responses to the post laboratory questionnaire did not reveal any significant predictors of post laboratory experience (Table 4). In follow-up analyses examining each predictor individually, Tellegen absorption was the only significant predictor of post lab experience ($b = 0.35$, $t = 2.37$, $p = 0.020$; note that this p-value would not be significant after Bonferroni correction), and absorption was also the only significant predictor in a variety of alternative models (e.g., treating avatar identity as a random rather than fixed effect or dropping avatar identity from the original omnibus model).

However, vividness of response to the virtual other as social presence was significantly associated with likelihood of reporting that they would follow, and did follow, the avatar's advice (willingness to follow: $b = 0.20$, $z = 3.74$, $p < 0.001$; followed advice: $b = 0.16$, $z = 2.33$, $p = 0.020$; see Table 5 and Figure 5). (We note, however, that Bonferroni correction would render the second finding non-significant.) Another way of saying this is that the most striking association with the sense of presence was an experience of responsive interaction. If someone reported that they felt that the avatar was real, they were more likely to say that they would or had followed his advice.

There were some subsidiary observations. People in the visible conditions were, if anything, slightly less willing to follow advice than those who saw no avatar at all ($b = -0.38$, $t = -2.33$, $p = 0.020$; not significant after Bonferroni correction). Those who reported a greater sense of environmental presence were more likely to report that they had followed the advice ($b = 0.14$, $t = 2.15$, $p = 0.031$; not significant after Bonferroni correction). People were also more likely to say that they would follow advice when given by the Leland avatar ($b = -0.39$, $t = -2.04$, $p = 0.041$; not significant after Bonferroni correction), although avatar made no difference to whether they reported following that advice ($b = 0.06$, $t = 0.23$, $p = 0.818$). The most striking and consistent observation remains the relationship between a sense of social presence, and a willing to follow, and the report that one did follow, the advice given by the avatar.
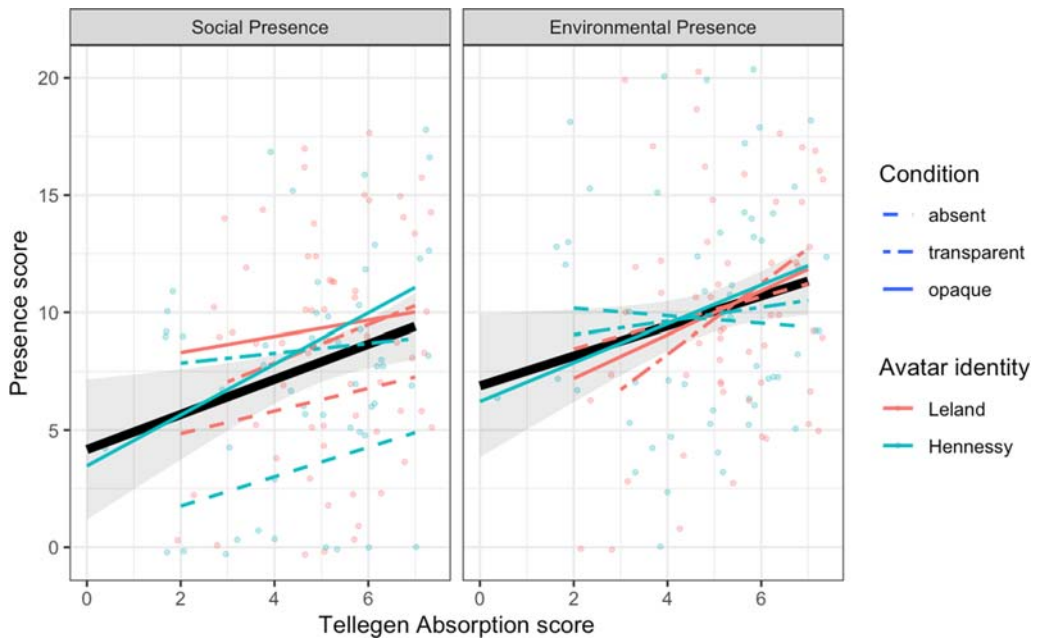
Figure 4. Relationships between Tellegen Absorption scores and Social and Environmental Presence scores. Smaller colorful lines indicate trends by condition and avatar identity; thick black lines indicate overall trends.

4. Discussion

We found that in the context of a short ten-minute intervention, imagination with an explicit image in virtual reality was more effective than imagination without an explicit image in virtual reality, and that a proclivity for absorption increased a person's sense of both social and environmental presence. We found little difference between an avatar that was clearly unreal (the dead boy in whose name the university had been founded) and an avatar of someone who was clearly real (the university president). But we also found something more unexpected: that a sense of presence was associated with a sense of back and forth communication and response. The more someone reported that they experienced the other being present in the laboratory, the more likely they were to report that they would follow and did follow the other being's advice.

In this study we learned that presence is relatively easy to invoke. It is unlikely that any participant in this study had any illusions about whether they were actually in a room with a dead teenager or a university president. Yet most people said that to some extent, they felt that the other was there.

Table 4. Results from a multiple linear regression model testing for effects of condition, absorption, avatar identity, social presence, and environmental presence on post lab experience ($n = 95$).

	Post lab experience				
	b	SE	95% CI	t	p
Intercept	8.31	0.24	[7.84, 8.79]	34.91	<0.001
Condition (contrast A): visible vs invisible	0.15	0.20	[−0.24, 0.54]	0.78	0.437
Condition (contrast B): opaque vs transparent	−0.25	0.27	[−0.78, 0.28]	−0.93	0.353
Tellegen absorption	0.28	0.15	[−0.03, 0.58]	1.82	0.072
Avatar: Leland vs grand mean	0.30	0.24	[−0.18, 0.78]	1.24	0.217
Social presence	0.06	0.07	[−0.07, 0.19]	0.90	0.369
Environmental presence	0.00	0.06	[−0.12, 0.11]	−0.08	0.938

Condition was coded with orthogonal contrasts (Contrast A: "visible" conditions (opaque and transparent avatars) vs "invisible" condition (avatar absent); Contrast B: opaque vs transparent conditions); avatar was effect-coded; and Tellegen absorption, social presence, and environmental presence were each centered at their observed means.

Table 5. Results from regression models testing for effects of condition, absorption, avatar identity, social presence, and environmental presence on willingness to follow advice received (response options: *no, maybe, yes*; $n = 115$) and whether one followed advice received (response options: *no, yes*; $n = 95$).

	Willingness to follow advice (ordinal regression)					Whether followed advice (logistic regression)				
	log-odds	SE	95% CI	z	p	log-odds	SE	95% CI	z	p
Intercept	–	–		–	–	−0.15	0.25	[−0.65, 0.34]	−0.60	0.551
Condition (A): vis.vs invis.	**−0.38**	**0.16**	**[−0.70, −0.06]**	**−2.33**	**0.020**	−0.27	0.21	[−0.70, 0.14]	−1.28	0.202
Condition (B): op.vs transp.	−0.05	0.21	[−0.46, 0.37]	−0.22	0.823	−0.36	0.29	[−0.94, 0.19]	−1.27	0.204
Tellegen absorption	0.04	0.13	[−0.21, 0.29]	0.32	0.751	−0.27	0.17	[−0.61, 0.05]	−1.61	0.108
Avatar: Leland vs grand mean	**−0.39**	**0.19**	**[−0.77, −0.02]**	**−2.04**	**0.041**	0.06	0.25	[−0.44, 0.56]	0.23	0.818
Social presence	**0.20**	**0.05**	**[0.10, 0.31]**	**3.74**	**<0.001**	**0.16**	**0.07**	**[0.03, 0.31]**	**2.33**	**0.020**
Environmental presence	0.04	0.05	[−0.05, 0.13]	0.93	0.350	**0.14**	**0.06**	**[0.02, 0.27]**	**2.15**	**0.031**
"No" vs "maybe" boundary	−1.17	0.24	[−1.64, −0.70]	−4.90	<0.001	–	–		–	–
"Maybe" vs "yes" boundary	0.98	0.23	[0.53, 1.43]	4.25	<0.001	–	–		–	–

Condition was coded with orthogonal contrasts (Contrast A: "visible" conditions (opaque and transparent avatars) vs "invisible" condition (avatar absent); Contrast B: opaque vs transparent conditions); avatar was effect-coded; and Tellegen absorption, social presence, and environmental presence were each centered at their observed means. Significant predictors of presence are in bold; note, however, that Bonferroni correction for all *p*-values included in this paper renders *p*-values ≥ 0.0016 non-significant.
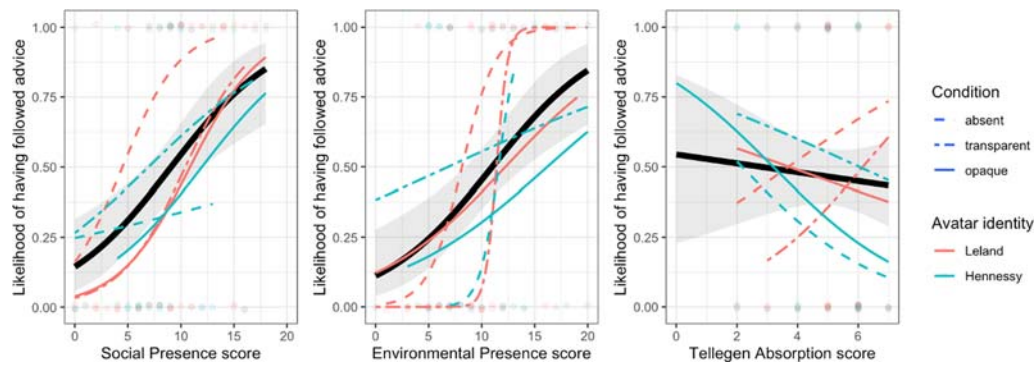

Figure 5. Relationships between Social Presence, Environmental Presence, and Tellegen Absorption scores and reports of having followed the avatar's advice after leaving the lab. Smaller colorful lines indicate trends by condition and avatar identity; thick black lines indicate overall trends.

We also learned that there are specific characteristics and conditions that make it more likely that someone will experience an ambiguously real other as being present. In this case, we learned that having a direct visual representation is more effective than imagination alone, at least in that ten-minute intervention, in evoking social presence. Inner sense cultivation is a practice of deliberately directing attention to inner sensory experience; VR practice likely serves as an enhancement of that practice. This study adds weight to Hume's observation (in our epigraph) that sensory enhancements help to make that which must be imagined (e.g., God) more real.

To be clear: one should not compare a 10-minute VR intervention to a developed prayer practice without many caveats. Prayer practice, of course, involves many repeated engagements with inner imagery. And yet the challenge of prayer practice is not unlike the challenge of VR use, which is to bring individuals into a kind of sensory contact with an immaterial presence. This work raises the question of whether a personal involvement with inner imagery might always be enhanced by the presence of outer imagery—with pictures, as well as stories.

Let us return to the most surprising finding of this work: that social presence predicted interaction, and that neither proclivity (absorption) nor exposure to explicit visual image did.

What is presence? To those who study faith, presence is the feeling of the nearness and realness of God. Phenomenologically oriented historians and anthropologists draw our attention to the role of attribution in identifying invisible others (see Csordas, 1997; Desjarlais, 2003; Taves, 2009; Throop, 2009). They find that the sense of the invisible other is a felt event interpreted in culturally variable ways (Cassaniti & Luhrmann, 2014). The term "telepresence" was coined by Marvin Minsky in 1980 to name the sense human operators might feel of being physically transported to a remote space via the teleoperating system. Since then, "telepresence"—or now "virtual presence," "mediated presence" or just "presence"—has been used by scholars of technology to refer to a sense of "being there" in an environment created by technology (Sheridan 1995; Schloerb, 1995; McLellan, 1996; Rheingold, 1991; Reeves, 1991). For these scholars, presence is a way of thinking about the human response to the system; a quality that can be measured and used as an indicator of the immersiveness—and thus effectiveness—of the simulated environment. More recently, as we have remarked, media studies scholars have divided presence into the categories of environmental (or spatial) presence, social presence, and self-presence (Lee, 2004; Ratan, 2013). There are also different dimensions of social presence (Biocca & Harms, 2002).

For neuroscientists, the concept of presence has referred to a sense of reality that allows one to take action. It is assumed that since reality is formed through actions and not appearances, the sense of "being there" in a virtual environment is grounded in the ability to "do" there (Flach & Holden, 1998; Zahorik & Jenison, 1998). Predictive coding models suggests that humans have models or representations of ourselves and the world that we use to make predictions of what we will experience (Friston & Kiebel, 2009; Seth et al., 2012; Taves & Asprem, 2017; van Elk & Aleman, 2017). Prior beliefs and sensory signals are constantly being updated when our predictions do not match our observations. There is thus a constant interplay between "bottom-up" multisensory integration and "top-down" conceptual stimuli converging and constituting these generative models we have of ourselves and the surrounding world. For these researchers, the feelings of presence of unseen others is understood as an illusion most likely caused by the misattribution of the source and identity of sensory signals (i.e., tactile and proprioceptive signals) coming from one's own body, which individuals then interpret to be spiritual or religious in origin (Andersen, 2019; Blanke et al., 2014; Cheyne, 2012; van Elk & Aleman, 2017).

In sum, presence has been understood in various fields as an interpretation of bodily sensation in response to environmental cues; one that contributes to the sense of "being there," the sense of reality or realness.

The goal of the present study as originally conceived was to use VR technology to test the effects of specific environmental cues in contributing to a sense of presence of an ambiguous other as a way to explore the question of proclivity and practice in religious experience, as well as to serve as an example of how VR could be used in studies of religious experience. We found that imagination with visual cueing was more effective than imagination alone in eliciting a sense of social presence of a virtual other. While at first glance this finding may not seem surprising, it was worthwhile testing experimentally as previous work had found that practices that hone aspects of kataphatic prayer practice (i.e., deliberate use of the imagination) could have real training effects (Luhrmann & Morgain, 2012).

More striking was our finding that this sense of presence predicted an experience of responsiveness and interaction. We believe this tells us that social presence is something that is distinct from the contributing factors of practice and proclivity. This suggests that previous studies of presence we may have glossed over the fundamental role or function of presence as an intermediary in processes of interaction and communication. That is, the majority of experimental work on presence—especially religious presence—has focused on the environmental cues that make presence as a sensation more likely. Implicit in this kind of study design is the assumption that presence can be reduced to its component parts—of environmental cues acting upon a standardized observer.

With this assumption, presence is a sensation induced within a perceiver; one made more or less likely by certain practices and proclivities of the perceiver.

Our perspective is different, though it does not contradict these other approaches. We suggest, in alignment with recent work by Corwin and Erickson-Davis (2020), that presence—as a feeling, a state of being, an indicator and an outcome—is best understood as a product of interaction between perceiver and the environment in which they are embedded. It cannot be reduced to mere bodily sensation—the interpretation of more rudimentary sensorimotor states of a standardized individual—nor to the collection of environmental attributes that render the experience of presence more likely. Instead, presence is a distinct phenomenon that is larger than these component and contributing parts; a process that is highly specific to both the individual perceiver and the environment with which they are embedded. Presence is, as Alva Noë points out in *Varieties of Presence,* the means through which we establish access to the world (2012). Social presence cues us into the fact that this access is experienced as a two-way channel. From our perspective, the sense of social presence fundamentally captures an experience of interaction or communication. We see humans as not only capable of communication, but also searching always for connection, like an iphone searching for a wifi network. We presume that humans look for and interpret the world as full of agents seeking to send them messages.

This model of a human mind seeking for an agency is slowly emerging as a powerful theoretical innovation of recent studies both in religion (Barrett, 2004; Boyer, 2001) and in psychosis (Bell et al., 2017; Fernyhough, 2004). Stephen Levinson describes humans as, effectively, "interaction engines" (Levinson, 2006). Levinson points out that the human mind is specifically adapted for conducting social interaction, and that "there is a very special kind of cognition that underlies language use, which is independent of language itself, but on which discourse is built" (2006, p. 86). His term "the interaction engine"—conceived of as an "ensemble of cognitive capacities and motivational predispositions that underlie human communication and interaction, independent of language" (2006, p. 86). We think of feelings of presence as underwritten by this ensemble, which provides the grounds for all communication and interaction with other and world.

Our contribution is to develop the role of interaction in understanding the experience of the presence of invisible others. By foregrounding the interactional level of communication in thinking about presence—to conceive of presence as more than a feeling or sensation of the individual, but as a phenomenon that involves a responsive and interacting world—we see presence as an emergent structure that is the product of minds and worlds in interaction (Corwin & Erickson-Davis, 2020). This does not deny the mental contents, sensory experience or forms of socio-cultural conditioning that accompany the presence produced, but it enables us to shift to a framework that allows us to better conceptualize what Noë calls the varieties of presence that are specific to each interaction. We believe this shift has important lessons for future study of religious experience.

The most basic purpose in both prayer and VR encounters is the establishment of an open channel for interaction; a shared state of readiness and responsiveness to each other. If a medium allows for the purpose to be realized (e.g., minimal lag time in a virtual environment, and set, setting and/or prayer practices of the religious practitioner), then it can succeed in establishing a common ground for more complex forms of communication to occur. In this framing, scholars of presence would do well to attend not just to the medium of the encounters with virtual or unseen others, but also to the aspirations or agendas of those or that which interacts.

The present study had several limitations. First, the change in identity of avatar halfway through the study introduced a potential selection confound. However, the means of dependent variables did not vary significantly between the two groups of participants. Second, we did not include a measure of social desirability, which may have been a confound to our participant's report of advice-following. Third, the measures we used for responsive interaction—willingness to follow advice and whether they followed the advice—were limited as a matter of being the imagined response of the perceiver (as advice they might give themselves). But it is not wholly unlike prayer practice, especially in Kataphatic Christian traditions, which often involves the practitioner making

a request and then listening for a response, with behavioral consequences. Finally, this study was exploratory. Future studies could be designed to test whether social presence plays a mediating role.

This brings us, in the end, to god, and to spirit. It is easy for both secular and religious observers to presume that what matters is the intentional being—the otherness—of the invisible other. The concept of a spirit's presence has meant, for many observers, an individual's private inner awareness of another individual being's existence. But if we allow ourselves to think about presence as communication, we think about it as social experience. The awareness of the supernatural is an awareness of responsiveness, aliveness, interaction. That more deeply captures the nature of the human quest for God, which is not so much an intellectual quest for knowledge of what is, but an emotional quest for relationship and response. That perspective captures also the dynamic interaction between a creature and her experience of a creator, as a relationship built through interaction and responsiveness.

Note

1. These excerpts have been slightly edited to preserve conversational flow. All speakers were participants in the Spiritual Disciplines Project, run by T.M. Luhrmann and funded by the John Templeton Foundation and the National Science Foundation, in which they were interviewed about a range of spiritual experiences.

Disclosure statement

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