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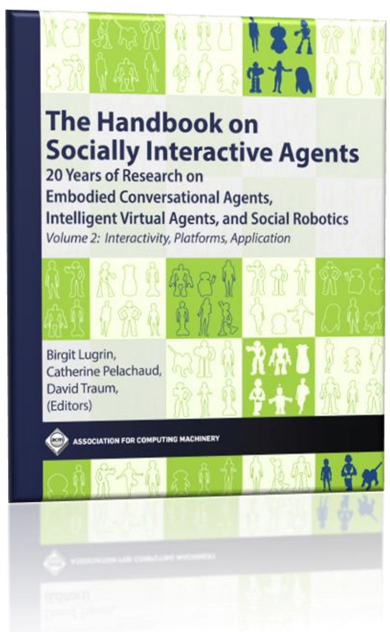

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28 Serious Games with SIAs

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Aiutami a fare da solo—Help me to do it myself
(Maria Montessori, [Montessori 2016, p. 69])

28.1 Motivation

Playing is exploring [Power 1999]. Both interconnect to the human drive of curiosity [Berlyne 1954, Kidd and Hayden 2015] and the essential emotional experience of security [Moser and Von Zeppelin 1996]. Explorative playing is one way to learn about strategies, concepts, and knowledge. A game can be described by ”the need to find or continue at once a response which is free within the limits set by the rules” [Caillois 2001, p. 8]. Such rules can be implicit or explicit. Implicit rules address social aspects of playing together, for example, being fair. Explicit rules might support games to be more available and understandable [Bente and Breuer 2009]. Usually, humans play games for having fun [Caillois 2001]. In general, the benefits a game could provide for a human player can be manifold. They depend on individual competencies, abilities, and the current situation [Garris et al. 2002b] (See Chapter 27 on “Socially Interactive Agents in Games” [Prada and Rato 2022] of this volume of this handbook for further details).

Computer games are games that rely on technology for input, output, and processing logic. In such games, the logic realizes the type of game (e.g., action, puzzle, and strategy). While the game type defines the general gameplay, the genre describes the narrative concept. Typical game genres are fantasy, mystery, or war [Grace 2005]. An observation might be that the genre concept in games is related to the genre concept in theater, movie, and TV. Computer games support the human drive of exploring.

Serious games are computer games that are explicitly designed to examine and train specific skills or knowledge. The concept of gamification is different from that for serious games. Gamification ”refers to the use [...] of design [...] elements [...] and characteristics for games [...] in non-game contexts” [Deterding et al. 2011, p. 13]. Serious games are explicitly designed to serve a serious purpose. Such games can be categorized by application areas (e.g., education [Prensky 2003], mental or physical health care [Macedonia 2008, Sawyer 2008], and training [Blackman 2005]). This categorization is related to the genre concept but misses a clear distinction of application area boundaries [Laamarti et al. 2014, Susi et al. 2007] and

[Ritterfeld et al. 2009, p. 10] (See also Chapter 27 on ”Socially Interactive Agents in Games” [Prada and Rato 2022] of this volume of this handbook for further details). A serious game’s application area defines its general narrative and content. Usually, serious games are evaluated according to how well users can improve skills by using them (Section 28.4). This chapter discusses serious games in the application area of training social skills employing Socially Interactive Agents (SIAs) with a focus on education and learning.

Why serious games with SIAs? We live in a social world. Social life and social interaction come with specific rules. Some are explicit, some are implicit. Both are defined by societies and their cohorts (See Chapter 13 on ”Culture for Socially Interactive Agents” [Lugrin and Rehm 2021] of volume 1 of this handbook [Lugrin et al. 2021] for further details). For the training of social skills, serious games with SIAs can be a game-changer for many individuals and even our society as a whole. To bring social training in serious games closer to a human natural interaction experience, the employment of SIAs is mandatory. SIAs implicitly convey social values and norms interactively. Technology-wise, such agents are (partially) autonomous computer programs consisting of various software modules and hardware (sensor and actuator) components [Vinayagamoorthy et al. 2006]. SIAs can be seen as a representative of the used software and hardware. They denote the main interface of the interaction of and simulate human-like interlocutors (Part II).

Pedagogical role play with such agents offers great promise for social skill training. It provides learners with a realistic but safe environment that enables them to train specific verbal and non-verbal behaviors. As an example, centered on empowerment and inclusion, such games can help individuals with special needs or parts of the population gain skills in a playful and fun way that can make the difference in their everyday lives. As a result, learners benefit from the game-like environment, which increases not only their enjoyment and motivation but also enables them to take a step back and reflect on their behavior if necessary.

While current serious games with SIAs analyze the user’s verbal and non-verbal behaviors for the purpose of the interaction, their primary objective is to expose users with socially challenging situations. Implicitly, they do aim at teaching users appropriate socio-emotional communication skills and norms directly (Section 28.3).

From a psychological point of view, SIAs are a powerful technology that can even trigger social emotions, for example, shame [Schneeberger et al. 2019]. This aspect can be explained by the advanced reciprocal and reactive interaction abilities of such agents that come close to human interaction abilities, e.g., [Gebhard et al. 2019b]. In general, their current state of the art might be sufficient that such agents might be able to serve as a psychological transfer or projection object [Grant and Crawley 2002]. With respect to ethical, legal, and social implications (See Chapter 3 on ”Social Reactions to Socially Interactive Agents and their Ethical Implications [Krämer and Manzeschke 2021] of volume 1 of this handbook [Lugrin et al. 2021] for further details), further interdisciplinary studies must be conducted to explore the phenomena and possibilities of game mechanics employed in educational settings, for example, employment for psychological wellbeing and treatment (Section 28.4).

The next sections cover a general overview of the most prominent learning concepts, the historical development of serious games with SIAs, as well as current challenges and future directions. Finally, the chapter ends with a summarization.

28.2 Concepts of Learning and User Experience

This section discusses concepts that are related to technology-supported learning in game-like environments. All of the addressed concepts apply to serious games with SIAs. The section starts with the general paradigms of motivation and learning by doing. Further, the concepts of collaboration, socialization, embodiment, immersion, storytelling, and interactive narrative (cf. storytelling) are considered. For each concept, the focus is on the individual learning experience. This personal experience is tightly connected to each subjective situational experience—hence, her or his own (internal) emotions.

As games have been perceived as very promising for learning for some time (Section 28.4), a variety of learning concepts have been applied to games [Nebel et al. 2016, Qian and Clark 2016]. This section mentions some of the most prominent ones to motivate and concentrate on new directions that currently seem promising, especially in the context of SIA. We also consider systems that implement elements of games even if they do not call themselves "games". They are relevant as predecessors of SIA, especially in the context of learning, with emphasis either on the concepts of social, interactive, or software agents.

Games have appreciated the role of motivation [Deci and Ryan 1985] that technology can play early on [Arroyo et al. 2003, 2014, Garris et al. 2002a], and continue to invest in this direction through concepts of creating meaningful socio-emotional experiences, which require cognitive effort [Kazimoglu et al. 2012]. Among the educational technologies, games come under the category of systems that concentrate on affective aspects, together with communities of learning and computer-supported collaborative systems [Näykki et al. 2019]. This notion derived to a large extent from children's play and their innate motivation that this is characterized by. This is connected to the need to explore and apprehend the world in which children emerge in their "pretend mode" [Fonagy and Target 1996]. Learning to walk, talk, understand physical properties, and social relations through role play and playing with dolls, to name a few. Similar emotional and cognitive modes can be observed in grown-ups in states of flow [Csikszentmihalyi 1990], or immersion [Barab et al. 2009], and learning through authentic experiences [Csikszentmihalyi 1916, Kolb et al. 2014]. These result in learning. Standard behavioristic elements of reward (and punishment) also aiming to increase motivation [Skinner 1948] were another prominent concept in games right from the beginning, as it was easily associated with the notion of "gaming" [Peirce et al. 2008]. Symbolic awards such as stars, medals, and trophies, are used to motivate participation as an equivalent of school grades with its advantages and disadvantages. Awards like this have found their way in novel approaches for immersive, interactive social training games [Damian et al. 2015a].

Motivation and behavioristic principles are not a standalone concept for learning. Elements of them are combined with the implementation of learning theoretical approaches, especially of the constructivist tradition, which has often been interpreted in the learning context as "learning by doing" [Schank 1995]. Here, the idea is that learning is knowledge construction, and hence emphasis should be put on supporting this construction. In this paradigm, inquiry or discovery learning [Squire and Jan 2007], are primarily based on the idea of self-directed learning and teaching problem-solving and domain skills [Squire and Jan 2007]. To address potential shortcomings of self-directed learning related to cognitive overload, systems provide scaffolds to guide learners through their learning experience as needed [Hmelo-Silver et al. 2007]. Minecraft probably exemplifies this theory as it provides possibilities to play as well as to create games. The aspect of creating games understands itself as drawing from the notion of constructionist learning [Kafai and Burke 2015]. Developers have also created authoring tools, to include domain experts and teachers in the development loop, for example, in SimQuest [Jong et al. 1998]. Simulation (games) [Lean et al. 2006] have been used especially for MINT subjects and to support problem-solving to this end [Hmelo-Silver et al. 2007, Tsovaltzi et al. 2010, White 1984] and also belong to the constructivist paradigm. Interactive inquiry systems and simulations implement game elements because of the interaction [Garris et al. 2002a]. They provide tools, for example, graphs or labs, depending on the phenomenon under investigation, which can simulate the results of changing the values of the parameters in the phenomenon. However, such systems do not themselves provide fully gamified experience. Still, they are often integrated into games, allowing, for instance, to solve mysteries in groups by combining information and using argumentation structures to learn together [Squire and Jan 2007]. Human-like agents (intelligent virtual agents or avatars) are also used in such systems to provide a social context to learning.

Such systems with collaborative learning affordances and agents implement in particular social constructivism, which is an extension of constructivism emphasizing the key role of the social context and social relations in constructing knowledge and goes back to Vygotsky [Vygotsky 1978]. Social constructivism is then commonly realized in such games as (computer-supported) collaborative learning [Stahl and Koschmann 2006, Van Joolingen et al. 2005]. In this context, agents have been used to motivate learning through a human figure, for instance, by taking into account gender issues in avatars [Arroyo et al. 2009], or by implementing successful human teaching tactics [Graesser et al. 2001]. Agents may guide learners through the tasks of a lesson, for example, by giving tips, present learning material, and concepts to be learned, pose questions and queries to prompt the learning process, and they may do all this by directly interacting with the learner in the form of an agent. An agent typically cohabits a virtual environment. It may support both actions and utterance input by students without natural language dialogue. It can also demonstrate actions in the environment, gaze, and gesture to capture and direct the student's attention [Rickel et al. 2000]. To increase the human-like effect, a considerable amount of effort was put early on to create agents that could behave like teachers. In addition to applying successful human teaching strategies, these agents demonstrate emotion and hold a natural language dialogue with the student [Graesser et al. 1999, 2001].

Socialization is another concept that has been drawing attention to describe and support learning processes, and its most popular understanding in this context is vicarious learning [Bandura 1991]. In vicarious learning, learners observe and learn practices as they occur in their social context. A major interest is to explain implicit learning processes in informal settings. Learning environments have tried to apply such aspects of learning, especially, for example, with regard to social roles [Johnson et al. 1998]. Moreover, games are often being situated in communities of practice [Lave 1991], which builds on the notion of the identity development feature of games [Beatty 2014].

Despite the significance of social aspects of learning, the value of emotion and the way it may be exploited for learning is only beginning to be appreciated, especially with regard to motivation and group interaction [Mullins et al. 2013, Polo et al. 2016, Tsovaltzi et al. 2017]. Considerations of empathic agents are also being integrated for learning, moving away from simple motivation constructs to better support emotions [Arroyo et al. 2009]. However, detailed modeling of the emotions as they occur in and through the interaction is still to be developed, and current emotional accounts are mostly based on observable measures of the interaction itself that are easier to track [Järvenoja et al. 2017]. Explicit models of individual intrapsychic emotional regulation, their role in interacting with SIAs, the possibility of leveraging such agents to trigger emotion regulation processes, and their learning potential have to our knowledge not yet been harnessed to support learning processes.

The social-psychological theory of embodiment [Niedenthal et al. 2005] is the direction that has probably inspired games based on SIA the most. In this context, "embodiment refers both to actual bodily states and to simulations of experience in the brain's modality-specific systems for perception, action, and introspection" [Niedenthal et al. 2005, p. 184]. Especially combined with situational learning [Lave 1991] it supported the creation of games that represent the world in as much detail as possible to depict situational elements of a domain [Barab et al. 2007, Gee 2008, Pellas 2014] Avatars are then used as a surrogate of the learner-player, which is supposed to carry over the embodied functions of learning [Riedl and Bulitko 2013]. As such, avatars may bridge the gap between emotional research in embodiment [Niedenthal et al. 2005] and learning. An application of embodied learning is perspective-taking, an aspect that has been developing based on neuropsychological findings supporting shared physical perspective-taking to enable socio-emotional perspective-taking [Cole et al. 2016, Kessler and Thomson 2010], and can have various applications in learning. Avatars are used to measure physical perspective-taking by having humans consider and report on the view of a human-like avatar [Samson et al. 2010]. This work also aligns with research on the role of self-awareness in the development of empathic concern [Hastings et al. 2000] that provides theoretical grounding. However, with respect to sharing physical perspective-taking with avatars specifically, findings are not conclusive [Cole et al. 2016]. This line of research has important implications on the use of avatars to increase immersion, as well as for training purposes. Both assume that the avatar that represents the human player in the virtual world manages the transfer of perspective and emotions [Fischer and Demiris 2019]—hence the term empathic agents [Gebhard et al. 2018b]. Roleplay with virtual agents is a popular alternative approach based on socio-emotional perspective-taking whose function relies on this effect [Wu et al. 2013]. It has been used to educate users about cultural sensitivity. Employing role play with IVAs that represent different cultures, users are supposed to develop a better understanding of other cultures. Eventually, the users are expected to develop intercultural empathy and reduce their negative attitudes toward different cultures. An example of such a system has been developed within the eCute project: The objective of MIXER (Moderating Interactions for Cross-Cultural Empathic Relationships) is to enable users to experience emotions that are usually elicited during interactions between members of a different group [Aylett et al. 2014].

Similarly, interactive narrative or storytelling [Rouse et al. 2018] applies the notion of immersion (and hence requires perspective-taking). However, a prominent characteristic is also the narrative itself because of theoretical accounts that narrative underlies our ability to construct reality [Bruner 1991]. Narrative, hence, carries the possibility of changing the way we experience it. This is especially relevant for interactive learning experiences. There, the idea is that users follow a narrative and empathize with the characters. This experience is supposed to occur, especially through the possibility to interactively intervene and change aspects of the narrative, for example, the plot. This experience is situated in 3D environments inhabited by often real-time rendered virtual agents, which can engage in dialogue, show gestures, and actions that influence the plot, including other characters [Mateas and Stern 2003]. Hence, users should feel like being part of the narrative and learn from the simulation of a first-person experience. Recent interactive narrative theories give a central role to emotional experience and the body as an interface between emotions and the outside world to explain the manifold experience space (cf. social-psychological theory of embodiment). This experience space may be created through interactive narrative systems and the possibility to engage in multiple perspectives through them [Knoller 2019]. As a result, a new class of immersive learning experiences can be created (Section 28.4).

Emotion regulation is becoming famous with the rise of embodiment, as emotions are considered embodied responses that signal personally relevant events that can act motivationally [Gyurak et al. 2011, McQuiggan et al. 2008]. Beyond what has been known before, we are moving into the age where emotion recognition and regulation are related to notions of identity, self, and other- awareness [Harrell and Lim 2017]. This awareness is key to creating a relationship in the sense of attachment [Garrelts 2002]. It is also related to considering situational aspects to create socially aware agents [Barrett et al. 2019]. Emotional regulation, for example, in the form of (self-)compassion [Diedrich et al. 2014], can mediate motivation through situation appraisal [Goldenberg et al. 2017]. Narrative-based games that aim to support metacognitive learning processes are now considered for emotion regulation [Chytiroglou et al. 2013]. In this particular game, users are able to explore, by multiple-choice interactions, the causal relationship between an emotional reaction and the situation, consequences of emotional responses, and effects of self-regulation of emotions. The game aims at learning new strategies for regulating emotions. Similarly, games have been used to train socially constructed attitudes, like eating habits [Ptakauskaite et al. 2016]. As such, new concepts of supporting motivation, especially through SIA is considering emotion regulation and have recently started to look at the interplay of empathy with values of motivation [Charrier et al. 2018, Gebhard et al. 2018a].

28.3 History and Overview

This section presents with selected examples an overview of how serious games with SIAs have evolved in the past two decades. The discussion starts with a brief mention of how technology is used to support instructions and learning processes.

The field of technologically supported instructions emerged in the 1980 years [Rieber 1996]. The work back then centered on the fundamental concept of play and related aspects. Although playing is an essential concept for the development of abilities, playing was generally considered as unserious. Playing was not respected, working instead was. Despite this misconception, technologically supported games emerged. They focus on the different categories of play, e.g., progress, power, fantasy, and self. One of the first examples was inspired by Piaget's view on concepts of how children develop and learn [Piaget 1976]. Today's serious games increasingly demand computational intelligence and perceptual skills to best grasp the player's attention, behavior, engagement, and game-progress while modeling often complex and demanding game environments. The set of computational features also includes (computational) emotional and social intelligence to allow a deeper understanding of the player on different motivational levels, and thenoptimally adapt the learning pace. Besides, due to the rapid development in mobile and body-worn sensor technology, games can be taken into players' real lives. (Chapter 27).

Concerning the use of SIAs, first systems are presented and their evolution is depicted. New methods and technology and interdisciplinary insights led to new concepts and fields of application. Serious games with SIAs provide users with a unique interaction experience. Some design aspects can be connected to a positive effect on learning and motivation. Wilson and colleagues [Wilson et al. 2008] as well as Bedwell and colleagues [Bedwell et al. 2012] identified eight attribute categories designers should be especially aware of when developing gamified environments: action language, assessment, conflict and challenge, control, environment, game fiction, human interaction, immersion, and rules/goals. All of them are highly relevant for the design of serious games with SIAs. However, the design of believable and consistent interaction experience with a SIA is an important factor, if not the most critical factor (Part IV).

The presented approaches are clustered in three groups that are interlinked and build upon each other but with a different focus: (1) content and story, (2) immersiveness and interaction, and (3) individual needs and adaptation. The shown serious games with SIAs in these three categories are built upon well-researched learning and user experience concepts, which are discussed in the section before.

28.3.1 Content and Story

This group of serious games with SIAs represents approaches that focus on the tasks modeling the content and stories and related concepts such as conveying individual and cultural values.

Around the year 2000, inspired by educational concepts, IVAs were employed to support learning processes. One of the first systems is Adele, a pedagogical agent that augments different web-based learning environments [Shaw et al. 1999]. These agents react to user actions (e.g. text input, multiple choice) and have background knowledge of the learning material, which they rely on during a learning session. Steve is a well-known example of such an agent [Rickel and Johnson 1998]. Steve is used in a game-style learning environment to teach the operation of certain submarine equipment. The combination of methods from different research areas of computer science, such as intelligent tutoring systems, computer graphics, and agent architectures, allows animated agents to take on different roles or present learning units from different perspectives in order to motivate trainees and students. Steve explains the exact procedures for maintaining specific devices step by step. He does this either in the tutor or the classmate's role, who asks questions and, in this way, teaches the learning units. The focus in the design of such agents is on representing the to be conveyed knowledge, the development of methods for the analysis of user actions, and the modeling of the pedagogical and didactic skills. The latter two were realized mostly by plan-based cognitive architectures. To increase user motivation, such agents were extended by a model of emotions. Thus, agents are able to represent emotions (e.g., in facial expressions) and exhibit an extended non-verbal communication behavior [Elliott and Brzezinski 1998]. Studies by van Mulken and colleagues [Van Mulken et al. 1998] show that complex facts are subjectively easier to understand and more entertaining due to the explanations by IVAs. Multiple IVAs can be used simultaneously in different roles for different topics [André et al.].

A bit later in the 2000 years, sophisticated approaches to interactive automatic storytelling with IVA appeared (See Chapter 26 on ”Interactive Narrative and Storytelling” [Aylett 2022] of this volume of this handbook for further details). A seminal work for that category is the Sam system. The IVAs is designed for learning literacy skills [Ryokai et al. 2003]. Sam has the appearance of a child and is in the role of an advanced student. Sam collaboratively tells stories in a sophisticated way in order to let children learn literacy skills. The Sam system used a fully functional voice recognition and artificial intelligence methods to manage the interaction with children who had no particular disorder to learn reading and writing. Although not intentionally designed as a serious game, the interactive drama Façade created by Mateas and Stern [Mateas and Stern 2003] sets new impulses for serious games using the concept of interactive storytelling. The drama game is designed around relationships between persons, probably the most important aspect of human life. It provides users with believable observations of social and emotional dynamics. The game's action language is intentionally designed based on text-based multiple-choice actions, which naturally slow down the game progress and give users time to overthink their next steps.

Other systems in this area allow an advanced exploration of individual social values and cultural values (See Chapter 13 on ”Culture for Socially Interactive Agents” [Lugrin and Rehm 2021] of volume 1 of this handbook [Lugrin et al. 2021] for further details). An example includes the anti-bullying Game FearNot! that has been developed within the European-funded project eCircus [Aylett et al. 2005]. The project investigates how social learning may be enhanced through interactive roleplay with IVA that establish empathetic relationships with the learners. It creates interactive stories in a virtual school with IVAs in the role of bullies, helpers, victims, and so forth. The children run through various bullying episodes, interact with the virtual agents after each episode, and provide advice to them. The benefit of educational roleplays of this kind lies in the fact that they promote reflective thinking. Results of a conducted evaluation [Sapouna et al. 2009] showed that the system had a positive effect on the children's abilities to cope with bullying. A similar approach is MIXER (Moderating Interactions for Cross-Cultural Empathic Relationships). The aim is enabling users to experience emotions that are usually elicited during interactions of members of a different group [Aylett et al. 2014]. To this end, children are confronted with scenarios in which IVAs appear to violate previously introduced rules in a game scenario. Such a situation leads inevitably to frustration and negative attitudes toward members of the other group. By interacting with MIXER, children are expected to learn to reflect on other groups' behaviors and reconsider potentially existing prejudices against them. The setting was inspired by the card-game BARNGA, which has been successfully used for the cultural training of adults [Thiagarajan and Steinwachs 1990]. Other than the authors' expectations, the MIXER game did not foster cultural awareness in children in a pilot study. The authors assumed that the designed learning objectives in MIXER were not appropriate for the age group, which could not cope with the negative rule–clash–based conflict.

28.3.2 Immersiveness and Interaction

This group of serious games with SIAs represents approaches that focus on creating immersive experiences that support a compelling interaction with SIAs.

The beginning of the new millennium saw the use of 3D visualization techniques are used to create more immersive interactive training simulations with IVAs. A common application area, for example, is the medical simulation of virtual patients and their reactions [Cavazza and Simo 2003]. The underlying system does simulate an internal patient model that also includes emotional states. Around the year 2005, such systems were used for virtual training and education purposes [Ieronutti and Chittaro 2005]. More recent approaches provide a more realistic simulation of internal (patient) models and provide more realistic and immersive experiences exploring social aspects [Deladisma et al. 2007, Ochs et al. 2016]. Another application area is military simulation. One prominent example is the Mission Rehearsal Exercise that uses IVAs in a physical environment that projects the 3d scene simulation on a curved wall. This speech-enabled interactive training system is supposed to train soldiers in tactically and strategically demanding situations that also involve negotiation with civilians [Hill Jr et al. 2003]. Later systems include more detailed modeling negotiation strategies including simulation of trust [Traum et al. 2005] or societal medical challenges [Lourdeaux et al. 2019]. Other approaches focus on creating a more immersive interactive experience in educating users about historical circumstances and combining a fully 3D projectable environment, such as the CAVE [Jacobson et al. 2005], and techniques of interactive storytelling [Cavazza et al. 2007]. Later research systems provide an extended analysis of the user's social cues during interaction and their interpretation concerning the user's internal states [Bee et al. 2010]. According to evaluations, the technology in general found to be used in games in terms of performance and acceptance [Lugrin et al. 2010]. The interpretation of recent study results suggests that for storytelling SR, the natural display of social cues (e.g., gaze, nodding, and smiling) or emotions is important for creating immersive transportation of users into the story [Striepe and Lugrin 2017].

Besides investigating aspects of virtual simulations to increase the experience of immersiveness, physical interfaces, such as RFID-based recognition of objects and user action, were investigated. A commercial example is the EyeToy game Kinetic by Sony (Sony Computer Entertainment, 2005). This game employs two 3D IVAs to motivate and animate fellow players to perform gymnastic exercises interactively. In content-oriented applications, users can associate a certain topic with a corresponding agent, which is beneficial for general understanding. One example is the IVA of the Autostadt in Wolfsburg. There, two IVAs, Jara and Taron, inform visitors of the Autostadt about their function while constructing a model car from segments. The detection of user interaction uses RFID-technology to sense which car segment has been placed on a construction table. In this playful way, knowledge about the car segments (e.g., front, cockpit, rear) and about IVA technology itself is conveyed [Ndiaye et al. 2005]. Based on this, more sophisticated simulations of IVAs, including the situational appraisal and believable emotional behavior, are created. An example is the virtual Poker Game with two IVAs as game opponents [Gebhard et al. 2008].

The design of the interaction and the dialog with an IVA always includes how much control can be given to the user. A mixed-initiative dialog provides more freedom to the user. However, it also requires more sophisticated language understanding capabilities than system-initiative dialog. In [Endrass et al. 2014], we compared system-initiative dialog with mixed-initiative dialog in a soap–opera–like game environment that included a text input interface to enable users to communicate with virtual agents. The users preferred the mixed-initiative dialog over the system-initiative dialogue even though the mixed-initiative dialog was less robust. Apparently, the experiential advantages of mixed-initiative dialog compensated for the lower amount of accuracy in natural language understanding.

28.3.3 Individual Needs and Adaptation

This group of serious games with SIAs presents approaches that focus on adapting to users' individual needs to support empathic interaction.

There are different approaches in which SIAs assist or train users individually as they adapt to individual needs (Part V). Typical areas of application are health and wellbeing, social skills, education, and motivation. The area of social training with SIAs emerged around the year 2000 [Badler 1997]. Most of the approaches focus on the fact that communication conveys social information and individual emotions. Both impact relationships, social togetherness, in private and professional life. Such games have seen a rapid evolution in recent years due to advances in the areas of social signal processing as well as improvements in the audio-visual rendering of IVAs. The games complement or even substitute traditional training approaches. The concept of empathy plays an important role in such training environments with IVAs, e.g., [Paiva et al. 2004]. There are similar approaches in SR, such as systems that train children on the autism spectrum to learn in an explorative game environment how to create social relationships [Dautenhahn 1999] or for more general the use [Breazeal 2004, Feil-Seifer and Mataric 2005].

As a use case for SIAs, the health context has been getting research attention for about 15 years (See Chapter 24 on "Health-Related Applications of Socially Interactive Agents" [Bickmore 2022] of this volume of this handbook for further details). One of the first systems is Fit Track with the IVA Laura [Bickmore et al. 2005]. Laura has the role of an exercise advisor that interacts with patients for one month on a daily basis to motivate them to exercise more. Laura was equipped with different effective patient–provider communication skills (e.g., empathy, social dialogue, non-verbal immediacy behaviors) to build and maintain good working relationships over multiple interactions. From the perspective of serious games, a study showed that using those relational behaviors significantly increases the working alliance and desire to continue working with the system. This work suggests that computer systems that interact with patients, especially those that engage patients in dialogue or long-term, repeated interactions, can benefit by explicitly designing in emotional and relational communication behavior (Chapter 23 on "Socially Interactive Agents for Supporting Aging" [Ghafurian et al. 2022] of this volume of this handbook).

Techniques for the recognition of human socio-emotional behaviors and their synthesis using IVAs have been investigated in various cases: They cover the training of social skills in (1) group interactions in various application domains [Chollet et al. 2018, Damian et al. 2015b, Lugrin et al. 2016] and (2) difficult face-to-face interaction in, for example, the medical situations [Johnsen et al. 2005] that even training the situation of breaking of bad news [Ochs et al. 2016], job interview situation [Anderson et al. 2013, Gebhard et al. 2018a, Hoque et al. 2013], or for a personal therapeutical assistance [DeVault et al. 2014, Gebhard et al. 2019a].

Within the project ASD-Inclusion [Schuller et al. 2015], techniques for the recognition of human socio-emotional behaviors have been employed to help children with autism improve their socio-emotional communication skills (See Chapter 25 on ”Autism and Socially Interactive Agents” [Nadel et al. 2022] of this volume of this handbook for further details). IVAs help children to learn how emotions can be expressed and recognized via gestures and facial and vocal expressions in a virtual game world. A requirement analysis revealed the need to incorporate an appropriate incentive system to keep children engaged. Therefore, the authors implemented a monetary system that rewarded children with virtual money. Attention Deficit Hyperactivity Disorder (ADHD) can be observed mostly in children characterized by inattention, hyperactivity, and impulsivity and is caused by issues in the frontal/striatum brain areas [Cubillo et al. 2010]. Virtual reality training games provide such children with engaging and user-friendly environments that improve their motivation [Peijnenborgh et al. 2016]. The training for children affected by some pathology requires a more fine-grained control of the SIA, compared to, for example, the Sam system [Ryokai et al. 2003]. As reported by Parsons and Cobb [Parsons and Cobb 2011], children with autism are ”often focusing on visual detail or *parts* rather than the whole”. This suggests that SIAs should be designed by minimizing details that have no functional goals. The recent BRAVO research project [Barba et al. 2019, Nunnari et al. 2019] investigates an SIA system that is designed as a companion in the roles of stimulating therapy guide and a playmate. The key to this work is the design of the interaction experience and the SIA role based on the expert knowledge of psychologists and therapists. Also, the SIA’s facial expression is designed according to the results of the systematic evaluation of the recognizable of such expressions (concerning human ones) by Tinwell and colleagues [Tinwell et al. 2011].

Although not explicitly designed as being a serious game, the technological approach of Sidner and colleagues [Sidner et al. 2018] using and comparing an always-on always-reactive IVA (cartoon-style) and SR (Reeti robot) to fight loneliness and provide a happy experience for older adults at home is worth mentioning here (See Chapter 23 on ”Socially Interactive Agents for Supporting Aging” [Ghafurian et al. 2022] of this volume for further details). For some activities the system provides, it features gamification aspects to keep interaction light and fun. Users can interact by speech and by typical GUI elements with the system, which detects and analyzes social signals (face, gestures, posture) in real time. The technology is supposed to be present in the people’s everyday life with the goal of being a companion to them. Which form of appearance (SR, IVA) is preferred by seniors and which kind is appropriate for specific tasks, such as entertainment, physical care with exercises, scheduling, casual small talk, and the news, was investigated in a rare one month-long pre-study. The study revealed that neither the IVA nor the SR compared to a control condition is significantly better in decreasing the degree of loneliness or increasing overall happiness. All participants reported a basic positive though not strongly positive attitude toward both agent forms. However, the SR was perceived as more trustworthy. This circumstance is explained with the less human appearance of the Reeti robot, which may have contributed to users' sense of trust because of the uncanny valley effect in creating robots that seem more human-like.

28.4 Current Challenges and Future Directions

This section focuses on particular challenges that come with the employment of SIAs in serious games in the application domains of social training, social companion, and therapeutical support. This domain requires a more integrative and interdisciplinary approach than ever. Within that scope, two areas of challenges are discussed: (1) empathic understanding and adaption to users and (2) evaluating such serious games.

28.4.1 Empathic Understanding

Researchers in the area of empathic agents are motivated by several reasons (See Chapter 10 on ”Emotion” [Broekens 2021] and 11 on ”Empathy and Prosociality in Social Agents” [Paiva et al. 2021] of volume 1 of this handbook [Lugrin et al. 2021], for further details). A general motivation is that agents are more likely to be accepted if they are aware of the user as a social actor [Picard 1997, p. 247]. This includes the motivation that agents should act in a social (familiar) way. Empathic behavior is a part of this, e.g., [Bickmore 2003, Tapus and Mataric 2007]. Connected are the research questions of is the system is showing social (empathic) behavior and has the believability of such systems increased, e.g., [Dautenhahn 2007, Lester et al. 1997, Paiva et al. 2004, Van Mulken et al. 1998]. In order to do so, such agents must come with the ability to understand others at the level of intentions, motivations, and feelings, which includes perceiving and understanding others' affective states and acting accordingly, e.g., [Bickmore 2003, Conati and Maclaren 2009],[Wilks 2010, p. 4], [Marsella and Gratch 2014, Paiva et al. 2017]. These requirements are connected with the research area that remains to be investigated, namely how perspective-taking might influence collaborative and argumentative learning for identity development and attitude change [Tsovaltzi et al. 2014].

The next generation of SIAs, which are empathic cultural-aware agents, consider social values and norms that come with requirements and challenges that put those of current SIAs to the test in the areas (1) explainability, (2) observation, (3) theory of mind of users, and (4) adaptation. SIAs must be able to explain themselves on the behavioral and motivational levels. This requirement is mandatory since empathy is a collaborative process that requires both partners to disclose (private) information in order to establish a necessary level of trust. Trust is a concept related to feeling secure [Moser and Von Zeppelin 1996], which is a base necessity to exploration and play. Hence, trust is mandatory for serious games with SIAs addressing social aspects.

SIAs observe the human-dialog partner on the level of social signals, including voice. Other technological sensors can be added (e.g., pulse or heartbeat). They detect essential patterns and sequences of social signals in interaction (e.g., smile, facial expression, gaze behavior, gestures, posture, or physiological values).

Using current and past multimodal information, approaches to SIAs try to understand the meaning of utterances and actions of a particular user. For the interpretation of behavior, different knowledge is needed that covers behavioral norms and values for the culture (e.g., Western, Eastern), possible group affiliation(s) (e.g., scouts, researchers, workers), and individual characteristics (e.g., personality). The social hierarchy (e.g., status), situational (e.g., home or work environment), and relational context (e.g., family member, work colleague, or stranger) must be considered too. Moreover, knowledge about internal (subconscious) processes related to mental states and related observable behavior is mandatory. Mainly, a model of emotions that differentiates between external (observable) emotions/social signals and internal emotions is required. The first steps in this direction have been made with, for example, the MARSSI simulation of internal emotional states and emotion regulation [Gebhard et al. 2018a] and a novel architecture for the emotional interpretation of social signals [Aylett et al. 2019]. For the future, a more in-depth focus should be on the processes of *intrapersonal* emotion regulation, coping, and display rules. These processes are influenced by culture, group affiliation, and even family or individual values and norms. All this information must be considered for the simulation of possible mental states of the dialog partner, based on possible representations of goals, motivations, and wishes that can be put in relation to the interpreted behavior and internal processes and emotions.

Great potential lies in the employment of SIAs that (inter)act empathically by respecting cultural, behavioral values and norms and also to respecting behavioral values and norms of groups and individuals. They show social-communicative abilities such as interpersonal emotion regulation, social mimicry, display rules, and emotional contagion. Therefore, the cultural-aware agent requires a representation of the dialog partner's motivation and goals (relevant mental states) that use a model of cultural values and norms but also model values and norms of groups and individuals. As argued before, all these models are related to the concept of trust, which is mandatory for next-generation social serious games with SIAs.

The possibility of SIAs to emulate trust and human-like relationships would allow the creation of even more natural and immersive social serious games. Such SIAs would be in the role of a trustworthy companion as a learning partner in long-term social serious games, for example, in the application areas of social conflict training or long-term therapeutic assistance. Such agents must have the ability to develop and repair trust that is most relevant for the concept of relationship [Lewicki and Bunker 1995]. A major requirement for this is that SIAs are able to adapt to individuals on various levels, especially considering the agent's role and status. This approach should reflect dynamic individual user aspects (e.g., physiological, such as the level of hearing or linguistic characteristics, such as the dialect or idiolect, and cognitive, such as the level of cognitive resources). Therefore, they should be able to learn individual characteristics, values, and norms and their relations (1) to internal representations such as motivation, goals, and wishes and (2) to behavioral aspects. The ability to adapt contains the ability to react and address misinterpretations/simulations and giving apologies. This approach has to include processes for reflecting and discussing interpretations and learning new values and norms. Social serious games with SIAs at this level would allow a secure place for exploring serious issues at the most individual immersive level of joyful experience.

Concerning societies and common knowledge and understanding, the SIA research might be a driving force too. In implemented community ideas, (serious) games aim to enhance motivation at the group level, but also to leverage knowledge co-construction. Hence, the realization of social aspects of learning goes beyond sharing results to get a trophy and merely competing against each other, like in typical ”non-serious” games. It rather builds on basic social comparison processes and relates them to games' cognitive or task structure. It thus embraces ideas of socio-cognitive conflict for knowledge co-construction [Mugny and Doise 1978]. Developers, therefore provide affordances such as chats with social media (e.g., wikis) and networking structures and design shared spaces for common projects, and allow the sharing of results not to compete, but to build on each other's contributions [Du et al. 2016, Fields et al. 2013, Garrelts 2014].

28.4.2 Evaluation

Across people and situations, serious games without SIAs seem to have positive outcomes and even dominate traditional learning methods for cognitive gain outcomes [Vogel et al. 2006]. Serious games employing SIAs can be categorized into two groups: the ones where SIAs are in the role of a teacher (cf. pedagogical agents) and those where SIAs represent interactants and enable difficult social situations to be experienced virtually (social training systems). These diversified applications require different evaluations, adapted to their individual purpose.

SIAs in the role of pedagogical agents, for example, Steve [Johnson and Rickel 1997], Herman the Bug [Stone and Lester 1996], and SmartEGG [Mitrovic and Suraweera 2000], support the learning of complex problems. The evaluations of these systems can include the rating of the agent concerning its physical appearance and behavior and the learner's assessment of the likability, helpfulness, or entertaining character of the whole system. Moreover, motivation, learning efficiency, and effectiveness can be either self or externally rated (objective or subjective). It seems that pedagogical agents can yield important educational benefits in the form of improved problem-solving, particularly for complex problems [Lester et al. 1997] and increase student motivation and perception of their learning [Mitrovic and Suraweera 2000]. However, there is no meta-analysis examining serious games with SIAs in the role of pedagogical agents to support learning and no studies that examine long-term effects of pedagogical agents (See Chapter 21 on ”Pedagogical Agents” [Lane and Schroeder 2022] of this volume of this handbook for further details).

SIAs exploited in the application area of social training systems mostly do not overtake the role of a virtual teacher explaining a specific problem. In those serious games, the learner is often confronted with a difficult social situation, for example, a job interview [Anderson et al. 2013, Gebhard et al. 2018a], bullying [Aylett et al. 2005], challenging pupils [Lugrin et al. 2016], or aggressive behavior [Bosse et al. 2018]. The SIAs are in the role of interactants with which the user trains the specific situation. The social training system can be evaluated by the user applying standard questionnaires measuring, for example, the believability of the agents' behavior [Niewiadomski et al. 2010] or the scenario or the user's experienced co-presence [Bailenson et al. 2005].

The evaluation of the learning effect of social training systems is more challenging for several reasons. The best evaluation of the learning effect would be to observe the situation that is trained in the serious game in the real environment before and after the training including an experimental as well as a control group [Field and Hole 2002]. Those in the wild measurements of training effects are often infeasible due to, for example, the rareness of situations, privacy of other people involved in the situation, or ethical issues. An alternative could be role plays because of the possibility of capturing real and natural behavior [Freedman 1969]. As non-verbal behavior is crucial in social situations, e.g., [Mehrabian 1972], role plays are particularly suitable [Sader 2013].

In both designs, in the wild as well as the laboratory setting, evaluation criteria have to be defined to assess the behavior of the user. However, in difficult social situations, the demands on those involved vary and it might be difficult to define what constitutes more or less desirable behavior due to different values, personalities, or societal rules. Therefore, the definition of externally assessed evaluation criteria for answering the question ”if the learning situation was handled well by the user” is complex. Due to the different contents of social training systems with SIAs, it is difficult to develop a gold standard for their evaluation. Hence, the evaluation of such systems should depend on the respective context and motivational goals.

Apart from an external assessment, another source of data is the assessment of the user. It is tempting to ask users after completing the social training to imagine the situation in a real environment and to state how they would behave. As correlations between statements about predicted behavior in questionnaires and the real behavior are low, those measures may not be meaningful at all. Using self-assessment questionnaires might be a better choice in asking users for their performance. This approach, however, comes with various difficulties. Also, there are several aspects that can hamper the validity of the results. General disadvantages for the self-assessment are (1) socially desirable responding [Van de Mortel et al. 2008]—tendency for people to present a favorable image of themselves on questionnaires self affirmation—and (2) individuals are driven to protect their self-integrity and therefore might give embellished answers regarding the learning effect [Steele 1988]. However, as an additional information the self-assessed performance is a good indicator for the success of a serious game with SIAs, especially in the context of social training systems.

One aspect that is still understudied are the long-term effects of serious games with SIAs, especially in application areas that focus on social values, such as social training systems, and therapeutical assistance.

28.5 Summary and Conclusion

This chapter addresses the use of SIAs for serious games in various application areas. Research in this field comes with the challenge of how and in which roles such agents are used.

Serious games with SIAs are powerful tools for interactive learning. SIAs that behave plausibly and look realistic are needed to bring social training in serious games closer to a human natural interaction experience. Careful design of the environment and interactivity must convey societal and individual values to let users have a consistent and believable experience.

With over 20 years of research, many serious games with SIAs for a broad spectrum of application areas have been developed and evaluated. The chapter clusters the games in three interlinked groups of different approaches focusing on content and story, immersiveness and interaction, and individual experience. They all employ well-researched paradigms and learning concepts, such as collaboration, socialization, embodiment, immersion, narration, and interactive storytelling.

The different approaches' richness reflects that there is no general method or recipe for creating a serious game with SIAs for a specific learning goal. Probably the most important reason behind this can be found in the individual differences in each of us. For every situation, we have different needs and requirements that influence how we manage situations.

Recently, serious games with SIAs that adapt empathically to individual users have been created and investigated. With the development of more precise technology-based detection methods of (non-)verbal cues and verbal understanding of the interaction, it has become more evident that the understanding of individual values remains difficult. A deep understanding of users, their actions, motivations, and wishes might not be possible since they might even not be obvious (consciously) the for the users themselves. All this is connected with how we are raised, which norms and standards (cf. cultural, cohort, and family) we got in touch with, and what personal experiences we made in our life journey. It seems necessary that approaches that allow an empathic adaptation to individuals need to explain and reflect on conveyed values and provide some ways to learn and adapt to new individual values.

The more an individual adaptation is required for processes of learning, training, and understanding, the more cultural and personal knowledge is required for the involved technological methods and techniques. This extension will lead to social serious games that employ SIAs to build and repair trust and long-term relationships. Both abilities are necessary for a joyful and secure long-term exploration of serious issues in various application domains. These challenges come along with the endeavor on how to evaluate and measure specific effects. In a sense, such kinds of serious games can be seen as a way to explore and reflect on values and norms of societies, cohorts, and smaller social groups.

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