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ABSTRACT: Motivated by rising demands for medical care and the recent trends in medical care delivery, this work designs, develops, and evaluates the augmented virtual doctor office (AVDO). AVDO is intended to provide group medical visits in cyberspace (Cyber GMV). This research adopts the design science approach to design AVDO based on the extension of media naturalness (MN) theory. AVDO is implemented in an augmented world setting that integrates real visual cues with a virtual-world technology (Second Life® in this case). The assessment of AVDO is carried out in two ways: (1) through a synthesis of the extended MN theory and technology acceptance theories to assess the relationships of design features as

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perceived by patients with outcomes that include understanding, perceived effectiveness, trust, and behavior intentions, and (2) through the assessment of AVDO's proof of value and proof of use as a supplementary channel for the delivery of medical care. Our work shows how the design features significantly influence outcomes and patients' positive views of the design's value and use. Theoretical and practical contributions of the work are presented.

KEY WORDS AND PHRASES: augmented virtual doctor office, augmented worlds, design science, group medical visits, health informatics, Second Life®, virtual worlds.

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In 2014, U.S. health-care spending was $3 trillion ($9,523 per person), accounting for 17.3 percent of the economy—the highest such percentage in the world.[1] The Affordable Care Act provides coverage for millions of uninsured people, thus substantially increasing the demand for medical services. Combined with the limited supply of physicians, the traditional approaches to medical-care delivery will strain to meet demand for medical services.[2] A governmental study projects shortages and states that "without changes to how primary care is delivered, the growth in primary care physician supply will not be adequate to meet demand in 2020, with a projected shortage of 20,400 physicians."[3] We need creative approaches to supplement the existing medical delivery channels and processes.

Pressure to develop new ways to deliver medical services encourages change through finding alternative methods, such as treating more than one patient at a time or reliance on opportunities afforded by evolutions in information technologies. Telemedicine emerged as the first phase in this evolution that used web-based communication, such as e-mail, chats, blogs, podcasts, portals, and social networks to provide medical care [98], and is advocated as a viable option in delivering medical care [59]. Companies such as Antari offer some medical-care services online.[4] However, patients have concerns about the credibility and quality of care as well as privacy protection and confidentiality when using telemedicine [58]. Another important perception is that the naturalness of communication is lost when current telemedicine technologies are used since they do not focus on fostering experiences similar to visiting a doctor face-to-face. Some physicians use video communication tools such as Skype for patient consultation. However, such communications lack the naturalness of going to a dedicated place for consultation and being in an environment similar to a face-to-face doctor visit. Consequently these technologies have limited acceptability by health-care providers or patients as reliable supplements to time-honored office visits [85].

Resource limitations accompanied by rising demand for medical services have increased interest in care models that boost physician productivity. One such model is called the "group medical visit" (GMV), also known as the group appointment or the shared medical appointment [44]. In GMV, the physician organizes the office visit to meet simultaneously with a group of patients who have the same symptoms or are patients of the same physician. Groups have long been used in mental health consultation and support, but GMV for general medical care is a relatively recent phenomenon. Although initially promoted as a complement to individual visits [70, 71], GMV is increasingly viewed as a prominent feature in the evolution of family medicine [48]; and has its own training programs and standards of practice.[5] Some facilities, such as the Cleveland Clinic,[6] offer GMV to their patients as an option. Research shows that GMV increases productivity, enhances patient and provider satisfaction, and reduces patient isolation and illness stigmas [48, 44]. However, GMV suffers from privacy issues, since people are reluctant to discuss their intimate health issues in the presence of others. Similar privacy issues exist when video-conferencing technologies such as Skype are used for GMV meetings.

Thus, the evolutionary trends in medical care point to using telemedicine and GMV. Both offer clear advantages in terms of access, convenience, productivity, and cost savings. However, the existing options suffer from one or more shortcomings in terms of communication richness, naturalness of visits, or privacy concerns. We suggest Cyber GMV as a place to go for group medical visits online. The design of a Cyber GMV should address two major shortcomings in telemedicine and GMVs: lack of naturalness and patients' privacy concerns. Such a design should provide a sense of shared space for communication similar to face-to-face while preserving patients' privacy. Individuals are normally uncomfortable to disclose their medical issues in groups. GMVs by nature inhibit individuals from the full disclosure of their medical conditions and the natural flow of patients' exchanges with the physician. For this reason, the design needs to maximize information sharing within the group and with the physician in natural settings while preserving patients' privacy. This study reports on the design and implementation of an artifact that address these two requirements: lack of naturalness in telemedicine and patients' privacy concern in GMVs.

Guidelines for theory-based design science by Gregor and Jones [40], Gregor and Hevner [41], and proponents of information systems (IS) research as applied science and engineering, Briggs et al. [20] and Nunamaker et al. [72, 73] emphasize the importance of design constructs that articulate features of design from users' perspective. In this work, we focus on the design features that promote naturalness of communication (face-to-face) and privacy. The objectives of this research are (1) the design and implementation of an artifact that supports Cyber GMV, and (2) the theory-based assessment of the artifact. The utility of a new artifact is reflected in its fitness and use [39, 41, 72]. The criteria for the assessment of any artifact in medical care delivery are its perceived effectiveness and use intentions by its stakeholders, including patients, medical care providers, and health insurance companies. However, acceptance and use by patients is a prerequisite for any such initiative. Hence, we focus on patients as users of the artifact in this paper.

Since naturalness is one of the main requirements of the design, we rely on the media naturalness theory [55, 56]. In our context, the MN theory provides a suitable lens for the design of our artifact because of its focus on face-to-face communication as the standard, which is the ideal in visits with doctors. We contextualize the guiding principles of MN theory to focus on Cyber GMV features that provide a desirable environment for patients. Moreover, we extend the MN theory in this context by: (1) addressing patients' privacy concern that prevents the natural flow of patients' medical information, and (2) extending the dimensions of MN to include the "physical-perceptual" dimension that addresses the physician's ability to "see" patients as in face-to-face visits. We implement this dimension by adding the "augmented world" to the design that combines the real and virtual worlds.

In our design, we use virtual worlds to design an online place that simulates the naturalness of face-to-face visits through an immersive environment with people being represented by their avatars while addressing privacy concern by making the avatars anonymous. We also combine two technologies—virtual worlds and real visual cues—to propose a design feature called the augmented world (AW) to enrich the naturalness of the environment and to provide patients with a delivery channel that is closer to face-to-face visits with a doctor. We call the resulting design and artifact the Augmented Virtual Doctor Office (AVDO). AVDO renders a rich social environment for patient–physician interactions in which multiple communication channels and interaction cues are used, hence promoting the naturalness of communication as well as addressing privacy concern in GMV.

We assess AVDO by using two methods. First, we rely on the theory-based design science guidelines [40, 41, 72] to assess how AVDO's design features promote its utility in terms of understanding, effectiveness, trust, and use intention. Second, we investigate the design's proof of value and proof of use through patients' direct assessment of AVDO [72]. The data for both assessments are collected through experiments with simulated medical sessions using AVDO. Our results support the positive influence of design features of AVDO as well as its proof of value and proof of use.

## Trends in Delivery of Medical Care

Design science theory requires the articulation of the scope, boundaries, and context of this study [40]. A review of the evolutionary trends in care delivery provides the context, scope, and focus of this study, and places our approach within the trajectory of feasible future changes.

## Group Medical Visits

Group medical visit (GMV) is an important trend that can break the mold of one-patient-at-a-time office visits. Currently, there are two types of GMV: patient-focused and physician-focused.[7] The patient-focused GMV makes the physician more efficient at handling patients and provides patients with more information as they hear discussions of other patients about their shared disease. We therefore, focus on the patient-focused GMV in this study. Despite multiple benefits for patients and physicians, GMV has major challenges that limit its adoption. Patients might not feel comfortable speaking candidly in the presence of other patients. Laboratory and examination results are often shared within the group, violating patient privacy. Moreover, as mandated by law, GMV requires large wheelchair-accessible rooms with a private examination room located nearby in case of the need for private examination [48, 70, 71]. These issues could be addressed by holding GMVs in an online setting (hence removing the need for large physical spaces), by incorporating augmented world technologies that enhance communication naturalness, and by making patients anonymous to preserve their privacy.

## Telemedicine

Telemedicine constitutes another evolutionary trend in breaking the mold of traditional medical care delivery. It means offering medical care online or via other telecommunication means.[8] Private payers reimburse for telemedicine, although at a slower-than-expected rate [95]. The U.S. government reimbursements started in the 1990s [18]. The 2014 Center for Medicare and Medicaid Services guidelines cover a wide range of acceptable telemedicine services,[9] indicating the acceptance of telemedicine as a valid means of providing medical care. There is a large body of literature on the efficacy and quality of care in telemedicine, covering a variety of services. However, in a meta-review of published work in telemedicine, it is reported that most work has been focused on the effectiveness and cost-savings associated with telemedicine; and there is inadequate research focusing on patients' perspectives and their use of and satisfaction with telemedicine [30]. Part of the problem is that many telemedicine systems are either ad hoc (such as using e-mails or video conferencing) or productivity tools (such as systems used for storage and exchange of medical images). A patient-centric telemedicine system supporting Cyber GMV requires the use of technologies that address the need for naturalness of environment and communication similar to patients' face-to-face encounters with medical care providers. Naturalness includes an immersive environment for patients' communication with the physician and other patients without loss of privacy.

## Choice of Technologies

### Virtual Worlds

Virtual worlds (VWs) have emerged as a rich model of online social interactions, particularly in 3D online gaming. VWs strive to create environments suitable for multiuser interactions in real time. Second Life® (SL) is one of the most successful among virtual worlds in terms of number of participants. It differs from other online games in purpose because it emulates real-world experience by providing an environment in which participants "live" through their avatars and take part in various social activities that mimic natural environments. Because of its suitability for creating immersive environments for interactions, a number of initiatives have explored the potential of SL for health-care education and services [12, 17, 42]. Examples of such applications include hospital simulation for managing responses to mass casualty [80], surgical assessment using virtual patients [76], and nurse training in the intensive care unit (ICU) process [19]. We chose SL as the base technology for our design because this platform makes it possible to build immersive environments that are critical for promoting communication naturalness and to create patient avatars that preserve patients' privacy. We augmented SL by incorporating real-world video communications in order to increase the naturalness of the design by allowing physicians to visually inspect patients on demand while preserving patients' privacy.

## Augmented Worlds

The idea of blending the real and the virtual has its roots in many fields. The idea goes back to the 1950s, when adding virtual objects to movies was first introduced [25]. Augmentation is viewed as a real-virtual continuum—starting from the real environment, to which virtual objects are added to enhance the real experience using computer graphics [66]. When the continuum gets closer to the virtual environment extreme, real objects are added to enhance the virtual experience. An augmented world is defined as any system that (1) is a mix of real and virtual, (2) involves real-time interaction, and (3) takes place in a 3D environment [5]. We use this definition in our discussion of augmented worlds.

The augmentation of the virtual and the real is an active area of innovation in medicine with a wide variety of application fields [9]. Examples include combining a patient's phantom and virtual images with real visuals in surgery [22, 33], using augmented reality to assist combat medics [96], interfacing rehabilitation equipment with virtual environments [82], and combining real and virtual therapy to treat posttraumatic disorders [84].

Augmentation has a number of advantages. Adding reality to virtual worlds provides access to additional layers of visual cues and information, supports the complex and layered representation of reality, and promotes media naturalness. Virtual parts in augmented reality could simulate reality to protect humans in risky environments. Moreover, virtual enhancement provides greater control and access to detail. While augmentation is applicable in various fields, at present there is no general platform (such as Second Life®) for augmented worlds.

In sum, current research places Cyber GMV and AVDO on the trajectory of trends in the delivery of medical care and the emerging technologies. The following sections report the theory-based design of AVDO that builds on these trends and the patient-centric assessment of design in terms of their impacts on patients' perceptions and their intention to use AVDO.

## Theory-based Design of AVDO

A patient-centric design for Cyber GMV requires guidance for the selection of features in the delivery system. One of the principles of design science is the reliance on theory to design an artifact and to examine its utility [20, 39, 40, 41]. Since GMV entails social interactions among patients and with the physician, theories that focus on social cues are candidates to guide the design. Two well-known theories have guided research in the effectiveness of media in social interactions—media richness theory [26] and social presence theory [88]. Media richness theory posits that the effectiveness of a communication medium depends on the richness of possible cues, and more complex and ambiguous tasks require richer cues. There have been conflicting reports on the validity of sole reliance on the richness of cues [13, 57]. The social presence theory provides a broader theoretical lens and focuses on users' perceptions of such cues. Social presence is defined as "the extent to which an individual psychologically perceives other people to be physically present when interacting with them" [23, p. 337], or "a sense of being with another in the virtual environment" [16, p. 460]. Building on the above two theories, the media naturalness theory takes the perspective of evolutionary psychology, arguing that during most hominid history, humans have primarily relied on face-to-face communication. As a result, our brains have evolved to capture and process face-to-face cues quickly and with minimum cognitive effort [56]. The MN theory defines the "communication naturalness" of a medium as "the degree of similarity of the medium with the face-to-face medium" [56, p. 407], and posits that communication naturalness increases understandability.

The level of communication naturalness has two dimensions: space-time and expressive-perceptual [55]. The space-time dimension involves two subfactors: (1) colocation in which individuals engaged in communication can see and hear each other, and (2) synchronicity in which individuals engaged in communication can exchange communicative stimuli in real time. The expressive-perceptual dimension involves three factors: (1) the ability to convey and listen to speech, (2) the ability to convey and observe body language, and (3) the ability to convey and observe facial expressions [56]. In designing AVDO, we rely on the MN theory and extend its dimensions in the context of medical care, as shown in Table 1 and discussed below.

## Space-Time Dimension

The space-time dimension of communication naturalness promotes social presence and creates a sense of "being there." Colocation is viewed as the extent of similarity to the face-to-face environment, which generates increased perceptions of social presence [50, 81], and as "the *feeling* that the people with whom one is collaborating are in the same room" [63]. Second Life® (SL) provides virtual places for people to go to and meet with other people's avatars, hence creating a sense of being there with others. For the AVDO design, creating a virtual place required

Table 1. Extended Media Naturalness (MN) Theory for Augmented Virtual Doctor Office (AVDO) Design

| Dimension | Principles and features to promote social presence and understanding |
|---|---|
| Space-time | Colocation: AVDO virtual structures and architecture, walking paths and signage, reception and education areas, medical objects, avatar representation of patients and the physician |
| | Synchronicity: synchronous interactions among avatars |
| Expressive-perceptual | Verbal messages: avatars' ability to talk and text |
| | Ability to observe body languages: avatars' movements and gestures |
| Extension: Physical-perceptual | Ability to selectively observe/perceive patients' physical aspects in real time. The augmented world (AW) combines virtual and real worlds to allow physicians to see the patients, while preventing patients from seeing each other in order to preserve their privacy |
| Extension: Privacy preservation | The capability to protect patients' identities by making patients' avatars anonymous to other patients. |

creating a medical campus architecture that resembles what patients normally see in face-to-face office visits. We designed the AVDO's structures and signage to be familiar to visitors to a medical campus. The architecture of AVDO includes an open-air arrival area, various walking paths with signage, a reception area for processing patients, educational buildings, and medical offices for patient visits (Figure 1).

Research in virtual worlds suggests that the avatar becomes a genuine representation of the real person in the online social context, replicating real-world social norms (gender and interpersonal distance) associated with "space sharing" when interacting with others [31, 60, 97]. Hence, we created avatars with different appearances. The physician avatars are dressed like real physicians—with white coats and a stethoscope. Patient avatars are designed based on their gender. Furthermore, it is reported that multiple 3D virtual artifacts invoke positive emotions in patients [3], hence increasing their immersive experience.

The AVDO design involves details such as creating and placing green plants and large windows with views, and includes objects expected in medical clinics such as wheelchairs, oxygen tanks, and IV poles. The physician office for GMV contains the physician chair and patient chairs in a half-circle around it. Partitions in the room provide the impression that individual examination could be possible. Patients and the physician share the space since they congregate in this place for the sole purpose of a Cyber GMV. Hence, AVDO provides an immersive experience of being in a medical clinic in a three-dimensional visual environment.

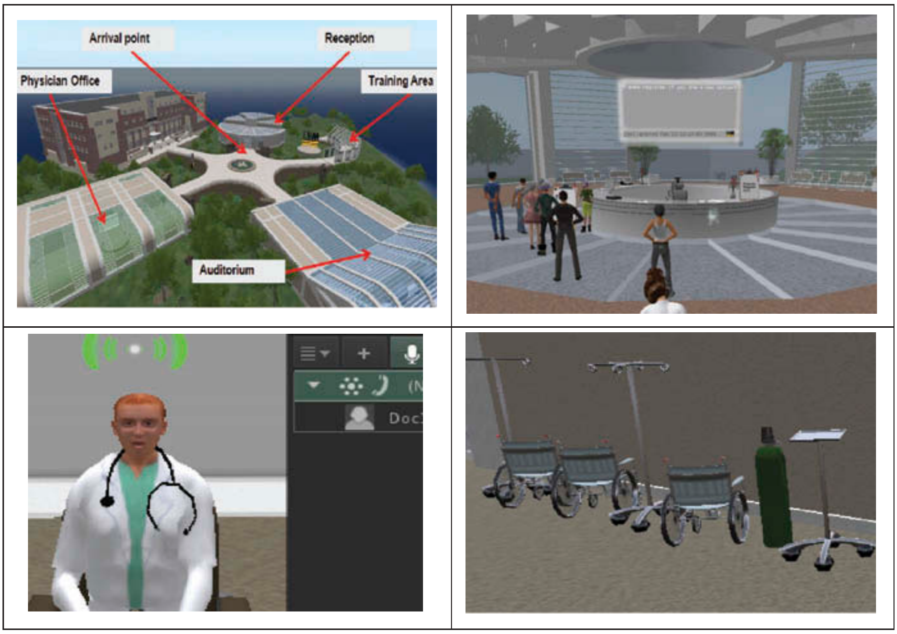



*Figure 1.* Top row: The Overall View of AVDO (left), the Reception Area (right); Bottom Row: Physician Avatar (left), Office Hallway (right)

The second factor of the space-time dimension is synchronicity—synchronous interaction allows for faster exchange of messages and immediate feedback [28]. AVDO supports synchronous interaction among the avatars through voice and text. The communication exchanges are delivered almost at the speed of face-to-face interaction in AVDO.

## Expressive-Perceptual Dimension

The expressive-perceptual dimension enhances communication and reinforces social presence. The first factor in this dimension involves conveying and listening to verbal messages. In AVDO, individuals can talk through their avatars, which convey audio and visual cues. The avatar emits the user's real voice to the room, audible to all other avatars in the room. A green wave on the head of the talking avatar lights up to indicate who is speaking. Thus, the group knows who is talking. Previous work related to avatars in virtual worlds suggests that, compared to other forms of mediated communication, communication via avatars is perceived as more social, warm, and personal [14, 86]. Hence, AVDO promotes the emotional arousal that creates a more immersive experience and affords users increased communication understanding.

Another supported communication facility is a chat box for instant text messages within the group, with the avatar's name identified as the source. This facility is important since specialized medical terms and drug names are discussed in GMV. The texting capability is helpful in removing the ambiguity and increasing understandability of such terms discussed in the group. If the recognition of patients' voices in the group poses a threat to privacy and confidentiality, patients can communicate only by text, while the physician can use both voice and text.

The second factor in this dimension involves conveying and observing body language. Avatars in AVDO are capable of different movements and gestures, such as being seated on chairs to start the session and standing up when it ends. When writing a message, all group members can hear the sound of typing while the fingers of the writer avatar show typing movements. These audio and visual cues alert the group and the physician that the avatar is writing a message to the group. This is helpful to the physician in managing the GMV, since the physician can pause for a few seconds to allow the message to be conveyed. Moreover, the body of the avatar responds to the mouse movement of the person or to the lack of activity. Individuals can convey emotions and feelings though their avatars in the group. For example, when laughing the avatar's body convulses and emits the sound of a belly laugh, when clapping the avatar claps and emits a clapping sound. These expressions increase group involvement since positive and negative feelings could be conveyed and the physician is able to monitor the group atmosphere. The third factor in the expressive-perceptual dimension is facial expression. Although there is some research at early stages to capture real emotions in SL [52], avatars in SL can use icons to express their emotions in a limited fashion.

The ability to examine patients' physical aspects selectively is natural in a face-to-face office visit, which needs to be included in Cyber GMV to improve its naturalness without interrupting the flow of the Cyber GMV session. Patients trust the physician's diagnosis if they feel that the physician has all the needed information. To support this factor, we propose the extension of the media naturalness theory to include the physical-perceptual as a separate dimension.

## Physical-Perceptual Dimension and Augmented World as Its Implementation

In the context of medical office visits, the physical-perceptual dimension focuses on the ability to selectively observe/perceive patients' physical aspects. This was implemented by augmenting the virtual and real worlds. We added a webcam video to AVDO to convey visual cues of patients to the physician on demand, based on two criteria: (1) real visual cues should not interrupt the flow of group sessions, and (2) the anonymity of patients should be preserved. This means that patients must be unable to see each other, whereas the physician should be able to observe patients' physical aspects as needed. To satisfy these two requirements, all voice communications (including all audio communications related to videos) were kept inside SL. The physician was able to see patients via a webcam. Figure 2 shows a session in AVDO.

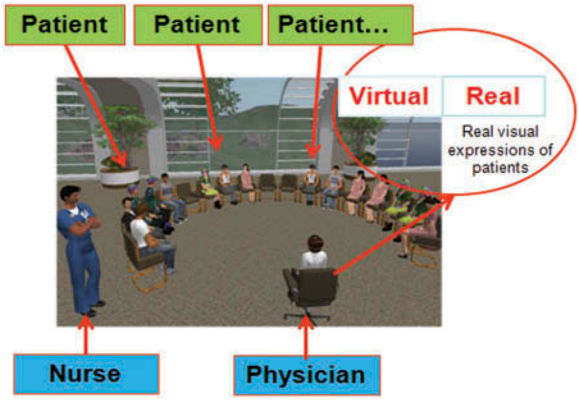



*Figure 2.* The AVDO Design for Cyber GMV

For example, when the physician (through his avatar) asks a patient to move closer to the webcam for a visual inspection, the physician's voice and the patient's texted response are conveyed within the SL session, and not from outside the virtual world. The webcam is a one-way visual cue since only the physician can see the real visual cues. No private communication between the physician and a patient is allowed through video communication, since doing so would interrupt the GMV session and alter the experience of immersion and shared space.

In this way, AVDO augments patients' real visual cues to the physician's view without interrupting the flow of group discussions or compromising the anonymity of patients. The augmentation enriches users' experience in GMV since the availability of real visual cues adds to the naturalness of experiences in AVDO.

## Privacy-Preservation Dimension

While media naturalness accounts for naturalness of communication in an open environment, the medical/health-care context adds another layer to the naturalness of communication in terms of privacy. Contextualization of a theory is accomplished by extending the theory to include constructs specific to the study's context [45, 94]. We extend the MN theory to the medical context by adding the privacy-preservation dimension, defined as a communication environment that allows the natural flow of communication while preventing the exposure of patients' personal information, thus protecting their privacy. This dimension is similar to face-to-face communications appropriately designed for interactions in medical offices. This dimension is also critical in Internet-mediated communications of private health information. In other words, being in the same "room" requires a room suitably designed for communicating private health information that adds to the naturalness of patient–physician encounters by preserving patients' privacy. AVDO makes it possible for patients to freely communicate with the physician avatar in a natural way (that could include real-world cues), allowing all GMV patients to be involved in all communications while preserving their privacy. This is done by making avatars anonymous in the GMV session. Only the physician has access to patients' real names that match with the pseudo-names used to create avatars.

## Theory-based Assessment of AVDO

The design science approach requires a rigorous assessment of design [20, 39, 40, 41]. Experimentation is one of the recommended approaches to assessment.

> Experimentation includes research strategies such as laboratory and field experiments. . . . It straddles the gulf between theory building and observation in that experimentation may concern itself with either the validation of the underlying theories (looking backward along the research life cycle) or with the issues of acceptance and technology transfer (looking forward along the research life cycle). Experimental designs are guided by theories and facilitated by systems development. Results from experimentation may be used to refine theories and improve systems. [73, p. 95]

We rely on experimentation through simulated medical group visits to assess AVDO from a patient-centric perspective in two ways: (1) theory-based assessment of AVDO's design in promoting its acceptance in terms of trust in AVDO, effectiveness of GMV sessions, and people's intention to use AVDO; and (2) direct assessment in terms of proof of value and proof of use [72]. Both assessments are carried out in experiments using AVDO in simulated medical sessions. The guiding theory in assessment is the extended MN theory and constructs that are relevant to the acceptance of technology. This is in line with the theory-based assessment rigor articulated in guidelines for design research [40, 41, 72].

### Design Features

Material features of AVDO include avatars, objects, and various communication channels. These attributes are designed to achieve the goal of social presence and afford people the immersive experience of being in the doctor's office. Therefore, in our design, AVDO's social presence, presence of AW, and lack of privacy concern are the prominent design features.

### Outcomes of AVDO Assessment

The theoretical lens used in the assessment of AVDO makes it possible to assess AVDO as both a medium of communication and a mode of delivery of medical services. As a communication medium, AVDO is designed based on an extension of the MN theory, and therefore its design features should be assessed based on the outcome in the MN theory—communication understandability. As a mode of delivery of medical services, AVDO should be assessed for its acceptance by patients in terms of effectiveness of group medical visits in AVDO, and people's willingness to trust it and use it for their doctor visits. This approach is in line with assessment guidelines in design science that recommend multiple metrics for assessment [41, 43]. The ultimate purpose of most, if not all, artifact designs is their adoption and use by target users, making use a critical value category in design science research [72].

Information technology (IT) use and use intention have been the outcome constructs for IT acceptance theories in information systems, including the technology acceptance model, the theory of planned behavior, and the theory of reasoned actions [4, 27]. Intention to use also reflects users' opinions about the acceptability of AVDO for future doctor visits. Therefore, we include intention to use AVDO as another outcome in the theoretical assessment of AVDO. Thus, the assessment outcomes of AVDO are measured by four constructs: communication understandability, GMV effectiveness in AVDO, trust in AVDO and intention to use AVDO. We call the conceptualized model the AVDO Assessment Model (Figure 3), and discuss its hypotheses below.

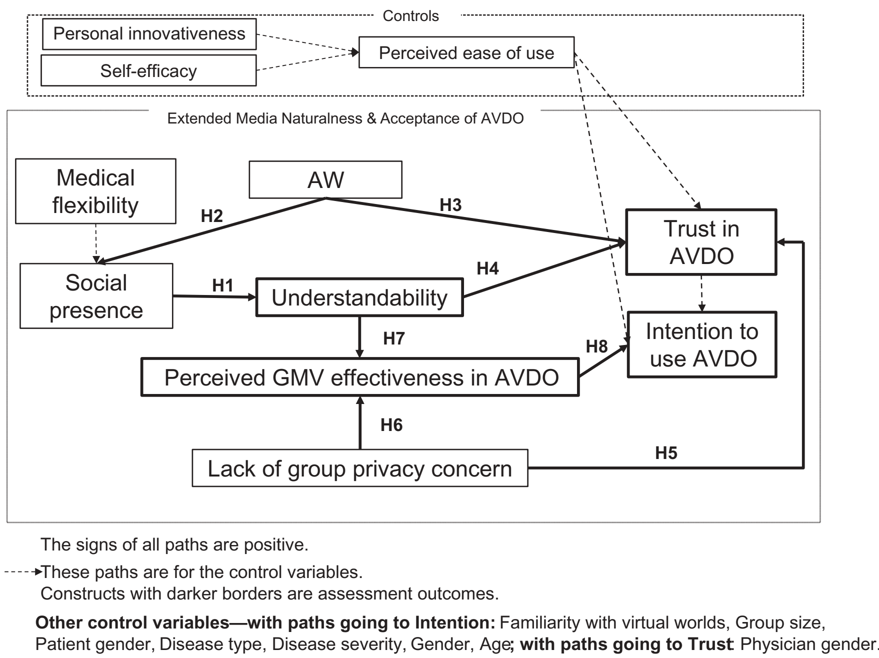



*Figure 3.* The AVDO Assessment Model

## Social Presence → Communication Understandability

In the MN theory, the main outcome of communication is the understandability (defined as the clarity and ease of comprehension) of what is being communicated. Kock [55] set forth the "media naturalness proposition" in which he argued that any decrease in communication naturalness increases the cognitive effort and ambiguity of communication. Here, we define communication understandability in AVDO as the clarity and ease of understanding what is being communicated [99], which includes all communicated information within the AVDO session. Applied to this context, social presence refers to perceptions of being physically present in AVDO and having a sense of being there in the doctor's office when communicating with the physician as in face-to-face interactions. It is shown that understandability is an important dimension of information quality [99]. We argue that AVDO's social presence promotes communication understandability. This assertion is strongly supported by evidence from multiple empirical studies.

In online education, social presence is shown to increase students' cognitive absorption and assists them in learning [61]. Studies in e-commerce have also indicated the significant role of social presence in promoting the informational value of communicated messages [49, 51]. Mennecke et al. [65] argue for a broader role of social presence in understanding others' minds. We, therefore, posit that AVDO's social presence promotes the understandability of communication in AVDO. Hence,

> *Hypothesis 1: Social presence in AVDO is positively associated with understandability of communication in AVDO.*

## AW → Social Presence

Communication is perceived to be interactive when responses are exchanged in real time with users being provided with immediate feedback based on their input [54, 69]. If a mediated environment enables a higher level of interactivity or naturalness similar to that of face-to-face communication, such as the ability to interact and respond in real time, the perceived similarity with the real world experience will increase [54]. The degree of interaction richness is influenced by the sensory depth and breadth of the mediated interface [91]. Depth refers to the quality of information communicated by a perceptual channel, while breadth relates to the number of sensory dimensions simultaneously presented [91]. A channel transmitting an image with more depth (3D image compared to 2D image) is perceived to provide higher sensory depth [49]. Similarly, a medium simulating multiple sensory channels has greater sensory breadth (e.g., television with both audio and video compared to radio with only audio). Thus, a message appealing to several perceptual systems should be better perceived than one that uses a single perceptual system.

With AW, patients in GMV know that the physician is able to visually examine them, if needed. This increases the similarity to natural communication. The physician can ask patients to show their physical symptoms on the webcam. Since close visual inspections are normal in office visits, this adds to the realism of the GMV office visit in AVDO for the patient being asked. Moreover, since all patients in GMV hear the physician asking a patient for a visual inspection (such as asking the patient to show the skin irritation on the webcam), the AW increases the realism of the GMV visit for all patients. Although the voice communication is within the virtual world, the knowledge that the physician can inspect patients visually adds an extra dimension to the cues and brings the communication closer to face-to-face visits. Hence,

> *Hypothesis 2: The augmented world (AW) in AVDO is positively associated with AVDO's social presence.*

## AW → Trust in AVDO

When the physician can see patients' visual cues, patients should feel more assured that physician can make an accurate diagnosis. Furthermore, one of the important aspects of trust in the context of medical care is the knowledge and expertise of the physician. The physician's ability to make an accurate diagnosis is critical in this context and increases trust. Furthermore, since AW brings AVDO closer to the traditional doctor office with which patients are familiar, their trusting connection becomes stronger with the physician [37, 38]. The ability to visually examine patients as needed portrays the physician as empowered and equipped to provide quality care. This sense of authority should increase patients' trust. Furthermore, the ability of the physician to ask more pertinent questions and conduct analysis within the GMV session tells the group what the physician is looking for, enabling all patients to share more accurate information. This increased richness should generate positive emotional reactions from patients [3], leading to a more favorable and trusting view of AVDO. Hence,

> *Hypothesis 3: The use of augmented world (AW) in AVDO is positively associated with trust in AVDO.*

## Communication Understandability → Trust in AVDO

In addition to the communication understandability outcome in the MN theory, the IT adoption constructs should also be accounted for in the assessment of AVDO. Trust is shown to be a prime determinant of what people expect from a social interaction, especially when the environment is uncertain and the cost of a mistake is high [34, 64]. In the context of health infomediaries, it has been shown that information quality, particularly understandability, has a significant impact on trust [90, 99]. The communication with patients is characterized by a high level of social interaction and a significant part of medical care consists of providing information and expert advice [92]. Thus, medical care is predicated on the ability of the physician to deliver unambiguous and understandable information. Moreover, physician errors can be quite costly to patients' health and finances. Hence, the desirable outcome of communication naturalness in terms of increased communication understandability should have a significant impact on trust in AVDO.

> *Hypothesis 4: Increased communication understandability in AVDO is positively associated with trust in AVDO.*

## AVDO's Lack of Privacy Concern → Trust in AVDO

Privacy concern has a number of definitions. Following Clarke [24] and Davis et al. [77], we define privacy concern as the desire to have control over the exposure and dissemination of one's personal private information. We extend the MN theory to include the influence of the lack of privacy concern in the medical context. Literature on trust in the technology adoption has shown that privacy concern has a significant influence on trust, particularly in the content of disclosing health information [6, 7, 8]. The perception of people about avatar anonymity addresses their privacy concern in AVDO and is measured by the construct called lack of privacy concern. Privacy has been shown to play an important role in patients' and customers' perceptions about providers [8]. Prior to participation in AVDO, patients are assigned avatars with names unrelated to their real names. The assignment process brings the focus on anonymity and privacy assurance to patients' attention. In using AVDO, when patients see that AVDO is designed to protect their privacy in GMV sessions by making their avatars anonymous, their trust in AVDO should increase. Hence,

> *Hypothesis 5: Lack of privacy concern in the GMV sessions in AVDO is positively associated with trust in AVDO.*

## AVDO's Lack of Privacy Concern → Effectiveness of GMV in AVDO

Running an effective group session in AVDO requires the preservation of patients' privacy. The anonymity of avatars in AVDO is designed to address privacy concerns of patients in group medical visits (GMV) and afford them privacy. In the design of AVDO, we argued that this anonymity makes it possible for people to be open about their private medical issues without feeling embarrassed in the group or risking privacy invasion. Privacy concern in the GMV group setting has been such a major issue that some have proposed removing the patient from the GMV session to discuss private issues [53], which defeats the purpose for which the GMV was originally designed. Patients attending the GMV in AVDO are anonymous, thus affording privacy to patients in the GMV session. The patients' anonymity in AVDO makes the GMV session a superior option since it deals with patients' privacy concern while maintaining the advantages of GMV. Hence, we argue that AVDO causes patients to perceive the GMV sessions in AVDO as more effective because they can share their medical problems with no concern about privacy.

> *Hypothesis 6: Lack of privacy concern in the GMV sessions in AVDO is positively associated with perceived effectiveness of GMV in AVDO.*

## Understandability of Communication → Effectiveness of GMV in AVDO

The MN theory argues that lower levels of naturalness lead to increased cognitive effort, increased ambiguity, and lower levels of psychological arousal in information communication, leading to misunderstanding and poor information communication [55, 56]. Understanding plays a critical role in group settings [46], particularly in GMV sessions, because the physician and patients use many medical terms for diseases, symptoms, drugs, reactions to drugs, procedures, and treatments in such sessions. Moreover, patients need to understand other patients' interactions with the physician as they describe their symptoms, experiences with various drugs, procedures, medications, and actions. With a higher level of understanding, patients in such sessions are able to accurately answer the physicians' questions, communicate their medical issues, comprehend the information provided by the physician, and learn from the exchanges between other patients and the physician. The clarity of communications and quality comprehensions ease and accelerate the flow of information, which makes the session more efficient and productive. This should lead patients to form positive perceptions about the effectiveness of the Cyber GMV session because they feel their medical issues have been addressed and they have gained better insights about the scopes and treatments of their medical conditions from the information exchanges within the session. Hence,

> *Hypothesis 7: The understandability of communication in AVDO is positively associated with perceived effectiveness of GMV in AVDO.*

## GMV Effectiveness in AVDO → Intention to Use AVDO

AVDO is designed for group medical visits online. It is expected that group sessions in such visits be conducted effectively, in a timely and coordinated fashion. Therefore, the perceived effectiveness of GMV in AVDO should increase people's acceptance of the technology in their future doctor visits. We argue that the benefits of an effective group medical visit motivate people to use AVDO as a supplementary channel for their medical care because an effective GMV session makes patients communicate their medical issues effectively and patients obtain useful information from their exchanges with the physician as well as other patients' exchanges in the session. Hence,

> *Hypothesis 8: GMV effectiveness in AVDO is positively associated with intention to use AVDO.*

## Control Variables

A large body of research in the acceptance and use of IT artifacts shows that IT artifacts' usefulness and ease of use influence users' acceptance and use [34, 93]. We have examined the usefulness of AVDO in terms of GMV effectiveness and communication understandability. However, users' assessment of AVDO could also be influenced by ease of use and users' attributes in terms of their technology self-efficacy and their openness to technology innovation called personal innovativeness [1, 2]. These constructs have been added to the model to control for any variations caused by participants' IT-related attributes and their perception about AVDO's ease of use. Similarly, the literature has established the significant impact of trust on use intention [34, 99]. This path has also been added to control for the variability in use intention due to trust in AVDO.

Another relevant control variable is medical flexibility. Recent studies have shown that resistance to change is an individual disposition that manifests itself in a variety of contexts and sources, including cognitive rigidity, preference for routine and habit, and negative emotional reaction to change [75]. While resistance to change is an inhibitor, flexibility facilitates cognitive engagement and involvement with new ways of doing business [15]. In our context, flexibility applies to receiving medical care offered through AVDO. Hence, we define medical flexibility as the willingness of patients to receive medical care in a new and nontraditional way. This control is relevant because AVDO provides patients with a new channel for receiving medical care. Patients' cognitive flexibility, tolerance for learning new ways, and willingness to change the habitual way of visiting doctors motivate them to immerse themselves in social interactions in AVDO, thus enhancing their sense of social presence. Hence, this control is an antecedent of social presence.

A number of other relevant control variables are included in the model, including gender of physician, patient gender and age, familiarity with virtual worlds, group size, disease type, and severity. Gender is shown to make a difference in the adoption of technology [36]. Hence, we included the gender of both the physician and patients as controls. Familiarity with technology is also shown to play a role in its adoption and use [34, 99]. It is recommended that theory contextualization should include context-specific control variables [45]. Since GMV sessions in AVDO could have different sizes, the number of patients in the group is used as a control. Since the type and severity of diseases could play a role in the group process, they too are controlled. The data for group size, type and severity of disease, and physician gender were controlled in the experiment. The data for the rest of the controls were collected from the participants.

## Research Method

The research method is experimentation using AVDO in simulated group medical visits and then collecting data from participants though a survey instrument.

### Artifact Development

The authors designed AVDO. The scripts for implementation were written in LSL (Linden Script Language). Three professional consultants with expertise in design and coding in Second Life® assisted in implementation and testing the flow. Based on the feedback, numerous modifications were made before finalizing AVDO. The process took eight months. The development of AVDO provided a proof of concept [41, 72].

### Instrument Development

To ensure construct validity, the instrument was developed based on existing scales except for items to measure perceived GMV effectiveness. Appendix A reports the instrument and the sources for item design.

### Pre-data-Collection Tests

The instrument and the data collection protocol in simulated AVDO sessions were pretested and pilot tested in multiple stages. The instrument and the data collection protocol were pilot tested through simulated sessions involving twelve participants. Based on detailed interviews with each participant, appropriate changes were made to the protocol and the instrument. All changes related to the data collection protocol were made with the approval of the physician. Finally, eight new participants assisted in evaluation of the protocol and survey instrument.

### The Experiment Protocol

A protocol for the lab experiment was developed in which participants were randomly assigned a list of disease symptoms (for either influenza or acne) that had one of three levels of severity and then attended the medical group session using AVDO for the doctor visit (Appendix B). The purpose of the simulated sessions was to have participants experience visiting a physician in a GMV session in AVDO for a specific health problem, and to collect data for assessing AVDO.

In order to measure the effect of the augmented world (AW), there were two types of sessions: purely virtual and augmented (AW = 0 or 1). Due to the technology requirement (with or without webcams), the sessions for AW = 0 and AW = 1 had to be scheduled separately. Therefore, the experiments were carried out in two rounds: Round 1 with no webcams in simulated sessions (AW = 0), and Round 2 with webcams in simulated sessions (AW = 1) in two consecutive academic semesters. There was no overlap between the participants in the two rounds.

Simulated sessions involved two diseases (influenza and acne) with three levels of severity (mild, medium, and severe), leading to six options. The reason for having these six options was to control for any bias that a single disease or a single level of severity may cause in the data. A qualified physician assisted the research team to identify levels of severity, symptoms at each level, and detailed treatment protocols that included diagnosis and recommended medical advice and prescriptions. The final protocol was checked and validated by the physician for accuracy. The participants were recruited from students at a large Midwestern university. Appendix B provides more details of the protocol.

The selection of diseases in the protocol was based on the participant population and their prior experience with the diseases. According to the National Institutes of Health (NIH), an estimated 80 percent of people between the ages of eleven and thirty have acne outbreaks at some point in their life. Influenza (commonly known as the flu) is the most common disease in the United States for all age groups and is among the top college illnesses [62]. According to the NIH, "influenza remains a major threat to public health. Recent studies show that in a typical influenza season, 5 to 20 percent of the United States population falls ill, more than 200,000 are hospitalized, and 36,000 die."[10] Thus, for the two diseases used in the simulated GMV sessions, the student population should be a suitable sample population.

## Data Analysis

### Sample

The data collection resulted in 322 usable observations. Sample statistics are reported in Table C1 (Appendix C). Since the data were collected in two rounds, we checked to see if there were significant differences in the two rounds in the subject attributes. There were differences in gender and age. We checked whether the model constructs related to subjects' attributes differed in the two rounds. Hence, we tested the difference in self-efficacy, personal innovativeness, medical flexibility, and lack of privacy concern since these constructs were personal constructs that were the antecedents in the model. We used the general item in each construct for these tests. As seen in Table C1 (Appendix C), these attributes were almost identical in the two rounds and had no statistically significant differences. We concluded that the two rounds did not differ in subjects' attributes in the model and therefore combined the two rounds into one sample for data analysis.

### Common-Method Bias

We followed the guidelines for the structural equation modeling (SEM) analysis [35]. To ensure against the threat of common-method bias (CMB), items were measured with semantic scales and neutral wordings [79]. After the data collection, we performed a number of checks for CMB.[11] Although the results were favorable, we decided to purify the data in the model estimation to ensure that CMB did not pose any threat to the analysis. To do so, we used a marker item, regressed all items with the marker, and used the residuals as data in the model estimation [79, 89]. We also compared the results using the original data and the purified data; the results were similar. We report the model estimation results with the purified data.

## Reliability and Validity Checks

The results of reliability checks for constructs are reported in Table C2 (Appendix C). The Cronbach values were well above the cutoff point of 0.70 [74]. All average variance extracted (AVE) values exceeded the recommended threshold of 0.50 [32]. The composite factor reliability values were also at or above the recommended 0.70 cutoff [87]. Thus, the reliability of constructs was supported. We compared the values of construct correlations with the square root of AVE to check if any correlation value exceeded the square root of AVE [32]. As shown in Table C3, Appendix C, none did. This provided support for the discriminant validity of constructs. The exploratory factor analysis (EFA) was conducted to further examine the discriminant and convergent validity of constructs. The results are reported in Table C4, Appendix C. All factor loadings were above the cutoff point of 0.70 except for two items, which were close to the threshold. The items loaded on their appropriate factors and there was no evidence of significant cross-loading. We performed the confirmatory factor analysis (CFA) using the measurement model. The measurement model was estimated using MPlus 7.3 [68]. Table 2 shows the fit indices of the measurement model.

All fit indices were desirably above (or below) the recommended cutoff value. Table C5, Appendix C reports the standardized CFA results, including items' factor loadings, *t*-values, and $R^2$. All item loadings were above 0.70, with

Table 2. Fit Indices for the AVDO Model

| Fit index | Measurement model | Estimated model | Recommended cutoff value* |
|---|---|---|---|
| Normed $\chi^2$ | 1.58 | 2.30 | <3.0 |
| CFI (comparative fit index) | 0.98 | 0.93 | ≥ 0.90 |
| TLI (Tucker–Lewis index) | 0.97 | 0.92 | ≥ 0.90 |
| RMSEA (root mean square error of approx.) | 0.043 | 0.064 | ≤ 0.10 |

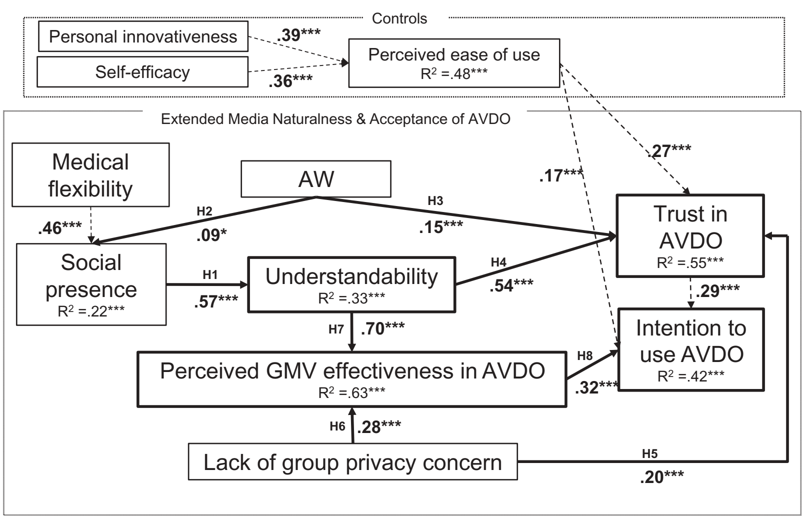
*Sources*: Hu and Bentler [46]; Muthén and Muthén [67].

statistically significant $t$-values and $R^2$ (all with $p < 0.0001$) [67]. Together, these results supported the discriminant and convergent validity of constructs. The assessment model was estimated using SEM and MPlus 7.3 [68].

## Model Estimation

Figure 4 reports the results.[12] The estimation used the mean-adjusted maximum likelihood, which adjusts the estimation result for nonnormality in the data. As shown in Table 2, all the fit indices for the estimated model were desirably above or below the recommended thresholds [46, 67]. These findings provided support for the model fit.

Furthermore, per Figure 4, the $R^2$ values were also statistically significant at $p < 0.001$. In sum, the fit indices and statistically significant $R^2$ values provided evidence for model fit. All paths were statistically significant, supporting all hypotheses H1–H8. The AVDO's social presence was significantly associated with understandability of communication, strongly supporting H1 at $p < 0.001$. AW impacted both social presence ($p < 0.01$) and trust in AVDO (at $p < 0.001$). AW influenced trust twice as much as social presence, indicating that the ability of the physician to examine patients is critical in trust building. Lack of group privacy concern was another feature in AVDO that was promoted by the anonymity of patients' avatars. It had a significant influence on patients' trust in AVDO as hypothesized in H5 ($p < 0.001$) and on their perceptions of GMV effectiveness in




*** p-value <0.001, ** p-value <0.01, * p-value <0.05, ns=not significant

**Other control variables—paths going to Intention:** Familiarity with virtual worlds (ns), Group size (-.13***), Patient gender (ns), Disease type (ns), Disease severity (ns), Visual inspection (.12***), Gender (ns), Age (ns); **paths going to Trust**: Physician gender (ns).

*Figure 4.* The Estimated AVDO Assessment Model

AVDO as hypothesized in H6 ($p < 0.001$). The path understandability → GMV effectiveness (H7) had the highest path coefficient in the model (0.70, $p < 0.001$) indicating that media naturalness plays an important role in this design. Furthermore, the path understandability of communication → trust in AVDO had the second highest coefficient (0.54, $p < 0.001$), indicating additional evidence supporting the critical role of media naturalness in AVDO design. Use intention is the ultimate goal of any design prior to its field implementation. The path of effectiveness of GMV → intention to use AVDO (H8) indicated a strong association (0.32, $p < 0.001$), hence supporting the role of effectiveness in the success of AVDO.

The constructs personal innovativeness, self-efficacy, and medical flexibility are users' attributes that play a role in the formation of their perceptions regarding AVDO, and thus needed to be controlled in the analysis. The significant association of personal innovativeness and self-efficacy with perceived ease of use, as well as the significant association of users' medical flexibility with their perception of social presence indicated the important role of these user attributes in the success of AVDO in practice. Other user attributes—age, gender, and familiarity with virtual worlds—were not significant in the estimated model.

Of other control variables, group size was significant with a path coefficient of –0.13 ($p < 0.001$). For sessions in which AW = 1, some subjects were visually inspected through the webcam and some were not. We controlled for the impact of having been inspected by a binary variable (visual inspection) in the outcome variable. The path coefficient for this control was 0.12 ($p < 0.001$).[13] This result indicated that being visually inspected by the physician enhances subjects' intention to use AVDO.

## Assessment Through Proof of Value and Proof of Use

Arguing for multiple values of IS research as applied science, Briggs et al. [21] and Nunamaker et al. [72] recommend investigating proof of concept, proof of value, and proof of use. Appendix D presents multiple analyses of AVDO's values in terms of comparison with traditional doctor visits, satisfaction, value, and use.

## Discussion

In this work, we designed and developed AVDO by contextualizing the MN theory to Cyber GMV and extending it by adding two new dimensions called the "physical-perceptual" dimension that focuses on the ability of the physician to selectively examine patients' real physical attributes, and the "privacy-preservation" dimension that addresses patients' privacy concern. The technologies that we used in developing AVDO included Second Life®, and augmenting it with the real world via webcam videos—hence the augmented world (AW) that implemented the physical-perceptual dimension. The implementation of the privacy-preservation dimension was accomplished by making patients' avatars anonymous.

We assessed AVDO in two ways. The first method of assessment was based on the synthesis of the extended MN theory with technology adoption theories. This was accomplished by developing a conceptual model that included design features (social presence, AW, and lack of privacy concern) to outcome constructs (understanding, perceived effectiveness of GMV in AVDO, trust in AVDO, intention to use AVDO) as well as a host of control variables based on technology adoption theories and AVDO-specific controls such as group size and patient attributes.

In the design of AVDO, we argued that the space-time and expressive-perceptual dimensions of AVDO create social presence, and lead to increased communication understandability, per the MN theory. Our results strongly supported the positive influence of social presence on understandability. Furthermore, we argued that the physical-perceptual dimension, implemented via VW, increases naturalness, which enhances social presence and trust. AW improved social presence significantly, which in turn improved understandability. Improved understandability was significant in impacting trust and perceived effectiveness of GMV in AVDO. This showed how these two design features—social presence and AW—significantly influence patients' trust and perceptions. Furthermore, the central role of understanding was confirmed.

We argued that preserving patients' privacy by using anonymous avatars leads to the lack of privacy concern, which promotes trust in AVDO and positive perceived effectiveness. Our results showed the significant influence of lack of privacy concern on both constructs. Together, these findings indicated that the theory-based design of AVDO was successful in increasing the naturalness of communication and promoted understanding, effectiveness of GMV sessions, trust, and intention to use AVDO.

The second method of assessment was the investigation of proof of value and proof of use (Appendix D). We compared AVDO with the traditional doctor office, examined satisfaction with AVDO, identified conditions under which patients would use and not use AVDO, and assessed value in terms of trust, use intention, quality of physician service, and reliability of medical service received in AVDO. The results indicated an acceptable level of proof of value and use, which provided further support for the success of the design.

Three results regarding control variables are noteworthy. Group size had a negative impact on the intention to use AVDO. Figure 5 shows the average of three items used to measure intention to use for three categories of group size. This indicates that health providers could not increase group size indiscriminately to save costs. There is a need to find optimum group sizes for GMV sessions. Another important finding is the significant impact of the physician's visual inspection of patients. Although no patients could see the physician, the fact that the physician was paying extra attention by inspecting a patient's visual cues increased the patient's willingness to use AVDO. Finally, our results also showed that patients'

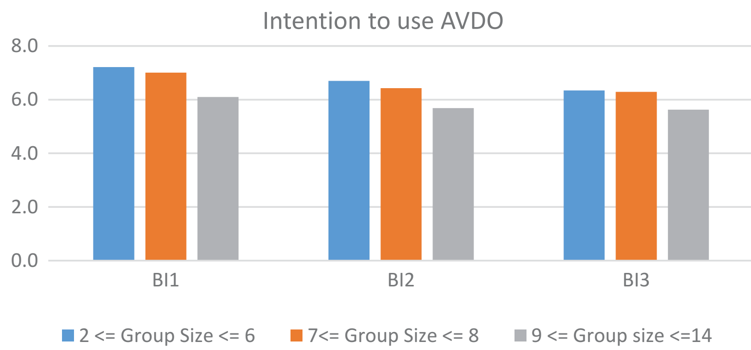



*Figure 5.* The Negative Influence of Group Size on Intention to Use AVDO

attributes are important in their willingness to use AVDO. People's innovativeness and openness to new nontraditional channels of delivery could play a role in selecting early adopters of AVDO.

## Implications

This work makes a number of significant contributions to theory and practice.

### Theoretical Implications

First, this work used the media naturalness (MN) theory to design the augmented virtual doctor office (AVDO). It shows that theory-based design could provide a solid basis for artifact design. There is an ongoing debate about the role of theory in design science [10, 11, 41, 43]. One view considers the design artifact itself as a knowledge contribution [43]. This view sees the goal of design science research as "building and evaluation of the artifact" [10, p. 2]. A second view "requires not just the artifact but a theoretical formulation of the design principles in the form that satisfies the criteria for a theory" [10, p. 2]. Another view argues that there is a contrasting duality in "design" versus "science" that must be addressed, and offers a typology of knowledge generation [11]. Moreover, it is proposed that the multi-methodological approach to IS research "consists of four research strategies: theory building, experimentation, observation, and systems development" [73, p. 94]. Our work contributes to this debate—that design and its assessment could be guided by theory.

Second, we contextualize and extend the MN theory. The extension of MN theory by contextualizing it to online medical services is a theoretical contribution for designing artifacts that deliver medical services online. We extended the MN theory in a number of ways. We added two dimensions that are critical in the health-care context—physical-perceptual and privacy preservation. The synthesis of the extended MN theory with the technology adoption theories provided another extension of the theory. This extended MN theory is a new contribution that makes it more suitable for application as a design science theory.

Third, we used the contextualized and extended MN theory for the assessment of the design. The results showed the influences of design features on success metrics —effectiveness of group medical visits, communication understandability, trust in AVDO, and intention to use AVDO for medical services. It has been argued that contextualization is important in creating theories with more granularity and specificity [45, 94]. Except for Dennis and Kinney [29] and Rice [83], there has not been adequate research in validating the tenets of communication theories regarding use. Contextualized and extended NM theory fills this gap, and our results showed the validity of the conceptualization.

Fourth, we assessed the design in two ways by (1) using the extended MN theory, and (2) using the proof of value and proof of use framework. This approach to design assessment provides two distinct perspectives regarding the influences of design features and the way they impact users' perceptions and behaviors. This approach contributes to the rigor of the assessment process.

## Practical Implications

This work has a number of practical implications. First, providers can use AVDO as an option for the delivery of medical care. The augmentation of the virtual world with real visual cues designed specifically to satisfy the Cyber GMV requirement is a technological innovation since it shows that with proper design, it is possible to remove the constraints of virtual worlds in order to increase the naturalness of communication.

Second, although telemedicine has been accepted by medical establishments such as insurance companies, clinics, and the federal government, the technology of delivering telemedicine has not kept pace with the concept of patient-centric telemedicine. Our design argues for developing technologies that are specific to the needs of patients and physicians in telemedicine and that remove the existing limitations. The Cyber GMV in our AVDO design is a push to break the limitations of group treatments. It is a win–win concept since patients can learn from other patients and access health care from anywhere and anytime; physicians can save time and energy by not having to repeat the same discussions with multiple patients with the same ailment; and medical establishments could reduce the cost associated with physician offices, such as buildings, heating and cooling, parking spaces, and maintenance. Our results indicate that caution is necessary in regard to the need to optimize the size of GMV sessions, as well as the impact of special attention paid to patients who are selectively examined closely in GMV sessions with AW capabilities.

Third, AVDO and the general concept of Cyber GMV remove the need for physical contact with patients. Although the lack of physical contact may be undesirable in some cases, for dealing with contagious diseases, this method of delivery may become a preferred approach. Furthermore, AVDO could provide fast and reliable treatments in areas that face sudden surges of need for medical care such as disaster areas and war zones. Thus, AVDO could provide access to medical care in areas where traditional methods cannot.

Finally, designs such as AVDO make it possible to pool resources from multiple nations and countries when disasters happen or wars break out, creating urgent needs for medical services. Such an environment makes it possible to integrate and deploy medical services in short order.

## Conclusions, Limitations, and Extensions

Our work proposed a new design using the virtual world, Second Life®, and augmenting the virtual with visual cues from video streaming to the physician. Its implementation, called augmented virtual doctor office (AVDO), provided the proof of concept for the design. The design was based on the extension of the media naturalness (MN) theory. Two methods of assessment showed the relevance of design features to patients. The first assessment method was based on an extension of the MN theory and its synthesis with the technology adoption theories. Our results showed that the design features positively influenced outcomes in understanding, trust, effectiveness, and intention to use AVDO. The second method of assessment included proof of value and proof of use, which showed positive outcomes. We concluded that the design and its implementation were successful in that AVDO can be used to provide medical care to patients thus contributing to increased patients' access to medical care.

As in most empirical studies, this research has limitations. The participants were chosen from the college student population (younger and educated) with assigned disease symptoms to simulate patients, which limit the generalizability of our results. This work should be replicated with real patients and different demographic mixes. Another limitation of this work is the nature of diseases used in the simulated sessions—influenza and acne. It is important to examine the acceptability of AVDO with other disease types and patient populations. These are areas for further investigation. Another limitation is that proof of use and proof of value assessments were carried out in a lab study in a simulated environment. These assessments should also be replicated in field experiments with real patients.

This work can be extended in multiple directions related to patient-care delivery. It opens new avenues for research to enhance AVDO and to investigate processes and structures that should be in place in order to serve patients' needs in various conditions and circumstances. It also provides new possibilities for further innovations. For example, it is possible to link patients' medical records to their avatars. As such environments become popular, patients could move from one virtual medical office to another carrying their medical information and lab results with their avatars.

Other extensions of this work include the investigation of methods for screening and assigning patients to the most suitable group, the types of diseases and stages of treatment most appropriate in the early adoption of AVDO, and the optimal group sizes for different diseases and their severity levels. Future extensions also include comparative studies of AVDO, such as GMV versus one-on-one visits, the quality of care in AVDO versus brick-and-mortar offices, native versus international physicians, and use of AVDO in different cultures. This work should also be extended to other services, such as physician group consultations for dealing with complex diseases and cases, centers for handling the medical needs of disaster victims, volunteer centers for doctors without borders, and medical care for U.S. service personnel serving abroad.

## Supplemental File

Supplemental data for this article can be accessed on the publisher's website at http://dx.doi.org/10.1080/07421222.2016.1243952

## Notes

1. www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/downloads/highlights.pdf.
2. http://www.cnn.com/2013/10/02/health/obamacare-doctor-shortage/.
3. bhpr.hrsa.gov/healthworkforce/supplydemand/usworkforce/primarycare/projectingprimarycare.pdf; www.aafp.org/practice-management/payment/coding/group-visits.html.
4. http://www.gmv.com/en/Healthcare/antari_ehealth_epidemiology_solutions/.
5. http://www.gpscbc.ca/psp-learning/module-overview/group-medical-visits/.
6. http://my.clevelandclinic.org/patients-visitors/prepare-appointment/shared-medical-appointments.aspx.
7. The patient-focused GMV was pioneered in 1990 by the Cooperative Health Care Clinic at the Permanente Medical Group. This model groups patients by disease types. The physician-focused GMV, known as Dropin Group Medical Appointment, groups patients based on their physicians [70, 71].
8. There are other labels, such as e-health, tele-health, remote therapy, or cyber therapy. Although there is no consensus about the definitions of these terms [30], telemedicine is viewed as focused on curative measures, whereas e-health is for preventative measures.
9. http://www.medicaid.gov/Medicaid-CHIP-Program-Information/By-Topics/Delivery-Systems/Telemedicine.html; http://www.cms.gov/Medicare/Medicare-General-Information/Telehealth/index.html.
10. https://report.nih.gov/nihfactsheets/Pdfs/Influenza%20(NIAID).pdf, p. 1.
11. We performed the Harman single-factor test. The acceptable level of explained variance ranges from 0.20 to 0.50 [68, 89]. Our result was 0.45. In the factor analysis of ten constructs with 84 percent of variance explained, the factor with the highest value had only 10 percent of variance explained (Table C4, Appendix C). Following Muthén and Muthén [68] and Pavlou et al. [78], we also examined the correlations among the constructs to see if any exceeded 0.90. No correlation value exceeded 0.90 (Table C3, Appendix C).
12. Per the guidelines of Gefen et al. [35], we tested a saturated model incorporating all possible paths. The estimation did not converge. We then developed a saturated model that included the major unspecified paths from left to right in Figure 4. Three variables—social presence, lack of privacy, and AW—were significant in some unspecified paths. We then tested the $\chi^2$ difference of the nested model (saturated) and the conceptualized model using

the guidelines provided by Short et al. [87] and described by Muthén and Muthén in http://www.statmodel.com/chidiff.shtml. The $\chi^2$ difference was not statistically significant.

13. Once this control was observed, we carried out two additional checks to see if the reported results were impacted. We ran the model by excluding those in the AW group who were not called on to come closer to the webcam. The results were similar to Figure 4. Another check was to code AW as an ordinal value (0, 1, and 2) indicating no use, availability, and use of video cues. The results for the estimation of this model were also very similar to those reported in Figure 4. We concluded that any confounding impact of availability vs. actual use of visual inspection in the augmented group was accounted for by including the control in the outcome variable.

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