Avatars and Embodied Agents in Experimental Information Systems Research: A Systematic Review and Conceptual Framework

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Abstract

Computerised graphical representations of human users and computer agents, known as avatars and embodied agents, have been extensively explored and investigated in Information Systems (IS) research and practice. Such digital representations can be employed in either 2D or 3D. In order to facilitate research on user and agent representations and their applications in IS, we conduct a systematic literature review and establish the current state of research on humans' perceptions and behaviours when interacting with avatars and embodied agents. Our findings are based on an analysis of 90 articles published in top outlets in the IS field. This review identifies 1) different types of avatar and embodied agent-mediated interactions with users, 2) current application domains of such representations, 3) their dimensionality, 4) affected psychological constructs, and 5) practical considerations for the design of such digital representations. Finally, we discuss limitations of current research and, based on these, directions for future work.

Keywords: avatars, embodied agents, experiments, literature review

1 Introduction

To facilitate computer-mediated transactions at the nexus of the digital and physical world, user interface designers frequently employ design elements that resemble human features as digital representations of humans and computer agents. Digital representations of human users are commonly referred to as *avatars*, while representations of computer agents are referred to as *embodied agents* (Fox et al., 2015). In information systems (IS) research and practice, digital representations have successfully been employed in a wide range of

applications, such as recommendation agents in e-commerce (S. Lee & Choi, 2017; Qiu & Benbasat, 2009), chat bots (Burgoon et al., 2016), tools for behavioural change (Sebastian & Richards, 2017; Song, Kim, Kwon, & Jung, 2013), and tutors in e-learning (Beege et al., 2017; Heidig & Clarebout, 2011).

Over the past two decades, researchers have conducted experiments to better understand users' perceptions and behaviours in their interactions with avatars and embodied agents. Through experiments, researchers are able to observe actual interactions between users and avatars or embodied agents, and their responses to these interactions, under controlled conditions. Importantly, experiments allow researchers to identify causal effects through controlled variations, in order to see how different avatar and embodied agent design features affect outcome variables (Shadish et al., 2002). In this paper, we provide a state-of-the-art account of experimental research on human interaction with avatars and embodied agents in 2D as well as 3D environments by means of a systematic literature review (SLR), aiming to address the following overarching research question:

> *RQ: What is the current body of knowledge in experimental IS research on design considerations, application contexts, behavioural outcomes, and influences on users' psychological constructs of avatars and embodied agents?*

The review covers 90 articles published in top-tier IS journals and conferences. It provides an overview of users' perceptions of avatars and embodied agents, their effects on human behaviour, and how such graphical representations can be applied in a variety of settings to facilitate computer-mediated interactions between humans, avatars, and computer agents.

The main contributions of our SLR can be summarised as follows. First, we develop a framework that conceptualises design parameters of avatars and embodied agents, and various interaction types. These interaction types include a user interacting with their own avatar and a user interacting with another user's avatar or embodied agents. Second, we identify the application domains in which avatars and embodied agents are being employed. Third, we pinpoint key theories applicable to designing avatars and embodied agents. Fourth, we discern common design concepts and, fifth, identify methods used for investigating avatars, embodied agents, and their influence on users' perceptions and behaviours. This paper therefore may serve as a reference point for researchers working on experiments related to avatars and embodied agents, providing them with a guide on common design parameters and concepts as well as an overview of theories for understanding the interactions between humans, avatars, and embodied agents. For practitioners, this review may serve as a starting point for design considerations when employing avatars and embodied agents in practice.

The remainder of this paper is organised as follows. In Section 2, we describe the literature review methodology. We then outline the fundamentals of avatars and embodied agents in the context of IS research and establish a conceptual framework of digital representations of users or other entities (i.e., another person or a computer agent) in Section 3.[1] Subsequently, in

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[1] Following the terminologies used by Ang et al. (2012), we use the term "*avatar*" to refer to an avatar representing another human being in the digital interaction. Note that other people's avatars are sometimes also referred to as *personas* in some studies (Vasalou & Joinson, 2009). Clearly, what is a self-avatar and what is an avatar depends on the perspective that one takes, e.g., the user perceiving their own avatar (*self-avatar*) or that same avatar being perceived by another user (*avatar*). In other words, the distinction between self-avatars and avatars is mainly driven by the perspective one takes.

Sections 4, 5, and 6, we summarise findings on self-avatars, avatars, and embodied agents, respectively. Finally, Section 7 concludes with a general discussion, implications for the use of avatars and embodied agents in practice, as well as directions for future research.

2 Research Methodology of Literature Review

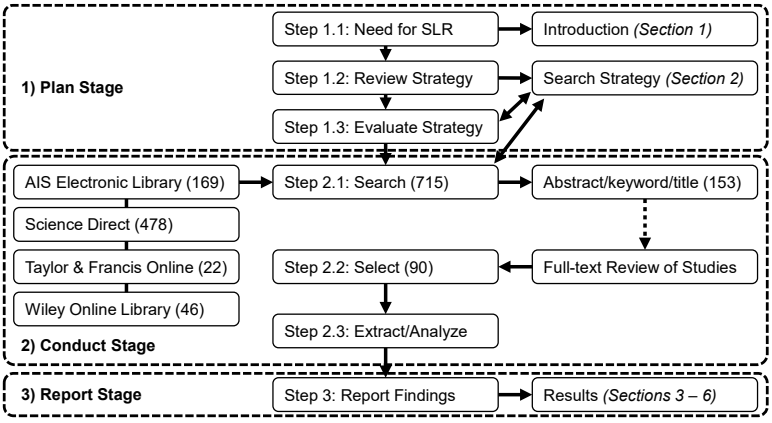
This paper follows the methodological guidelines provided by Kitchenham & Charters (2007) for performing an SLR. We focus on studies on avatars and embodied agents conducted under controlled laboratory and field settings with human participants. The process is divided into three distinct stages: *plan, conduct,* and *report*, as can be seen in Figure 1. In the plan stage, we identify the need for an SLR, develop a review strategy, and evaluate it. During the conduct stage, we then execute the search in databases, select appropriate studies, and analyse them. Finally, we document and report our findings in the report stage.

An initial exploratory search was conducted on Google Scholar using the search query "avatar" OR "virtual self" AND "experiment" as a starting point. While reviewing the obtained results, we extracted key terms used in these studies to further develop our search string. Next, we selected a well-established set of databases for conducting SLRs in the IS context (i.e., AIS Electronic Library, ScienceDirect, Taylor & Francis Online, Wiley Online Library). We then performed a full-text search on these databases using ("avatar" OR "embodied agent" OR "virtual self" OR "virtual presence") AND "experiment".

The initial search string included the term virtual-self, as this concept is frequently considered in research on avatars and embodied agents, and is hence in line with the research question we would like to address in this literature review. After carefully screening through results of the initial search, we extended the search string to include characteristic terms that have appeared within the reviewed papers. Specifically, we included the concept of *presence* in the search string, as it represents one of the main constructs that is being investigated in digital representations and human interactions, and the term *embodied agent* was included too, as it refers to graphical representations of computer agents in the interaction and sometimes is used interchangeably with the term *avatar*. Finally, we constrained the search to include only experimental studies because of their potential to reveal actual interactions between humans, avatars and embodied agents under controlled conditions (see also the Introduction section).

We included all academic journals under the category of *Information Management* (IM) in the ABS Academic Journal Guide 2015 (ABS, 2015). In addition, we included full research papers published in two top IS conferences as recognised by ACPHIS (2013).[2] In terms of selection criteria, we included only peer-reviewed papers reporting on experimental IS research with actual interactions between human participants and avatars or embodied agents. We excluded studies that 1) focused only on surveys without actual interactions between users and digital representations, 2) investigated robots rather than virtual representations, 3) included disembodied, that is, non-graphical representations, or 4) were research-in-progress.

[2] Conferences included are the International Conference on Information System (ICIS) and European Conference on Information System (ECIS). These two conferences were selected as they were ranked A by IFIP (2015).



Distribution of Studies	#
Basket of Eight (i.e., EJIS, ISJ, ISR, JAIS, JIT, JMIS, JSIS, MISQ)	6
Top IS Conferences (i.e., ECIS, ICIS)	4
Other IS Outlets in ABS Ranking (e.g., CHB, DSS, ESwA, IJEC, IJHCS, I&M, I&O, IT&P, JCMC)	80
Σ	90

Figure 1. Stages of the SLR and distribution of studies

We used the defined search string and searched the title, abstract, and keywords of studies in the selected databases. This search resulted in 715 hits (see the conduct stage in Figure 1), of which 625 were journal publications and 90 were conference publications. Then, the first and second authors independently screened the title, abstract, and keywords against the research question and selection criteria to identify relevant papers for the review. The agreement rate between the two authors was 94.97% (679 out of the 715 papers). Discrepancies were resolved by discussion with the fourth author (36 papers, 15 included, 21 excluded). Finally, the first author performed a full text review on the studies, resulting in 90 research papers (86 from journals, 4 from conferences). Table A1 in the Appendix provides an overview of all included studies, providing concise information on the specific type of interaction, dimensionality, context, psychological constructs, environments, and sample size for each study.

3 Conceptual Framework

According to Representation Theory (RT), the fundamental purpose of an IS is to provide users with a faithful representation of some real-world phenomena (Recker et al., 2019). The main tenets of RT posit that IS will 1) be employed if they provide users with a more *cost-effective* way to obtain knowledge about a focal real-world phenomenon than observing it directly, and 2) yield higher usefulness the more *faithful* the phenomena are represented. Common examples for the application of RT include data modelling, object-oriented modelling, and process modelling (Burton-Jones et al., 2017; Recker et al., 2019). Similar notions can be applied when it comes to avatar design: An avatar provides a digital representation of a person in the real-world, while an embodied agent represents a computer agent. Employing these representations can increase *cost-effectiveness*, e.g., in the provision of health and education services over a distance and/or to a large audience (Beege et al., 2017; Heidig & Clarebout, 2011; Noorbergen, Adam, Attia, Cornforth, & Minichiello, 2019); it may also increase *faithfulness* of the representation, as avatars usually have human features that capture the naturalness of interpersonal encounters in the real-world (Nowak & Rauh, 2006).

In this paper, we distinguish two perspectives in terms of human interactions with avatars, namely *self* and *other*. The "self" perspective refers to a user's interaction with their own avatar, often involving facial and body features, gestures, sound, or other forms of behaviour and expression. Following this perspective, the avatar is referred to as a self-avatar (Vasalou & Joinson, 2009). The "other" perspective refers to a user's view on other humans (computer agents) represented by avatars (embodied agents).

Through their self-avatars, users may directly or indirectly engage with others. Based on the different spheres and levels of interactions, we develop a conceptual framework that differentiates between five different interaction types, as shown in Figure 2. From the figure, we see that interactions with avatars can be distinguished as *human-to-self-avatar* (H2SA), *human-to-avatar* (H2A), and *self-avatar-to-avatar* (SA2A). Similarly, humans may interact with embodied agents directly (*human-to-embodied-agent*, H2EA) or through their avatars (*self-avatar-to-embodied-agent*, SA2EA). Among the 90 reviewed studies, a majority considered SA2A (34), followed by H2A (21), H2EA (20), H2SA (17), and SA2EA (8) interactions. Note that here the total adds up to more than 90 because some studies have investigated more than one interaction type. The framework captures commonly examined psychological constructs for specific interaction types. Table 1 provides definitions for the psychological constructs that appear in the framework and their usage in different types of interactions.

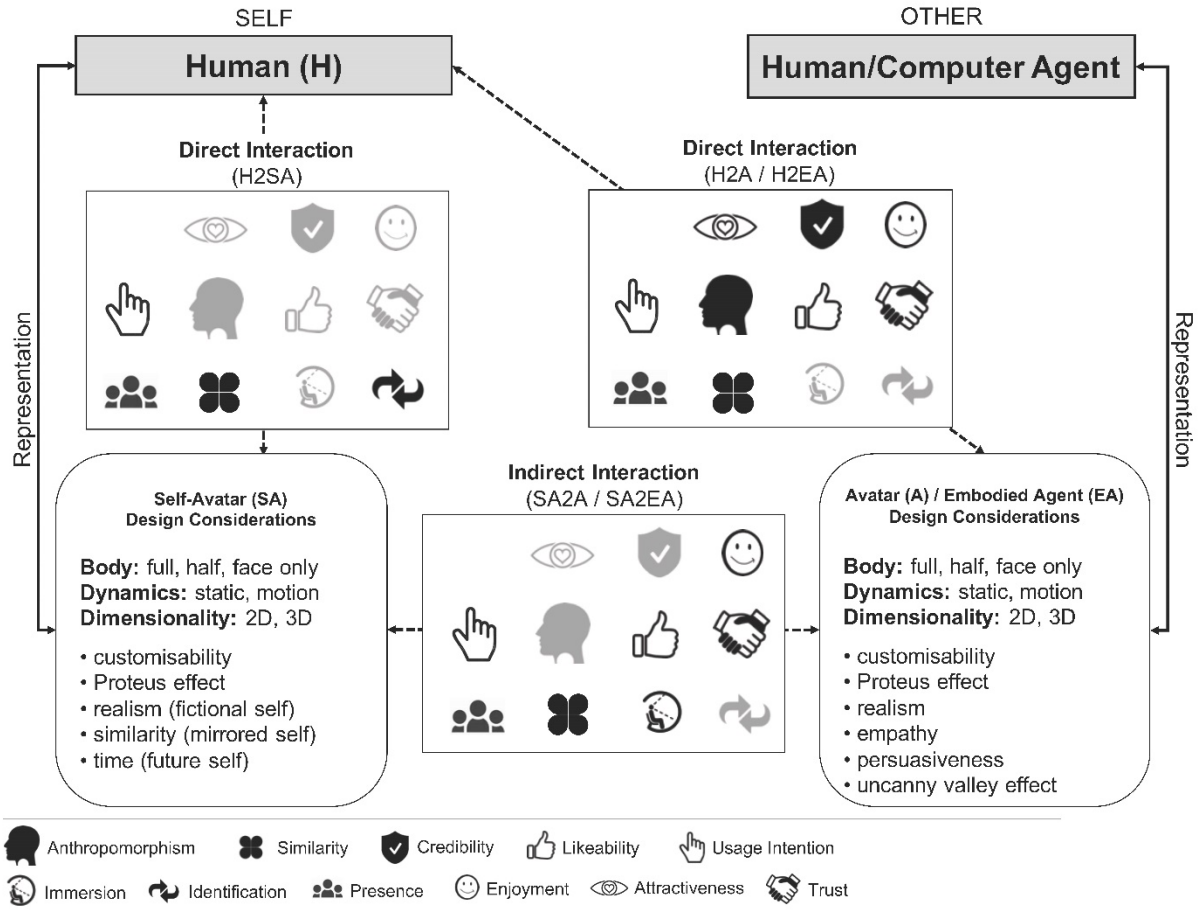


Figure 2. Conceptual framework of digital representations and their interactions

Note: All icons used have been sourced from SVG Silh and Pixabay (https://svgsilh.com & https://pixabay.com; Creative Commons CC0 1.0). The greyed-out icons are not considered in the respective interaction type. For readability, only constructs that are used by at least two studies are shown. Realism includes behavioural, emotional, or visual realism. The complete list of constructs can be found in Table A1 in Appendix A.

Constructs	Description	Usage
Anthropomorphism	The degree of humanness of the digital representation as perceived by the user	**H2A:** Nowak et al. (2015); Nowak & Rauh (2006, 2008) **H2EA:** Y. Kim & Sundar (2012a); Krämer et al. (2013)
Attractiveness	The degree of attractiveness of the digital representation as perceived by the user	**H2A:** Keng & Liu (2013); Leding et al. (2015); Nowak et al. (2015); Nowak & Rauh (2006); Westerman et al. (2015) **H2EA:** Burgoon et al. (2016)
Credibility	The degree to which the digital representation is perceived as believable	**H2A:** Nowak et al. (2015); Nowak & Rauh (2006, 2008) **H2EA:** Y. Kim & Sundar (2012a)
Enjoyment	The degree to which the user enjoys the interaction with the digital representation	**H2A:** Li & Lwin (2016); Rodrigues et al. (2016) **H2EA:** S. Lee & Choi (2017); Qiu & Benbasat (2009, 2010) **SA2A:** Guadagno et al. (2011); Song Kim, Kwon, et al. (2013) **SA2EA:** Guadagno et al. (2011); Jin (2010)
Identification	The degree to which a user identifies themselves with the digital representation	**H2SA:** Seo et al. (2017); Song, Kim, Kwon, et al. (2013)
Immersion	The degree to which a user feels immersed in the virtual environment during the interaction with the digital representation	**SA2A:** Gerhard et al., (2004); Goel et al. (2013); Grinberg et al. (2014) **SA2EA:** Gerhard et al. (2004)
Intention to use	The user's intention to use the digital representation	**H2A:** Y. Lee et al. (2009); Nowak & Rauh (2006); Rodrigues et al. (2016); Westerman et al. (2015) **H2EA:** Gong (2007); S. Lee & Choi (2017); Qiu & Benbasat (2009, 2010) **H2SA:** Fox et al. (2013); Suh et al. (2011) **SA2A:** Fox et al. (2013); Galanxhi & Nah (2007); Lester & King (2009)
Likeability	The degree to which the user likes the digital representation	**H2A:** Bacev-Giles & Haji (2017) **H2EA:** Brave et al. (2005); Gong (2007); Groom et al. (2009); Kang & Gratch (2014); Nunamaker et al. (2011) **SA2A:** Ang et al. (2013); Guadagno et al. (2011); Hanus & Fox (2015) **SA2EA:** Guadagno et al. (2011)
Presence	The degree to which a user feels present in the virtual environment with the digital representation	**H2A:** Kang & Watt (2013); Y. Lee et al. (2009); Li & Lwin (2016); Rodrigues et al. (2016) **H2EA:** Kang & Gratch (2014); Y. Kim & Sundar (2012a); Qiu & Benbasat (2009, 2010) **H2SA:** Fox et al. (2013); Seo et al. (2017); Won et al. (2015) **SA2A:** Felnhofer et al. (2018, 2014); Fox et al. (2013); Franceschi et al. (2009); Gerhard et al. (2004); Grinberg et al. (2014); Guadagno et al. (2011); Guegan et al. (2017); Hammick & Lee (2014); Jin (2012); Kohonen-aho & Tiilikainen (2017); Ratan & Sah (2015); Sutcliffe & Alrayes (2012); Wu et al. (2015) **SA2EA:** Felnhofer et al. (2018); Gerhard et al. (2004); Guadagno et al. (2011); Kohonen-aho & Tiilikainen (2017)

Constructs	Description	Usage
Similarity	The degree to which the user perceives that the digital representation is similar to them	**H2A:** Bacev-Giles & Haji (2017); J. Kim (2011); Nowak & Rauh (2006); Wrzesien et al. (2015) **H2EA:** Beege et al. (2017; Tamborini et al. (2018) **H2SA:** Seo et al. (2017); Suh et al. (2011); Vasalou & Joinson (2009); Wrzesien et al. (2015) **SA2A:** Dolgov et al. (2014); Fehrenbacher & Weisner (2017); Guegan et al. (2016); H.-K. Kim & Kim (2016); J. Kim (2009); J. Kim & Park (2011); Martens et al. (2018); Spence et al. (2013); Westerman et al. (2015)
Trust	The degree to which the digital representation is considered trustworthy by the user	**H2A:** Balas & Pacella (2017); Nowak et al. (2015) **H2EA:** Brave et al. (2005); Gong (2007); Nunamaker et al. (2011); Qiu & Benbasat (2009); Riedl et al. (2011, 2014); Tamborini et al. (2018) **SA2A:** Ang et al. (2013); Fehrenbacher & Weisner (2017); Galanxhi & Nah (2007); Guadagno et al. (2011); Jin (2012) **SA2EA:** Guadagno et al. (2011)

Table 1. Definitions of constructs and their usage in different interaction types

3.1 Avatars

Previous research has studied generic avatars (e.g., Franceschi et al., 2009), customised avatars (e.g., Nowak et al., 2015), or a combination of both (e.g., Suh et al., 2011). Generic avatars are pre-created with some characteristics such as gender, but cannot be customised by users (Dolgov et al., 2014; Ratan & Sah, 2015). Customised avatars, in contrast, allow users to make deliberate choices on appearance (Guegan et al., 2016).

In H2SA interaction, a user controls the movement and/or appearance of their self-avatar by some controlling device (Pessoa et al., 2014). Note that H2SA does not necessarily involve other users' avatars. Here, the interaction between the user and their self-avatar often only expresses the user's inputs through the avatar (Won et al., 2015). In H2A interactions, users interact with others' avatars. They may, for instance, observe the avatar's appearance and behaviour and implicitly evaluate the entity behind it (Nowak & Rauh, 2008). In SA2A interaction, human users control their respective avatars to interact with others through them (e.g., Sutcliffe & Alrayes, 2012). Typical purposes are collaborations and meetings in business contexts (Guegan et al., 2017; Huang et al., 2010), collaborative problem solving (Guegan et al., 2016), or multi-person entertainment (Dolgov et al., 2014; Martens et al., 2018).

3.2 Embodied Agents

Embodiment refers to the visual representation of an abstract idea, a thing, or a person (Taylor, 2002). An embodied agent, in this sense, describes "a perceptible digital representation whose behaviours reflect a computational algorithm designed to accomplish a specific goal or set of goals" (Bailenson & Blascovich, 2004, p. 64). The majority of the reviewed studies investigated embodied agents that exhibit at least some human-like features. In this context, anthropomorphism refers to the degree of humanness of embodied agents, that is, "the extent to which an image is perceived to resemble human characteristics and has human morphology" (Nowak & Rauh, 2006, p. 154). Exemplary applications include the provision of information (Carlotto & Jaques, 2016), product recommendations in e-commerce (Qiu & Benbasat, 2009), or screening interviews (e.g., Nunamaker et al., 2011). In SA2EA interaction, a user controls an avatar and interacts with an embodied agent through their avatar. Common

examples can be found in automated business processes such as job interviews or information delivery (Y. Kim & Sundar, 2012b).

3.3 Artefact Design

For digital representations of humans, Davis et al. (2009) identified three main factors that affect people's perception of self-avatars and (others') avatars. These are 1) avatar appearance, 2) perceived presence (i.e., the sense of being in an environment with another person) (Steuer, 1992; Won et al., 2015), and 3) immersion (i.e., users' perception to be interacting with the virtual environment rather than their physical environment) (Guadagno et al., 2007). These factors are inherently different to those in the human perception of embodied agents.

Our conceptual framework provides an overview of the different forms of appearances employed in the reviewed studies. It considers the dimensionality in which the interaction takes place (i.e., 2D and/or 3D), the dynamics of the visual interaction (i.e., static, motion), and the overall level of embodiment (i.e., face only, half body, full body). Furthermore, the framework lists a number of design considerations for the different types of digital representations that will be further explored in the subsequent sections. Table 2 summarises the artefact design that has been considered for different interaction types.

Artefact Design		Interaction Type					Total
		H2SA	SA2A	SA2EA	H2A	H2EA	
Body	Full	15	30	8	6	7	**66**
	Half	0	0	0	5	7	**12**
	Face only	2	4	0	6	6	**18**
Dynamics	Static	3	4	0	12	5	**24**
	Motion	14	30	8	6	15	**73**
Dimensionality	2D	2	6	0	10	9	**27**
	3D	16	31	8	8	12	**75**
Total		**52**	**105**	**24**	**53**	**61**	

Table 2. Artefact design for different interaction types

Note: Numbers here refer to the number of studies for the respective artefact design and interaction type. The total number adds up to more than 90, due to the fact that some studies have investigated more than one interaction type or artefact design.

One important aspect in this regard is customisation (e.g., Guadagno et al. 2011; Nowak & Rauh, 2008). Customisability refers to the possibility to design and modify an avatar's appearance (Behm-Morawitz, 2013), that is, the degree "to which [it] can be created, selected, or changed to comply with user preferences" (Teng, 2010, p. 1549). In 36 out of the 90 reviewed studies, researchers allowed participants to customise their self-avatars with personalised features (e.g., see Vasalou & Joinson, 2009). In other experimental settings, the degree of visual realism of an avatar is controlled to achieve specific interactional outcomes, for instance, to increase avatars' credibility (e.g., Nowak & Rauh, 2006). Here, self-avatars may depict photorealistic, fictional, or supernatural characters (Vasalou & Joinson, 2009).

3.4 Presence and Immersion

One central concept for understanding avatars and embodied agents is presence. In our framework, it represents one of the most frequently-investigated constructs. Digital interaction is generally considered an unnatural way of human communication, as the interaction partners are separated physically (Carter et al., 2015; Grudin, 2001). However, avatars can be used to establish presence anyway (Kang & Watt, 2013), that is, user A's sense of being in an

environment with user B, where users are digitally represented across space or time, and react to each other or to stimuli (Heeter, 1992; Steuer, 1992; Won et al., 2015). There are different concepts of presence, which include individual-, physical-, social-, co-, tele-, and virtual presence (see Franceschi et al. (2009) and Nowak & Biocca (2003) for details).

Closely related to presence, immersion refers to the degree to which users experience being within a virtual rather than in their actual physical environment (Guadagno et al., 2007). Realistic environments yield higher presence, which in turn lead to higher immersion (Guadagno et al., 2007; Jin, 2012). In gaming, for example, Teng (2010) found that higher immersion enhances user loyalty to the game. Immersed users can also be more socially engaged (Grinberg et al., 2014).[3]

3.5 Experimental Research on Avatars and Embodied Agents

Laboratory and field experiments are typically employed to investigate human behaviour when interacting with avatars and embodied agents. In fact, the majority of experimental studies in the field of IS involving avatars or embodied agents have been conducted in laboratory settings, where researchers are able to tightly control environmental parameters, mitigate confounding effects, and thus can establish causality of effects between system design and human perceptions, physiology, and behaviour. In our SLR, for example, as many as 84 studies were conducted in laboratory environments, while only five studies were conducted in the field and one based on both laboratory and field experiments. The six studies that conducted field experiments controlled different aspects of real-world settings. These include customers of an electronic banking application (Rodrigues et al., 2016), self-tracking of physical activities in users' everyday environments (Sanchez-Valdes & Trivino, 2015), airport security screenings (Nunamaker et al., 2011), and students' performance, engagement, and presence in an online course (Barata et al., 2017; Franceschi et al., 2009; Lester & King, 2009).

3.6 Application Contexts

Avatars and embodied agents have become widely used as design elements in IS research. By providing a graphical representation of humans and computer agents, they have been shown to create positive user experience (e.g., usability, collaboration), support learning processes (e.g., performance, engagement), and facilitate behavioural intention (e.g., physical activity, usage intention, purchase intention) in a wide range of applications. Based on the studies we reviewed, the application contexts include business, education, entertainment, health, and social interaction. Table 3 summarises the number of studies for each application context and interaction type.

[3] Importantly, the use of avatars can also increase involvement and trust between users behind the avatars. The outlined concepts of presence and immersion are central to research on avatars, and we will repeatedly use and refer back to these notions in the subsequent sections.

Context	Interaction Type					Total
	H2SA	SA2A	SA2EA	H2A	H2EA	
Business	1	6	1	6	8	**22**
Education	3	5	0	1	1	**10**
Entertainment	6	8	1	1	5	**21**
Health	2	0	2	1	1	**6**
Social	5	15	4	9	3	**36**
Total	**17**	**34**	**8**	**18**	**18**	

Table 3. Application contexts for different interaction types
Note: Numbers here refer to the number of studies for the respective context and interaction type. The total number adds up to more than 90, due to the fact that some studies have investigated more than one interaction type for the respective context.

4 Interaction with Self-Avatars

4.1 Self-Avatar Concepts

Digital environments enable users to interact and communicate in ways that go beyond those of traditional channels (Goel et al., 2013; Hämäläinen et al., 2008; Mccreery et al., 2012). To do so, they need to represent themselves therein (Mallan, 2009). Self-avatars function as tools for representation, immersion, and interaction with others in virtual worlds (Ducheneaut et al., 2009; Koles & Nagy, 2012). This section synthesises the results of studies on a user's interaction with their own avatar, covering the design dimensions *customisability, realism,* and *time*, as well as the avatar's effects on user perceptions and behaviour. Overall, 11 studies (13.1% based on our SLR) considered H2SA interactions in different contexts such as health (H. E. Kim et al., 2017; Sanchez-Valdes & Trivino, 2015), business and entertainment (Kaye et al., 2018; Peña & Chen, 2017; Won et al., 2015), and education and social interaction (Seo et al., 2017; Song, Kim, Kwon, et al., 2013; Vasalou et al., 2008; Vasalou & Joinson, 2009).

For the dimension of time, some avatar concepts refer to a *future* state of the represented person (Song, Kim, Kwon, et al., 2013), while avatars in a *now* state refer to the current or currently desired state. A special case of future self-avatars is the idealistic representation. Based on the *self-idealism paradigm*, an ideal self refers to what the user *aims* to become in the future and may include aspects of education, socialisation, role models, societal norms, and preferences (Dunn & Guadagno, 2012).

For the dimension of realism, there are *mirrored* and *fictional* representations (e.g., Peña et al., 2016; Suh et al., 2011; Vasalou & Joinson, 2009). The concept of a *mirrored self* refers to self-avatars that resemble the actual person as much as possible (Vasalou et al., 2008), which may include mirrored behaviours and gestures, representing aspects of the user in the real world (Burton-Jones et al., 2017; Recker et al., 2019). It can be seen as a simulated, mirror version of the self, and reflective of the offline self, as well as has the potential to influence the individual in meaningful ways. For example, previous research has demonstrated that avatars that show the consequences of smoking by means of altered physical appearance are capable of creating a sense of risks associated with smoking (Song, Kim, Kwon, et al., 2013).

The concept of *fictional self*, in contrast, represents the user as a fictional, possibly fantastic character. Users may represent themselves as fictional characters to escape from their actual selves (Greenwood, 2008), or to gain new perspectives, experiences, and knowledge (Shedlosky-Shoemaker et al., 2014). For example, a user may hide their identity and use an authoritative or persuasive avatar for a new role.

4.2 Influences on User Perceptions and Behaviours

While much research considers how one user's avatar affects other users, *a user's (self-) avatar can also affect their own perceptions and behaviours* in the virtual environment and in the real world (Yee et al., 2009). This phenomenon is known as the *Proteus effect* (Yee & Bailenson, 2007). The effect is rooted in self-perception theory (Yee et al., 2009), positing that there will be modifications in self-perception based on the behaviour and/or characteristics of a user's avatar (Fox et al., 2013). For instance, users may adopt new behaviours (desirable or undesirable) from their self-avatars (Fox & Ahn, 2012; Seo et al., 2017), and exhibit increased confidence and willingness to disclose information when being represented by attractive self-avatars (Yee and Bailenson, 2007). Also, users exhibit increased physical activity when represented by athletic instead of obese self-avatars (Peña & Kim, 2014). To understand the Proteus effect, it is important to consider how the characteristics of a user's avatar affect behaviour specifically. Relevant mediating constructs in this regard include 1) self-relevance, 2) self-identification, 3) emotional attachment, 4) presence, and 5) anthropomorphism (Behm-Morawitz, 2013; Jin, 2012; Nowak & Rauh, 2006; Pessoa et al., 2014; Ratan & Dawson, 2016; Seo et al., 2017; Song, Kim, Kwon, et al., 2013; Vasalou et al., 2008).

Self-relevance describes "the extent to which the user of a mediated representation that appears and/or behaves like the user is closely connected to the self" (Ratan & Dawson, 2016, p. 3). *Self-identification* refers to "the cognitive connection between an individual and an avatar, with the result being that the individual regards the avatar as a substitute self or has such an illusion" (Suh et al., 2011, p. 715). Both concepts capture how users identify and relate to their digital representation. Importantly, customisability increases self-identification and self-relevance (Bailey et al., 2009; Lim & Reeves, 2010). In turn, self-identification and self-relevance are found to increase emotional attachment with the avatar (Suh et al., 2011). Also, users pay more attention and feel physically more similar to self-avatars when these avatars reflect them visually as compared to avatars that reflect others (including celebrities, ideal faces, and strangers) (Seo et al., 2017).

Next, *emotional attachment* describes "an emotion-laden, target-specific bond between a person and a specific object" (Thomson et al., 2005, p. 77). Higher degrees of self-relevance and self-identification typically yield stronger emotions when interacting with the environment through one's avatar (Ratan & Dawson, 2016; Ravaja et al., 2006). In addition, users who customised their self-avatar also experience greater emotional attachment to it – which, in turn, increases the avatar's power to affect their behaviour (H.-K. Kim & Kim, 2016). Emotional attachment with one's avatar also increases perceived *presence* in the virtual environment, which can be defined as the state in which "users experience their virtual self as if it were their actual self, perhaps even leading to an awareness of themselves inside the virtual environment" (Tamborini & Skalski, 2006, p. 227). Also, it has been shown that self-avatars can stimulate presence for blind users, helping them to explore environments virtually and identify objects in virtual spaces before visiting the actual site (Cobo et al., 2017).

Anthropomorphism captures how a human-like avatar appears, including naturalness and richness with regards to typical human cues (Nowak & Rauh, 2006). In the context of self-avatars, it has been shown that this factor increases users' emotional attachment and their perceptions of the avatar's credibility (Nowak & Rauh, 2006). Evil-looking and corpse-like avatars, on the other hand, affect users' perception of engagement and behaviours negatively when contrasted against heroic and attractive avatars (Peña & Chen, 2017).

5 Interaction with Another Person's Avatar

5.1 Avatar Concepts

In this section, we explore how users interact with other users represented by avatars. Overall, 22 of the reviewed studies (26.2%) considered H2A interactions, that is, the direct interaction of a user with another user's avatar. Moreover, 28 studies (33.3%) considered SA2A interactions, that is, interactions between avatars. The studies are of various contexts such as entertainment (e.g., Dolgov et al., 2014; Dunn & Guadagno, 2012; Goel et al., 2013; Martens et al., 2018), education (e.g., Ang et al., 2013; Franceschi et al., 2009; H. E. Kim et al., 2017; Lester & King, 2009; Sutcliffe & Alrayes, 2012), business (e.g., Hanus & Fox, 2015; Nowak et al., 2015), health (e.g., Spence et al., 2013), and social interaction (e.g., Jin, 2012; Kohonen-aho & Tiilikainen, 2017; Wu et al., 2015).

Previous research suggested two marked goal-directed dimensions of avatar design, namely *persuasiveness* and *empathy/emotionality*. Persuasive avatars, also referred to as authoritative avatars (Beale & Creed, 2009), are avatars designed to affect users' choices (Bengtsson et al., 1999; Hanus & Fox, 2015). One way to achieve persuasiveness is to give users the ability to customise the avatar before the interaction (Hanus & Fox, 2015). For instance, an avatar may be customised to represent a doctor with high authority in the medical field (Peña et al., 2009). In contrast, the concept of empathic/emotional avatars refers to avatars designed with non-verbal cues and behaviours such as smiling, which can create an emotional connection with users (H.-K. Kim & Kim, 2016). Felnhofer et al. (2018) found that users interacting with avatars that are controlled by other users reported higher levels of empathy and involvement than users interacting with embodied agents.

5.2 Influences on User Perceptions and Behaviours

How an avatar is perceived by its interaction partner(s) is crucial for how it affects their behaviours. First, avatars of high anthropomorphism are perceived as more credible by their interaction partners (Nowak & Rauh, 2008) and can improve communication (Kang & Watt, 2013; Khashe et al., 2017). Visually realistic avatars are found to have higher capability of mitigating undesired and facilitating desired behaviours than unrealistic ones (Nowak et al., 2015), e.g., promoting compliance (Khashe et al., 2017). In this vein, Kang & Watt (2013) found that more visually realistic avatars elicit higher levels of immersion, presence, and trust, which enriches interaction between users and creates more truthful interactions (Hooi & Cho, 2013; Sutcliffe & Alrayes, 2012), and increases users' intention to work together to achieve a common goal (Lim & Reeves, 2010). Ang et al. (2013) found that perceived trust and likeability increase if an avatar exhibits human-like behaviours. Thus, conveyed by perceptions of presence and trust, visually realistic avatars will typically have stronger impacts on user behaviour (Khashe et al., 2017). H. E. Kim et al. (2017) found that avatar-based training can lower anxiety and facilitate interpersonal encounters for patients with social anxiety.

Second, similarity refers to the perceived degree of psychological and/or physiological resemblance between a user and their interaction partner's avatar, including visual appearance, demographic factors, values, beliefs, behaviours, education, training, or knowledge (McCroskey et al., 1975; Nowak & Rauh, 2006). Higher similarity yields stronger perceptions of group belonging and virtual team identification (Guegan et al., 2017; J. Kim & Park, 2011; Midha & Nandedkar, 2012), playing an important role for interaction effectiveness (McCroskey et al., 1975; Webster & Wong, 2008). Guegan et al. (2017) and Wrzesien et al. (2015)

also noted that similarity between avatars and users impacts social behaviours and group structuring. Bailenson et al. (2006) pointed out that users tend to find others who are physically and psychologically similar to themselves not only more attractive, but also more persuasive. However, this perception of similarity and presence depends on users' senses of shared context with other users (Kohonen-aho & Tiilikainen, 2017). Users pay more attention within virtual environments when avatars reflect their own gender (Martens et al., 2018). Users represented by foreign avatars are perceived not similar to them, considered as out-group members, and hence excluded from the group (Schneider et al., 2017). Moreover, the perception of similarity is not limited to gender and physical appearance, but also related to ethnicity and culture. For example, Spence et al. (2013) found that avatars that reflect users' ethnicity are associated with an increased usage intention compared to avatars that do not.

Third, beyond realism and similarity, Leding et al. (2015) showed that avatars with high perceived attractiveness exert strong influences on human behaviour. In this regard, Westerman et al. (2015) found that users are more inclined to interact with physically attractive rather than unattractive avatars. For online social interaction, Bacev-Giles & Haji (2017) found that users rated avatars as more attractive and likeable if the avatars are perceived to be similar to them. For online advertisements, Keng & Liu (2013) found that using dynamic, attractive, and 3D (as compared to static, 2D, or unattractive) avatars increase advertisement effectiveness. Moreover, Guadagno et al. (2011) found that a smile can create a sense of connection and increase trust between the interaction partners, enjoyment, and satisfaction. However, when avatars are compared to real human images directly, Balas & Pacella (2017) found that users rated avatars less trustworthy. Also, people would refuse to share knowledge with a colleague represented by an avatar (Fehrenbacher & Weisner, 2017). Fabri et al. (2005) found that the use of emotional (as compared to non-emotional) avatars increase user involvement in social communication tasks.

Fourth, users are more likely to be persuaded if an avatar exhibits angry (rather than soft) and/or male (rather than female) voice (Lehto & Oinas-Kukkonen, 2011). In a recent study (Khashe et al., 2017), it is found that users may be more easily persuaded when a message is communicated by avatars rather than voice or text. In this regard, androgyny refers to "a rating of the avatar's (lack of) masculinity or femininity" (Nowak & Rauh, 2006, p. 154), affecting several perceptual and behavioural measures. For example, high avatar androgyny is found to reduce the associated user's credibility (Nowak & Rauh, 2008). Similarly, inappropriately dressed avatars are rated as less anthropomorphic and less credible (Nowak et al., 2015).

Finally, uniqueness indicates that an avatar is different from other digital representations. Uniqueness of avatars, such as unusual physical features, or social or psychological differences, can impair interaction effectiveness (Kang & Watt, 2013; J. Kim, 2009). J. Kim (2011) stated that users represented by avatars that have visual cues similar to those of their group members perceive a higher level of threat to their uniqueness, compared to those represented by avatars with unique visual cues, leading to lower agreement rates with others.

6 Interaction with Embodied Agents

6.1 Embodied Agent Concepts

In this section, we focus on embodied agents and their effects on interaction partners. Overall, 19 of the reviewed studies (22.6%) considered H2EA interactions and 4 (4.8%) considered SA2EA interactions. The studies are of multiple contexts such as business (e.g., S. Lee & Choi,

2017; Nunamaker et al., 2011; Qiu & Benbasat, 2009), entertainment (e.g., Brave et al. 2005; Mousas et al. 2018; Peña et al. 2016), education (e.g., Ang et al., 2013; Carlotto & Jaques, 2016), health (e.g., Beege et al., 2017; Jin, 2010; Y. Kim & Sundar, 2012b), and social interaction (e.g., Dechant et al., 2017; Kang & Gratch, 2014; Krämer et al., 2013).

The *computer as social actors* (CASA) paradigm posits that humans apply social rules and norms when interacting with computers (Bailenson & Blascovich, 2004; Nass et al., 1994). Specifically, visually and behaviourally realistic embodied agents yield higher engagement and involvement between interaction partners (Burgoon et al., 2016; Gerhard et al., 2004). Hence, much of the existing literature on embodied agents is centred on different forms of agent realism, where the differences between human, behavioural, visual, and emotional realism are distinguished. Different design considerations for embodied agents in terms of 1) realism and 2) persuasive and empathic design concepts have also been suggested by previous research.

6.2 Realism

First, *human* realism of embodied agents refers to behavioural, visual, and emotional characteristics (e.g., face and voice) of embodied agents that should be consistent with human characteristics (Mitchell et al., 2011). It represents an important factor for humans as they are more likely to interact with human-like than non-human-like embodied agents (Groom et al., 2009; Parise et al., 1999). In this sense, higher human realism may contribute to a higher degree of faithfulness of the digital representation, as it more closely resembles interpersonal interactions in the real world.

Second, *behavioural* realism refers to the presence of natural movements, gestures, and reactions of embodied agents (von der Pütten et al., 2010). Manipulation of behavioural realism was found to influence human and avatar responses (Bailenson et al., 2005; Slater et al., 2009), where higher levels of behavioural realism would lead to more likeable and trustworthy embodied agents (Groom et al., 2009). High levels of behavioural realism are usually considered more appropriate in terms of social behaviour and responses (Guadagno et al., 2007; Nass & Moon, 2000). Embodied agents equipped with realistic motion and physical appearance have greater influence than static or remoted embodied agents, as they stimulate genuine social interactions (Mousas et al., 2018).

Third, *visual* realism refers to "the degree to which the images of the simulated world are perceived to be real" (C. Lee et al., 2013, p. 548). According to Slater et al. (2009), visual realism has two components. First, geometric realism captures whether the digital representation looks like the real object that it represents. Second, illumination realism refers to the fidelity of lighting (Slater et al., 2009; Strauss, 1990). Notably, visually detailed embodied agents are found to create a sense of social presence (Kwon et al., 2013).

Fourth, *emotional* realism refers to the expression of emotions similar to that of humans (Beale & Creed, 2009). Emotion expression entails the ability to establish emphatic relationships between the embodied agents and users (Ahn et al., 2007). In e-learning, for instance, embodied agents with realistic emotional expression can enhance learning experiences and outcomes (Dickey, 2005). As Beale & Creed (2009) discussed, the importance of emotional consistency in embodied agents and appropriateness to the context could enhance the overall interaction.

6.3 Persuasive and Empathic Embodied Agents

Human-like embodied agents (e.g., a salesperson; Hanus & Fox, 2015) can be more persuasive when compared to using text or voice in the context of e-commerce (Qiu & Benbasat, 2010). Importantly, embodied agents that represent human features are likely to be viewed as more authoritative and persuasive by their interaction partners (Qiu & Benbasat, 2009). For example, Bailenson & Yee (2005) found that embodied agents with high behavioural realism that mimic user gestures are more persuasive and likeable than agents without this feature. In the context of health, however, Sebastian & Richards (2017) found that embodied agents representing doctors are not more persuasive than actual medical doctors for mental health patients.

Empathic embodied agents display emotions, which can influence users by increasing likeability and trustworthiness (Brave et al., 2005). For education, Maldonado et al. (2005) found that emotional embodied agents positively enhanced students' performance, experience, and perceptions of the embodied agents' intelligence and credibility. Beege et al. (2017) noted that embodied agents' age is irrelevant when activated alongside with text. Additionally, Bickmore & Picard (2005) found that embodied agents equipped with a range of non-verbal behaviours (e.g., hand gestures, nod, eye gaze) increase the connection between users and embodied agents, which lead to greater likeability and trust. Importantly, users perceived empathic embodied agents as more caring, sociable, likeable, and trustworthy, and they reported to perceive significantly higher levels of support when an embodied agent created the feeling of an actual partner during the interaction (Brave et al., 2005; S. Lee & Choi, 2017).

6.4 The Uncanny Valley

While human realism is important, all too realistic embodied agents bear the risk of making people feel uncomfortable and often result in negative reactions (Burgoon et al., 2016; Mara & Appel, 2015). This effect is known as the "uncanny valley", which, according to MacDorman & Ishiguro (2006) and Mori (1970), refers to human-like digital representations that appear almost, but not exactly like real human beings and consequently stimulate feelings of eeriness and revulsion. Since people usually *know* that the displayed entity is artificial (regardless of whether representing a human or not), and not a video stream of an actual human being, interaction design should keep a safe distance from realism in order to avoid the uncanny valley effect. In this sense, designers may employ a stylised or "comicified" representation with empathic features (Teubner, Adam, Camacho, & Hassanein, 2014).

It is also essential to ensure a balance between appearance and behaviour of embodied agents to avoid the uncanny valley effect (Allbeck & Badler, 2004; Groom et al., 2009; Mitchell et al., 2011). On one hand, users dislike embodied agents that are too realistic (e.g., human replica; Groom et al., 2009) and exhibit negative responses to unrealistic (non-human-like) embodied agents such as zombies (Mousas et al., 2018). On the other hand, people experience lower levels of satisfaction when communicating with a less realistic (e.g., animalistic) digital representation. Hence, designers should include characteristics that increase relatedness, feelings of being understood, attractiveness, empathy, and so forth that appear natural to users to avoid the feeling of eeriness. Interacting with embodied agents that do not reflect users' ethnicity is rated as less trustworthy compared to interacting with embodied agents that do (Tamborini et al., 2018).

It is worth noting that this eeriness is not only about human-like physical appearances of embodied agents, but also about the display of emotion states. The design of embodied agents should focus not only on human-like appearance and behaviour, but also on emotions displayed by embodied agents (Beale & Creed, 2009; Saygin, 2011). An embodied agent that smiles with a concerned voice is suggested to be problematic, as it exhibits inconsistency in audio-visual realism (Beale & Creed, 2009), which may in turn reduce users' perceived faithfulness of the digital representation. Designers should, therefore, consider contextual appropriateness to embodied agent emotional displays to avoid the uncanny valley effect.

7 Discussion and Conclusion

7.1 Summary of Findings

Over the past twenty years, researchers from the IS domain have conducted controlled experiments in laboratory and field environments to better understand the interactions of human users with digital visual representations of humans (avatars) and computer agents (embodied agents). To stimulate research that extends the knowledge of avatars and embodied agents, and potentially enables innovative applications of such digital representations, we conducted the present SLR. Based on this review, we provided a comprehensive overview of the extant literature on experimental research on avatars and embodied agents and identified key aspects that affect human perceptions and behaviours when interacting with avatars or embodied agents. Table 4 provides a summary of our findings.

Interaction Types	Design Considerations	Psychological Constructs	Examples of Implications of Design Choices	Examples of Interaction Outcomes
H2SA	Customisation, Proteus effect	Similarity	Users feel more self-relevance and similar to their avatars if they can customise them	Positive effects on helping behaviour (e.g., Dolgov et al., 2014)
		Presence	Users feel more socially present using their self-avatars	Increased emotional attachment to avatars (e.g., H.-K. Kim & Kim, 2016)
H2A / SA2A	Customisation, Realism, Proteus effect	Similarity	Users feel similar to customised avatars that resemble them in terms of gender, physical appearance, and ethnicity	Increased sense of group belonging (e.g., Guegan et al., 2017)
		Attractiveness	Users prefer to interact with or use attractive avatars	Reduced risk-taking behaviour (e.g., H.-K. Kim & Kim, 2016)
		Anthropomorphism	Users prefer to interact with more human-like avatars in terms of visual, behavioural, and emotional realism	Perceptions of higher naturalness in interaction (e.g., Garau et al., 2003)
		Presence	Users feel more socially present in the interaction with human-like avatars	Higher degrees of immersion (e.g., Franceschi et al., 2009)

Interaction Types	Design Considerations	Psychological Constructs	Examples of Implications of Design Choices	Examples of Interaction Outcomes
H2EA / SA2EA	Realism, Uncanny valley	Anthropomorphism	Users prefer adequately realistic and human-like embodied agents that exhibit consistency in terms of visual, behavioural, and emotional realisms (human-like realisms)	Irritation and disengagement for too low (e.g., Mousas et al., 2018) or too high (e.g., MacDorman et al., 2009) levels of anthropomorphism
		Enjoyment	Users perceive interactions with embodied agents as less enjoyable if these exhibit inconsistency in terms of visual, behavioural, and emotional realisms	Disengagement from the interaction if not enjoyable (e.g., Groom et al., 2009)
		Similarity	Users prefer to interact with embodied agents that are similar to them (e.g., in terms of gender, appearance, or ethnicity)	Higher involvement and trust in the embodied agent (e.g., Tamborini et al., 2018)
		Presence	Users prefer to interact with human-like embodied agents	Higher levels of liking and credibility as a source of information (e.g., Y. Kim & Sundar, 2012a)

Table 4. Summary of findings from the SLR

In the context of human interaction with *self-avatars* (H2SA), experiments have shown that when people are given the freedom to customise their avatar, it would not necessarily reflect their actual selves (Vasalou & Joinson, 2009). Customisation enables users to create a sense of relevance with their avatars, which, in turn, can increase identification with the self-avatar. Notably, if there is a strong sense of self-relevance, this may affect the user's behaviour positively or negatively (Proteus effect) (Fox et al., 2013). Emotional attachment with the self-avatar is an important aspect of the digital representation if the purpose of interaction is to change user behaviour. Perceived similarity and customisation of digital representations lead to emotional attachment with avatars (H.-K. Kim & Kim, 2016) and higher levels of self-presence (Seo et al., 2017). Basically, customisation should be available to facilitate behavioural change, as users would customise their avatars to their liking.

In the context of human and self-avatar interaction with *another person's avatar* (H2A and SA2A), the user or self-avatar interacts with another person's avatar to achieve a common goal. Research has shown that avatar representations affect the interaction partners' perceptions via the construct of anthropomorphism. Garau et al. (2003) found that interactions with realistic avatars, in terms of visual (human-like) and behavioural realisms (consistent with human behaviours), are considered as more natural (i.e., to feel more like a face-to-face interaction). Attractiveness of digital representations influences the interaction partners' behaviours in terms of risk taking (H.-K. Kim & Kim, 2016). Psychological similarity emphasises the importance for the avatar to be part of a team (Guegan et al., 2017), which means that the avatar's customisation should be consistent, so it can be identified as part of the team or group. Uniqueness and similarity are two important constructs for ensuring that an avatar can be identified by the interaction partners. Immersion and presence, which work interchangeably, are important for H2A and SA2A interactions too. That is, presence increases immersion and vice versa. Presence is magnified by the fact the interaction partners can see and hear each other (Franceschi et al., 2009), which attracts user attention. Interacting with avatars can result

in behavioural change due to the Proteus effect, which affects users' behaviours either by acting similarly or differently to other avatars in the interaction.

In the context of human and self-avatar interaction with an *embodied agent* (H2EA and SA2EA), research showed that human realism in an embodied agent should reflect natural human behaviour, appearance, and emotion. It is important to ensure that all human realism dimensions are matched with actual human behaviour, emotion, and visual cues in order to avoid the uncanny valley effect (Groom et al., 2009), which means that unmatched human realism can irritate people and lead to disengagement (Mitchell et al., 2011). Human realism is an important aspect of embodied agents' representation, to create a digital representation that has human-like features and also to create a sense of social cues in the interaction. This is because humans usually prefer to digitally interact with a representation that is similar to them. The perception of similarity here is not limited to physical appearance or gender between users and digital representations, but also includes ethnicity and culture (Tamborini et al., 2018). Human realism and psychological similarity can increase the sense of presence, immersion, and involvement with the embodied agent. These, in turn, will ensure enjoyment, information credibility, likeability, and trust between the interaction partners. Similarly, information provided by an embodied agent is more credible and believable if it exhibits human-like features (Kim & Sundar, 2012a), and if these features are consistent with actual human features. Expectedly, likeability of embodied agents hinges on matching human features realistically. In summary, human realism can induce trust (Riedl et al., 2014), which enables the interaction partners to share information or work collectively with the embodied agent.

To summarise, appearance and behaviour of avatars and embodied agents are important antecedents of interaction outcomes and may lead to negative (e.g., disengagement and untrustworthiness) or positive (e.g., enjoyment) user reactions. According to Guadagno et al. (2007), the more anthropomorphic an embodied agent or avatar appears, the more realistic its interactional behaviour such as facial expressions or smiles needs to be for the digital representation to stimulate appropriate social/behavioural responses. Hence, in line with RT (Burton-Jones et al., 2017; Recker et al., 2019), avatars and embodied agents may yield higher faithfulness (e.g., in terms of credibility, similarity, presence) if these representations closely resemble the real-world phenomena of human cues in interpersonal interactions (e.g., Groom et al., 2009; Nowak & Rauh, 2006). In contrast, less anthropomorphic representations, that is, with inconsistencies in behavioural, emotional, and visual realism, may lead to adverse outcomes in the interaction between humans and digital representations.

7.2 Practical Implications

Most digital interactions of avatars and embodied agents focus on stimulating changes in user experience (e.g., emotion) and facilitating targeted behaviours. Based on the present literature review, we have identified six factors designers should particularly take into account when considering the design and implementation of avatars and embodied agents in practice.

First, designers should be aware of the *Proteus effect*, which relates an avatar's characteristics to its "owner's" own behaviour (Fox et al., 2013; Peña et al., 2009, 2016; Yee and Bailenson, 2007). The Proteus effect occurs when users are represented by avatars in a virtual environment (Yee et al., 2009). It can have positive implications when there is a need to change certain behaviours or perceptions. In this sense, a positive appearance of avatars can increase user confidence – especially in conversations or negotiation tasks (Won et al., 2015; Yee &

Bailenson, 2007). Expectedly, a negative connotation (e.g., overweight avatars) can dampen user motivation and mood by reinforcing unhelpful judgment, while an athletic avatar may promote liveliness and boost physical activity (Peña & Kim, 2014). It is hence important for designers to carefully take into account the Proteus effect, as their virtual designs may have unimagined or undesired consequences in the physical world (H.-K. Kim & Kim, 2016).

Second, designers need to consider the *uncanny valley effect*, which occurs when the appearance of a representation looks almost like a real human, but just not fully so (Beale & Creed, 2009; Tinwell et al., 2011). Since virtually all avatar designs will not achieve full human realism, designers should – despite their efforts to embed human and social cues such as facial features and gestures – keep a safe distance from all too realistic avatars. In this sense, a deliberate abstraction and stylisation, for instance, using comic faces, may be a viable option. Moreover, they should employ attractive and empathetic avatars to reduce uncanny impulses.

Third, designers need to consider the concept of *presence* for the design of digital interaction, as this does not represent the natural form of communication among humans. Designers should focus on features that stimulate presence to make the interaction appear social. Previous research has shown that digital representations that exhibit consistent behavioural realism yield greater social influence (Kang & Gratch, 2014). Importantly, digital representations that are similar to users are perceived as more sociable, enjoyable, and useful to interact with than dissimilar ones (Bacev-Giles & Haji, 2017; Qiu & Benbasat, 2010; Seo et al., 2017). Designers should be aware of this to stimulate presence.

Fourth, *persuasive* design of digital representations is used to influence users' behaviours or decisions towards a specific idea. Research has shown that users prefer to interact with powerful and authoritative avatars, which can achieve better outcomes (Fox et al., 2013; Schultze, 2011). Also, digital representations with strong facial expressions increase persuasiveness. Hence, for behaviour change, more engaged avatars are preferable over passive ones (Hyde et al., 2015). Moreover, persuasion can be supported by higher anthropomorphism (e.g., using detailed facial expressions). Overall, more visually realistic avatars convey stronger messages, increase the chances to persuade users (Khashe et al., 2017) and, in turn, guide behaviour (Aljaroodi, Adam, Chiong, Cornforth, & Minichiello, 2017; Noorbergen et al., 2019).

Fifth, designers should consider *empathic* elements in designing digital representations. Empathy creates a sense of social interaction for the interaction partners. Experiments with digital representations have shown that a simple display of emotion can change the result of an interaction. Importantly, users dislike embodied agents that display inconsistent emotions (Beale & Creed, 2009) and exhibit negative responses to agents with pale and gaunt appearances (Mousas et al., 2018). Additionally, empathic elements should be appropriately matched with human emotions and their transitions (Burgoon et al., 2016). Empathic elements are important aspects of designing digital representations, because they make the interaction more supportive, enjoyable, trusting, and open for the users (Guadagno et al., 2011). Empathy leads to more positive interactions, including greater likeability and trustworthiness between the interaction partners (Brave et al., 2005). Designers should consider including characteristics of non-verbal and verbal behaviour to increase emotional attachment (Beale & Creed, 2009).

Lastly, designers should ensure that *customisability* is available to users, as it enhances the connection between users and their digital representations (Hanus & Fox, 2015; Ratan & Sah, 2015). Enabling users to create their own avatars would make the users more carefully engaged

in preventative (e.g., quitting unhealthy habits) or proactive behaviour (e.g., picking up healthy routines) (Y. Kim & Sundar, 2012b). Customisation is used to change or enhance the user's behaviour and try to elevate the user's level of emotional attachment (Ducheneaut et al., 2009; Hanus & Fox, 2015). Therefore, designers should ensure that digital representations can be customised by the users to create a stronger emotional connection.

7.3 Future Research Directions

Building on the findings of our literature review, we have identified three major directions for future IS research on avatars and embodied agents. First, in terms of *research methodology*, it needs to be noted that the majority of reviewed studies were exclusively conducted experiments in laboratory settings (84 out of 90 studies) and only six studies considered a field setting (e.g., Barata et al., 2017; Rodrigues et al., 2016; Sanchez-Valdes & Trivino, 2015). There is limited knowledge as to how critical the real-world context is for transferring results of laboratory studies to the field. This can be addressed in future research by putting a stronger emphasis on field experiments. Further, so far only eight studies considered physiological measurements (e.g., see Lim & Reeves, 2010). However, it is known that human emotional responses involve unconscious processes (Walla & Panksepp, 2013). Hence, there is a need for more physiological studies to uncover the unconscious effects of digital representations on users and their links to user perceptions. It is also necessary to note that our review has focused exclusively on experimental research. There is thus a need for future research to discern whether the results presented here are intrinsic to experimental studies. This can be achieved through a complementary review that focuses on other (non-experimental) research methods or through multi-method approaches that combine experimental and non-experimental approaches (e.g., focus groups, interviews).

Second, our review has identified several interesting knowledge gaps in terms of *avatar appearance*. So far, studies on self-avatars have exclusively focused on face-only or full-body avatars (see Table 2). It would be interesting to investigate half-body avatars in the self-avatar context and contrast it to the results of face-only and full-body avatars. Further, while research has emphasised the importance of high similarity between the user and a digital representation, the majority of studies on similarity considered just the avatar's physical appearance (e.g., body size, clothing, hair) or gender. Only three studies have explicitly considered the user's ethnicity (Fehrenbacher & Weisner, 2017; Spence et al., 2013; Tamborini et al., 2018). Digital representations in these three studies were based on, and hence represented, the ethnicity of (1) African-American and Caucasian people (Spence et al., 2013; Tamborini et al., 2018), and (2) Asian and Caucasian people (Fehrenbacher & Weisner, 2017). It is known that visual appearances that are appropriate for one culture can be inappropriate in another (Abdallah & Douglas, 2010; Aljaroodi, Chiong, & Adam, 2017; Yusof & Zakaria, 2007). Therefore, further research is needed to explore the effects of similarity and other constructs (e.g., credibility, likeability) in the context of users' culture and ethnicity. Also, the scope should be broadened beyond Asian, African-American, and Caucasian cultures (e.g., Arabian and Indigenous cultures).

Third, the degree of overlap in the psychological constructs investigated by the different studies is quite low, even within the five interaction types (see Figure 2). While presence and similarity emerge as the most widely-used constructs, other constructs such as attractiveness, enjoyment, and likeability have only been investigated by about 10% of the studies. Also, there is no study that has explored the 11 constructs listed in Table 1 simultaneously. There is thus

a lack of understanding of the interrelationships between them (e.g., credibility, likeability, enjoyment, and similarity), and how these relationships between constructs may be dependent on whether the user is interacting with an avatar or an embodied agent.

7.4 Concluding Remarks

Our study has provided a concise overview of the different digital representations investigated in experimental IS research, including avatars and embodied agents. The degree of anthropomorphism represents a pivotal lever for designers of digital user representations. Notably, digital representations can affect people in manifold ways, including the Proteus and uncanny valley effects. We hope that researchers and practitioners will find this systematic review useful as a reference for experimental research on avatars and embodied agents to inform implementations of digital user representations in practice.

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Appendix A: Literature Summary Table

Table A1. Experimental Studies on Avatars and Embodied Agents in IS Literature.

Authors (year) [Outlet]	Brief Description	Avatar / Embodied Agent Design [Interaction]	Application [Context]	Psychological Construct(s)	#P (Env)
Gerhard et al. (2004) [IJHCS]	Explores hybrid avatar/agent model to achieve permanent users' presence and increase user experience	full body, motion, 3D [SA2A/SA2EA]	collaboration [business]	awareness, immersion, involvement, presence	20 (Lab)
Brave et al. (2005) [IJHCS]	Effects of an embodied agent's emotions upon users	face only, static, 2D [H2EA]	blackjack game [entertainment]	emotionality, likeability, trust	96 (Lab)
Nowak & Rauh (2006) [JCMC]	Effects of avatars physical appearance on users' perceptions	face only, static, 2D [H2A]	interaction [social]	androgyny, anthropomorphism, attractiveness, credibility, intention to use, similarity	255 (Lab)
Galanxhi & Nah (2007) [IJHCS]	Effects of avatars on deceptions vs. truth on users in online chats	face only, static, 2D [SA2A]	interaction [social]	deceptiveness, intention to use, trust, user anxiety	94 (Lab)
Gong (2007) [IJHCS]	Effects of a happy talking-head EA on users' trustworthiness, and competence of the EA	face only, motion, 2D [H2EA]	book review [entertainment]	competence, emotionality, intention to use, likeability, trust	24 (Lab)
Hämäläinen et al. (2008) [CHB]	Effects of avatars on group learning activity performance in collaborative environments	full body, motion, 3D [SA2A]	collaboration [education]	knowledgeability	64 (Lab)
Nowak & Rauh (2008) [CHB]	Effects of a user's avatar on other's perceptions of the avatar	face only, static, 2D [H2A]	interaction [social]	androgyny, anthropomorphism, credibility	255 (srv) 230 (Lab)
Vasalou et al. (2008) [IJHCS]	How users present themselves via avatar in social media (actual self and ideal self)	full body, motion, 3D [H2SA]	social media [social]	emotional attachment, self-representativeness	20 (Lab)
Franceschi et al. (2009) [JMIS]	Compares presence in text-based virtual environment (blackboard), virtual world (second life), classroom	full body, motion, 2D/3D [SA2A]	eLearning [education]	group presence, presence, user engagement	24 N. A. 24 (Fld) 24 N. A.
Groom et al. (2009) [IJHCS]	Effects of EA's behavioural realism on people's responses	full body, motion, 3D [H2EA]	survival game [entertainment]	likeability, persuasiveness, behavioural realism, user comfort	80 (Lab)
J. Kim (2009) [CHB]	Effects of avatars' visual similarity on group identity and conformity	face only, static, 2D [SA2A]	group identity [social]	similarity	164 (Lab)
Y. Lee et al. (2009) [DSS]	Explores how users perceive avatar email differently from traditional email	full and half body, static, 2D [H2A]	communication [business]	intention to use, presence	742 (srv) 505 (srv) 452 (Lab)
Lester & King (2009) [JCMC]	The study compares student performance between traditional classroom and virtual classroom (blackboard and second life)	full body, motion, 2D/3D [SA2A]	classroom [education]	knowledgeability	161(Fld) 173 (Fld)
Qiu & Benbasat (2009) [JMIS]	Effects of an embodied agent on users' social presence, trust, and enjoyment	half body, static, 2D [H2EA]	eCommerce [business]	enjoyment, intention to use, presence, trust, usefulness	168 (Lab)
Vasalou & Joinson (2009) [CHB]	Explores the different self-presentation designs via avatar for blogging, dating, & gaming	full body, static, 3D [H2SA]	blogging, dating, gaming [social]	attractiveness, self-awareness, self-representativeness, similarity	71 (Lab)

Authors (year) [Outlet]	Brief Description	Avatar / Embodied Agent Design [Interaction]	Application [Context]	Psychological Construct(s)	#P (Env)
Huang et al. (2010) [CHB]	Effects of avatars on team's performance interaction in a virtual meeting	full body, motion, 3D [SA2A]	virtual meeting [business]	cooperativeness, satisfaction	485 (Lab)
Jin (2010) [CHB]	Effects of a virtual agent on enjoyment and evaluation of computer-aided education	full body, motion, 3D [SA2EA]	stress management [health]	educational value, enjoyment, self-efficacy	60 (Lab)
Qiu & Benbasat (2010) [IJHCS]	Effects of an embodied agent on users' social experience	half body, static, 2D [H2EA]	eCommerce [business]	enjoyment, intention to use, presence, usefulness	188 (Lab)
von der Pütten et al. (2010) [CHB]	Evaluates whether interacting with either an avatar or an agent lead to higher level of attention	full body, motion, 3D [H2EA/H2A]	social behaviour [social]	behavioural realism, presence, rapport	83 (Lab)
Guadagno et al. (2011) [CHB]	Effects of empathy on people when interacting with virtual human representation	full body, motion, 3D [SA2A/SA2EA]	interaction [social]	emotionality, enjoyment, likeability, presence, satisfaction, trust, user comfort, supportiveness	38 (Lab)
J. Kim (2011) [JCMC]	Explores how group visual similarity strengthen the group identification	face only, static, 2D [H2A]	discussion [business]	similarity	258 (Lab)
J. Kim & Park (2011) [CHB]	Effects of an avatar's uniform appearance on users' willingness to agree to a majority opinion in virtual groups	face only, static, 2D [SA2A]	discussion [social]	similarity	345 (Lab)
Nunamaker et al. (2011) [JMIS]	Effects of an automated interviewing agent on arousal, behaviour, and cognitive effort	face only, motion, 3D [H2EA]	interview [business]	knowledgeability, likeability, trust	88 (Lab) 81 (Lab) 29 (Fld)
Riedl et al. (2011) [ICIS]	Investigates trust in terms of participants playing against humans or against embodied agent	face only, static, 2D [H2H/H2EA]	trust game [business]	trust	18 (Lab)
Schultze (2011) [ICIS]	Explores how virtual worlds users construct agency (possible and ideal self), identity, and worlds within in-worlds experience	full body, motion, 3D [H2SA]	second life [entertainment]	agency	35 (Lab)
Suh et al. (2011) [MISQ]	Explores effects of avatar similarity to actual self on users' attitudes toward the use of avatar and identification	full body, motion, 2D/3D [H2SA]	virtual store [business]	intention to use, similarity	92 (Lab)
Dunn & Guadagno (2012) [CHB]	Effects of users' gender and personality type on avatar representation	full body, motion, 3D [SA2A]	video game [entertainment]	gender, personality type, self-esteem, self-representativeness	174 (Lab)
Jin (2012) [CHB]	Effects on avatars on user's self-disclosure interpersonal communication	full body, motion, 3D [SA2A]	interaction [social]	presence, trust	117 (Lab) 148 (Lab)
Y. Kim & Sundar (2012a) [CHB]	Effects of computer anthropomorphism on presence and credibility	full body, motion, 2D [H2EA]	health information [health]	anthropomorphism, credibility, presence	93 (Lab)
Y. Kim & Sundar (2012b) [CHB]	Effects of realistic self-avatar on risk-taking behaviour	full body, motion, 3D [SA2EA]	health information [health]	attractiveness, visual realism	95 (Lab)
Mccreery et al. (2012) [CHB]	Effects of the big five personality dimensions on users' helping behaviour in virtual environment	full body, motion, 3D [SA2A]	video game [entertainment]	personality type, self-interest, self-representativeness	39 (Lab)
Sutcliffe & Alrayes (2012) [IJHCS]	The study compares students' performance in blackboard and second life in terms of usability and user experience	full body, motion, 2D/3D [SA2A]	collaboration [education]	emotionality, presence, user collaboration	38 (Lab) 63 (Lab)
Ang et al. (2013) [CHB]	Effects of avatar body gestures on performance and satisfaction in school tasks	full body, motion, 3D [SA2A]	school task [education]	intelligence, likeability, satisfaction, trust	64 (Lab)

Authors (year) [Outlet]	Brief Description	Avatar / Embodied Agent Design [Interaction]	Application [Context]	Psychological Construct(s)	#P (Env)
Fox et al. (2013) [CHB]	Influences of choosing avatar that is sexualised or non-sexualised on user's self-objectification	full body, motion, 3D [H2SA/SA2A]	interaction [social]	intention to use, presence	86 (Lab)
Goel et al. (2013) [ISJ]	Investigates what influences users to return to a virtual world	full body, motion, 3D [SA2A]	interaction [social]	immersion, intention to return, presence, social awareness	175 (Lab)
Kang & Watt (2013) [CHB]	Effects of avatar realism on communication socially	face only, motion, 2D [H2A]	communication [social]	anthropomorphism, presence, realism (visual, behavioural), satisfaction	198 (Lab)
Keng & Liu (2013) [CHB]	Effects of an avatar's attractiveness on online advertisement	face only, static, 2D [H2A]	advertising [business]	attractiveness, purchase intention	1514 (lab) 687 (Lab)
Krämer et al. (2013) [IJHCS]	Effects of an agent's smile on participants' evolution and smiling behaviour	half body, motion, 3D [H2EA]	conversation (smiling) [social]	anthropomorphism, emotionality (smile)	104 (Lab)
Kwon et al. (2013) [IJHCS]	Effects of various virtual environment conditions upon users' level of anxiety	half body, motion, 2D/3D [H2EA]	job interview [business]	visual realism, user anxiety	60 (Lab) 20 (Lab)
Song, Kim, Kwon, et al. (2013) [CHB]	Effects of smoking avatar representations on users' perceived risk of smoking	full body, motion, 3D [H2SA]	game [education]	identification, intention to quit	62 (Lab)
Song, Kim, Tenzek, et al. (2013) [CHB]	Effects of an avatar on competing in exercise video games on users' playing time	full body, motion, 3D [SA2A]	exergame [entertainment]	competitiveness, enjoyment, mood, self-efficacy	72 (Lab)
Spence et al. (2013) [CHB]	Effects of the avatar ethnicity and similarity on health-related information	face/ shoulder only, static, 2D [H2A]	communication [health]	behavioural intentions, similarity (ethnicity)	207 (Lab)
Dolgov et al. (2014) [CHB]	Effects of avatar customisation on helping behaviour	full body, motion, 3D [SA2A]	video game [entertainment]	identification, similarity	54 (Lab) 25 (Lab)
Felnhofer et al. (2014) [CHB]	Effects of users' gender and age on presence, empathy, and collaboration	full body, motion, 3D [SA2A]	café [social]	empathy, gender, presence	124 (Lab)
Grinberg et al. (2014) [CHB]	Effects of avatar on social engagement and immersion in the virtual environment	full body, motion, 3D [SA2A]	interaction [social]	immersion, presence, user engagement	35 (Lab)
Hammick & Lee (2014) [CHB]	Effects of an avatar on shy users to express themselves freely	full body, motion, 3D [SA2A]	communication [social]	interactivity, presence	58 (Lab)
Kang & Gratch (2014) [CHB]	Effects of embodied agents' behavioural realism on users' self-disclosure	half body, motion, 3D [H2EA]	counselling interviews [social]	behavioural realism, emotional state, presence, likeability	171 (Lab)
J.-E. R. Lee (2014) [CHB]	Effects of avatar' diversity on offline racial identity	half body, motion, 3D [H2A]	social identity [social]	user willing to reveal racial identity	56 (Lab)
Peña & Kim (2014) [CHB]	Effects of avatars' size on physical activity in exergame using accelerometers	full body, motion, 3D [SA2A]	video game [entertainment]	NA	96 (Lab)
Riedl et al. (2014) [JMIS]	Investigates trust in terms of participants playing against humans or against embodied agent to make decision and learn	face only, static, 2D [H2H/H2EA]	trust Game [business]	trust	18 (Lab)
Sylvia et al. (2014) [CHB]	Effects of playing video games with an unrealistic male body on actual body satisfaction	full body, motion, 3D [H2SA]	video game [entertainment]	satisfaction, body and self-esteem	50 (Lab)
Hanus & Fox (2015) [IJHCS]	Effect of customising an avatar on intrinsic motivation, brand liking and purchase intention	full body, motion, 3D [SA2A]	sale [business]	agency, likeability, motivation, purchase intention	80 (Lab)
Leding et al. (2015) [CHB]	Effects of an attractive avatar on the perception of viewing actual human	full body, static, 3D [H2A]	attractiveness [social]	attractiveness	120 (Lab) 234 (Lab)

Authors (year) [Outlet]	Brief Description	Avatar / Embodied Agent Design [Interaction]	Application [Context]	Psychological Construct(s)	#P (Env)
Nowak et al. (2015) [JCMC]	Effects of an avatar's clothing and anthropomorphism on trust and message clarity	full body, static, 2D [H2A]	dating or job interview [business]	anthropomorphism, appropriateness, attractiveness, credibility, trust	397 (Lab)
Ratan & Sah (2015) [CHB]	Effects of an avatar's identity characteristics on avatar users' behaviours	full body, motion, 3D [SA2A]	video game [entertainment]	engagement, motivation, self-representation, presence, self-relevance	64 (Lab)
Sanchez-Valdes & Trivino (2015) [ESWA]	Effects of an avatar emotion on users' physical activities	face only, static, 2D [H2SA]	physical activity [health]	emotionality, motivation	3 (Fld)
Westerman et al. (2015) [CHB]	Effects of different types of avatars created for social or dating/ romantic situations on users	half body, static, 2D [H2A]	networking [social]	attractiveness, intention to use, similarity	206 (Lab)
Won et al. (2015) [JCMC]	Effects of an avatar's movement on user's movements on the real world	full body, motion, 3D [H2SA]	communication [entertainment]	motivation, presence	53 (Lab) 20 (Lab)
Wrzesien et al. (2015) [CHB]	Influence of the physical similarity of avatars on user's emotion regulation training	full body, motion, 3D [H2A/H2SA]	emotion regulation [education]	similarity	22 (Lab)
Wu et al. (2015) [CHB]	The study explores the effects on verbal behaviour in virtual interaction	full body, motion, 3D [SA2A]	communication [social]	behavioural intention, presence	32 (Lab)
Burgoon et al. (2016) [IJHCS]	Effects of an embodied agent on the outcomes of decision-making tasks	face only, motion, 3D [H2H/H2EA]	communication [business]	attractiveness, expectedness, dependability, receptiveness	70 (Lab)
Carlotto & Jaques (2016) [IJHCS]	Effects of an embodied agent on users' in a learning environment	full body, motion, 2D [H2EA]	learning [education]	expressiveness, motivation, relevance, satisfaction, willingness to repeat	72 (Lab)
Guegan et al. (2016) [CHB]	Effects of avatars on users' creativity Performance in collaborative meeting	full body, motion, 3D [SA2A]	meeting [business]	similarity	114 (Lab) 54 (Lab)
H.-K. Kim & Kim (2016) [CHB]	Explores the emotional bonds between the individual and their avatar	full body, motion, 3D [SA2A]	driving [social]	attractiveness, emotional closeness, similarity	111 (Lab)
Li & Lwin (2016) [CHB]	Effects of self-avatars on user's presence and enjoyment	full body, motion, 3D [H2A]	video game [entertainment]	enjoyment, identification, presence	322 (Lab)
Peña et al. (2016) [JCMC]	Influences of avatar's body size on physical activity using accelerometers	full body, motion, 3D [SA2EA]	exergame [entertainment]	NA	96 (Lab)
Rodrigues et al. (2016) [CHB]	Effects of avatars use in business application on customers	half body, static, 3D [H2A]	gamification e-banking app [business]	ease of use, enjoyment, usefulness, intention to use, presence	183 (Fld)
Bacev-Giles & Haji (2017) [CHB]	Examines impressions of avatar online profiles for gender stereotype impressions	full body, static, 3D [H2A]	interaction [social]	gender, likeability, similarity	239 (Lab)
Beege et al. (2017) [CHB]	Investigates the influence of stereotypes on learning, cognitive load and motivation as well as time spent with the embodied agent	full body, motion, 3D [H2EA]	health material [health]	gender, similarity	84 (Lab)
Balas & Pacella (2017) [CHB]	Examines the perceived trustworthiness of avatars' and humans' faces	face only, static, 2D [H2A]	interaction [social]	sensitivity, trust	51 (Lab) 20 (Lab)
Barata et al. (2017) [CHB]	Examines students' performance in gamified collage course	full body, motion, 3D [H2SA]	learning [education]	ease of use, continuity, engagement	35 N.A. 52 N.A. 54 (Fld)
Cobo et al. (2017) [CHB]	Examines distant exploration of places and time spent with avatar for blind people using smart phone	full body, motion, 3D [H2SA]	interaction [social]	NA	19 (Lab)

Authors (year) [Outlet]	Brief Description	Avatar / Embodied Agent Design [Interaction]	Application [Context]	Psychological Construct(s)	#P (Env)
Dechant et al. (2017) [CHB]	Examines virtual reality to diagnose social anxiety	full body, motion, 3D [SA2EA]	interaction [social]	user anxiety	119 (Lab)
Fehrenbacher & Weisner (2017) [ICIS]	Examines knowledge sharing while interacting with real human images vs avatars	face only, static, 3D [SA2A]	communication [social]	similarity (ethnicity), trust	97 (Lab)
Guegan et al. (2017) [CHB]	Examines the effects of visual cues of social identity on group performance	full body, motion, 3D [SA2A]	brainstorming [business]	identification, presence (social cues)	72 (Lab)
Hofer et al. (2017) [CHB]	Examines the effects on avatars' expression on users fear reactions.	full body, motion, 3D [H2SA/SA2A]	video game [entertainment]	agency, physical appearance (avatar embodiment)	103 (Lab) 104 (Lab)
Khashe et al. (2017) [CHB]	Investigates influence of avatars' communication style and gender on user compliance	half body, motion, 3D [H2A]	communication [business]	communication style, gender	214 (Lab)
H. E. Kim et al. (2017) [CHB]	Examines the effects of mobile-based self-training performance for social anxiety	full body, motion, 3D [H2SA]	self-training [health]	avoidance	22 (Lab)
Kohonen-aho & Tiilikainen (2017) [ICIS]	Examines the effects of virtual world in virtual team performance of informal interaction	full body, motion, 3D [SA2A]	virtual team [business]	presence	36 (Lab)
Kothgassner et al. (2017) [CHB]	Examines a virtual social exclusion scenario and tests for behavioural consequences	full body, motion, 3D [SA2A/SA2EA]	interaction [social]	emotional state, presence, self-esteem	45 (Lab)
S. Lee & Choi (2017) [IJHCS]	Investigates embodied agents' recommendations for movies on users' experience and self-disclosure	full body, motion, 3D [H2EA]	online services [business]	enjoyment, intention to use, satisfaction	225 (Lab)
Peña & Chen (2017) [CHB]	Examines how activating prosocial and antisocial concepts affect successive prosocial behaviours and intentions	full body, motion, 3D [H2SA]	video game [entertainment]	prosocial behaviour (helping), prosocial intention	309 (Lab)
Schneider et al. (2017) [CHB]	Examines the effects of online exclusion	face only, static, 2D [H2A]	interaction [social]	belongingness, emotional state, self-esteem	105 (Lab) 85 (Lab)
Sebastian & Richards (2017) [CHB]	Examines the effects of educational embodied agents on performance of mental health patients using videos for intervention	half body, motion, 3D [H2EA]	training [health]	NA	245 (Lab)
Seo et al. (2017) [CHB]	Investigates self-presence when users are exposed to self-avatars	face only, static, 3D [H2SA]	interaction [social]	identification, presence, similarity	25 (Lab)
Tamborini et al. (2018) [CHB]	Examines the effect of embodied agents' ethnicity on trust	motion, full body, 3D [H2EA]	video game [entertainment]	similarity (ethnicity), trust	205 (Lab)
Felnhofer et al. (2018) [CHB]	Investigating social avoidance and prosocial behaviour towards avatars and agents	full body, motion, 3D [SA2A/SA2EA]	interaction [social]	agency, empathy presence, user anxiety	95 (Lab)
Kaye et al. (2018) [CHB]	Examines the effects of explicit priming and avatar gender	full body, motion, 3D [H2SA]	video game [entertainment]	competence, identity, self-esteem	120 (Lab)
Martens et al. (2018) [CHB]	Examines avatars' and users' difference and similarities on time spent with avatar	full body, motion, 3D [SA2A]	video game [entertainment]	similarity	124 (Lab)
Mousas et al. (2018) [CHB]	Examines the effects of appearance and motion of embodied agents on users' emotional reactivity	half body, motion, 3D [H2EA]	virtual character [entertainment]	emotional reactivity, emotional valence	72 (Lab)

Note: **MISQ**: Management Information System Quarterly; **JMIS**: Journal of Management Information System; **ISJ**: Information System Journal; **ESWA**: Expert Systems with Application; **DSS**: Decision Support System; **JCMC**: Journal of Computer-Mediated Communication; **ICIS**: International Conference on Information System; **IJHCS**: International Journal of Human Computer Studies; **CHB**: Computer in Human Behaviors**; H2H**: human to human interaction; **NA**: not applicable; **lab**: laboratory experiment, **srv**: survey; **Fld**: field; **N.A.**: No Avatars used; **#P**: Number of Participants; **2D:** Two dimensional; **3D:** Three dimensional; **Env.**: interaction environment

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