Socially Interactive Agents in Games

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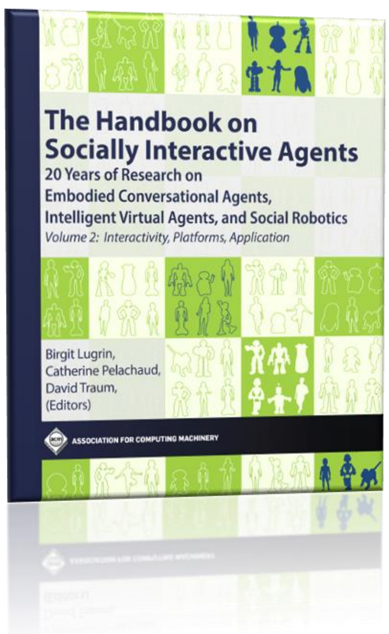

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27 Socially Interactive Agents in Games

Rui Prada and Diogo Rato

27.0.1 Motivation

Socially Interactive Agents (SIAs) have been part of games from the very beginning, although their dimensions of sociality have evolved through time. SIAs are elements commonly used in games to provide conflict as they help to define the gameplay dynamics and the challenges players face, for example, by incorporating enemies or characters that have information and resources that players need. But SIAs are also elements that provide support to players, for instance, as characters that offer help and accompany the player through the journey of the gameplay experience. SIAs are crucial to conveying a social dimension to the game world and support its social immersion and social believability. In games with more prominent stories SIAs can take narrative roles and functions as well. The use of SIAs in games is not just a typical element but is also an added value with a great impact on the experience of players. Placing SIAs in games increases game enjoyment [Dignum et al. 2009] and better SIAs are demanded by players [Afonso and Prada 2008]. In fact, some games are praised for the autonomous characters that they present.

Nonetheless, to create immersive experiences, players' expectations about SIAs must be satisfied. As with increasingly higher fidelity regarding digital characters' visuals or the embodiment of robotic game partners, the behavior of these game characters also demands more fidelity and complex social mechanisms. This represents both a need and an opportunity for the development of AI in game characters. The social dimensions of the game worlds that game characters populate are increasingly more complex, for example, involving multiple characters, within artificial societies, that act together with other AI characters and with players, who need to understand and adapt to multiple situations. To cope with this, characters need more complex abilities, in particular to have social needs and goals to be able to act socially. In turn, if characters in games display a wider range of behaviors and autonomy, the available options to players are enhanced, increasing the social interaction space that the game affords. This promotes a higher feeling of agency in players and represents an opportunity for novel game mechanics.

SIAs can be used in games for several different reasons and purposes and can play different roles in the game dynamics and experience. The abilities they need depend on the roles they play. In this chapter, we will discuss the roles SIAs play in games and the requirements and challenges for SIAs to be successful in each role. We will present an historical overview of SIAs in games Research and in the Industry, incorporating SIAs developed for digital and physical interactions (e.g., both virtual agents and social robotics). We will discuss open challenges and present promising directions for future work.

27.0.2 Models and Approaches

27.0.2.1 Games, Players and Experience

A game is an activity performed with no direct practical goal. It is a setting for playful interactions, where the outcome of the actions does not have direct meaningful implications in the real world. The actions performed make only sense in the context of the fictional world created by the game. The game experience is bounded by a *magical circle* that separates these two worlds [Huizinga 1938, Zimmerman and Salen 2003]. Players act on both worlds, but the actions taken in the real world have enhanced meaning in the context of the game, for example, in the real world players press a button but in the game world they jump or use a magical item. The motivational factors for actions are framed in the game world and the consequences of the actions are negotiable and only meaningful there as well [Juul 2005]. There are, of course, consequences in the real world, as players spend time and resources and their physical and psychological states change, but those are not directly intended by the player. The real-world consequences can be the initial trigger to start a game experience (e.g., players start a game to relax or spend time), but they are not the ones that keep the player engaged in the game through time. The term game is also, frequently, used to refer to the artefact that supports the game activity, for example, the board and pieces of a chess game or the software and hardware that runs the game. In this chapter, we will use the term game to refer to the aggregation of both concepts. A game is treated as an activity supported by technology.

Furthermore, games are different from mere playful interactions (e.g., toys) as they bring structural elements to the interaction experience. Games have rules that describe the mechanics of the interactions and define what is allowed and disallowed. The rules can be enforced by the technology that implements the game (typically done in digital games), but this may not be the case. For example, a player can move a chess piece to any place in the board (nothing prevents that in the real world), but only a few positions constitute a valid move as only a few make sense in the game world.

The game rules also support the definition of variable and desirable outcomes, for example, objectives and winning conditions. These guide players in establishing preferences over the states of the game world, as some are more desirable or more meaningful to them. The preferable game states represent focal points that players try to achieve during the gameplay experience. Players' decisions and actions are grounded on moving the game's world state closer to one of those desirable states. The progression in the game and, typically, the score, is dependent on the distance of the game state to one of these focal points. The closer it gets, the higher is the sense of progression in the game and, typically, the higher is the score players achieve.

The gameplay dynamics that sustains reaching the outcomes, usually, represents a conflict, as there are elements that try to "oppose" the players' actions and make it difficult for them to achieve the desired states. This can be done by adding explicit entities in the game (e.g., other players or AI enemies) that take actions to counter the player, but it is also implicit in the nature of the gameplay dynamics. The gameplay may have elements that pressure players (e.g., time limits) and makes it harder to make decisions or to perform actions. For example, performing the actions in the game world may require high hand coordination skills that players need to master (e.g., typical in fighting games) and making decisions may require a deep understanding of a social system with a complex economy, involving resource management and awareness of social motivations and needs (e.g., typical of strategy and role-play games).

The existence of conflict means that to reach one of the desirable outcomes, players need to make an effort to overcome the opposing forces, as the game does not evolve in the direction of one of the desirable states by itself (without the intervention of the player). That usually means that players need to learn and improve their abilities to understand the game world and its dynamics in order to act in an appropriate way to address and overcome the obstacles and hard choices they face. The level of conflict, or difficulty, is defined by design and can promote a more *casual* or more *hardcore* gameplay experience. It will be more *hardcore* if it demands higher effort, skill, and knowledge from the player or, in a general sense, if it requires more dedication and commitment from the player.

However, the nature of the resultant experience is highly dependent on the abilities, interests, and knowledge of the players and specially their attitude toward the game.

By playing a game, players assume a mental attitude with three important elements: (1) commitment to pursue one of the desirable outcomes, (2) willingness to make a real effort to achieve the necessary changes in the game world, and (3) acceptance of the conditions and restrictions defined by the game rules. The game experience is broken, or exhausted, if one of the three attitudinal elements is compromised. If players cannot find something they wish to achieve by playing the game, they will not engage and will not play. Also, playing is voluntary, if players are not willing to invest time and effort to move the game forward, they will not engage as well. This can happen if the demanded effort is beyond their capabilities or availability of resources, or if the desired outcomes are not appealing enough. In fact, there must be a balance between the two elements. Achieving an outcome in the game must involve an acceptable cost for the player. All this must be possible within the limits that the game defines. Players need to understand how the game world works and be able to act according to the rules. In general terms, players need to be able to identify what they can do in any gameplay situation and what is the impact of their actions. The outcomes that players pursue must also be framed in what the gameplay affords. If players do not figure out how the game works, it will be hard for them to engage with the game. The understanding of the game is often supported by the fiction that the game presents, which grounds the interpretation of the game world on known metaphors, and the quality of the feedback that players get in response to their actions.

Interestingly, players often pursue outcomes in the game beyond what is explicitly defined by the rules. This means that players may be committed to playing the game in ways different than explicitly designed. For example, they may try to beat the opponents in the game while not using weapons, try to delay the victory to the last moment even if that gives them less score, or perform actions that are not explicitly rewarded. The Internet is full of examples of tricks that players do with games. *Speed-runs*[1] are a prominent example. Nevertheless, players more easily commit to outcomes that are rewarded in the game and only define and pursue different outcomes when the ones defined by the game rules have been explored. But, in fact, the game may itself define open-ended goals that do not restrict nor guide the players too much, making it the players' own responsibility to define what they want to achieve in the game. What is crucial for the game is to support players in the ability to commit to goals (even if self-defined) that are framed within the *magic circle*, that is, only meaningful in the world and fiction that the game creates.

Playing a game is a subjective experience. And, typically, different players have different gameplay experiences with a game. Apart from having different skills and knowledge about the game (and games in general), players also have different motivations to play. Some play for mastery, others are driven by curiosity, and others play to get a social experience, for example [Yee 2006]. The game itself is a vessel for the experience. The success of a game is, therefore, dependent on the experience it is able to convey. The experience is built by the actions players perform in the game world, but it is more about what players feel and the memories they build by playing the game. It is the feeling of success and improvement, the feeling of living in and exploring an interesting world or taking part in an engaging story, and the feelings of fellowship developed while playing with others that are the key elements of a game experience.

To promote the game experience is the ultimate goal of the game. The success of the game experience is related on the level of immersion elicited in the players. This comes in different dimensions, as players may be immersed by different factors (often working together). Players are immersed by the space the game creates, both physical and social; by the sensorial sensations they receive, typically, visual, audio, and haptic; by the challenges and tasks they face; and by the emotional journey they live. When deeply immersed, players experience an altered sense of time. The quality of the immersion depends on how believable the game world is. How it is able to sustain the suspension of disbelief and maintain the illusion it tries to convey - for example, making players believe that they are traveling in outer

[1] A *speed-run* is a playthrough the entire game performed in the minimal amount of time.

space, that they are a rock star, that they are able to fly, or that they are interviewing a real criminal. This means that the meaning and interpretation of the players' actions inside the *magic circle* are perfectly conveyed.

27.0.2.2 The Roles SIAs Can Play in Games

Social interaction is part of the experience most games convey. It is natural that SIAs have important roles to play in those games. Note that we consider as SIA, any game actor that has some level of embodiment and has explicit social interaction with a player or other SIAs - independently, of the level of agency and complexity of the behavior it displays. SIAs can use simple internal mechanisms, even just following predefined scripts, or can use more complex mechanisms supporting advanced behaviors.

To study the roles SIAs can play in games, we first discuss the nature of the social interaction experience that games promote. Social interactions can be addressed and analyzed from different perspectives in games. On one hand, social interactions are part of the gameplay dynamics, as several game actors interact to make the game progress. These social interactions are not necessarily positive. Game actors can fight, steal, exchange resources, share information, coordinate actions, and so on. The actions performed by game actors are also interpreted beyond the gameplay dynamics and may have specific meanings in the game fiction and narrative. In this perspective, the roles SIAs play are narrative roles, of characters in stories, such as, protagonist, antagonist, and so on. We can also consider the game as an artefact to support social interactions among players. In this sense, the social interactions are interpreted by the player in the real world, outside the *magic circle*.

The different perspectives of social interaction in games suggest different types of roles for the SIAs depending on the dimensions of the experience that they influence. SIAs in games may act in three distinct layers:

- The *Player layer* that refers to the game actors in the real world rather than the game world. The interpretation of the social interactions at this level is framed outside the game world and not within the *magic circle*. *Players* are actors external to the game that, nevertheless, influence the course of the game (e.g., are performing actions in the game through the control interface). Players can be human or artificial (AI controlled). In this layer we may also fit people (or SIA) that are not taking actions in the game but have an interest in the game. For example, supervisors of the game or the gameplay's audience.
- The *Gameplay layer* that encapsulates the game actors as *agents* capable of acting in, and perceiving, the game world. The social interactions in this layer have a functional dynamics that change the game's world state and move the game forward. This layer frames SIAs, and their interactions, as elements of the gameplay mechanics.
- The *Narrative layer* that presents the *characters* that take part in the game's story and support the creation of fictional interpretations of the game world. The social interactions

from this point of view sustain the fantasy conveyed by the game. It excludes the agents that are not crucial for the fiction or story and may include characters that are not actors from the gameplay perspective.

A game actor may be projected into multiple layers if it takes part at the different social dimensions of the game (see Figure 27.1). For example, players often have an avatar in the game that represents them. The avatar is the agent that performs the actions in the game world for the player. Avatars may have some autonomy and make some decisions about the actions to perform or may strictly follow what is requested by players. Players may have different avatars in different phases of the game (e.g., Thomas was Alone (Bithell Games, 2012)) or even have a direct choice on which avatar to take in each situation (e.g., Trine (Frozenbyte, 2009)). The avatar is often the vehicle to define the limits of players' actions and perceptions of the game world, as is also a mechanism to help players project themselves into the game world, supporting immersion. The avatar binds the way players see themselves in the game world and how others see them in the game as well. Nevertheless, games do not necessarily provide avatars to players, and they may directly manipulate the objects in the game world and may have social interactions with the gameplay agents without having an explicit embodiment in the game world.

Many agents in the game world are not controlled by players (e.g., are not avatars), these are frequently referred to as Non-player Characters (NPC). NPC, typically, have both gameplay functions and narrative functions. The gameplay layer captures the mechanics of the interactions that the agents support (e.g., which actions they perform and how they respond to the actions of others). This defines the affordances of the social interaction space that players can explore in terms of gameplay. These interactions have, additionally, some interpretation in the fictional world and may convey narrative meaning. These are captured in the narrative layer, where the agent is perceived as a character in a narrative setting. For example, an agent may be the means by which players get a resource needed for gameplay (e.g., ammunition), and may represent a character that players can relate to and that shares stories about the game world.

In the case of a social robot playing a tabletop card game like Sueca [Correia et al. 2016], the SIA takes the role of an artificial player in the player layer. The game world is supported by physical items (e.g., the table, the cards) and there is no need for an avatar as the player directly manipulates the cards. Additionally, the game does not define a fiction or narrative that projects the SIAs in the narrative layer. But a social robot can also control an avatar or play a character in a narrative if the game supports such a setting, for example in tabletop Role-play Games [Fischbach et al. 2018].

All layers are important to building a good game experience, but games define them deeper according to the experience they try to provide. For example, the feelings of fellowship are more strongly conveyed by the social interactions in the player layer, the feelings of mastery

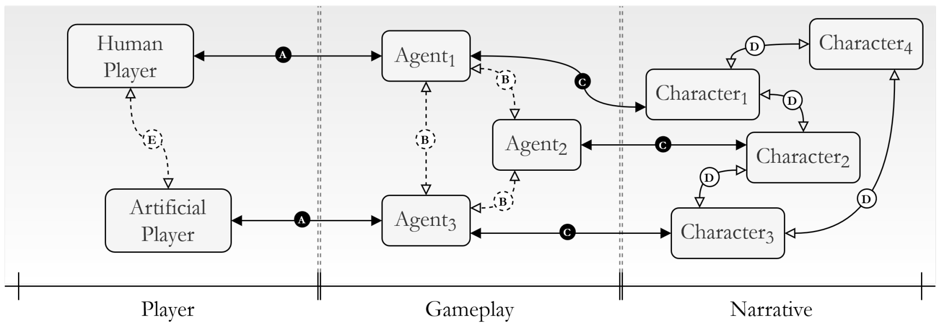

Figure 27.1 SIAs social roles landscape in games. A visual representation of the three layers of social interactions in games: *Player*, *Gameplay* and *Narrative* layers. Edges A, B, C, D and E represent the different kinds of interactions: player-agent, agent-agent, agent-character and character-character.

are conveyed by the gameplay layer, and the feelings of fantasy are conveyed by the narrative layer. Each layer presents different challenges for SIA. For example, for a SIA to perform well in a game and support the games' target experience, it will need to be able to be part of the players' community; to be able to offer challenging social interactions to players (e.g., that need coordination or the use of persuasion); or to be able to play roles that enrich the fiction and the narrative, respectively. In fact, it is important to align the roles in the perspectives of the three layers to provide high-quality game experiences and promote players' immersion. For example, it is desirable that storytelling and gameplay are well integrated in a game, and for that there should be a strong relation between the actions that agents perform in the game world and their narrative meaning in the story setting.

We will center our discussion on the social roles that SIAs can take in terms of gameplay. We discuss how these are related to the other layers, but we will not focus on narrative functions of SIAs and types of players in games. The reasons are, on one hand, because, with a few exceptions [Warpefelt and Verhagen 2016], studies about the gameplay functions of SIAs are not common, but also because the use of SIAs for narrative scenarios are discussed in chapter 26 on "Interactive Narratives and Story-telling" [Aylett 2022] of this volume of this handbook.

The definition of the three layers helps us study and define the concrete elements SIAs need for each dimension of a game's social experience. These promote distinct types of social exchanges framed in nested contexts. Many social interactions occur inside the game and are framed by the contexts that the game creates, but the social interactions extend outside the game world as well. There, the social context is wider and includes awareness of the contexts that the game creates.

- *In-game interactions*: all social interactions that occur within the game world. These can be of two types:
  - *In-character interactions*: are social interactions framed by the fiction and narrative of the game. These are character to character social interactions that are coherent with the fiction and the narrative established by the game. Character' actions and drives should be consistent with the fantasy portrayed by the game and the character's narrative goals.
  - *Out-of-character interactions*: are social interactions that have the gameplay mechanics and dynamics as the core frame of reference. These are agent to agent interactions that are coherent with the gameplay rules. Agents are driven by the gameplay goals and their actions are not necessarily aligned with the game's narrative. For example, players may use their avatar to steal a powerful item from another agent to get a gameplay advantage (e.g., deal more damage), while the motivations of the character to steal are not supported in the narrative. The main concern in this example is to maximize performance and points and not keep the agent in-character. Another example is the case of dialogue interactions whose content is about gameplay mechanics rather than characters' speech.
- *Out-game interactions*: all social interactions that occur outside the game world. These can also be of two types:
  - *Interpersonal interactions*: are social interactions that take place between the players outside the game world. These are not conducted through the game world (e.g., are not performed through agents or objects in the game world and do not use in-game communication tools.). These are out-of-character interactions as well, and are not subject to the fictional narrative nor the gameplay rules. These interactions often extend beyond the gameplay session. For example, players may keep discussing the game results for a while after finishing playing or start discussing the strategy for an incoming match.
  - *Cross-layer interactions*: are social interactions that engage game actors across different layers, mixing and bridging the context of interaction. These can be, for example, player to agent social interactions, when players do not have avatars and directly request actions from agents (e.g., their soldiers in a squad). Can also be character to player social interactions, when a character talks directly to the player, for example, to express frustrations about their decisions. In fact, all "out of character" social interactions involving game characters are inherently cross-layer interactions and take the character out of the narrative context. In this case, the meaning of its actions is no longer only bounded by the narrative and fiction but is also based on the other layers.

There are several social roles SIAs can take in terms of the gameplay layer. The first distinction is referent to the collaborative nature of the social interaction toward the player. SIAs may play roles as teammate, opponent, or be independent.

- *Teammate* - by taking this role, SIAs are committed to work together with the player. They perform tasks that are required by the challenges provided by the game. Typically, these tasks cannot be solved alone. Teammates share goals and all succeed if the goals are achieved. They can take team-specific sub-roles depending on the structure and task of the team. To play as a teammate, SIAs need to be able to understand the team's social context, shared goals, and plans and be able to execute the actions of the plan that typically require some kind of coordination.
- *Opponent* - by taking this role, SIAs are committed to obstruct players and try to avoid their success. Players need to overcome these SIAs to be able to progress in the game. The SIA in this role may also be racing with players to achieve victory for themselves. To perform this role, SIAs need to be able to understand the challenge they impersonate and be able to execute, and define, strategies to beat the players.
- *Independent or Neutral* are SIAs that have individual goals and purpose in the game world that are not strictly aligned to helping the player nor committed to obstructing their victory. The goals SIAs have in this role are not related to the goals players try to achieve to win the game, but these SIAs may help the players and join a coalition and team up with players for a while, if that fits their purpose. They may also oppose the players if their own goals are threatened or if they team up with the opponents in a coalition.

In the case where SIAs work together with players they can have different roles depending on the relation they have or build with players. They can play roles as companions, subordinates, advisers, or helpers.

- *Companions* accompany the journey of the player. Sometimes referred to as "sidekicks", they are "on screen" with the players most of the time of the gameplay experience. They pay special attention to the goals and actions players try to perform but may have their own goals as well. Companions often have a presence in the narrative layer, as well, to support building a deep interpersonal relation with the player.
- *Subordinate* is an agent that perform tasks for the players. Also referred to as henchmen or minions. They mostly perform tasks and goals delegated by players. This involves a power relationship as players have control over the goals that subordinates commit to. These agents have autonomy but only to fulfil the designated goals. They may be proactive, nevertheless, and autonomously take goals they believe that are relevant to the player.

- *Adviser or helper* is a SIA that indirectly contributes to the efforts players make toward achieving their goals in the game. Advisers convey information to players about the game state and provide advice about gameplay actions and strategies. They can be specialized in certain areas of gameplay (e.g., economic, military, research, as in the Civilization game series). The information may be proactively suggested or only given when explicitly requested by players. They often introduce players to the game mechanics and support their learning about the game.

There are several SIAs in games that are independent and neutral regarding the players' goals. They have their own goals in the game, and it cannot be assumed that they will have a benevolent attitude toward players' requests. They are, nevertheless, important to conveying the gameplay experience and it is expected that players need to interact socially with these SIAs to progress in the game.

- *Provider* is a SIA that provides resources, information, services, and tools that players need to progress in the gameplay and fulfil their goals. The players get what they need after a successful interaction with providers. This means that they, typically, need to make an effort to succeed in the interaction. This may be a simple commercial exchange (e.g., if the provider is a shopkeeper) or may require some kind of negotiation. But the option to freely provide the resources after a simple contact is open as well. The effort in this case is the time spent to go to the provider. Providers may also unlock new gameplay options (e.g., avatar abilities).
- *Challenger* is a SIA that provides challenges to players (e.g., a quest giver). These are somehow similar to providers as they may provide rewards as well. But their main role is to explicitly define goals for players to follow. They may serve as "gatekeepers" that lock and unlock the game progression as they may have strong control over the goals that are open to the players. The challenger role may be taken by an opponent as it may raise a special confrontation goal for the player that is triggered once the player meets it for the first time (e.g., a boss battle).
- *Commentator* is a SIA that describes the gameplay action and may present an assessment of the gameplay results as well. Commentators are not at the service of the player as the advisers. Although, the information they provide can be useful to help and guide players. They present a shared view of the game state to all the agents in the game world that can influence the gameplay decisions. However, they often serve the audience of the game (e.g., commenting on a football match), which includes players. In this sense, they have cross-layer agent-player interactions or may even be placed outside the game world (at the player layer).
- *Background* are SIAs that are used to bring social life to the game world. They do not influence the game progression but may be affected by it. These SIAs react to players

and engage in social interactions if requested. Background SIAs provide context to the interactions with other SIAs and may depict and support understanding of the game's social world. They often have a strong representation in the narrative layer to help enhance the social dimensions of the fictional world. Nevertheless, they are actors in the gameplay layer as they may constrain the gameplay actions players take (e.g., a player may not be allowed to kill an opponent in a public space).

The social roles SIAs assume can vary depending on the situation. A SIA may take more than one different social role at the same time. For example, a SIA may be a companion and adviser at the same time and may act as a subordinate or provider in other situations. Therefore, context is important. The same player can interact with the same agent in different situations, and each is driven by different social roles. Both the agents and the players need to understand the relation between context and roles.

We would like to highlight that, despite not being the focus of the discussion here, the narrative layer is crucial for the experience, in particular to support building social relations and emotional attachment with the SIA apart from the practical perspective of the gameplay layer. But we want to stress, as well, that to have good integration between the gameplay and the narrative experience of a game, it is important to reflect carefully and define the social roles the SIA take in terms of gameplay together with the narrative roles they will play. The gameplay is the unique aspect that differentiates games from other storytelling media.

27.0.3 History / Overview

To study the evolution of SIAs applied in games, it is important to acknowledge that the embodiment they assume is a critical factor to distinguishing them. As such, we divide our review of the past two decades of SIAs in games into two categories: *virtual SIA* (agents in digital environment) and *robotic SIA* (agents with a physical embodiment). Also, it is important to note that in this chapter we only refer to SIAs clearly used in games, both from academia and industry. And we do not include contributions in which SIAs are applied to Serious Games (as these are discussed in chapter 28 on "Serious Games with SIAs" [Gebhard et al. 2022] of this volume of this handbook) and we do not focus on the use of SIAs as narrative elements (as discussed in chapter 26 on "Interactive Narratives and Story-telling" [Aylett 2022] of this volume of this handbook).

27.0.3.1 Virtual SIAs in Games

Since the birth of digital games, the game industry has presented players with increasingly more complex and believable environments. From simple 2D grid-based maps to large procedurally generated worlds, games present several opportunities for players to explore their landscape and interact with their entities. Among these game elements, SIAs are often used in commercial games to present its story. Still, there are cases where these social agents assume an important role in the gameplay layer, with a direct impact on the game systems.

In recent years, games evolved to support larger virtual worlds, more characters and, ultimately, larger and richer interactive spaces between players and SIAs. One of the most used approaches to supporting richer social interactions with SIAs is through *verbal behaviour*. In games, SIAs' dialogue can be used to request actions from players, usually guiding them through the narrative or providing additional challenges to further explore the environment. However, they are also used as channels to share accessory information about the game experience and establish empathic and meaningful relationships between the player and the game elements.

SIAs' dialogue is often supported by the fictional story on the narrative layer but the actual exchanges happen with agents in the gameplay layer. Some games use linear narratives that offer a near cinematic experience supported by well-written dialogue lines where SIAs engage in dialogue with other agents following a rigid script, as in Uncharted: Drake's Fortune (Naughty Dog, 2007) or in The Last of Us (Naughty Dog, 2013). This approach reduces the player's capability to influence the narrative flow in a discernible way. To create a false sense of agency, in Uncharted 4: Drake's Fortune (Naughty Dog, 2016) certain conversations between the player and SIAs requested dialogue options with no impact on the storyline but still demanding the player's input at the gameplay layer. But in linear narratives, SIAs are also used to mimic a living world by promoting social interactions between agents. For instance, in The Last of Us (Naughty Dog, 2013) and Far Cry 4 (Ubisoft, 2014), developers were able to create interesting conversations between SIAs by adapting the dialogue based on their context, the player's actions, and other game events. On the latter, the player's companion is also capable of assessing possible threats and channel that information to the player using dialogue. In BioShock Infinite (Irrational Games, 2013), a system that used the player's companion to highlight relevant interesting locations was introduced. In addition to her dialogue lines, an intelligent system that positioned this SIA in the game world was used to shift players' attention to unexplored parts of the scene.

Other games rely on richer dialogue interactions with SIAs that are supported by *dialogue systems* that offer multiple conversational choices. One of the most common effects of these conversational gameplay is the impact on the narrative's ending, usually organized in branches. BioWare's Star Wars: Knights of the Old Republic series, which started in 2003, introduced SIAs that spontaneously engaged or interrupted players and other agents' conversations in an meaningful and impactful way to the experience. Several of Quantic Dream's titles, such as Fahrenheit: Indigo Prophecy (2005), Heavy Rain (2010), or Detroit: Become Human (2018), rely on multiple dialogue choices to affect short-term interaction with other SIAs and the environment, as well as long-term relationships, leading to multiple game endings. Although the player is presented with a reduced set of options every time the game demands for a dialogue action, its limited range of affordances hides a rather complex branching narrative that is disclosed throughout the gameplay. Some open world games, such as Fallout 4 (Bethesda Game Studios, 2015) and Assassin's Creed: Origins (Ubisoft, 2017), populate their worlds with unique agents that can engage the player in conversations that reveal information about game events (e.g. such as side-quests) that expand the gameplay space.

Using the player actions toward other SIAs, including through dialogue systems, to affect *game systems* rather than the narrative is a different approach toward creating emerging experiences. Both Alpha Protocol (Obsidian Entertainment, 2010) and Fallout: New Vegas (Obsidian Entertainment, 2010) use a reputation system that models player's action toward other game characters that lead to different social interactions with agents and their faction's members. In The Elder Scrolls IV: Oblivion (Bethesda Game Studios, 2006), agents' behavior is guided by a morality system that affects their obedience to social norms depending on the need to satisfy their personal goals. While playing Anthem (BioWare, 2019), the player is offered dialogue options during conversations that affect how other SIAs, and respective factions, perceive the player's reputation, limiting the number of resources available. In Dying Light 2 (Techland, 2022), the game agents are managed by a morality system that controls the social interactions with the player, filtering the resources provided to the player, the combat opportunities, among other restrictions that directly affect the gameplay. These systemic approaches enable the player to have a more direct contribution in shaping the gameplay experience.

Other titles elevate the dialogue between the player and other SIAs to a core mechanic of the gameplay. One particular game that excels at using dialogue systems to affect the gameplay is L.A. Noire (Team Bondi, 2011). The player's character is a detective and a significant portion of the interaction with SIAs (witnesses and suspects) relies on questioning them to expose lies. On one hand, the player must gather information about the crimes by questioning them about the evidence collected. On the other hand, the player must challenge the SIAs statements when they are lying by watching their verbal (the information) and non-verbal behavior (facial expression and posture). Besides using dialogue system, games also rely on *parser-based* solution, as is the case with Façade [Mateas and Stern 2003] and Event[0] (Ocelot Society, 2016). Façade is a well-known interactive drama that uses a parser-based solution to handle player's written input during a conversation with two game characters [Mateas and Stern 2003]. The player's goal is to save the marriage of the two SIAs by interacting with them through open dialogue. The game has several endings that can be reached based on the player's interventions and the characters reaction to them (modeled by a drama manager). The interactive space affords several possibilities for the player as the social relationship between the two SIAs changes during the game. The commercial game Event[0] (Ocelot Society, 2016) also used a parser-based approach to consume the player's input when interacting with an AI managing a spaceship. During the game, the player must communicate with the agent controlling the ship's systems through written commands. These interactions not only modify the environment but also affect the relationship between the player and the agent.

Besides the conversational mechanisms of game agents, other social capabilities have been endowed to SIAs in games. For instance, in Black & White (Lionhead Studios, 2001), the creatures learn from the players actions and adjust their interactions with the environment and its characters accordingly. In Alien Isolation (Creative Assembly, 2014), throughout the game the main enemy seems to evolve by learning new approaches that are unlocked in the SIAs behavior trees.

In combat scenarios, agents can also coordinate their efforts by assuming specific combat roles and adhering actions from other SIA. In F.E.A.R (Monolith Productions, 2005), enemies exhibited a squad behavior using Goal-Oriented Action Planning (GOAP) to coordinate attacks that show dynamic and coherent behavior among several SIA. In Halo 3 (Bungie, 2007), enemies and allies are recruited to join combat tasks as necessary and the collective behaviour of each bundle of SIAs helps establishing a sense of coordinated action. The enemy SIAs in The Last of Us (Naughty Dog, 2013) can coordinate ambushes on the player where a coordinator agent assigns different roles to each agent in combat (e.g. flanker). Dishonored 2 (Arkane Studios, 2016) also has coordinated crews of SIAs that join their efforts to intelligently searching or attacking the player. Group interactions were also addressed in the Perfect Circle game [Prada and Paiva 2009]. In the game, one player solves a series of puzzle-like challenges together with four SIA. They need to cooperate and coordinate decisions about the best course of action. This research stressed the importance of addressing the socioemotional dimensions of the group dynamics together with the instrumental actions.

Another approach to strengthen the social relationship between agents and players is to design SIAs that exhibit human-like capabilities, such as emotions and personalities. Each NPC in Far Cry 4 (Ubisoft, 2014) had a micropersonality that characterized the NPC's motivations, needs, and desires and helped creating an illusion of agency when these SIAs interacted with each other. In Event [0] (Ocelot Society, 2016), the AI character models its stress level and affection toward the player, adapting the social interactions between them accordingly. Similarly, the alien in Alien Isolation (Creative Assembly, 2014) models the player's stress level to balance the gameplay between stressful and relaxed moments. Researchers have also explored game agents with complex decision-making mechanisms that promote interesting interactions. Using Fallout 3 (Bethesda Game Studios, 2008) modding capabilities, researchers have deployed a canine companion capable of identifying the intent behind the player's actions and give advice [Doirado and Martinho 2010].

In other games, SIAs can have a long-term social relationship with the player while going on with their lives. The agents populating the Hitman (IO Interactive, 2016) world exhibit situational awareness by interacting with other SIAs based on their context when performing their routines. In Red Dead Redemption 2 (Rockstar, 2018), all SIAs have daily routines and, when encountering other characters, the interactions are influenced by past events and exchanges with the player. Both previous games also highlight the value of proxemics, namely when norms are violated, such as trespassing private property. The SIAs in these games will adjust their actions based on the social distancing between them and the player.

In game genres such as strategy, management, and simulation, the player does not directly interact with SIA. However, he/she can manipulate the environment, thus affecting the social dynamics of the population. To an extent, the NPCs are capable of socially interacting with each other and the world but are unaware of the presence of the player. In The Sims series (Maxis), the SIAs not only have a complex human needs model but also were able to interact with each other and allow for emergent social relations to unfold. Besides the daily routines, such as eating or sleeping, the characters could establish social relationships with other NPCs based on their mood and personality. Other games such as Sim City (Maxis, 1989) or Cities: Skylines (Colossal Order, 2015) invites the player to modify the game environment with no interaction over the NPCs in the world. Rather, the player must rely on these modifications to shape the physical elements of the game, thus defining the social dynamics of the populations and, ultimately, influencing their interactions. In Prom Week, the player must satisfy social goals for each level in order to progress in the game [McCoy et al. 2011]. These goals are satisfied when the interactions between the NPCs, which are triggered by the player's input, lead to a certain social state. The SIAs rely on the Comme il Faut (CiF) model to manage the social physics of the game [McCoy et al. 2010]. CiF was also employed in mods for commercial games such as The Elder Scrolls V: Skyrim (Bethesda Game Studios, 2011) and in Conan Exiles (Funcom, 2018) to improve the social interactions between NPCs [Guimaraes et al. 2017] as well as extending the original model with an emotional appraisal mechanism [Morais et al. 2019] toward creating more believable characters.

Other games use social simulations techniques to generate worlds before gameplay. Then, throughout the game, the player can interact with the game characters and experience the resulting social environment. Dwarf Fortress (Bay 12 Games, 2006) uses several techniques to procedurally generate populations for the player to experience. The underlying complexity of the generation includes models for the relationships of the NPCs that can be contemplated during gameplay and a knowledge propagation system that generated plots and events to be explored by the player while interacting with the world and its social beings. Another example of a gameplay experience that revolves around knowledge propagation is Talk of the Town [Ryan et al. 2015]. The communication between NPCs are subject to several mechanisms that shape the exchanges between characters, in particular social phenomena such as lying or eavesdropping.

Besides the systems that manage the opponent civilizations, on the Sid Meier's Civilization series NPCs are used as advisers in different game-related subjects (e.g., military strategies, financial policies). Additionally, the player can interact with SIAs that represent enemy civilizations through in-game combat or diplomacy.

27.0.3.2 Robotic SIAs in Games

Social robots have rarely been used in commercial games (note that we are excluding toys in this analysis, where the use of robots is more common). Yet, during the last two decades several researchers used games to explore the interactive space between human players and social robots. These robotic players are usually placed in games to support experimental studies and are capable of promoting a small set of interactions. However, this type of SIA tends to assume a place not fully explored in game environments with their virtual counterparts.

Understanding the impact of SIAs' *embodiment* in games has been explored in several research works in social robotics. In 2003, Christoph Bartneck explored how the placement of a robotic character on a "future intelligent home" would affect the enjoyment of interactions in the household [Bartneck 2003]. A game setting was used to conduct an experimental study where participants would have to trade stamps with an eMuu SIA (robotic or digital embodiment). The results suggest that participants were more willing to forgive the robotic player's errors when compared to the digital counterpart.

Also, in [Komatsu and Abe 2008], researchers conducted an experimental study to investigate if the presence of a robotic SIA would persuade participants. All participants would play Nintendo's Picross game for a brief period of time alongside a social agent (either an embodied or a digital version of PaPeRo). Then, participants with the robotic partner would be interrupted and the agent was replaced by the digital version. After 10 minutes, the agent would ask the participants if they wanted to play another game. The results suggest that players were more willing to change games when the robotic partner was physically present and the backstory was read. Using a chess game, researchers studied how the opponent's embodiment (robotic and digital version of iCat) would affect the participants enjoyment [Pereira et al. 2008]. The results indicate that players' enjoyment is higher when playing against a robotic partner. Using the Keepon robot, researchers studied if the embodiment of a conversational robotic tutor (physical, digital, none) had an effect on the performance of humans while solving puzzles [Leyzberg et al. 2012]. The results suggest that using a robot increased the participants' learning gains over the course of the experiment. In [Wrobel et al. 2013], the authors conducted a user study to assess elder users' enjoyment while player a card game with a social agent. Wrobel et al. used the game of trivia StimCards to explore how elderly people engaged with a laptop (no embodiment), a virtual agent (digital embodiment), and a robot (physical embodiment) while playing the card game and receiving feedback. The results show that the robotic version was preferred to the virtual agent due to its physical presence.

To investigate not only the impact of the embodiment but also the physical presence SIAs had on player's perception of the robot, researchers extended the possible modalities to include real-time videos of robotic players (through tele-presence). Using the classic Tower of Hanoi puzzle, Wainer et al. studied the human's performance and perception of social interactions while playing a game with a robot (ActivMedia Pioneer 2) [Wainer et al. 2006]. The findings indicate that physical embodiment can affect the perception of a social agent's capabilities and the player's enjoyment of a task. To further explore the role of "material embodiment", the authors conducted another experimental study using the same scenario [Wainer et al. 2007]. The results demonstrated that the physical robot was interpreted as more helpful, watchful, and enjoyable than the tele-present and digital versions. Also, participants identified the embodied versions of the robots as more perceptive and appealing. In [Komatsu and Kuki 2009], the authors concluded that players who interacted with a robotic agent followed by its digital version attributed the same character and personality to the robotic and digital versions.

To deploy social board game opponents, Pereira et al. identified several design guidelines for developing socially present artificial players [Pereira et al. 2012]. The guiding factors identified were used to develop a scenario using the popular game Risk where three participants play against a robotic player using the EMYS robot. This scenario allowed researchers to conduct an experimental study that verified that when the guidelines proposed were applied to the design of the SIA, participants' perceived *social presence* improved [Pereira et al. 2014]. Similarly, in [Fischbach et al. 2018] researchers design an interactive tabletop game with a robotic game master that can assume multiple roles during the game and promote collaborations between players.

The effect of *emotional expressions* by social robots has also been researched in the context of game applications. Bartneck [Bartneck 2003] conducted an experimental study to understand if robots' emotional expressiveness was relevant during a negotiation game. The results of the study suggest that the enjoyment of the player increased when the robotic character expressed emotional responses. In 2008, Leite et al. designed and developed a game scenario that placed a social robot capable of exhibiting emotional behavior (iCat) as the player of a chess game. Using this scenario, a preliminary study that brought children and robots together to play a game of chess revealed that the human player's perception of the game increased when the robot's affective state was aligned with the game state [Leite et al. 2008a]. The authors used the same scenario to study how the agent's emotional expressiveness [Leite et al. 2008b] influenced a human players' performance. The results show that players performed better when the social robot displayed emotional behavior. Using an iCat robot to play a card guessing game, researchers studied how children in different age groups would express emotions based on the game's outcome [Shahid et al. 2010]. The results suggest that young kids are more expressive than older ones when collaborating with a robot.

Using the Coin and Strings board game, researchers studied how a human player would perceive its social performance when playing against an emotional social robot (EMYS) [Petisca et al. 2015]. The authors concluded that a robotic opponent capable of sharing emotion, might hinder the human-robot interaction and the social perception of the robot. To explore the effect of emotional sharing and competence while executing a task, the authors conducted another study that focused on the effect of each one of the previous factors on the perception of a robotic opponent in a game [Petisca et al. 2016]. The findings suggest that when placing robotic players in a very competitive scenario, such as this board game, the robot's emotional responses might be ignored by the player. Still, when the competence of the robot was lower, the participants perceived it as more concerned about the player when compared to the high competent variant.

The use of verbal and non-verbal behavior was also studied in the context of social robots playing games. Using AIBO (a pet robot), researchers created a scenario for the robot to learn how to play several games based on the feedback provided by a human participant [Austermann and Yamada 2008]. The scenario was used to study how different modalities of feedback (speech, gesture, and touch) affect the perception of the robot learning capabilities (measured with questionnaires). The results show that speech and touch are the most natural ways of providing feedback. Komatsu et al. used a treasure hunting game to explore if subtle expressions, such as fast sounds, when expressed by a robot companion (MindStorms) would affect a human player's actions [Komatsu et al. 2010]. The authors conducted an experimental study that shows subtle expressions as a successful mechanism to convey a robot internal state and also suggest that players adapted their decisions based on the type of the subtle expression used. Similarly, in [Leite et al. 2013], the authors studied different types of empathic behaviors, and their findings suggest that facial expressions and verbal utterances positively affected the perception of friendship toward the robot.

In [Lehman and Al Moubayed 2015], the authors elaborate on the 2D platform game Mole Madness used to study the interaction between a robotic player (using FurHat) that can interact with a human player while both control the game character through speech commands. Researchers used this game scenario to conduct an exploratory study on children's verbal and acoustic synchrony while exploring the engagement of speech-controlled gameplay [Chaspari et al. 2015]. Additional studies to explore how prosodic patterns would influence children engagement during a game were conducted [Chaspari and Lehman 2016, Sadouohi et al. 2017]. Both experimental studies indicate that when a robot synchronize its speech prosody with the children from the start of the game, the engagement is higher when compared to the robots that did not exhibit any synchrony from the start.

Using the humanoid robot NAO, researchers studied how robots different social categories would affect human behavior during a card game [Häring et al. 2014]. In the scenario, all players had to interact with two robots: one belonging to participants' social in-group and the other one being a social out-group member. They conducted an experimental study in which participants were either asked to collaborate with the in-group and compete with the out-group (congruent condition) or vice-versa (incongruent condition). Their findings indicate that players evaluated their actions more positively in the congruent condition and more challenging in the incongruent.

In [Shahid et al. 2014], the authors explored the effects of playing alone, with a robot, or with a friend in the interaction with social partners. The subjects were kids from different cultural backgrounds (Pakistani and Dutch). On the one hand, the results show that Pakistani kids enjoyed the collaboration more than the Dutch ones. On the other hand, participants had an increased enjoyment and expressiveness while playing with robots than when playing alone, but less than when playing with a friend.

Toward studying how players socially interact with robots with different roles (partners or opponents) and goals (relationship-driven or competitive), researchers used the Sueca card game with multiple robotic players. In [Oliveira et al. 2018], an experimental study was conducted, and its results suggest that players gazed more toward the competitive robot when it was their partner, while players gazed more toward to the relationship-driven robot when it was their opponent. The authors also identified a higher frequency of socioemotional support toward human (when compared to robots) and partners (when compared to opponents). Using the same scenario, researchers explored group-based emotions and membership preferences in teams of humans and robots [Correia et al. 2018]. The authors concluded that group-based emotions (that reflect the group actions) were able to emphasize trust and group identification more than the individual robot (with emotions that focus on individual behaviors).

Toward promoting collaborations in teams of humans through the presence of a robot, researchers placed a social robot (using Keepon) alongside a team of two playing a game called build-a-rocket [Strohkorb et al. 2016]. In this scenario, players had to collaborate to conclude the task while the robot periodically participates with interventions about the task or about the interpersonal relationship of the players. The results of an experimental study with children suggest that a robot with task-oriented interventions help to increase the participant's scores while a more relationship-focused robot improves participants' perception of their performance.

In [Correia et al. 2019], an experimental study using the competitive and relationship-driven robots were used to determine the human player's preferences toward the robots. The findings indicate that when no previous interaction with the robot occurred, participants preferred the relationship-driven robot. However, when participants had already played with the robot, their preference is influenced by other factors (e.g., competitiveness of the human player or the game outcome).

Placing iCat as a bystander that interacted with two humans playing a chess game, researchers concluded that, when the robot displayed empathic behaviors, players rated their companionship higher when compared to the ones that interacted with the neutral robot [Leite et al. 2010]. In a real-world environment with children, another experimental study was conducted with a fully autonomous version of iCat capable of recognizing facial expressions and exhibiting appropriate empathic behavior [Leite et al. 2012]. The results support previous findings, indicating that the empathic cues of the robot had a positive effect on the perception of the robot.

Using a trick-taking card game called Sueca [Correia et al. 2016], researchers conducted two experimental studies (one with elderly participants [Correia et al. 2016] and another with younger players [Correia et al. 2017]) to investigate the humans trust levels toward robots. Both studies suggest that humans are capable of trusting a robot as a game partner in a card game. However, trust levels vary based on previous interactions with the artificial partner: players that had already interacted with the robot increase their trust levels more than participants that had already interacted with human players.

To understand what social interactions between children and robots were beneficial to establish a long-term engagement, researchers designed game setting that placed a NAO robot playing Snakes and Ladders with children [Ahmad et al. 2017]. Using this game, an experiment was conducted, and the results indicate that adaptations based on the game state had no effect on the long-term interaction. However, emotion-based and memory-based adaptions had an effect on the sustainability of the relationship between child and robot.

Using a NAO robot and a railroad route construction game, researchers explored how a robot's vulnerability would affect players' trust [Strohkorb Sebo et al. 2018]. Using this scenario, an experimental study was conducted with groups of four players (three humans and the robot) and evidence suggest that when the robot said vulnerable utterances, the participants showed more trust-related behaviors toward the human partners. To study how robot's trust violation and subsequent repair would affect the players' relation toward the robots [Sebo et al. 2019], the authors conducted another study based on the previous game that indicates that denying culpability might yield benefits while repairing human-robot trust, but not when deception is involved.

27.0.4 Similarities and Differences between Virtual and Robotic SIAs

Both fields of virtual and robotic SIAs acknowledge the added value of SIAs for the players' experience in games. But the literature on social robots in games has not yet matched the number of commercial and research work that deploy virtual agents in games. The application of SIAs in virtual worlds has been addressed for longer, but in recent years there has been increased interest in research on the use of robots in games as well. Both areas have been through significant changes in the past 20 years due to technological advances. Still, their research directions do not often align with each other, but both can benefit from wider awareness of each other's contributions and achievements.

In Social Robotics, researchers focused their efforts toward studying the effects of using an embodied player on the players' experience. But, with a few exceptions, the focus of study is often the relationship between players and the robots and not the perceptions and attitudes toward the gameplay itself. The interaction with social robots that play the game through an avatar or that play other roles rather than of an artificial player are not much explored. Robots sometimes take other roles together with the player role (e.g., the role of companion), but the social interactions are framed at the player layer, in the real world, and do not enter the gameplay and narrative layers of the interaction experience, for example, do not cross the *magic circle* into the game world.

Contrarily, Virtual Agents in games take more roles in the gameplay and narrative layers. However, they are not used as artificial players with a representation in the player layer that players can relate to outside the game world. There is extensive work on AI to play games, but the focus is on the creation of mechanisms to solve the game without any regard for the embodiment of the artificial player nor the social relations it can build with players, hence cannot be considered as SIA.

There is a natural bias of the research target by each field given the nature of the embodiment of the SIA, which is either strongly grounded in the real world or in the game's virtual world. It is hard to decouple the use of SIAs from the embodiment they assume.

Both fields address the SIAs embodiment, virtual or physical, and take the expressivity of the body as an important factor. Both found results on the impact of the embodiment in the game experience. When it concerns artificial players, a physical embodiment seems to be preferable. But, comparisons for other gameplay roles have yet to be performed. This will demand a different view of robot roles in games and the nature of games implementation will need to change as well. It needs to more easily integrate robots and other physical objects as gameplay elements. In turn, the degrees of freedom of the embodiment in virtual agents are higher and the expressivity of the body has been explored from an artistic point of view in addition to the strict social functions.

The complexity of the games used in the two fields is different. The games used in social robotics are much simpler in terms of gameplay. And the competences the SIAs demonstrate are also simpler, for example, the dialogue interactions are more restricted. This is on one hand, justified by the higher focus on the embodiment in the social robotics field that address less often the gameplay mechanics, but it is also because of the higher difficulty in the realization of more complex behavior and context awareness for social robots compared to virtual agents. The creation of rich interactive environments for games is also easier in a virtual domain compared to the real world.

Nevertheless, both fields give importance to the social intelligence of the SIAs and the emotional dimensions of social interaction. In fact, all matters discussed in the previous chapters of volume 1 of this handbook [Lugrin et al. 2021], in particular, in Parts I, II, III, and IV, are quite important for SIAs in games, regardless of the type of embodiment. For example, social cognition, expressive and non-verbal behavior and models of interactivity discuss work that can be used to empower the capabilities of SIAs in games.

There are still many open opportunities for the research of SIAs in games. The whole interactive space that covers the range of possible affordances that SIAs, both virtual and robotic, can bring to games while performing the roles discussed in Section 27.0.2 has not yet been fully explored in game research, although commercial games make use of such SIA. Part is covered in domains that we excluded in our analysis, for example, serious games and pedagogical agents (discussed in Part V of this volume) conduct research that fits well in social roles, such as advisers and companions. But, for some other social roles, the research on SIAs for games is not extensive. It can take inspiration from other fields, for example, multiagent systems, that deal with teamwork, decision-making, and coordination, or social psychology that define models for social behavior, and game design and user experience research in general. In fact, the research efforts need to bring together AI with experience design and focus on the contributions of SIAs for the gameplay dynamics.

27.0.5 Current Challenges

The roles discussed in Section 27.0.2 have been used in games but not all have been extensively explored and addressed by research. Therefore, the interaction capabilities of SIAs in such social roles are typically simple. This limits the interaction space available to players, which reduces their sense of freedom and autonomy while interacting with such SIA. This affects players' perceptions about the SIA, their abilities as social actors, and the quality of the social immersion, affecting the quality of the overall game experience.

There are many open challenges regarding the capabilities needed to perform well, autonomously, the different gameplay social roles. For example, more research is needed to make SIAs play well the role of teammates and to be perceived as autonomous and trustworthy partners. Research is needed for opponents as well, for example, to make them able to present to the players gameplay challenges of a social kind, involving lying, persuasion, and taking into account social dynamics such as in-group and out-group bias, for example. The neutral SIAs can gain relevance in the game experience if they display stronger autonomous social behavior as well. They can show social motivations and goals, for example, to gain status in a group or to pursue a relationship with another SIA, and they can be more selective about the collations they enter and the support they give to players. This latter case requires memory and moral judgement mechanisms to avoid, for example, having SIAs blindly helping players that have been mistreating them and their friends.

In general, that are big challenges for the creation of SIAs with good social behavior in games, in particular, regarding the ability to understand social context, be aware of and understand social reality, and be able to adapt behavior to the context and other game actors (other SIAs and players). Adaptation to the player's goals is one of the current research trends. But adaptation to the social context based on all the SIAs present in a gameplay situation also raised some attention. This may allow SIAs to change attitude toward players when new members join the team and provide means for SIAs to change social roles if they can take more than one.

Another major challenge SIAs face in games is the ability to show coherence in their behavior, and, at the same, time avoid repetitions that break their social believability and the players' social immersion. Players often interact with SIAs for many hours during a game playthrough. In general, the creation of SIAs that deal well with long-term interactions is still a big and open challenge. Again, this will require good memory and situation assessment mechanisms.

The communication with players and among SIAs, in a way that players can understand, is another open research challenge. This inherently implies dealing with Natural Language Processing (NLP) (for example, as discussed in chapter 5 on "Natural Language Understanding in Socially Interactive Agents" [Pieraccini 2021] of volume 1 of this handbook [Lugrin et al. 2021]). Current NLP advances are opening new opportunities to SIAs. SIAs can have more flexible conversations with players, which have been typically quite restricted. For example, chat and voice interaction are being explored as novel gameplay interaction modes in games. This also opens the possibility for SIAs to participate in communication channels outside the game world (in the player layer). But this raises the additional challenge of supporting expression and understanding of informal conversations with lots of symbols, emoji, and non-normative vocabulary and spelling. However, if SIAs take the role of artificial players, and take part in the player layer, participation in these communication channels will be important. Research in robotic SIAs that, typically, uses robots as artificial players in board game scenarios, where the verbal social interactions are essential for gameplay and to convey game experience, must address this challenge. But even if not pursuing NLP, addressing communication with SIAs in a way that is flexible and controllable at the same time is an open and crucial design and research challenge. It is also a challenge to extend this communication beyond the game session, addressing pre- and post-game interactions and dealing with repeated game sessions (e.g., playing the same game more than once).

There are specific additional challenges concerning the use of robots in games. Robots still need better capabilities to manipulate the physical components of a board game. Getting full understanding of the board game state is still challenging as well for more complex games with several types of components. But even in the case where the game is fully digital, which is typically realized using digital touch surfaces, the robots need to deal with social embodiment. For example, they need to be able to understand the social proxemics, keeping in mind the embodiment of other players and having appropriate gaze behavior.

One general challenge is to achieve a stronger collaboration between research and game developers. Researchers will gain richer environments and social interactions to explore access to wide variety of players, and much interesting data to study. Game companies will gain knowledge and tools to understand better what autonomous SIAs can bring to games and become more equipped to create stronger SIAs in their games.

The use of autonomous SIAs comes as a game design challenge as well. Designers and developers need to make sure that the autonomy added to the SIAs does not go against the game design goals and in fact strengthens the design principles. Autonomy and complex AI behavior is not always needed. There is increasing interest in automated testing and validation tools to assess the complexity of the gameplay space and the way players play a game to make sure that the afforded interaction experience fits the design goals.

27.0.6 Future Directions

Research of SIAs in games have yet many open challenges and opportunities for future directions. First of all, as stated before, there are social roles that are underexplored by research. A promising example is the use of virtual SIAs that take the role of embodied artificial players capable of engaging in social interactions in several activities related to playing games. These should include playing the game but also taking part in the moments shared before and after playing the game. A further step would be turning such SIAs to true playmates that can play any game and, therefore, share heterogeneous gameplay experiences with players. This research would combine the research fields of SIAs and general gameplaying, such as Thyia the forever gameplayer [Gaina et al. 2019], for example.

In turn, there are several future directions for the use of robots in games. Researchers need to explore the use of robots in gameplay centered roles, placing robots as gameplay elements that are not artificial players. Robots could, for example, take the roles of *subordinates* (e.g., minions) that players control through delegation of actions or *providers* of resources or information engaging in negotiations with players. Note that these kind of roles have been explored in research but have not been taken into the domain of games, hence, have not been considered in terms of gameplay value. The use of robots this way, making them part of the game world, is promising for games like Live Action Role Playing Games (LARPG) and real life murder mystery games, which are becoming more popular.

The use of Augmented Reality (AR) is of great value to support the idea discussed above. A very interesting future direction is to combine research on AR with Social Robots in the context of games. AR can support the creation of gameplay experiences in physical environments that take advantage of the embodiment of robots and at the same time reduce the difficulties that robots still have with the manipulation of physical game elements. Players' direct social interaction with the robot can be also enriched by AR, for example, by augmenting the views and perceptions over the state of the robots that could improve understanding (e.g., augmenting the robots' expressivity) and by granting more contextualized options for the interactions, for example, parameterization that may be difficult using natural language and may be cumbersome using a classic graphical user interface.

Two related ideas are the use of social robots as avatars for players, exploring robots for the telepresence of players in physical games, and the use of social robots as players of fully digital games, by means of using a game controller as human players do. These ideas reflect the opportunities that SIAs with better capabilities can bring to game design. We believe that SIAs with enhanced social intelligence and autonomy, with both physical and virtual embodiment, will spark novel and completely new gameplay interactions that have not yet been explored by game designers. For example, there are opportunities to explore social interactions that are not built on top of explicit conversations, as SIAs become more competent in understanding player's intentions. In a different perspective, SIAs can also be used in the process of game design by taking the role of co-creators to improve the creativity of the game designers. This would combine the research of SIAs with the research of procedural generation of games and computational creativity.

One promising research direction for the use of SIAs in games is sustained by a need expressed by players. Games are making more use of large open worlds, often procedurally generated (e.g., No Man's Sky (Hello Games, 2018)), but these large worlds need to be populated by many SIAs to avoid conveying feelings of emptiness. The challenge is to procedurally generate large amounts of SIAs that show diverse and coherent social behavior and convey the feeling of organized social groups and populations that fit the generated worlds. Additionally, these SIAs should bring gameplay value as well as enhancing the social dimension of the game world.

27.0.7 Summary

SIAs are commonly used in games and their use and complexity has grown in the past years. SIAs typically take the role of virtual agents in virtual worlds, but more recently, as the field of social robotics emerged, interested in the use of robotic SIAs in games has increased.

SIAs have been used in games for several different reasons, taking several different social roles. They help to create and sustain the social dimensions of the game and improve the social immersion of players to convey better gameplay experience. SIAs can be artificial players, be part of the gameplay dynamics, and help to convey narrative meaning. In this chapter, we discussed the most common roles SIAs can take in games with focus on their contributions to gameplay.

We presented several examples in the use of SIAs in games both with virtual and physical embodiment. The research and use of SIAs has been different depending on the embodiment they take. In the case of Social Robotics, most research places the SIA as an artificial player, while that is not the case of Virtual Agents. Virtual Agents take more gameplay-related roles. Anyway, there are still many open opportunities for research, for both type of SIAs, related to the agents' capability of social performance. For example, games provide rich social worlds with several game actors and demand long-term interactions with diverse situations, which are still a big challenge. In fact, many SIAs in games still show simple behaviors that can be improved by using more advanced AI. With stronger SIAs, the gameplay offered to players can be enhanced in ways that are not yet explored. With better capabilities, SIAs can augment the interaction affordances and provide an enhanced sense of agency when players interact with SIA. Integrating such SIAs in the experience comes as a game design challenge as well.

It is important for the research of SIAs in games to mutually share the different perspectives that have been explored in different communities, in particular, virtual agents and social robotics, but also combining knowledge from other domains related to game AI in general, game design and interaction technology relevant for games.

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