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Design principles for social exchange in social virtual reality-enabled virtual teams

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Abstract

Social virtual reality (SVR) is a novel technology that can simulate and potentially enhance our face-to-face interactions. However, our understanding of interpersonal communication in SVR is still limited. To address this research gap, we describe how SVR enables social exchange (i.e., fundamental communication patterns of trust and reciprocity between individuals), which is closely related to virtual team performance. We present an information systems design theory for social exchange in SVR-enabled virtual teams (SE-SVR). Drawing from affordance theory and social exchange theory, we describe how SVR material properties (i.e., avatars, virtual objects, virtual space, and verbal and nonverbal communication features) enable and foster social exchange in SVR. As a theoretical contribution, we propose design principles for social exchange in SVR and connect them with testable theoretical propositions. Furthermore, we present the concept of interacting with presence, which facilitates users' affordance perceptions in SVR. We conceptually validate our design principles and illustrate our design through an artifact instantiation: XR Campus, which is a minimum viable product of a collaborative platform for the ECIU University. Our SE-SVR theory has important research and practice implications because it explains how critical aspects of organizational remote communication can be considered in SVR design.

Keywords Social virtual reality · Affordance theory · Social exchange theory · Trust · Reciprocity · Design theory

1 Introduction

> Life-world: A pre-given social world in which subjects experience themselves as being united by a quality of "togetherness" (Metzinger 2018).

Virtual reality (VR) can be described as "the effect of immersion in an interactive three-dimensional computer-generated environment in which the virtual objects have spatial presence" (Bryson 1995, p. 13). Although the potential of VR for organizations has been known for several decades, development and uptake efforts have been limited (Slater and Sanchez-Vives 2016). However, recent insights indicate the potential for the wider acceptance of VR (e.g., Jalo et al. 2020; Torro et al. 2021). Currently, VR technology-related developments are advancing exponentially in terms of hardware, software, and services because many major technology companies are investing heavily in VR (Facebook 2021a; Dugdale 2021). Many scholars and practitioners believe that social virtual reality (SVR)—that is, a multi-user VR with avatar-based interaction—is an integral part of VR technology development (e.g., Jalo et al. 2020; Metzinger 2018; Steffen et al. 2019; Torro et al. 2021). Accordingly, numerous consumer and enterprise SVR applications that, for example, enable the hosting of virtual events, facilitating distributed business meetings, or remote collaboration, have emerged to illustrate this progress in SVR.[1]

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[1] Some examples of consumer applications include VRChat, and Meta's Horizon Worlds, while examples of enterprise SVR include Glue, Horizon Workrooms, and MeetinVR. Many SVR applications have been used to facilitate virtual meetings, workshops, and conferences (e.g., see https://educatorsinvr.com/).

At the same time, the emergence of the COVID-19 pandemic has revealed that maintaining work-related social ties or building interpersonal trust is difficult via conventional remote working tools (Gorlick 2020; Franklin 2020). These observations are in line with the well-known paradox (e.g., Dubé and Robey 2009) of information technology (IT)-mediated work, namely, that effective virtual teams tend to require aspects of face-to-face communication (e.g., co-location of participants). Interestingly, decades of empirical and theoretical studies illustrate that SVR is a potential solution to this problem, as it can simulate and potentially enhance face-to-face communication processes (e.g., Bailenson et al. 2004; Pan and Hamilton 2018; Slater 2009). However, the sociotechnical foundations for SVR to facilitate interpersonal communication are still missing, so there is a need for a "rigorous conceptual analysis" (Metzinger 2018, p. 5) of SVR. Accordingly, the theoretical foundations that explain how SVR can improve communication within organizations remain insufficiently comprehended (Dincelli and Yayla 2022).

The goal of our paper is to provide a theoretical understanding of social exchange in SVR. Social exchange theory (SET) is one of the most widely used paradigms for explaining workplace behavior and communication (Cropanzano and Mitchell 2005). Positive social exchange (i.e., a positive assessment of messages that leads to stronger social ties) is also considered critical in terms of team performance and cohesion (e.g., Lawler 2001; Lin et al. 2019; Salas et al. 2015). For example, studies have shown that familiar individuals transfer and process complex information more effectively than unfamiliar individuals do (e.g., Aral and Alstyne 2011; Davison et al. 2013; Hansen 1999). We draw from Blau's (1964) microlevel view of SET, focusing on interpersonal communication. Reciprocity and trust are fundamentally interconnected concepts in SET (Blau 1964; Cropanzano and Mitchell 2005). Reciprocity is a universal moral code that binds different social systems together (e.g., Blau 1964; Blumstein and Kollock 1988; Nowak and Sigmund 2005). Trust is a favorable outcome of reciprocity and vice versa; a show of trust communicates that cooperation is anticipated and tends to be reciprocated with a behavior that validates that trust. As such, SET (i.e., patterns of reciprocity and trust) helps us frame some of the most fundamental communication processes related to positive social exchange (Fig. 1).

Affordance theory (Gibson 1977) suggests that actors perceive action potentials in their environment that enable them to reach their goals. Prior information systems (IS) studies have extended the original theoretical framing with functional affordances, which are action potentials provided to users by the material properties of a technology (e.g., Markus and Silver 2008). Material properties, in turn, refer to the essential features of the technology (Markus and Silver 2008), such as communication features in social networking services. The actions taken are referred to as affordance actualizations (Bernhard et al. 2013; Volkoff and Strong 2017). This view of the affordances of technology has enabled IS researchers to uncover how essential technological features may be used to account for important organizational outcomes. For example, visibility features (e.g., profiles and posts that others can access) of social media enable employees to accomplish work in new ways (Treem and Leonardi 2013). We draw upon these views from the IS context, choosing this theoretical framing because it can provide a framework for how SVR material properties could be perceived and used to enhance organizations' IT-mediated interactions. In general, we argue that SVR functional affordances enable "an ideal form" (Slater and Sanchez-Vives 2016, p. 27) of remote collaboration. Affordance theory can thus help us understand how SVR enables beneficial communication processes in an organization. However, it does not explain different contextual communication outcomes, such as social exchange.

Although affordance theory and SET can potentially be aligned to inform us how social exchange unfolds in SVR, certain requirements must be met in order for SVR material properties to fully support social exchange affordance actualization in SVR. For this purpose, we present the concept of *interacting with presence*, which facilitates users' affordance perceptions in SVR. In our theoretical analysis, interacting with presence comprises four distinct forms of illusions: Slater's (2009) classical *place illusion* and *plausibility illusion*, which are supplemented by *social presence illusion* (Skarbez et al. 2017) and *embodiment illusion* (Schultze 2010). Place illusion is the result of technology's capacity to create a virtual space and support sensorimotor actions, which our brains treat as "real" (Slater 2009, p. 1). Plausibility illusion refers to the logical consistency of these illusions—the feeling that the illusions are really happening not only because they look real or allow seemingly realistic interactions (with spaces, objects, or other avatars) but also because they seem plausible (Slater 2009). Social presence illusion emphasizes technology's capacity to transmit communicative signals (verbal and nonverbal; Skarbez et al. 2017). Embodiment illusion refers to body ownership of one's avatar, including physical qualities, such as appearance, as well as possible internalized attitudes and behaviors of the avatar (Schultze 2010). Interacting with presence thus facilitates how the action potential of SVR material properties is perceived in SVR and how this enables the user's realistic behavioral and emotional responses in SVR. Insufficient amounts of interacting with presence (e.g., an environment that does not respond to user actions) may lead to decreased user perceptions of social exchange action potential in SVR.

In this paper, we provide an IS design theory (Gregor and Jones 2007) for social exchange in SVR (SE-SVR). This theory is meant to offer insights into how SVR can be designed to support and enhance social exchange in organizations. We believe that our theory contributes significantly to IS and design science research because it reveals a new conceptual understanding of VR technology as a sociotechnical system. Specifically, our study elaborates on how SVR enables novel patterns of social exchange in virtual teams, such as enhancing presumptive trust building via avatar profiles or customized avatar characteristics and enhancing cognitive-based trust via the ability to spatially observe others and their behavior in task-related or informal activities.

Our theory makes four key contributions: first, we align SVR functional affordances with SET to help explain novel forms of social exchange in SVR; second, we provide SVR material properties; third, we introduce interacting with presence that facilitates users' affordance perceptions in SVR; and fourth, we provide design principles with multiple testable propositions. Drawing from Gregor et al. (2020) and Gregor and Jones (2007), the validation of our theory and its design principles occurs deductively. However, to illustrate the utility of our theory, we also build and evaluate an artifact instantiation (Gregor and Jones 2007; Gregor et al. 2020), XR Campus, an MVP (minimum viable product) of an SVR platform developed for the ECIU (European Consortium of Innovative Universities) University. In general, we believe that our study can help organizations develop novel and beneficial SVR communication practices. Our findings are especially relevant for organizational settings with an increased demand for social and mental alignment between participants, such as problem solving or decision making in globally distributed virtual teams.

The paper is structured as follows. First, we begin by providing the theoretical background for our study, covering SVR material properties, Gibson's (1977) affordance theory, and Blau's (1964) framework for social exchange. Second, we present the SE-SVR design theory, including its design principles, testable propositions, and the illustration of our design principles via the development of XR Campus. Finally, we conclude by discussing the implications of SVR and possible future research topics. We hope that our theory will provide a solid foundation for further research on enhancing social interaction in SVR.

2 Theoretical background

Although VR's conceptual and technological roots date back decades, and modern VR is a technology that many organizations across different fields use (Slater 2016), there seems to be little understanding of the social aspects of VR. Only a decade ago, there was a lack of "significant organizational applications" (Schultze 2010, p. 434) available for VR. This technological landscape has since changed dramatically, and the importance of VR-related research in the IS field has also increased. Recent developments emphasize the importance of increasing the theoretical and practical understanding of VR's social perspective (Metzinger 2018; Torro et al. 2021), which currently represents a major gap in the literature. More specifically, the literature does not explain how social interactions in SVR could be designed to help organizations use SVR effectively (Dincelli and Yayla 2022). IS research stands at the intersection of the sociotechnical and organizational domains, providing an optimal position from which to address this research gap.

Next, we explain through the affordance process (Bernhard et al. 2013) how SVR material properties enable different forms of social interactions. However, affordance theory does not explain interpersonal communication or its outcomes, so we draw from SET (Blau 1964; Cropanzano and Mitchell 2005) and analyze social exchange via patterns of reciprocity and trust.

2.1 The material properties of social virtual reality (SVR)

VR is a novel technology used to facilitate social interaction. In VR, participants can turn, move, and interact almost as they do in the real world. Additionally, VR is not bound by the laws of physics; participants can take multiple perspectives, go back in time, turn gravity on or off, and so forth (Dede et al. 2017; Bailenson et al. 2004). However, the most important aspect of VR use may be that our brains largely treat it as real (Minderer et al. 2016; Slater 2018). Movements in virtual space, which result in corresponding perceptual changes and synchronized sensorimotor actions of our virtual embodiment (i.e., avatars), create illusions to which our brains tend to adapt. Therefore, VR has been found to have many benefits in fields such as education (Dede et al. 2017) and psychology (e.g., clinical diagnosis and therapy and ecologically valid research; Foreman 2010; Pan and Hamilton 2018; Rosa and Breidt 2018). This blurred line between the physical and digital realms has attracted widespread scientific interest in the technological and social domains (Fox et al. 2009; Metzinger 2018).

Affordance theory (Gibson 1977) states that, in terms of individuals being able to operate in the environment, perception becomes a tool for action. Gibson (1977) calls these perceived action potential affordances. For example, classroom affordances include teaching and learning, depending on individuals' goals and abilities. SVR functional affordances of IT, in turn, refer to the relations between the material properties of a technology and how they can be used by the users in a particular context (Faraj and Azad 2012). According to Bernhard et al. (2013), an affordance process comprises affordance existence, perceptions, actualization, and outcomes. They define affordance existence as the outputs of technological features and organizational strategies. Affordances thus exist because of these two factors. Affordance perceptions refer to perceptual processes that are influenced by information about affordances (i.e., cues for a user that affordances exist). Some affordances may be perceived, whereas others may not. The same is true for affordance actualization: some perceived and recognized affordances are actualized, whereas some are not. In the final phase, the affordance outcomes should represent the meaningful results representing the actions of an organization, system, or individual. In this paper, we draw from affordance theory because it can explain how the actualization of SVR functional affordances can lead to favorable organizational outcomes.

SVR material properties are constitutional building blocks of SVR that enable different interaction and communication processes, much like physical atoms in the real world. These properties include avatars, virtual space, virtual objects, verbal communication features, and nonverbal communication features (Table 1). Next, we describe the key notions of SVR material properties, which serve as a foundation for this study.

An *avatar* is a digital self-representation of a user in a virtual world. Its features can be broken down into two categories: form realism, which refers to the avatar's recognizable form (e.g., the human body), and photographic realism, which refers to the degree of detail rendered upon the avatar (e.g., shadows and shades of color). Behavioral realism relates to the avatar's behavioral accuracy (e.g., movement-related details, including postures, gestures, facial expressions, and gaze; Oh et al. 2016; Bailenson et al. 2006) and, therefore, closely relates to the avatar's ability to transmit behavioral cues among participants. In order for avatars to behave realistically, participants' physical sensorimotor actions (e.g., head, body, and hand movements) are tracked and displayed by the avatar.

One of the most important aspects of SVR relates to the individual's self-presentation in the VR. Avatar characteristics may have psychological and behavioral implications depending on the avatars that the participants use, a phenomenon known as the Proteus effect (Yee and Bailenson 2007, 2009; Sherrick et al. 2014). For example, Yee and Bailenson's (2007, 2009) studies show that participants assigned taller avatars performed better in negotiation tasks than those with shorter avatars. Likewise, participants assigned attractive avatars disclosed more personal information and used less personal space when interacting with others than those with less attractive avatars. In another series of studies, participants who saw their avatars exercise and be rewarded for exercising were likelier to increase their physical activity in a real-world setting (Fox et al. 2009).

In SVR, participants navigate a *virtual space*, which can be anything and scaled to any size, "from an atom to a universe" (Foreman 2010, p. 226). Freedom of movement in virtual space varies based on how the system tracks participants' movements (e.g., head and hand position and orientation; Slater 2018; Anthes et al. 2016). SVR enables manipulating time and space, turning gravity off (Bailenson et al. 2004), and observing and interacting with 3D objects in egocentric or exocentric views (Dede et al. 2009). Spatial sound creates the illusion that a sound in virtual space is coming directly from its source (Poeschl et al. 2013). Room-scale VR embeds the VR into a physical environment, enabling real-time interactions in a physically shared setting (Greenwald et al. 2017).

In SVR, *virtual objects* can be anything that has an equivalent in the physical world but without the corresponding scale and interaction boundaries. For example, a user can interact with a 3D model of a machine and see it in an exploded view, separately handling each part. Virtual objects can include tools, tables, whiteboards, and embedded 2D screens that enable videoconferencing, or remote desktop interfaces and web browsers in a virtual meeting. Avatar profiles, as "floating billboards" (Bailenson et al. 2004, p. 435), can present a participant's name, physical location, role in an organization, skills, competencies, and other relevant information.

Various *verbal and nonverbal communication features* are rooted in the SVR physical core. Verbal interaction includes speech and text-based interactions. Nonverbal interaction is closely related (but not limited) to the avatar's behavioral realism and its ability to transmit behavioral cues among participants, such as gestures, posture, facial expressions, and gaze. The forms of nonverbal interactions include physical appearance, movement and body language (kinesics), gaze (oculesics), tone of voice (vocalics), use of personal space (proxemics), touch (haptics), environmental features (e.g., in the SVR context, the features and arrangement of virtual space, virtual objects, lighting, and sounds), scent and odors (olfactics), and the use and perception of time (chronemics; Burgoon et al. 2011). In addition, acronyms, emoticons, and interpersonal tone allow participants to convey nonverbal cues in text-based interactions (Walther 1995).

SVR also enables many forms of asynchronous and synchronous interactions. In general, synchronous interaction is emphasized when there is a need for dialogue, problem solving, or mutual understanding, especially if there is low familiarity and/or a lack of redundant information among individuals (Dennis et al. 2008). For this purpose, SVR can provide real-time avatar-based interaction or videoconferencing with participants both within and outside of VR (see Facebook 2021b). Asynchronous interaction is generally more effective when individuals convey a large amount of raw data or information (Dennis et al. 2008). In this regard, SVR participants can annotate 3D models via text or voice using applications, such as IrisVR, InsiteVR, and AllVR, or share and present texts and documents in a virtual meeting using Glue or Hyperfair. Embedding text-based chat rooms in SVR allows near real-time many-to-many communication without the limitations of participants' physical or virtual locations.

2.2 Social exchange as patterns of reciprocity and trust

SET is a widely used paradigm for explaining workplace behavior and communication (Cropanzano and Mitchell 2005). We draw from Blau's (1964) microlevel view of SET, focusing on interpersonal communication as a form of exchange. Reciprocity and trust are ideal–typical manifestations of social exchange (Blau 1964; Cropanzano and Mitchell 2005). A series of experimental studies shows that strong social ties and individual reputation in a social system are built under conditions of reciprocity and trust (Ostrom and Walker 2003). Strong social ties are not only the cornerstone of our well-being (House et al. 1988) but are also critical in terms of enhancing collaboration performance in organizations. For example, well-acquainted individuals transfer and process complex information effectively (e.g., Aral and Alstyne 2011; Davison et al. 2013; Hansen 1999).

Trust is a favorable outcome of reciprocity, which, in turn, tends to positively affect patterns of reciprocity (Blau 1964; Ostrom and Walker 2003). In our paper, we emphasize that reciprocity affects trust through the mechanism of trustworthiness, whereas trust affects reciprocity through the mechanism of trusting behavior (Molm 2010; Ostrom and Walker 2003). These relationships are demonstrated through the design principles of our theory.

2.2.1 Reciprocity

In contrast to pure economic exchanges, social exchanges are commonly governed by the norm of reciprocity (Gouldner 1960); typically, individuals feel obliged to pay back (i.e., reward) what others have done for them. Gouldner (1960, p. 161) describes reciprocity as a "pattern of mutually contingent exchange of gratifications." Reciprocity is also a fundamentally important moral code that binds different social systems together (e.g., Nowak and Sigmund 2005; Granovetter 1973). Positive sentiments, such as respect and approval, are integrally connected with the norm of reciprocity (Blau 1964). Furthermore, reciprocity could be viewed as an essential starting mechanism for strengthening social ties in their early stages (Gouldner 1960).

We operationalize reciprocity in organizational relationships using four categories: (1) *reciprocal interaction (social bonding)*, (2) *informal reciprocity*, (3) *emotional reciprocity*, and (4) *reciprocal services*. Reciprocal interaction (social bonding) indicates general verbal and nonverbal social bonding behaviors, such as providing respect in exchange for advice or positive sentiments and attitudes toward others (Blau 1964; Skågeby 2010). Informal reciprocity and emotional reciprocity (see Altman and Taylor 1973) refer to communication as "emergent patterns of behavior that are not part of the formal organization" (Morand 1995, p. 834). Reciprocal services (Granovetter 1973) indicate explicit task-related activities and doing favors for others, such as carrying out tasks or providing helpful information.

2.2.2 Trust

Mayer et al. (1995, p. 712) define trust as follows:

> the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party. (p. 712)

Trust is one of the most widely studied concepts in a variety of disciplines, such as psychology, management, and economics (Levin and Cross 2004; Mayer et al. 1995), as well as in the IS and knowledge management fields (e.g., Järvenpää et al. 2004; Lowry et al. 2010; Robert et al. 2009). To analyze individuals' demands, attitudes, and expectations in interpersonal communication, we deal with trust as *trustworthiness* (Mayer et al. 1995).

Trustworthiness is based on the *ability*, *benevolence*, and *integrity* of a trustee and is affected by the trustor's propensity—their general willingness to rely on others. Mayer et al. (1995, p. 717) describe ability as a "group of skills, competencies, and characteristics that enable a party to have influence within some specific domain." This set of knowledge and skills is domain specific, so the trustor believes that the trustee has the ability to do what they are supposed to do (Lankton et al. 2015; Mayer et al. 1995). Benevolence is based more on the trustee's character (Colquitt et al. 2007); Mayer et al. (1995, p. 718) describe benevolence as "the extent to which a trustee is believed to want to do good to the trustor, aside from an egocentric profit motive." Finally, Mayer et al. (1995, p. 719) define integrity as "the trustor's perception that the trustee adheres to a set of principles that the trustor finds acceptable," including personality traits, such as openness, loyalty, fairness, and consistency (Colquitt et al. 2007).

3 SE-SVR design theory

In this section, we build the SE-SVR design theory, which depicts how social exchange can be supported and enhanced in the organizational use of SVR. According to Gregor and Jones (2007), IS design theory can be divided into eight core parts: *purpose and scope, justificatory knowledge, form and function principles, testable propositions, constructs, artifact mutability*, *principles of implementation*, and *expository [i.e., artifact] instantiation*. The purpose and scope of SE-SVR design theory are to provide a sociotechnical understanding of SVR requirements in the context of social exchange. SET (Blau 1964) and affordance theory (Gibson 1977) provide justificatory knowledge to analyze and explain social exchange via SVR material properties.

Furthermore, we base our theory on the view that SVR has the potential to simulate and enhance social interactions (e.g., Bailenson et al. 2004; Pan and Hamilton 2018; Slater 2009). Drawing on the IS, VR, and communication literature, we argue that SVR enables "an ideal form" (Slater and Sanchez-Vives 2016, p. 27) of remote collaboration and social interaction. Our theory posits that the actualization of SVR functional affordances leads to favorable organizational outcomes, such as increased team performance. In this regard, each action potential of reciprocity and trust is treated as an SVR functional affordance. More specifically, the actualization of SVR functional affordances happens through social exchange when individuals demonstrate trustworthiness (i.e., the effect of reciprocity on trust) and trusting behavior (i.e., the effect of trust on reciprocity), for example, in the case of the former, when they provide emotional support to other users, and, in the case of the latter, when they evaluate others based on their traits and abilities. Both aspects of social exchange strengthen the social ties of the organizational users of SVR, which, in turn, tend to increase their collaboration performance.

Regarding form and function principles, we provide multiple SVR design principles that describe the structural properties of our theory. We link social exchange affordances with the technical design of SVR material properties. We also provide multiple testable propositions for each design principle. Each proposition is a heuristic rule of thumb,

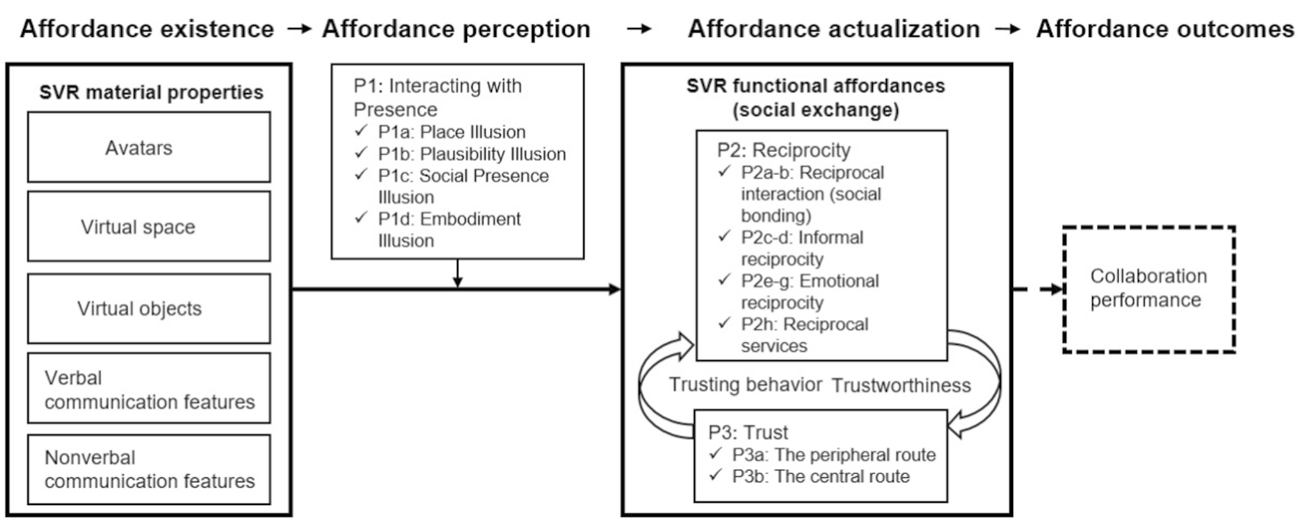

Fig. 1 The affordance process (Bernhard et al. 2013) and the key constructs of SE-SVR design theory (SVR material properties, SVR functional affordances, design principles, and testable propositions), as well as their relationships

Table 1 SVR material properties and their characteristics

SVR material properties	Characteristics of SVR material properties
Avatars	Form and photographic realism (appearance), behavioral realism (behavior), sensorimotor actions, and avatar customization
Virtual space	Spatial navigation, freedom of movement (e.g., head and hand orientation and position), and spatial sound
Virtual objects	3D/2D objects and interactivity with objects
Verbal communication features	Speech and text-based interaction
Nonverbal communication features	Physical appearance, movement and body language, gaze, tone of voice, use of personal space, touch, environmental features, scent and odors, use and perception of time, emoticons, and textual cues

which should not be interpreted strictly but in the following form: "if you want to achieve *Y* in situation *Z*, then something like action *X* will help" (Aken 2004, p. 227). We also present the concept of interacting with presence, which facilitates the perception of SVR material properties and their functional affordances. More specifically, interacting with presence explains how interactions that are perceived as physically and psychologically real lead to better socioemotional communication consequences in SVR. For example, an avatar's facial expressions can convey the participant's basic emotions through subconscious micro-expressions, depending on the level of detail of the simulation.

We illustrate our conceptually validated design principles by providing an artifact instantiation (i.e., an example from a real system; Gregor and Jones 2007) for our theory. In this regard, we describe how our design principles guided the user requirements specification of an MVP of a collaborative SVR application—XR Campus. Furthermore, we illustrate how XR Campus supports the actualization of SVR functional affordances and what its limitations are.

According to Gregor and Jones (2007), IS design theory also entails some degree of artifact change (i.e., artifact mutability). In this regard, it is anticipated that the effect of media characteristics on communication effectiveness diminishes among familiar individuals (e.g., Walther 1995; Dennis et al. 2008). Accordingly, SE-SVR's design principles and propositions will be more accurate in predicting communication among individuals who are not well acquainted.

Next, drawing from SVR material properties, affordance theory, and SET, we theorize and discuss the three SE-SVR design principles and corresponding propositions. At the end of each section, we present a summary of the key aspects of SVR for each design principle (Tables 2, 3, 4). After this, we illustrate our social exchange-related design principles via XR Campus MVP.

3.1 Principle #1: Design an SVR environment, interactions, and avatars that allow for maximum interacting with presence

Presence (commonly known as the sense of *being there* in a virtual place) is a diverse concept that has attracted wide academic interest for decades (Dede et al. 2017; Slater and Sanchez-Vives 2016). Recent advancements in and the improved availability of VR technology have driven this research forward significantly (Slater 2018; Riva et al. 2014). Presence relates to how we "behave, what we pay attention to, and how we understand and remember events" in a virtual environment (Riva et al. 2014, p. 2). The International Society of Presence Research describes presence as follows:

> [a] psychological state in which even though part or all of the individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience. (Schultze 2010, p. 437)

Indeed, presence is a combination of psychophysiological (i.e., psychological and physiological) illusions in which participants tend to, at least partly, forget the role of technology in the process.

Slater's (2009) classical deconstruction of presence includes two concepts: place illusion and plausibility illusion. Place illusion is a sensation that occurs when we first enter a virtual space. It is the most central element of VR

Table 2 Key aspects of SVR for interacting with presence

Place illusion:
• A high degree of sensory immersion (e.g., stereoscopic visuals, spatial sounds, and haptics; "how the world is perceived")
• Valid sensorimotor actions (e.g., the ability to turn the head in order to look around in virtual space and the ability to touch virtual objects)
• Valid effectual actions (e.g., the ability to move and manipulate virtual objects)
Plausibility illusion:
• A logically coherent user experience ("what is perceived")
• Ecologically valid responses to the participant's actions from the VR system
Social presence illusion:
• A multi-user environment with multiple communication tools (e.g., avatars, videoconferencing, and text-based tools)
• Avatars as communicative tools and display systems (e.g., verbal and nonverbal, intentional and unintentional, and conscious and subconscious)
Embodiment illusion:
• Valid sensorimotor actions, which are synchronized with avatar movements
• Photorealistic avatars
• Multiple avatars for different body ownership illusions
• Avatar customization features that enable participants to alter their online identities and behaviors (the Proteus effect)

technology use and refers to an experience in which we perceive virtual space "through using our whole body, via a set of implicit rules involving head turning, leaning, reaching, looking around, bending an ear toward, and so on" (Dede et al. 2017, p. 21). Plausibility illusion refers to the logical consistency of these illusions—a feeling that the illusions are really happening because they not only look real or allow seemingly realistic interactions (with spaces, objects, or other avatars) but also seem plausible.

Skarbez et al. (2017) introduce the concept of social presence illusion because Slater's (2009) description of presence does not include aspects of social interaction. Together, these aspects provide information about presence and social interaction but do not include a perspective of the self in the social interaction. Certainly, self-identification and its possible behavioral implications (e.g., the Proteus effect) may affect how individuals interact with one another. Because of this, we include self-presence in our analysis, treating it as embodiment illusion.

The technological sophistication of a VR system and its interaction content may affect how these illusions are created. Together, these illusions lead to a user's perception of the potential for interaction, both physical and psychological, with the virtual world, virtual objects, virtual others, and their virtual embodiment. Therefore, we suggest the concept of interacting with presence and the following principle:

P1: Interacting with presence (i.e., place illusion, plausibility illusion, social presence illusion, and embodiment illusion) improves users' affordance perceptions in SVR and thus the actualization of SVR functional affordances.

3.1.1 Place illusion

When we first enter VR, our attention is consciously and subconsciously focused on our new environment (Slater 2009). At this point, the notion of the self may be abandoned for a moment (Metzinger 2018). This sensation is a classical form of place illusion (Slater 2009), which is "the strong illusion of being in a place in spite of the sure knowledge that you are not there" (Slater 2009, p. 3551). We adopt Slater's (2009) view that place illusion is a result of *sensory immersion*, which is created by the objective technological capabilities of a VR system. Sensory immersion can be described as the extent to which the VR system can "support [an] individual's sensorimotor contingencies" (Slater 2018, p. 432). Sensorimotor contingencies refer to how we use our bodies to perceive the world with different senses (e.g., visual perception, hearing, and touch). For example, when we move our heads in VR, the movement results in corresponding changes in the images around us. We may also bend down and take a closer look at virtual objects. Spatial sound and the ability to use our bodies enable us to move closer or turn an ear toward the sound source we want to hear. Accordingly, haptics may enable us to touch virtual objects. These sensorimotor contingencies are *valid sensorimotor actions* (Slater 2009). Furthermore, interacting with virtual space, virtual objects, and other avatars may lead to effects that change the surrounding environment. For example, we may reach out and grasp a virtual object, such as a virtual laptop. We may take a closer look at the laptop and turn it to see how light reflects on it from different angles. These interactions are *valid effectual actions* (Slater 2009) that result in changes in our virtual environment because the laptop is not a static object; we can interact with it physically.

As Shultze (2010, p. 440) describes, "sensory immersion is a technology's ability to create a convincing, immersive environment with which the user can interact." Place illusion is the result of sensory immersion. The technological capabilities of a VR system set limits for sensory immersion, which is the sum of sensory data (e.g., stereoscopic visuals, spatial sounds, and haptics), valid sensorimotor actions (e.g., being able to turn one's head, look around, navigate in virtual space, or touch virtual objects), and valid effectual actions (e.g., moving and manipulating virtual objects). Therefore, we suggest the following sub-principle:

P1a: Place illusion in SVR is a result of sensory immersion, which is facilitated by valid (sensorimotor and effectual) actions supported by technology.

3.1.2 Plausibility illusion

Presence is not solely about the extent to which technology can produce sensory immersion. Presence also requires plausibility illusion, which is dependent on the credibility of the events occurring in virtual space. Slater (2009) describes plausibility illusion as an illusion that seems to be happening, although we know for sure that it is not. Plausibility illusion requires *coherence,* which results from an internally logical and consistent user experience (Skarbez et al. 2017). If place illusion is about the extent to which VR systems respond to sensorimotor contingencies, plausibility illusion relates to the coherence of VR systems' dynamic adaptations to actions. Slater (2009) describes this by stating that, while place illusion is about *how* we perceive the virtual environment, plausibility illusion is about *what* is perceived.

Let us return to the example in which we grasp a virtual laptop in our hands. The power seems to be switched on, so we try to use it. However, the keyboard and screen do not respond to our actions. This breaks the coherence of our experience. If the mechanisms that simulate the physics of pressing the laptop buttons are not properly designed, the lack of coherence (and thus the lack of plausibility illusion) reduces our feeling of presence. In other words, plausibility illusion requires a virtual environment that can logically respond to our actions in an ecologically valid way. Therefore, SVR should be able to simulate the expectations we have from real-world interactions, or alternatively, construct an internally logical framework for interactions within SVR.

Slater (2009) notes that plausibility illusion is not merely about physical realism but also about the content of the experience. For example, Dede (2009, p. 66) discusses how VR can trigger "powerful semantic, psychological associations by the means of the content of an experience." For these reasons, VR has been used extensively in treating patients with anxiety and various phobias (Parsons and Rizzo 2008). Meanwhile, various symbolic or narrative factors are especially important when using VR in an educational context (Dede et al. 2017). Therefore, we suggest the following sub-principle:

P1b: Plausibility illusion arises from the inner logic and consistency of the user experience in SVR.

Many VR researchers from the social sciences (e.g., education, clinical psychology) posit that place illusion and plausibility illusion play critical roles in simulating real-world interactions. For example, Dede (2017) states that, when place illusion and plausibility illusion are both properly designed, participants are likely to behave realistically in the VR. This has far-reaching consequences. For example, VR has been used extensively for psychological therapy since the late 1990s. This is only possible because VR affects patients to a sufficient degree for clinicians to engage in the therapeutic process (Dede et al. 2017). Furthermore, Slater (2018, p. 432) elaborates on how presence (i.e., place illusion and plausibility illusion) does not create a cognitive illusion but a perceptual illusion in which our cognition slowly starts to react, even though we "know that this [illusion] isn't real."

Skarbez et al. (2017) state that VR developers can significantly affect the design of sensory immersion and coherence. We suggest that the balance between these two concepts is critical when designing SVR. For example, functional issues with sensory immersion during VR use can also reduce coherence, leading to a reduced feeling of presence. Furthermore, interactions that are too complex may lead to, for example, misaligned virtual objects and avatars, diminishing the realism that the developer attempts to capture. This logic may apply to different social exchange processes, such as when subtle nonverbal cues (e.g., facial expressions) are interrupted.

3.1.3 Social presence illusion

The original description of presence (Slater 2009) did not include social interaction (Skarbez et al. 2017), which is essential in social exchange. Therefore, we draw from (Skarbez et al. 2017) and present social presence illusion as a result of (1) co-presence (being with another individual in a virtual space), (2) the technology's capacity to transmit (verbal and nonverbal) communicative signals (e.g., via avatars, videoconferencing, or text-based tools), and (3) the plausibility of the communication process. In this context, plausibility in communication could mean, for example, the design of an avatar and its ability to respond using nonverbal interaction methods, such as gaze, touch (e.g., haptics) or facial expressions, in a plausible manner.[2]

In SVR, avatar-based interaction enables communication processes that simulate face-to-face interaction in a shared space. In the real world, the human mind builds various hierarchical patterns and probabilities from the surrounding environment while trying to minimize the potential errors created by those predictions (Bargh and Chartrand 1999; Metzinger 2018). Similarly, individuals try to predict one another's mental states, emotions, and intentions via verbal and nonverbal communication cues (Gweon and Saxe 2013). In SVR, this interaction is facilitated by avatars, which act as both "screen[s] and viewer[s]" in communication (Gonzalez-Franco and Lanier 2017, p. 3). Therefore, SVR design should consider the following sub-principle:

P1c: Social presence illusion in SVR depends on both the technology's capacity to transmit verbal and nonverbal communicative signals and the plausibility of the communication process; in SVR, avatars are both communicative tools and display systems (verbal and nonverbal, intentional and unintentional, and conscious and subconscious).

3.1.4 Embodiment illusion

Embodiment illusion describes a body ownership illusion (i.e., self-presence) in which we treat our virtual representations as versions of our real selves (Schultze 2010). Similarly, embodiment illusion enables users to perceive their nonverbal affordances for communication ("this is really me"). The realism of the avatar has potential to affect the level of embodiment illusion in SVR. For example, Lin and Jörg (2016) found that embodiment (hand) ownership illusion was better with a more realistic human hand model

[2] For an example of the plausibility of the communication process, see Seymor et al.'s (2018) study, which presents a computer-controlled agent, BabyX, which can provide highly realistic verbal and nonverbal responses during a discussion.

compared to a less realistic hand model. Embodiment illusion is also enhanced by personalized avatars (Banakou et al. 2013) and sensory immersion (Slater 2009). The Proteus effect (Yee and Bailenson 2007, 2009) illustrates the potential behavioral implications of avatar characteristics (e.g., in terms of self-disclosure). Slater (2016) argues that virtual embodiment may result in changes in attitudes, perceptions, cognition, and behavior. Similarly, SVR enables individuals to enter "altered situations and identities" (Gonzalez-Franco and Lanier 2017, p. 1) by, for example, customizing their avatars. Vasalou and Joinson (2009) recognize that people also tend to favor different avatar characteristics in different communication situations. In an organizational context, avatar customization thus enables individuals to alter their avatars depending on the communication context (e.g., formal presentation or informal socializing). Therefore, we suggest the following sub-principle:

P1d: Avatar characteristics, avatar realism, and sensory immersion have the potential to affect self-presence and, in turn, affect online identity and behavior (the Proteus effect).

3.2 Principle #2: Design interactions that support verbal and nonverbal social bonding, informal reciprocity, emotional reciprocity, and reciprocal task-related activities

According to SET, reciprocity can be understood as exchanges that occur in daily life (Blau 1964; Cropanzano and Mitchell 2005). In the organizational context, reciprocity can be operationalized as (1) reciprocal interaction (social bonding), (2) informal reciprocity, (3) emotional reciprocity, and (4) reciprocal services. Reciprocity can range from sharing personal interests and emotions (Altman and Taylor 1973) to more explicit reciprocal services, such as doing favors for others (Granovetter 1973). Reciprocity is characterized by unspecific obligations toward others and involves feelings, such as affection, gratitude, and (eventually) trust. Over time, positive reciprocity drives tie strengthening and leads to more complex processes, such as group cohesion (Blau 1964).

Reciprocal interaction (social bonding) refers to verbal and nonverbal communication that emphasizes different social bonding mechanisms, such as complements, gratifications, or rituals (Skågeby 2010). Additionally, nonverbal reciprocity occurs when individuals respond to one another's behaviors with similar (or otherwise appropriate) behaviors (Burgoon et al. 2016). In the organizational context, informal reciprocity, and emotional reciprocity (Altman and Taylor 1973) refer to a process in which individuals develop social relationships via mutual self-disclosure, including sharing personal interests, observations, and opinions. Emotional reciprocity refers to emotional communication, in which nonverbal communication plays an especially important role (Burgoon et al. 2016). Both informal reciprocity and emotional reciprocity could be described as "emergent patterns of behavior that are not part of the formal organization" (Morand 1995, p. 834). Reciprocal services indicate doing concrete favors for others, such as helping a colleague with a work-related task or providing helpful information.

All these forms of reciprocity play a crucial role when individuals evaluate one another's traits and characteristics in terms of building stronger social ties. Therefore, we suggest the following principle:

Table 3 Key aspects of SVR for reciprocity affordances

Reciprocity affordance 1: The ability for reciprocal interaction (social bonding)
• Verbal and nonverbal reciprocity (e.g., via avatars and text-based tools)
• Tools for guiding, assisting, and exchanging ideas, complements, and gratifications
• A high degree of behavioral realism for avatars to increase mimicry
• Possibilities to automate or enhance nonverbal communication (e.g., avatar emotes, automated mimicry)
Reciprocity affordance 2: The ability for informal reciprocity
• Avatar customization and avatar profiles as an online identity management system
• Avatar customization to boost self-disclosure, which is mediated by visual anonymity, avatar realism, and the Proteus effect
Inclusive access (i.e., anyone can join) and unscheduled communication (i.e., a virtual space that is open at any time)
• Informal interactive content, such as games and videos
Reciprocity affordance 3: The ability for emotional reciprocity
• Tools that enable explicit emotion talk (i.e., speech, text)
• A high amount of avatar's behavioral realism (e.g., facial expressions, gestures, posture, and gaze)
• Avatar, virtual space, and virtual object customization to increase the potential for emotional contagion
• Possibilities to automate or enhance nonverbal communication (e.g., emoticons, enhanced smiles, avatar emotes)
Reciprocity affordance 4: The ability for reciprocal services
• A virtual space that supports cooperation and task-related activities
• Transparent task management to increase indirect reciprocity

P2: In social exchange, reciprocity communicates an individual's trustworthiness via reciprocal interaction (social bonding), informal reciprocity, emotional reciprocity, and reciprocal services.

3.2.1 Reciprocal interaction (social bonding)

SVR affords the emergence of fundamental patterns of verbal communication (speech and text) and nonverbal communication in a virtual environment. Verbal interaction via speech and text each has its own advantages and disadvantages; speech is a natural, real-time interaction that conveys rich nonverbal cues, such as tone of voice. However, speech is limited to a smaller number of people because of time constraints and limited communication bandwidth (obviously, not everyone can talk at the same time). If the interaction is not recorded, a message transmitted via speech starts to degrade slowly over time. On the contrary, text extends everywhere and remains. Text-based interaction enables individuals to interact with many people at the same time (Dennis et al. 2008), albeit with a slower pace of tie strengthening (Walther 1992).

A stream of research shows that nonverbal communication is crucial to communication effectiveness because individuals tend to rely more on nonverbal cues than verbal cues when they assess the social meaning of a message (Burgoon et al. 2011). For example, with the help of nonverbal communication, individuals provide information, regulate interaction, promote affiliation, and facilitate task goals (Fiske et al. 2010). Theoretically, every form of nonverbal communication could be simulated in SVR. Additionally, SVR could be designed to modify or filter nonverbal behavior or even render nonverbal behaviors that participants have not performed (Bailenson et al. 2004). In SVR, the most essential tool for nonverbal communication is, of course, an avatar. Most affordances for nonverbal communication relate to the avatar's physical movement. For example, we may clap our hands when appreciating a presentation, give a thumbs-up when agreeing with an idea, or move closer to one another as a sign of affection. However, many forms of nonverbal behavior occur subconsciously because such behavior is fast and automatic (Fiske et al. 2010). We tend to cultivate innumerable nuanced nonverbal cues in our environment that have a foundational effect on social bonding behavior (Fiske et al. 2010).

In the social exchange and reciprocity context, the most important aspect of nonverbal communication may be *mimicry* or *mirroring*, a conscious or subconscious act of simulating others' behavior, such as postures, mannerism, or facial expressions (Lakin and Chartrand 2003; Iacoboni 2009). Subconscious mimicry could also be described as *the chameleon effect* (Bailenson and Yee 2005; Bargh and Chartrand 1999). Mimicking can be viewed as a positive "feedback loop" (Tarr et al. 2018, p. 3693) that creates rapport between individuals. In SVR, avatar emotes (i.e., predefined animations of an avatar's movements) can also be used to display the avatar's postures and manners without the user physically moving (e.g., Sansar 2021). Besides behavioral mimicry, which focuses on mimicking a participant's physical movements, Yee and Bailenson (2009) show that manipulating the facial similarity of an avatar may affect participants' behaviors and create closeness toward avatars that resemble their physical selves.

Interestingly, some scholars (e.g., Bailenson et al. 2008; Metzinger 2018) suggest that mimicry could be automated in VR. For example, algorithms could be used to synchronize each individual's interactions to *the same wavelength*. Bailenson and Yee (2005) find that a four-second delay in gesture copying (head movements) is enough for the vast majority of people not to notice a computer-controlled avatar (agent) copying their gestures. Despite this, compared with a non-mimicking avatar, mimicking agents received more positive ratings for likeability and persuasiveness (Bailenson and Yee 2005). However, detecting mimicry manipulation significantly decreases many of these effects (Bailenson et al. 2008). Other researchers have discovered that, compared with static computer-controlled agents, mimicking agents are perceived as more realistic, believable (Schönbrodt and Asendorpf 2011), and empathetic (Hasler et al. 2014).

In summary, SVR affords different social bonding activities via verbal and nonverbal communication, some of which can also be automated or enhanced in SVR. However, effective nonverbal communication also requires simulating an individual's conscious and subconscious behaviors. Therefore, we suggest the following sub-principles:

P2a: Reciprocal interaction (social bonding) emphasizes different verbal and nonverbal social bonding activities, such as guiding, assisting, and exchanging ideas, complements, and gratifications.

P2b: A high level of behavioral realism of an avatar (i.e., the high quantity and quality of behavioral details that can be captured and displayed by an avatar) enhances nonverbal social bonding activities, such as mimicry.

3.2.2 Informal reciprocity

Informal interaction has always been closely related to the affordances of our physical environment. In early history, stories emerged while people socialized by a campfire. Today, spontaneous and casual water cooler conversations are crucial parts of any *informal organization* (Morand 1995). In the context of online communities, Spagnoletti et al. (2015, p. 371) discuss the *public square* metaphor, a place where "members of local communities can physically meet to share knowledge and participate in social life."

To analyze how informality could be leveraged in SVR, we first operationalize it into two distinctive forms. We draw from Kraut et al. (1990) and discuss informality as (1) participation and (2) presentation. The former includes the possibility of engaging in discussions with or without personal reference and communicating outside the user's professional role. For example, a participant may choose which information to disclose in their avatar profiles when entering an informal virtual space. The latter indicates the content of communication, such as the discussion topics (e.g., interests, personal matters) and how they are communicated (e.g., language and speech register, unarranged agenda). This conceptualization allows us to theorize what informality could potentially mean in the SVR context.

SVR material properties constitute the technological framework that enables various communication processes. However, to achieve a specific outcome, such as informal reciprocity, there are also certain requirements for how the affordances for informal communication are perceived in a virtual space. For example, in the real world, physical space obviously sets requirements for and facilitates communication. Accordingly, the requirements for this space differ depending on the communication context (e.g., break room, conference room). Similarly, objects in that space may be associated with different human activities based on context. For example, a company may have a room with tables, chairs, computer displays, a coffee maker, and a billiard table. In this example, the physical space and its objects are specifically meant for informal communication and the interactions associated with it, such as watching videos, drinking coffee, or playing billiards. At the same time, people can discuss personal matters or work-related topics without the restrictions or expectations that they have in formal meetings. However, these interactions are possible only if this physical space is used properly; rules, roles, and timetables diminish informality (Kraut 1990) and may turn the space into a conference room, removing any possible informal interaction-related benefits. A break room may, of course, have its own set of rules (such as washing coffee mugs after use), but these could be thought of as distinct parts of the formal organization.

Conventionally, organizations have used different text-based tools (such as micro-blogging or instant messaging) to enhance informality (Hung et al. 2008; Davison et al. 2013; Zhao and Rosson 2009). Technically, text-based interaction and other asynchronous interactions support informality because they do not interrupt formal work processes, and they enable behaviors, such as multitasking (Davison et al. 2013; Walther 1995) and voluntary participation (Zhao and Rosson 2009). SVR enables similar affordances for informal communication.

Drawing from the aforementioned example of a real-world break room, we introduce the metaphor of the *virtual break room*. The virtual break room leans on many advantages that exist in various text-based communication channels. Ideally, the virtual break room enables unscheduled participation and is available for all relevant parties. Interaction is at least partly decoupled from organizational rules and formal roles. However, unlike text-based communication channels, the virtual break room is also a physical space with interactive content that enables various informal activities. Therefore, we suggest the following sub-principle:

P2c: The virtual break room facilitates informality because of its low intrusiveness and lack of rules, roles, and timetables, encouraging free participation and spontaneous communication and interactivity.

Physical media characteristics may also affect how individuals perceive the affordances for informal communication. For example, studies have shown that a medium conveying a low number of social cues and enabling visual anonymity significantly increases spontaneous self-disclosure among individuals (Joinson 2001; Barak and Gluck-Ofri 2007). For example, in text-based interactions, participants report higher degrees of confidence in discussions mainly because immediate responses are not necessarily needed, and the participants can conceal their nonverbal behaviors (Tidwell and Walther 2002). In general, individuals tend to compensate for the lack of nonverbal cues in text-based communication with increased self-disclosure (Walther 1992). On the contrary, video and telephone conferencing are perceived as more formal, and individuals tend to disclose less personal information via these media (Fish et al. 1992; Tidwell and Walther 2002). This may relate to factors such as pauses, interruptions, simultaneous speech and problems with turn-taking, or perceived over-use of the visual channel (O'Malley 1996).

In the SVR context, the Proteus effect (Yee and Bailenson 2007, 2009) suggests that avatar appearance has the potential to affect how willing individuals are to disclose personal information to others. The avatar characteristics of both communication partners can potentially affect the outcome of the communication. This may be due to altered self-presentation, the removal of identity cues (e.g., visual anonymity), or behavioral confirmation, "the process whereby the expectations of one person (typically referred to as the perceiver) cause another person (typically referred to as the target) to behave in ways that confirm the perceiver's expectations" (Yee and Bailenson 2009, p. 9).

The Proteus effect may lead to anti-social, anti-normative, or pro-social behavior. Removing identity cues may help some individuals express themselves more in formal and informal situations. For example, a study by Aymerich-Franch et al. (2014) suggests that avatars with faces dissimilar to the participants' real faces may reduce those participants' anxiety levels in public speaking situations. Bailenson et al. (2006, p. 359) suggest that some individuals would probably disclose more information with "a hybrid realism solution"—an avatar with a high degree of behavioral realism but a low form and low photographic realism (i.e., an avatar that does not strongly resemble the participant but behaves realistically).

Kraut et al. (1990, p. 5) describe informal communication as something that is "spontaneous, interactive and rich." We argue that avatar-based interaction has many possible unique affordances that relate to this description. Informal communication can occur with or without personal preferences, depending on which avatars individuals choose to use and what information they are willing to disclose in their avatar profiles. Customizable avatars with a high degree of behavioral realism may maintain high self-disclosure without lowering the benefits of subtle verbal and nonverbal communication. Many SVR material properties also have the potential to facilitate spontaneous interactions. Whereas the lack of rules and roles in the virtual break room encourages spontaneous action, SVR material properties enable it physically via interactions with virtual objects and other avatars. For example, virtual space enables close physical proximity, which is usually highlighted in informal communication (Burgoon et al. 2016; Kraut et al. 1990). Nonverbal communication (e.g., gestures and mutual gaze) in a virtual space enables more effective turn-taking (Bailenson et al. 2002), and spatial sound has the potential to tackle issues with simultaneous speech by identifying the spatial position and volume of audio sources. Therefore, we suggest the following sub-principle:

P2d: Avatar-based interaction enhances informality because of the Proteus effect and the visual anonymity of the real user while also enabling subtle verbal and nonverbal communication in a co-located environment.

3.2.3 Emotional reciprocity

Emotional reciprocity can be divided into emotion talk and expressing emotions (Derks et al. 2008). The former emphasizes discussions about emotions, whereas the latter emphasizes nonverbal communication. In an organizational context, emotional reciprocity relates to informal reciprocity. According to Altman and Taylor (1973), individuals tend to initially discuss superficial topics, such as the weather or entertainment; if these interactions are rewarding (i.e., the social ties become stronger), the individuals may disclose more personal information, such as emotions.

Prior studies have shown that individuals communicate emotions similarly via IT and face-to-face communication (Derks et al. 2008; Walther 1996). For example, text-based communication conveys nonverbal cues in an interpersonal tone (Walther 1995). As discussed above, individuals also tend to disclose more personal information in text-based interactions than in videoconferencing or face-to-face discussions (Weisband and Kiesler 1996), perhaps because asynchronous communication often enables visual anonymity and emotion talk without time constraints.

However, emotional reciprocity is more effective in face-to-face communication because of its real-time nature and its capacity to transfer rich nonverbal cues (Walther 1992). Similarly, expressing emotions in SVR emphasizes an avatar's behavioral realism and nonverbal communication ability, such as facial expressions, gestures, and posture. For example, gaze is one of the most studied areas of nonverbal communication (Bailenson et al. 2004). With gaze, we communicate not only a point of interest but also intimacy and acceptance (Bailenson et al. 2004). In SVR, an avatar's realistic facial expressions can significantly enhance emotional intensity (Faita et al. 2015).

Emotion talk and expressing emotions have distinct communication patterns. In principle, individuals can discuss emotions extensively without showing any emotions at all. It is also possible to show emotions without saying anything (e.g., via multiple types of emojis). Each of these communication patterns is supported by various SVR material properties. Therefore, we suggest the following sub-principles:

P2e: Verbal communication (via speech and text) in SVR facilitates emotional support and exchange through the explicit discussion of emotions.

P2f: Nonverbal communication (e.g., facial expressions, gaze, gestures, posture, tone of voice, emoticons) in SVR enables participants to express emotions and emotional intensity.

As discussed in the informal communication context, SVR has the potential to enhance (or suppress) how willing individuals are to disclose personal information to others. We argue that self-disclosure is mediated by visual anonymity, avatar realism, and the Proteus effect. Similarly, different SVR material properties could be instrumental in affecting individuals' emotional reciprocity.

In the emotional reciprocity context, perhaps the most interesting phenomenon is emotional contagion, a form of mimicry that is defined as "the tendency to automatically mimic and synchronize expressions, vocalizations, postures, and movements with those of another person's and, consequently, to converge emotionally" (Hatfield et al. 1993, p. 96). In SVR, expressing emotions could be automated to enhance emotional intensity. For example, Oh et al. (2016, p. 1) use enhanced artificial smiles to manipulate social interactions in SVR, finding that "participants who communicated with each other via avatars that exhibited enhanced smiles used more positive words to describe their interaction experience compared to those who communicated via avatars that displayed smiling behavior reflecting the participants' actual smiles." Compared with the actual smile-reflecting condition, the enhanced smile condition left the participants in a better mood. Interestingly, more than 90% of the participants did not consciously notice this manipulation.

Avatar appearance and behavior may also have unwanted consequences for emotional reciprocity. For example, the *uncanny valley* effect (Mori et al. 2012) describes the phenomenon in which increasing an avatar's photographic realism increases affinity toward the avatar but only to a certain point. Avatar appearance may be considered wrong or even repulsive when human face representations are static or non-responsive. A body of literature describes the uncanny valley effect, but the vast majority of these studies used digital representations of human faces that were static or non-responsive without real-time reciprocal interaction (Seymour et al. 2018). It is important to note that real-time interaction with an avatar may significantly mitigate the uncanny valley effect (Seymour et al. 2018). Therefore, highly realistic avatars, even those that are not perfectly realistic, may be viable solutions in SVR design. However, the need to mitigate the uncanny valley effect must be considered in SVR design. Furthermore, this design probably requires a multisensory approach because the uncanny valley effect may occur via senses other than visual perception, such as touch (Berger et al. 2018).

The characteristics of a virtual space and virtual objects can also be adjusted "to manipulate users' feelings while in a virtual space" (Fox et al. 2009, p. 99). In an organizational context, this could mean, for example, users' ability to customize their virtual offices or collaborative spaces in order to evoke emotional responses from others, such as relaxation (Riva et al. 2007). Customizing an avatar's physical appearance and surrounding environmental features could then act as a nonverbal communication tool in SVR. Therefore, we suggest the following sub-principle:

P2g: The characteristics of a virtual space, virtual objects, and avatars have the potential to evoke different emotional responses, thus affecting the emotional state of the interacting individuals.

3.2.4 Reciprocal services

Reciprocal services (Granovetter 1973) can be considered an explicit form of reciprocity, such as doing favors for others. Reciprocal services highlight the importance of task-related activities and cooperative interactions. In IS, reciprocal services generally emphasize the transparency and openness of interactions (Faraj and Johnson 2011). In its simplest form, reciprocal services manifest in the exchange of specific and uncodified information, such as seeking help or collaborating (Faraj and Johnson 2011). For example, people seek help, solve one another's problems, exchange ideas, and give credit for good ideas. Tools that facilitate reciprocal services are often embedded in workflow or knowledge management systems (Wasko and Faraj 2000).

Interestingly, in SVR, participants can actually perform favors, such as assisting a colleague with a task in a virtual space (e.g., Elvezio et al. 2018). Just as architects design a building and construction workers assemble it in the real world, a digital building can be designed and assembled in a collaborative virtual space. Similarly, reciprocal services in SVR can relate to providing help not only mentally but also physically. The multisensory interactions (e.g., touch, voice) that support collaborative tasks in a virtual space, such as moving and interacting with virtual objects, are considered basic potentials of VR (Fox et al. 2009).

Because SVR can simulate or enhance real-world interactions (Bailenson et al. 2004; Pan and Hamilton 2018; Slater 2009), SVR material properties can be tied to various forms of reciprocal services. Every task or communication process that exists in the real world (or in another IS) can be simulated in SVR.

In general, reciprocity communicates trustworthiness (Blau 1964). Reciprocity based on a genuine positive interest toward others is emphasized; unselfish behavior enhances social exchange because individuals tend to have an increased moral obligation to return these favors (Gouldner 1960; Blumstein and Kollock 1988; Nowak and Sigmund 2005). Furthermore, *indirect reciprocity*—"I help you and somebody else helps me" (Nowak and Sigmund 2005, p. 1)—plays a critical role when reciprocity accumulates through a network. Eventually, these direct and indirect reciprocal interactions manifest as *generalized reciprocity*, which is considered an essential mechanism in developing all social life (Blau 1964; Blumstein and Kollock 1988; Nowak and Sigmund 2005). Considering these basic premises of reciprocal services, we suggest the following sub-principle:

P2h: Reciprocal services emphasize altruistic behavior that manifests in a virtual space that supports task-related activities, transparency, and cooperation.

3.3 Principle #3: Design trust building processes for the peripheral and central routes

Hung et al. (2004) argue that cognitive-based trust is formed via three distinct routes at different relationship stages. First,

Table 4 Key aspects of SVR for trust affordances

Trust affordance 1: The ability to build trust via the peripheral route (presumptive trust building)
• Avatar and user profiles for the assessment of participants' different peripheral cues (e.g., user roles)
• Avatar customization as an impression management system
• Real facial information (e.g., via videoconferencing or photorealistic avatars) to promote high initial trust among strangers or acquaintances or for ad-hoc trust building processes, such as when discussing sensitive topics
Trust affordance 2: The ability to build trust via the central route (cognition-based trust building)
• Avatar-based interactions with co-location, synchronous communication, and high behavioral realism
• Collaboration tools, simulations, and informal interactions that enable the accumulation of shared experiences and the assessment of others' abilities, integrity, and benevolence

individuals who lack a shared history and information about one another form trust via the *peripheral route*, which relies more on presumptions than on deliberate evaluations of one another's traits. In this case, peripheral cues, such as social categories, third-party information, rules, roles, and reputation, play important roles. Second, once individuals have acquired some information from one another, they form trust via the *central route*. The central route emphasizes trust building that requires cognitive effort from a trustor, including a more elaborate appraisal of a trustee's traits, such as ability, integrity, and benevolence. Third, when individuals have a long period of shared history, they form trust via the *habitual route*.[3] In this stage, trust building has become a habit that requires low cognitive effort.

In social exchange, trustworthiness is a favorable outcome of reciprocity. Trusting behavior, in turn, tends to positively affect reciprocal relationship development. Trusting others requires some level of risk taking, and in developing social bonds, trustees tend to live up to the trustor's expectations (Blau 1964; Molm 2010). Therefore, we suggest the following principle:

P3: In social exchange, trusting behavior enhances reciprocity and is determined by the peripheral and central routes.

3.3.1 The peripheral route

There is a strong consensus among scholars that evaluating others' trustworthiness is, at least partly, intuitive (e.g., Petty and Caioppo 1986; Kahnemann and Egan 2011; Evans and Stanovich 2013). Robert et al. (2009) have empirically studied trust building processes in virtual teams. The study supports the view that assumptions based on social cues and categories (e.g., a trustee's profession, organizational role, and/or gender) are dominant in building initial trust. In general, unfamiliar people tend to judge others based on their characteristics instead of their behavior. Initial trust is fragile; it may decline gradually over time as individuals start to build trust through the central route. However, these initial judgments matter because they may also influence how people interpret others' behaviors at later trust building stages (Robert et al. 2009).

Riedl et al. (2014) compare how individuals form trust in relation to static avatar faces and static human faces. Their study showed that, although individuals tend to trust humans more than they trust avatars, the trust building rate is similar in both conditions. Therefore, the photographic realism of an avatar probably matters the most in the initial trust building stage. Photographic realism is a matter of technological sophistication and the degree of effort made to create those details. Importantly, technologies that create photographically realistic avatars are already under development, such as photorealistic volumetric capturing (Konttori 2021; Orts-Escolano et al. 2016). In addition, embedding videoconferencing into SVR offers interaction with real-world facial information that exploits individuals' natural tendency to trust human faces more than artificial ones. Therefore, photographic realism could be beneficial, such as when introducing new team members into virtual teams.

SVR also enables the transfer and processing of social cues via asynchronous interactions, such as text. In general, individuals tend to adapt their communication behaviors to the IT they use (e.g., Kock 2004; Walther 1992). For example, a lower synchronicity medium enables individuals to craft more elaborate messages (Dennis et al. 2008; Petty and Caioppo 1986), increasing the number of social cues that relate to different presumptions (Robert et al. 2009). Accordingly, asynchronous interaction allows individuals to reprocess messages more thoroughly because a real-time response is not necessarily required. This enhances social bond development in IT-mediated interaction, but it still requires time and effort (Walther 1995). Moreover, according to many studies, positive social behavior in IT-mediated interaction even exceeds that in face-to-face interaction (see

[3] We focus on the peripheral and central routes in our theoretical analysis because "over the long run, communication transcends media" (i.e., media characteristics affect communication performance less between well-acquainted individuals; Dennis et al. 2008, p. 578).

Walther 2011) because individuals can strategically modify their self-presentation and create a version of an impression management system (Walther 1995).

Considering these basic trust building premises, we argue that SVR has unique affordances that relate to building trust via the peripheral route. Many of these affordances relate to indirect or asynchronous interactions. For example, avatar profiles could enclose relevant and individuating information from the real person behind the avatar (e.g., role in an organization, interests, and mutual friends). Thus, individuals would be able to create, modify, and present peripheral cues that they think are relevant to others. Similarly, customizing their avatar appearance enables individuals to alter their self-presentation strategically in order to appear more trustworthy. A body of empirical studies suggests that, in general, individuating information has a "massive" (Kunda and Thagard 1996, p. 292) impact on challenging certain stereotypes. Therefore, we suggest the following sub-principle:

P3a: In SVR, the peripheral route for trust building is enhanced in indirect interactions, such as conveying and observing avatar profiles or avatar characteristics.

3.3.2 The central route

Individuals form long-lasting attitudes toward others mainly via the central route. Using the central route also depends on an individual's motivation and ability to process the message received. If these requirements are not met, the peripheral route, which requires less cognitive effort, is used, likely resulting in no change or a less significant change in attitude. However, information acquired via the peripheral route may increase an individual's motivation to activate the central route. (Hung et al. 2004; Petty and Cacioppo 1986). For example, if the message sender's disciplinary competence or professional status is perceived as sufficient via the peripheral route, the message receivers would be more motivated to use the central route for further evaluation. In general, trust building via the central route is more effective in face-to-face situations because of the availability of rich social cues and real-time interactions, which allow individuals to accumulate personal knowledge faster. Meanwhile, conventional IT-mediated interaction conveys fewer social cues and, coupled with possible asynchronous interaction, leads to slower trust building processes (Hung et al. 2004).

The central route for trust building requires cognitive evaluations of information related to trustees' abilities, integrity, and benevolence (Hung et al. 2004). In SVR, this information is likelier to be acquired in avatar-based interaction that can potentially simulate natural face-to-face interactions. Individuals can more effectively predict and mentalize others' trustworthiness via interactions that contain rich social cues and monitoring mechanisms, such as direct observations, co-location, and shared experiences (Riedl et al. 2014; Roberts et al. 2009). Our minds are naturally adjusted to face-to-face communication (Kock 2005, 2009), which helps us effectively predict others' thoughts and intentions (i.e., mentalize; Baron-Cohen 1991; Carruthers and Smith 1996). Mentalizing is also a major determinant of human trust behavior (Riedl et al. 2014). Besides revealing facial features and expressions, face-to-face communication is effective because of the real-time exchange of other communicative stimuli, including speech and body language. Co-location and real-time communication (verbal and nonverbal) also help individuals share the same interaction context, requiring less effort from communicators and likely leading to less ambiguous communication outcomes (Kock 2004, 2009).

Avatar-based interaction in SVR takes advantage of the shared space, allowing participants to directly supervise and control how other avatars interact, communicate, and behave in a co-located environment. Interactions in SVR also enable shared experiences to exist, just like experiences that usually manifest in the real world. These experiences could relate to carrying out different task-related activities, such as simulations or training, or engaging in different forms of informal social bonding.

The behavioral realism of avatars depends on how accurately the individual's movements in the real world (e.g., facial expressions, gestures, and postures) are captured and then rendered into their avatar. High behavioral realism enables subtle nonverbal behavior, such as leaning forward, whispering in another's ear, or using one's gaze to navigate social situations. These particular affordances for nonverbal communication are non-existent in conventional forms of IT-mediated interactions. A body of literature (e.g., Bailenson et al. 2006; Guadagno et al. 2007; Steed and Schroeder 2015) suggests that behavioral realism is the most important form of avatar realism when an individual is influencing others. Similarly, Riedl et al. (2014, p. 106) note that the "increased amount of humanlikeness that is induced by nonstatic information (e.g., gestures or animated facial expressions)" could probably reduce the effort needed in trust-related mentalizing processes. Therefore, we suggest the following sub-principle:

P3b: In SVR, the central route for trust building is enhanced in direct avatar-based interaction with co-location and a high degree of behavioral realism.

3.4 Implementation and evaluation of design principles through XR Campus MVP

XR Campus is an MVP of a collaborative SVR platform for the European Consortium of Innovative Universities (ECIU). Its main goal is to enhance students' capabilities in solving complex and open-ended problems on real-life challenges in remote work conditions. The development and implementation of XR Campus was a one-year project (10/2020–10/2021) by Tampere University and Zoan (one of the leading VR development companies in Europe), the preparation of which started in spring 2020.[4] XR Campus fits well with the evaluation of design principles and theoretical propositions, as they formed the basis for the user requirements specification and thus the selection and development of critical features and functionalities for the platform. These platform features, their priority in the MVP phase of development, and implementation status at the end of the project are described in Table 5 (some of the more technical details, such as application programming interfaces or software development kit extensions, have been omitted for clarity). This feature list was developed in collaboration with researchers, end-user representative from ECIU University, and application developers, and was evaluated and prioritized in relation to SVR's design principles as well as the implementation timeline and budget. XR Campus was opened by EU Commissioner Mariya Gabriel in October 2021.[5]

The following sections provide a detailed description of the functionalities of XR Campus, and the data collection and analysis methods employed to evaluate the implementation of SVR's design principles within the platform's functionalities. The purpose of this section, as per Gregor and Jones (2007), is to support and illustrate SE-SVR theory's design principles through the instantiation of an artifact, a real system example. While the creation of an artifact instantiation is not mandatory to support an IS design theory, it enhances the effectiveness of conveying the intended message to a target audience (Gregor and Jones 2007; Peffers et al. 2018). Thus, an artifact instantiation is presented here to complement the conceptual validation of IS theory's design principles (Gregor and Jones 2007). The design principles' rationale is based on deductive reasoning derived from previous knowledge presented in the theoretical background of this paper. This approach is extensively acknowledged as a commonly employed method in IS design theory (see Gregor et al. 2020; Gregor and Jones; 2007; Peffers et al. 2018). Additionally, as design theory cannot be "proved," the objective is to demonstrate and evaluate its utility (see Venable et al. 2016).

[4] An illustrative video about the appearance and functionalities of XR Campus can be found at https://www.eciu.org/news/xr-campus-virtual-reality-for-instant-collaboration-shared-understanding-and-focus (accessed 12 August 2022).

[5] Be part of it: EU Commissioner Mariya Gabriel will open the ECIU University XR Campus!: https://www.eciu.org/news/be-part-of-it-eu-commissioner-mariya-gabriel-will-open-the-eciu-university-xr-campus (accessed 12 August 2022).

3.4.1 Data collection

Data to evaluate the artifact were collected iteratively from multiple different sources during the project's lifecycle. In collecting data, the researchers followed Sein et al.'s (2011) suggestion and emphasized the authenticity of the data over controlled settings. The data were collected in the form of field notes (Phillippi and Lauderdale 2018) involving the researchers' remarks of observations, conversations, and user behaviors that emerged during the development of the platform. The authenticity of the data was ensured by collecting field notes as soon as, for example, end users' or system developers' comments emerged during the meeting or workshop or within XR Campus. Using field notes enabled the collection of rich and authentic data from all key stakeholders involved in the development and testing of the platform. For example, the platform's functionalities and features were discussed and evaluated iteratively in weekly development meetings involving researchers from Tampere University, end-user representatives from the ECIU, and developers and system architects from Zoan. Almost all weekly meetings included a representative from each stakeholder group. Additionally, between January 2021 and September 2021, there was a monthly version release of XR Campus. To resolve bugs and prioritize development activities, system developers and architects collected feedback from researchers and ECIU representatives during this release. Also, during February and September 2021, a total of eight workshops and demo sessions were held (each lasting between one to two hours)—in which users, including ECIU teachers and students, tested the application. Events related to the development of XR Campus, participants of these events, and outputs included in the field notes gathered from these events are presented in Table 6.

It is worth noting that due to many planned features being under development or not yet available, conducting extensive testing with end-users during the early development phase of XR Campus was impossible. Moreover, factors such as the privacy of stakeholders, the nondisclosure agreement, and the authenticity of testing the platform, often done inside the early releases of XR Campus, made it difficult to collect data using recordings. However, drawing on Sein et al.'s (2011) approach, the researchers were actively involved in building the IT artifact as part of the development team. This emphasized our authentic participation in various development activities, allowing for a reciprocal dialogue between the project's stakeholders. Consequently, to capture the richness of this process, we compiled numerous documents (e.g., meeting minutes, email messages, and notes from workshops and demo sessions) for later analysis. A qualitative study involving end-user interviews was also conducted, in which student groups (six groups, a total of 20 members) were systematically guided to use different SVR platforms (e.g.,

Table 5 Initial XR Campus requirements and features

Requirement type	Requirement name	Priority (spring 2021)	Description	Implementation status (Oct. 2021)
Hardware	VR	A	VR support for both tethered and standalone head-mounted displays	Partly implemented
	Desktop	A	Access to the platform for Windows and Mac users	Not implemented
	WebXR	B	Access to the platform via browser	Not implemented
Communication and navigation	Avatars	A	The ability to customize the avatar according to the user's appearance or into something that does not resemble the user	Implemented
	Avatar profiles	A	Avatar profiles displaying name, affiliation, user verification, competences, etc	Partly implemented
	Nonverbal communication	A	Body language, emojis, hand-tracking, eye tracking, etc	Partly implemented
	Spatial sound	A	Multi-group communication in a shared space	Implemented
	Voice control	C	Voice assisted features	Not implemented
	Group facilitation	A	E.g., admin tools for gathering users to a specific location	Not implemented
	Basic navigation mechanisms	A	Free movement, teleportation, flying	Implemented
	Annotations and feedback	A	Comments and annotations in, e.g., 3D objects	Not implemented
	Transformed social interaction	C	Filtering and/or modifying nonverbal behavior	Not implemented
Tools	Presentations	A	E.g., PowerPoint, PDFs	Partly implemented
	Videowall	A	E.g., YouTube	Partly implemented
	360 videos	B	Watching and displaying 360 videos in a multi-user environment	Implemented
	Whiteboard and 2D drawing	A	A virtualized whiteboard, pen, and Color Picker	Implemented
	3D drawing	A	3D drawing tool, Color Picker	Implemented
	Sticky notes	A	Sticky notes bound to user profiles	Partly implemented
	Laser pointer	A	Laser pointer for, e.g., presentations	Implemented
	3D models	A	Importing, turning, rotating, and scaling of 3D models	Implemented
	Desktop sharing	C	Ability for to share content from users' desktops into VR	Not implemented
	Camera	B	Camera for taking pictures/videos within VR	Not implemented
	Assessment tools	C	Assessment of learning activities and targeted competences	Not implemented
Integrations	File sharing and presenting	A	Office 365, Google Slides, Dropbox, etc	Not implemented
	Social media	B	Social media integrations, e.g., Twitter, Facebook	Not implemented
	ECIU Learners Wallet	A	Learning Wallet (ECIU) displaying users' learning and competences	Not implemented
Environment	Public space	A	A large public space, "Park"	Implemented
	Collaborative space	A	Collaborative space, "Challenge Room"	Implemented
	Scalability	C	Ability to create new instances from environments	Not implemented
	Persistency	A	Persistent virtual world and its content	Implemented
	Physics	B	Laws of physics, such as gravity	Partly implemented
Performance	Latency	A	Low latency	Implemented
	Audio quality	A	High spatial audio quality	Implemented
	Rendering	A	Rendering optimization for, e.g., avoiding jarring effects in standalone devices	Implemented
User profiles	Teacher	B	Teacher-facing app and assets	Not implemented
	Student	B	Student-facing app and assets	Not implemented
	Guest	B	Guest-facing app and assets	Not implemented

Spatial) and provide detailed feedback for the development of XR Campus (Torro et al. 2022). The early development version of XR Campus was used in collecting the data for this study but not to the extent that it would have itself enabled a systematic evaluation of the MVP's functionalities. User comments related to XR Campus were added as complementary remarks to the field notes.

3.4.2 Data analysis

Field notes provided rich contextual insights for the data analysis (Phillippi and Lauderdale 2018). In analyzing the data, various remarks in the field notes were coded according to the affordance process framework (i.e., the analysis of affordance perceptions and actualizations; Bernhardt et al.

2013). Here, affordance perceptions that were not fully actualized enabled the identification of various limitations of affordance actualization. Data analysis followed principles of qualitative content analysis (Berg 2004), in which trust and reciprocity affordances provided overarching categories. These two affordances also formed the core of XR Campus's user requirements specification to be evaluated (i.e., what the system is supposed to do from the user's perspective).

During the data analysis process, we organized field notes, such as comments from users during demo sessions or ideas from ECIU representatives in meeting minutes, according to overarching labels derived from SE-SVR theory. As advised by Berg (2004), using trust and reciprocity affordances as the basis, we first labeled the data under these two categories while constantly ensuring that the labels were compatible with the data and SE-SVR theory. Next, we searched for remarks related to specific SVR material properties, such as synchronous and asynchronous communication or avatar behavioral realism, and their functionalities that either enabled or limited the realization of affordances. In accordance with SE-SVR theory's design principles, trust and reciprocity affordances were thus aligned with critical SVR material properties in our analysis. Finally, after reflecting on the findings, one data-driven category emerged to complement the analysis: hindrances for SVR material property implementation. These hindrances were categorized under context (e.g., the ECIU's needs for SVR use), technology (e.g., limited computing power of standalone devices), and cost effectiveness (e.g., the cost of implementing features outside the platform's core activities). As a result, we had developed our coding scheme that contained trust and reciprocity affordances, critical SVR material properties, affordance actualization in the MVP, and, as a data drive category, hindrances for SVR material property implementation (see Tables 7, 8). After several iterations, the data analysis matured.

3.4.3 Evaluation of SVR functional affordances in XR Campus

After implementing XR Campus, all key stakeholders of the project (including researchers, developers, and ECIU representatives) concluded that its design is worth considering. Findings from the data indicate that critical SVR material properties, such as synchronous and asynchronous communication, avatar customization, and shared space and interactions (formal and informal), supported various social exchange affordance actualizations. In general, the potential and utility of the platform in facilitating remote work at the ECIU was considered unique (see ECIU 2021). However, it was also found that many affordances—although perceived as novel and beneficial—were not yet fully actualized at the MVP stage of the platform. Improvements in, for example, an avatar's behavioral realism (e.g., avatar gaze with eye tracking), workflow transparency (e.g., ability to connect tasks to users), integrations with existing IS (e.g., importing content from organizational IS), the implementation of multimodal user input (e.g., ability to use a physical keyboard in VR), and the development of informal content and playful interactions were identified as critical in mitigating the limitations of full affordance actualization. In this regard, it was observed that adhering to SVR's design principles helps to eliminate these issues in the potential future development of the platform. These findings and examples from the data are summarized in Tables 7 and 8.

4 Discussion and contribution

In this paper, we have developed an SE-SVR design theory that describes how social exchange can be supported and enhanced in the organizational use of SVR. We illustrate social exchange via two fundamental communication processes in Blau's (1964) microlevel view of SET: reciprocity (i.e., demonstrating trustworthiness) and trust (i.e., trusting behavior). In this study, we make four important theoretical contributions: first, we align SVR functional affordances with SET to help explain how SVR can simulate real-world social exchange processes and facilitate novel forms of social exchange; second, we introduce SVR material properties as integral SVR characteristics; third, we present the concept of interacting with presence, which facilitates users' affordance perceptions in SVR; and fourth, we provide design principles and testable theoretical propositions for social exchange in SVR.

SE-SVR design theory contributes to IS and design science research because it solves a significant *construction problem* (Van Aken 2004), namely, how to build an SVR system that supports and enhances social exchange in virtual teams and, therefore, potentially increasing their performance. Understanding the connection of SVR material properties with SVR functional affordances and their perceptions helps organizations use SVR to enhance social exchange among employees. Prior VR research posits that VR could be used for new forms of communication practices that do not exist in real life (e.g., Bailenson et al. 2004; Bailenson and Yee 2005; Yee and Bailenson 2009). We extend this perspective with SE-SVR by offering a theoretical explanation of how this can happen in the organizational context. The proposed theory is important because SVR can simulate and extend real-world communication patterns of reciprocity and trust, thus potentially overcoming the many symptomatic communication barriers of conventional IT.

As a second theoretical contribution, SVR material properties provide analogous counterparts of SVR in comparison with the real world: avatars versus humans, virtual space versus physical space, virtual objects versus physical

Table 6 XR Campus MVP development phases, events, participants, and outputs included in the field notes

Development phases and events	Participants	Outputs included in the field notes
Initial system requirements specification (*Jun. 2020–Nov. 2020, excl. July*)	Researchers, developers, end-users (ECIU representatives)	Initial system requirements specification and feature prioritization documents (based on design principles P2 and P3), notes from project preparation meetings
Weekly development meetings (*Nov. 2020–Nov. 2021, excl. July*)	Researchers, developers, end-users (ECIU representatives)	Weekly collected documents and notes on feature evaluation and prioritization, system performance optimization, resolution of usability issues, bug fixing, testing, etc
Monthly development version release of XR Campus (*Jan. 2021–Sep. 2021*)	Researchers, developers, end-users (ECIU representatives)	Monthly collected documents and notes on the evaluation and prioritization of the features to be included in the next release
Workshops and demo sessions (*Feb. 2021–Sep. 2021*)	Researchers, developers, end-users (students, teachers, ECIU representatives)	Authentic end-user data and comments from eight workshops and demo sessions (e.g., feature evaluation and prioritization, system performance testing and evaluation)
End-user interviews (*Feb. 2021–Apr. 2021*)	Researchers, six student groups (20 students in total)	End-user interview data collected using XR Campus MVP and other SVR platforms (see Torro et al. 2022)
XR Campus MVP launch (*Sep. 2021*)	Researchers, developers, ECIU and EU representatives	Authentic end-user data and comments

objects, and virtual verbal and nonverbal communication versus real-world verbal and nonverbal communication. However, SVR material properties have characteristics that extend the possibilities of real-world interactions and other IT technologies. The value of our unpacking of SVR material properties is created specifically from the latter view, which conceptualizes SVR as an extension of previously known communication practices. Logically, SVR material properties are somewhat immutable, enabling a solid SVR technological framework that will remain stable over time as the technology continues to develop.

As a third theoretical contribution, we provide the concept of interacting with presence, which facilitates the perception of SVR functional affordances so that SVR material properties could be used effectively for social exchange or other interpersonal or group-level interactions. More specifically, interacting with presence explains the novelty of SVR technology through the affordance process (i.e., affordance existence, perception, actualization, and outcomes) (Bernhardt et al. 2013), thus providing a perceptional model for SVR. Extant VR affordance research in an organizational context (e.g., Steffen et al. 2019) has recognized the generalized affordances created by VR but has not studied the social aspect of VR or the affordance process enabled by SVR in depth. According to Strong et al. (2014), there is a feedback loop where the outcomes of affordances (e.g., increased team performance in SVR) can transform organizational strategies. In addition, the implementation of technology (e.g., SVR) can shape the existence of affordances by equipping organizations with new capabilities for action. In this regard, our study contributes to the implementation of SVR by organizations in a way that emphasizes the distinct advantages of SVR. This may aid organizations in exploring novel modes of operation in a virtual setting. Interestingly, the lack of interacting with presence may explain, for example, why the use and adoption of desktop-based virtual worlds in organizations has remained significantly low in the past (see Dincelli and Yayla 2022; Srivastava and Chandra 2018).

Our fourth contribution is providing prescriptive knowledge for social exchange in SVR. We provide three detailed design principles for supporting and enhancing social exchange in SVR. Each design principle contains multiple testable heuristic propositions for SVR design for a total of 17. Our study contributes to design science research by providing normative and conceptual descriptions of SVR requirements in a social exchange context. In this regard, we believe that the deductive and theoretical insights of our theory also constitute a contribution to SET (Blau 1964) by providing a deeper understanding of social exchange in a novel context (see Baskerville et al. 2018). Our study also responds directly to a major gap in research, which tries to capture how "technology developers incorporate features into communication systems specifically designed to support

Table 7 User requirements specification for SVR functional affordances in XR Campus: Reciprocity

Reciprocity affordances	Critical SVR material properties	Requirement description	Hindrances for SVR material property implementation	Affordance actualization in the MVP
Reciprocal interaction (social bonding)	Synchronous and asynchronous communication	Users must be able to have real-time discussions in a shared space. Users must be able to guide, assist, and exchange ideas, complements, and gratifications asynchronously	**Context:** - **Technology:** - **Cost efficiency:** Some asynchronous communication features, such as 3D model annotations, may not be cost efficient to implement	**Elements supporting affordance actualization:** Reciprocal interaction (social bonding) is emphasized in real-time avatar-based communication (verbal and nonverbal). The shared space and spatial sound enable natural, interpersonal, or small-group discussions, which, for example, enhance teachers' abilities to encourage student engagement in VR. 3D models and other immersive content provide the context for communication **Limitations of full affordance actualization:** Social bonding affordance actualization is limited mainly because of the lack of avatars' behavioral realism (only users' head and hand movements are tracked and displayed). The lack of postures, mannerisms, gestures, and facial or eye movements in avatar-based interactions diminishes users' abilities for mimicry or other forms of nonverbal social bonding. Furthermore, asynchronous communication features (e.g., writing on sticky notes or drawing on whiteboards) are not specifically built to support social bonding behavior (e.g., feedback mechanisms are missing)
	Avatar's behavioral realism	Users' movements (e.g., hands, facial expressions, and gaze) must be tracked and displayed via avatars to boost mimicry and other forms of nonverbal social bonding	**Context:** Participating universities need low-cost standalone HMDs **Technology:** Advanced user tracking (e.g., eye tracking and face tracking) is not a standard feature in current-generation low-cost standalone HMDs (e.g., Oculus Quest 2) **Cost efficiency:** The use of more expensive standalone HMDs with integrated eye tracking (e.g., Pico Neo 2 Eye) or eye tracking as an add-on device (e.g., in VIVE Focus 3) may not be cost efficient	

Table 7 (continued)

Reciprocity affordances	Critical SVR material properties	Requirement description	Hindrances for SVR material property implementation	Affordance actualization in the MVP
Informal reciprocity	Avatar and user profiles	Users must be able to disclose personal information (e.g., hobbies) via their avatar or user profiles	**Context:** - **Technology:** - **Cost efficiency:** -	**Elements supporting affordance actualization:** Informal reciprocity in XR Campus is emphasized in different playful activities, such as flying, firing of fireworks, or playing with 3D models. Users also have an option to choose between personal avatars built from a photo and impersonal avatars and to select multiple different dress styles for their avatars. Furthermore, a large, shared space (“Park”) enables private informal communication without disturbing other users **Limitations of full affordance actualization:** Users’ interest in informal activities declines rapidly because of the lack of informal content and playful elements, which significantly reduces the amount of informal reciprocity
	Avatar customization	Users must be able to customize a personal or impersonal (e.g., non-human) avatar	**Context:** The use of impersonal or informal avatars may distract students’ focus from learning and collaboration **Technology:** - **Cost efficiency:** Developing a unique and highly detailed avatar customization system for informal use may not be cost efficient	
	Virtual space customization	Users must be able to build their persistent and customizable *virtual break room* or play area	**Context:** Participating universities need low-cost standalone HMDs **Technology:** The performance of standalone HMDs and the level of optimization in the current avatar system limit the number of avatars in virtual space (currently 32) **Cost efficiency:** A large amount of customized and persistent content leads to higher server costs	
	Informal content and interactions	Users must have some possibilities to interact informally (e.g., games) and import informal content, which is experienced as personal and fun (e.g., videos, memes)	**Context:** Informal content and interactions may distract students’ focus from learning and collaboration **Technology:** - **Cost efficiency:** Developing a variety of highly engaging informal features (e.g., games) may not be cost efficient	

Table 7 (continued)

Reciprocity affordances	Critical SVR material properties	Requirement description	Hindrances for SVR material property implementation	Affordance actualization in the MVP
Emotional reciprocity	Avatar's behavioral realism	Users' movements (e.g., hands, facial expressions, gaze) must be tracked and displayed via avatars	**Context:** Participating universities need low-cost standalone HMDs **Technology:** Advanced user tracking (e.g., eye tracking and facetracking) is not a standard feature in current-generation low-cost standalone HMDs (e.g., Oculus Quest 2) **Cost efficiency:** The use of more expensive standalone HMDs with integrated eye tracking (e.g., Pico Neo 2 Eye) or eye tracking as an add-on device (e.g., in Vive Focus 3) may not be cost efficient	**Elements supporting affordance actualization:** Users have some possibilities to display emotions (e.g., via voice pitch, use of personal space, and hand movements). They can also select the skybox for the virtual space among the options of summer, autumn, winter, and spring. Users can switch the background music on/off **Limitations of full affordance actualization:** The lack of avatars' behavioral realism (e.g., natural gaze and facial movements) significantly reduces users' abilities to express emotions. Enhanced or automated nonverbal communication is not yet available. Mechanisms that support and evoke emotional responses (e.g., virtual space customization or selection of background music) are still limited
	Enhanced nonverbal communication	Users must be able to enhance their nonverbal communication via, for example, enhanced smile or emojis	**Context:** - **Technology:** - **Cost efficiency:** -	
	Virtual space customization	Users must be able to customize their virtual space to enable evoking the desired emotional responses (e.g., emotional contagion via background music or the visual atmosphere)	**Context:** - **Technology:** - **Cost efficiency:** Developing a diverse virtual space customization feature may not be cost effective. Persistent, customizable environments also lead to higher server costs	

Table 7 (continued)

Reciprocity affordances	Critical SVR material properties	Requirement description	Hindrances for SVR material property implementation	Affordance actualization in the MVP
Reciprocal services	Transparent task management system	Users must be able to view the ownership and status of individual tasks, re-assign the ownership of tasks, and provide help to others, preferably also from outside VR	**Context:** The integration of existing organizational IS with VR requires advanced IT capabilities and resources from European HEIs **Technology:** - **Cost efficiency:** Connecting tasks in VR to, for example, assignments in other IS may not be cost efficient	**Elements supporting affordance actualization:** Users can download and interact with 3D models, draw on whiteboards or use 3D drawing, create 2D presentations, and watch 360/2D videos together in a shared space. Users can also own and spawn sticky notes and use them outside VR via the XR Campus web application
	Virtual space and tools for work and collaboration	Users must be able to work efficiently in VR and build a shared collaborative space as *a living 3D document*	**Context:** The use of XR Campus emphasizes unique and open-ended problem-solving activities during a limited time window (e.g., a couple of weeks) **Technology:** Keyboard see-through (i.e., ability to see and use a physical keyboard in VR) is supported only by a limited number of HMDs, keyboards, and laptops **Cost efficiency:** A large amount of customized and persistent content leads to higher server costs	**Limitations of full affordance actualization:** The lack of a transparent task management system and the ability to re-assign tasks and help others (also asynchronously and outside VR) does not allow the full emergence of reciprocal services and indirect reciprocity. The lack of multimodal user input (e.g., keyboard see-through or Voice-to-Text) prevents both the efficient performance of tasks and the ability to provide help to others efficiently. The content in a collaborative space is not yet persistent, and it is not integrated with organizational IS, which prevents iterative work and the associated positive feedback loops connected with the performance of real-world tasks

Table 8 User requirements specification for SVR functional affordances in XR Campus: Trust

Trust affordances	Critical SVR material properties	Requirement description	Hindrances for SVR material property implementation	Affordance actualization
The peripheral route	Avatar and user profiles	Users must be able to display their organizational positions, skills, competencies, task progression, or other relevant information via avatar or user profiles	**Context:** - **Technology:** - **Cost efficiency:** -	**Elements supporting affordance actualization:** Cartoonish avatars in XR Campus are built based on real facial information (avatars are made from photos), which enables users to display some amount of individuating information. User roles (i.e., *teacher* or *student*) are also displayed above avatars **Limitations of full affordance actualization:** Presumptive trust building is currently limited because of the lack of informative avatars or user profiles and photographically realistic facial information (e.g., photorealistic avatars or facial images in user profiles). Avatar customization is still limited
	Avatar customization	Users must be able to customize their avatars to, for example, reflect their personalities. Users must be able to display real facial information in order to boost initial trust building	**Context:** Participating universities need low-cost standalone HMDs **Technology:** The performance of standalone HMDs limits the amount of details and photographic realism in the avatars **Cost efficiency:** Developing a unique and highly detailed avatar customization system and optimizing it for standalone HMDs may not be cost efficient	
The central route	Avatar's behavioral realism	Users' movements (e.g., hands, facial expressions, and gaze) must be tracked and displayed via avatars	**Context:** Participating universities need low-cost standalone HMDs **Technology:** Advanced user tracking (e.g., eye tracking and face tracking) is not a standard feature in current-generation low-cost standalone HMDs (e.g., Oculus Quest 2) **Cost efficiency:** The use of more expensive standalone HMDs with integrated eye tracking (e.g., Pico Neo 2 Eye) or eye tracking as an add-on device (e.g., in Vive Focus 3) may not be cost efficient	**Elements supporting affordance actualization:** Various collaboration tools, such as whiteboards, sticky notes, 3D/2Ddrawing, 3D models, or 360/2D videos, enable real-time collaboration in a shared space. The space can be selected from the options of "Challenge Room" (small) or "Park" (large), according to users' needs. The larger space ("Park") allows for multiple simultaneous small-group discussions. Code-based access increases privacy **Limitations of full affordance actualization:** Cognitive-based trust building is not yet sufficient because avatars' behavioral realism is low, and collaboration tools and features do not enable efficient and transparent reciprocal workflows. A lack of informal content and interactions decreases sociability and the opportunity to create shared experiences
	Shared space and interactions (formal and informal)	Users must be able to spatially observe how others work and operate (e.g., use collaboration tools in a virtual office, conduct work operations in a simulation, or play games). The shared space must enable private or small-group discussions	**Context:** The use of XR Campus emphasizes unique and often open-ended problem-solving activities during a limited time window. Informal content might distract students' attention from learning and collaboration **Technology:** - **Cost efficiency:** Developing context-dependent simulations or highly engaging informal content (e.g., games) may not be cost efficient	

and enhance relational functions" (Walther 2011, p. 443). The design principles in our theory are illustrated and evaluated through artifact instantiation (Gregor and Jones 2007; Gregor et al. 2020)—XR Campus.

As a practical contribution, SE-SVR theory helps organizations develop beneficial communication practices in SVR, which can have significant impacts on virtual team performance. Our theory helps organizations compare the potential benefits and novelty of SVR in relation to conventional IT. In general, efficient social exchange in SVR emphasizes avatars' high behavioral realism (e.g., gaze and facial expressions), informal interactions (e.g., games), transparency of workflows (e.g., ability to assign, receive, and implement tasks), and physical collaboration in a shared space (e.g., brainstorming). Presumptive trust building tends to emphasize avatars' photographic realism, but it can potentially be enhanced by providing individuating information via customized avatar characteristics or avatar profiles. Furthermore, using the Proteus effect and automated or enhanced nonverbal gestures (e.g., mimicry) can provide interesting possibilities for new forms of socialness and group dynamics in SVR-enabled virtual teams. The concept of interacting with presence provides organizations with a sociotechnical foundation for how SVR should be designed to serve as a substitute for face-to-face social interactions, many of which are subconscious. We believe that our design principles are useful for system architects and managers who build and implement enterprise SVR, especially those aimed at managing high-performing virtual teams.

4.1 Limitations and future research

This study has some limitations. Due to the study's deductive approach in building an IS design theory, we conceptually validated our theory, but did not conduct empirical validation. However, we hope that our research will serve as a theoretical foundation for the further empirical investigations (e.g., comparative, and experimental studies) of social exchange in SVR in the future. Furthermore, we did not discuss social forces, such as hierarchy or social norms, which may affect social exchange. The study was also focused on SVR characteristics rather than on VR hardware (e.g., tracking, controllers, HMDs). The connection between VR hardware and interacting with presence still requires extensive studies, such as in terms of haptics and brain–computer interfaces (BCI; Metzinger 2018). Furthermore, we also encourage researchers to further study how human interactions and identities in SVR can be modified because the possibilities seem almost endless. The connections between other emerging technologies, such as artificial intelligence, and SVR also need to be explored for various purposes, such as to determine how computer-controlled avatars can be built as believable social actors that guide and assist users in SVR.

In conclusion, there is an immense lack of knowledge about how social interaction unfolds in SVR. This study provides a detailed description of how SVR can facilitate communication processes that have the potential to enhance social exchange and thus improve virtual team dynamics and performance. We believe that our study offers a strong foundation for future discussions of SVR as a sociotechnical system, and we hope that our work will inspire further research aimed at bridging existing theories of human behavior and communication with the practical use of SVR within organizations. As such, our study also serves as a call to action for researchers to explore the possibilities and limitations of SVR for organizations.

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Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors have no competing interests to declare that are relevant to the content of this article.

Consent for publication All authors consent to the publication of the manuscript in Virtual Reality Journal.

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