THE UNIVERSITY OF CHICAGO

ROLE-PLAYING WITH ROBOT CHARACTERS: GAMIFICATION AND NARRATIVE AGENCY FOR INCREASING USER ENGAGEMENT

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ABSTRACT

Live entertainment is moving towards a greater participatory culture, with dynamic narratives told through audience interaction. Robot characters offer a unique opportunity to mitigate the challenges of creating personalized entertainment at scale compared to human actors, as they can be automated and thus continually perform for small audience groups. In a between-subjects user study ($n = 46$), we created an immersive storytelling experience where users role-play as a detective with two distinct robot characters where users either (1) primarily watch the two robots converse (control condition), (2) have a greater degree of involvement and self-identification in the story by talking with the robots in-character (narrative agency condition), or (3) have a more active role in playing games and solving puzzles (gameplay agency condition). Our results show how increasing the degree of user agency in an entertainment experience, either through narrative agency or gameplay agency, increases users' flow state, sense of autonomy and competence, sense of immersion and enjoyment, and social perceptions of the robots during the experience. These findings suggest that increasing user agency can lead to an increase in engagement, which can be extended to broader interactions with robots where role-playing in stories and manipulating agency can be incorporated. We also present design recommendations for future interactive narrative experiences featuring robot characters.

CHAPTER 1

INTRODUCTION

Live immersive entertainment is becoming increasingly popular in today's experiential economy, where audience members are able to physically step into the world of a story and are empowered to create emergent narratives by interacting with their surroundings. Immersive theater shows such as *Sleep No More* position audience members as walkaround observers of actors playing scenes in a hotel [83], while role-playing experiences such as *Star Wars: Galactic Starcruiser* cast participants as the heroes in a story with opportunities to interact with popular characters [17]. Audience members are thus able to experience unique narrative arcs driven by their background and actions. However, great operational costs are associated with hiring actors to scale up these experiences for large audiences and create personalized interactions, such that audience members are ultimately placed in a "pyramid of participation" where only a select few are afforded the opportunity to influence the story of an experience compared to being passive observers [82]. Analogous to how Audio-Animatronic robots in theme park attractions (e.g. *Carousel of Progress*) can function as actors in a proscenium theater show, we believe that using robot characters in interactive entertainment experiences offers a unique opportunity to mitigate the challenges of scale, as robots can repeatedly perform scenes while dynamically responding to audience members.

In this work, we explore the use of robot characters in creating audience engagement in narrative experiences. Prior work has shown the benefits of using robot characters with distinct personalities and form factors when people interact with more than one robot to increase engagement [79], robot comedians using traditional joke-telling techniques have been successfully deployed in the wild [80], and robots have been used to positively facilitate player interaction as a game master in an immersive puzzle game and to tell stories as actors [41, 26]. However, no work to our knowledge has yet explored the use of multiple robots to facilitate role-playing with users in a narrative context similar to immersive theater. Drawing from theories in game studies [50, 61], we consider how the gameplay and narrative dimensions of an entertainment experience can be influenced by robot characters to affect player mindsets and engagement.

Our study investigates paradigms for creating human-robot interactions in entertainment contexts that best lead to close relationships with robot characters and user engagement, which we use flow state and satisfaction of players' psychological needs as proxy measures for [31, 63]. In particular, we place participants in a live role-playing scenario involving detective work and solving puzzles alongside an advisor robot and a peer robot, then we adopt techniques from interactive digital storytelling to increase participants' opportunity to participate in either the gameplay (e.g. actively solving puzzles) or the narrative (e.g. making choices to explore the game's world) of the experience and compare it against a baseline experience with little interaction with the robot characters. We therefore increase either gameplay or narrative agency for the user against a control condition and examine how flow state, player experience of need satisfaction, and perceptions of the robot characters are improved with greater user agency.

CHAPTER 2

BACKGROUND

2.1 Engagement in Human-Robot Interaction

Engagement is an important aspect of human-robot interaction (HRI), where user engagement leads to more positive experiences in tasks facilitated by robots and greater social perceptions of robots. Sidner et al. define engagement as "the process by which interactors start, maintain and end their perceived connection to each other," leveraging both verbal and non-verbal behaviors [67]. In particular, O'Brien and Toms view engagement as a multi-step process, where a point of engagement is first created through "the aesthetic appeal of the interface [and] the users' motivations and interests," then engagement is maintained through "feeling connected to the technology," having feedback on their experience, and generating interest and affect [54]. These affective states can be induced by social robots by proactively engaging people in tasks, following human social cues in conversation, and having a greater anthropomorphic appearance [8, 33]. Prior literature has evaluated human engagement with robots using a range of measures. Anzalone et al. and Rich et al. rely on computer vision methods to track users' head orientation and gaze, in which users had face-to-face interactions with robots in tasks involving looking and pointing at objects. Users were viewed as more willing to engage if they directed their attention towards objects at moments when robots were also looking at them [2, 62]. Ramachandran et al. automatically estimated children's engagement on educational tasks with a robot tutor by using a partially observable Markov decision process model and determining if children were guessing on problems compared to making honest attempts [59], and they also used percentage of time spent talking during a "think-aloud" tutoring session as a measure of engagement [58]. Other methods involve context-based expert annotation of videos of verbal robot interactions [64] and using a vision-based affect detection model when playing chess with an iCat robot [11].

As opposed to research studies that primarily view engagement as a measure of time spent on-task, we are interested in investigating engagement when playing narrative games with robots. This can involve a positive change in both psychological state and observable physiological behavior [28]. That is, while prior methods in human-robot interaction are well-suited in tracking direct engagement and compliance with robot mediators, we are interested in seeing if players are also internally engaged with gameplay and narrative content. Doherty and Doherty suggest flow theory as a framework to measure engagement in human-computer interaction research, where users reach a "state of optimal and enjoyable experience" created through factors such as "a tractable challenge, immersion, control, freedom, clarity... and changes in one's sense of identity" [15]. Flow can then be applied to the models created by Douglas and Hargadon and by Hookham and Nesbitt, where immersion is experienced with flow, and flow influences observable user behaviors related to engagement [16, 28]. According to self-determination theory, flow is also linked with the psychological needs of autonomy, competence, and relatedness in players, which are important attributes for facilitating motivation and engagement in games [36, 63]. In this work, we apply flow theory from a games studies perspective to a novel interactive entertainment experience with robots that is previously unexplored in the literature, where we holistically measure engagement using validated scales related to flow state, immersion, and player need satisfaction during the experience [31, 63].

2.2 Robot Characters in Storytelling & Entertainment

Robot characters with personalities have been previously used to tell stories and entertain audiences. Simmons et al. emphasize the importance of *believable* robot characters, where robots should have consistent personality, nonverbal expressions, and a backstory similar to an actor in a play [68]. They deployed a robot receptionist in the wild that interacts with passersby through verbal utterances about their day and can react to input dialogue typed by users. However, they found that open-ended interaction also led to higher expectations of the robots from users. Other work employ robot characters in specific use cases with more limited user interaction, such using an AIBO robot with a dog-like appearance as a therapeutic tool for dementia patients [72], Manzai robots that perform scripts using facial expressions and synthesized voices [26], and using a NAO robot as a stand-up comedian that tells adaptive jokes based on audience laughter [80]. While these robots primarily act passively and generate entertainment for audiences through their performances, our work focuses on placing users directly in the stories that robots are telling, as immersive and interactive storytelling media (e.g. *Façade* [45]) create new forms of user engagement [81].

In particular, directly interacting with robots that tell stories creates positive experiences. Ligthart et al. showed how children who interact with a storytelling robot that provided co-creation opportunities in a branching narrative enjoyed the story more and paid more attention compared to when not having agency [40]. Kory and Breazeal also suggested that robot characterization when cooperatively playing a storytelling game with a child positively affects learning outcomes [35], where children are more likely to learn from an adaptive peer robot. Finally, Bravo et al. explored how students could control expressive robot actors to tell stories that taught scientific concepts [7]. While prior work has demonstrated the importance of co-creating stories with robots, engaging with social robots as peers, and positioning robots as actors in a dramatic piece, we integrate all three concepts in our work, framing it as a role-playing entertainment experience involving robots. In addition, we use games in the experience as a mechanism to engage users, building on work done by Lin et al. where a robot character in an immersive puzzle game was more effective in promoting social engagement and creating a fun experience compared to a human facilitator [41]. Following design recommendations from Rato et al. and Leite et al., we use asymmetrical social roles between the player and robots to "enable richer social interaction" [60], and we use two robot characters as actors to allow for narrative moments where participants can observe the story instead of taking an active role in it [38]. We therefore combine ludic and narrative techniques explored in prior HRI literature to create a novel live role-playing experience with robots whose core purpose is to provide entertainment value.

2.3 Human Interactions with Multiple Robots

Interactions between a human and more than one robot can also lead to new social perceptions compared to interaction between one robot and a user. Häring et al. found that when playing a card game with two robots, participants perceived a cultural in-group robot more positively when they were their teammate compared to when an out-group robot was their teammate [29]. Research by Fraune et al. extend this in-group vs. out-group effect, showing that videos of groups of mechanomorphic iCreate robots induced negative responses in participants, whereas groups of in-group anthropomorphic NAO robots create more positive responses and are viewed as less threatening, perhaps due to their more human-like social behavior [24]. On the other hand, groups of robots can also be more positive compared to a single robot. Another study by Fraune et al. found that while groups of the same robot may appear threatening, participants were more willing to interact with robots in a diverse group and viewed them more positively [23]. As a result, we create a narrative in-group relationship between the two robot characters and participants in our experience, with two anthropomorphic robots that are different models.

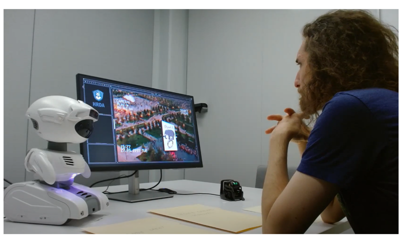
Diverse groups of robots can also lead to different modalities of engagement and affect user behavior. Salomons et al. showed how multiple Keepon robots with different aesthetics playing a word association game with a participant could influence participants' conformity with the robot group's decision [65]. Erel et al. demonstrated how multiple robots can create an out-group effect on human participants, where non-anthropomorphic robots created feelings of social exclusion in a ball-tossing game where the two robots tended to pass to each other and not the participant [19]. On the other hand, Vázquez et al. created a robot lamp sidekick that was co-located with a robot character shaped like a furniture item, which increased children's attention to verbal interactions in a game scenario compared to when the sidekick was not present [79]. Tan et al. also showed that a social robot could increase the likability of a functional robot by making requests to it in a social manner and that users preferred when the robots spoke their thoughts aloud compared to covertly exchanging information [73]. We extend the multi-robot, character-based interaction from Vázquez et al. in our work, where we create a full narrative arc that participants influence through their actions. We also aim to create an inclusive interaction and prevent an out-group effect by juxtaposing the two robot characters' personalities, not witholding any information from the participant in the context of the story, and directing conversation towards the participant.

Overall, our work explores a new form of interaction with multiple robot characters, creating a narrative and game experience that draws from immersive theater and actively involves participants by creating moments of role-play, gamification, and co-creation of the story. Following this, we also investigate how measures of engagement traditionally used for games can be applied to human-robot interaction.

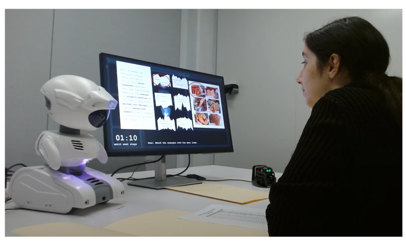
CHAPTER 3

METHODS

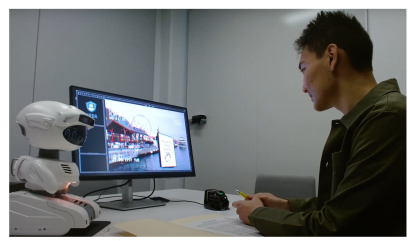
We conducted a between-subjects user study where participants role-played as a detective in an immersive experience to solve three crimes alongside two robot characters. Participants experienced either (1) **the control condition**: a baseline version of the experience with minimal opportunities to directly engage with the two characters, (2) **the narrative agency condition**: a version where they had greater opportunity to influence the story and develop a sense of character by talking with the robots, or (3) **the gameplay agency condition**: a version where they had an active role in solving puzzles with the robots. After the 25-minute experience, participants took a survey assessing their engagement with the experience and the relationships they felt with the robot characters. This study was approved by the University of Chicago's Institutional Review Board (IRB22-1970).



(a)



(b)



(c)

Figure 3.1: During the experience, participants interacted with an advisor robot and a peer robot character by (a) introducing their detective background and decoding a billboard code, (b) gathering clues around a restaurant and solving a cryptic puzzle, and (c) defusing a bomb and debating if they should use it to retaliate against the story's antagonists.

3.1 Hypotheses

Our study investigated four hypotheses that suggest the potential benefits of increased narrative and gameplay agency on user experience and engagement. Moser and Fang state that immersive narratives can "augment" interactive experiences, and branching decision points with meaningful effects in a video-based story created an “illusion of choice” and perception of causal agency [49]. This narrative agency and sense of control is subsequently linked to a greater sense of flow state, immersion, and user enjoyment and thus engagement [18, 32]. Agency also helps satisfy players’ intrinsic needs of autonomy, competence, and relatedness [71]. We therefore hypothesize that these effects will apply when users make narrative choices in an immersive experience facilitated by robot interaction:

- $\mathbf{H}_1$: Increasing **narrative agency** when interacting with robot characters will lead to increased engagement, which can be seen through increased (a) flow state, (b) player need satisfaction (autonomy, competence, relatedness), and (c) enjoyment and feelings of immersion.

Increasing user involvement in the gameplay of an experience may also lead to greater engagement, as seen through increased flow state and player need satisfaction. Tan and Hew found that meaningful gamification of a learning task increased feelings of motivation, which can be explained by increased flow state [55, 73]. In turn, self-determination theory says that user motivation helps fulfill their intrinsic needs for autonomy, relatedness, and competence [63]. Increasing risks for failure in conjunction with feedback in digital games, which we collectively refer to as gameplay agency, also helps satisfy player needs of competence and autonomy [1, 75]. We hypothesize that these results from prior work in digital games will be also seen in a live role-playing game with robots:

- $\mathbf{H}_2$: Increasing **gameplay agency** when playing with robot characters will lead to increased (a) flow state and (b) player need satisfaction.

Finally, increasing the amount of agency and thus potential for interacting with robots may affect users’ perception of them. For example, Paetzel et al. found that engaging in a collaborative game interaction upon first seeing a robot increased its perceived likability [52]. Role-playing multiplayer games also tend to increase social closeness among players, especially when in collaborative roles [14]. At the same time, participating in an interactive narrative could be awkward or uncomfortable if users are unsure of how to interact with characters or could not identify with their in-world character [47]. We therefore hypothesize that manipulating user agency when interacting with robots could have both positive and negative social effects:

- $\mathbf{H}_3$: **Increased agency** and opportunities to participate will cause players to feel more awkward, vulnerable, and uncomfortable in a role-playing experience with robots.
- $\mathbf{H}_4$: **Increased agency** in an experience will cause players to feel that robot characters are warmer and have a closer relationship to them.

3.2 Experience Design

The user study was designed as an immersive experience that followed a traditional narrative structure with believable characters, similar to experiences found in theme parks or other entertainment venues with animatronic robots. Drawing from design techniques for interactive theater [39], we wrote a script that primarily follows a canonical trajectory (i.e. pre-scripted performance), with moments where the audience interaction could lead to alternate dialogue paths but not substantially change the narrative arc of the experience due to the robots' inability to improvise new dialogue and scenarios. Consequently, the experience remained centered around its plot of two robot detectives onboarding the participant to the fictional Human-Robot Detective Agency (HRDA) through solving a series of crimes. A sense of perceived meaningful agency is instead developed through opportunities to self-identify with one's character in the experience, mechanics to personalize the gameplay experience to player progress and ability, and discrete narrative choices, as described in [37] and [10].

3.2.1 Character Design

We used two physically-embodied social robots with distinct personalities in our study, casting them as a more senior detective in an "advisor" role (named Agent Jay) and a junior recruit in a "peer" role (named Agent Lee). Using multiple robots allowed us to replicate an interactive theater show where the focus is primarily on actors, without exerting continuous pressure on participants to drive the story forward with interaction or potentially increasing audience boredom by having only one character deliver monologues. Prior work has also shown how two robot characters with different social dynamics can increase engagement [79], and we wished to replicate that in our experience.

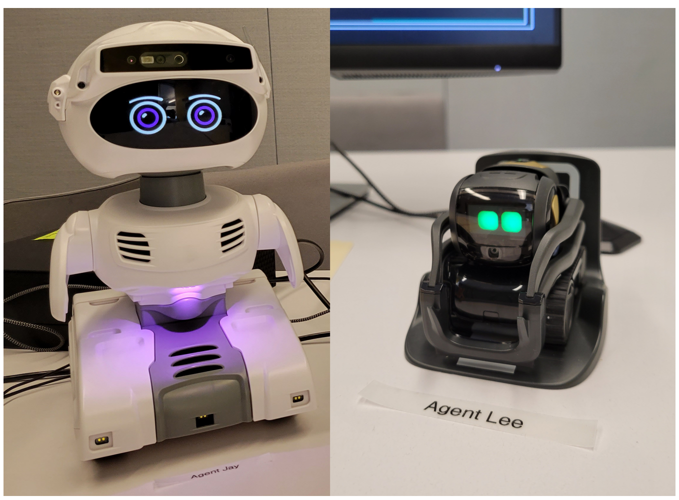


Figure 3.2: The advisor robot (left, Agent Jay) and the peer robot(right, Agent Lee) were played by a Misty II and Anki Vector robot, respectively.

The peer robot is played by a small Anki Vector robot with a high-pitched voice, which we chose to better characterize them as a new detective who is still prone to mistakes and reckless decisions, more emotive towards the events of the story, and is learning alongside the participant. Their head moves up and down to gaze at participants when speaking and listening, with eyes animating from side to side, which has been shown to increase perceptions of attentiveness and sociability [78]. In addition, we created a "peer" robot compared to a "tutor" robot to increase participant attention towards the robot and more effectively complete the puzzles in the experience, as suggested by [34]. Questions and tasks from the advisor robot when solving mysteries are directed towards both the peer robot and the participant as a team, which the peer robot may then defer to the participant to address depending on the experimental condition. The peer robot also used inclusive language (e.g. "us," "we") in their dialogue and was scripted to make a logical mistake when solving a puzzle at the beginning of the story to build trust [84]. Following design principles suggested by [42], they provide affirmation when the participant is helping the team succeed, while they are also independent and can suggest an alternate path if the participant is making a mistake.

In contrast to the peer robot, the advisor robot is played by a larger Misty II robot with a deeper voice and a blank stare on its face. We chose these aesthetics to convey a greater image of trust and authority, consistent with the advisor robot's characterization. Misty also has greater degrees of freedom compared to Vector, which allows it to move its head to gaze at the peer robot, the participant, or the researcher running the study. This better facilitated conversation turn-taking behavior when the voice synthesis programs of both robots otherwise created unnatural pauses in dialogue [51]. Having an "advisor" or "host" character enabled them to control the flow of the experience for the participant, countering the peer robot's behavior when they steer the missions off-track [61]. From a practical standpoint, the advisor robot also conveyed more important logistical information to participants (e.g. rules for a game involving defusing a bomb), as pilot participants found it occasionally difficult to understand Vector's voice.

Overall, the juxtaposition of the two agents, both in robot aesthetics and in personality, allowed for a dynamic story to be constructed while diegetically inserting the participant as an additional member of the team. The robots' appearance also conform with their social roles, which may make participants more easily accept them [74].

3.2.2 Story & Game Design

The story of the three-act experience centers around the participant joining the Human-Robot Detective Agency as a new detective, advised by the senior detective Agent Jay and partnering with Agent Lee as a peer to solve crimes from the HRDA's remote control center in the study location. They are facing troubles with cybercrime in Chicago, where a crime mob called the Ghosts is causing chaos. In an establishing scene, the researcher acts as a member of HR called Agent Q and introduces the participant to the advisor robot and the peer robot. The researcher then leaves, and the call to action involves the Ghosts leaving a message on a billboard pointing the team to a Chicago street intersection.

The intersection contains a map with three restaurants on it, and the rising action of the story follows the HRDA as they send their remote agent, Agent Kay, to a restaurant in one of Chicago's ethnic neighborhoods. They explore around to find that the Ghosts have left a note saying that they removed a key ingredient from the restaurant's menu; the peer robot and the participant work together to find a clue trail containing a cryptic puzzle to figure it out, then communicate the missing ingredient to the restaurant owners.

When the first narrative arc is resolved, the climax occurs in the third act with the Ghosts suddenly planting a electromagnetic pulse bomb at Navy Pier. The participant asks questions about the bomb to defuse it to the advisor robot, who relays responses back from Agent Kay. In the aftermath of defusing the bomb, the peer robot and the advisor robot debate on what they should do with it; the peer robot says that they should replant the bomb and retaliate at the Ghosts to prevent further crimes, while the advisor robot upholds values of justice and says it will cause further destruction. They turn to the participant to make the final decision, which concludes their workday.

A 19-page script that followed conventions of immersive theater was written for the experience, with a linear plot structure and opportunities for branching paths and dialogue based on audience decisions and the experimental condition. Escape room puzzle design principles were also incorporated into the narrative, where an easy warm-up puzzle to decode the billboard is at the beginning of the experience, followed by the more involved restaurant puzzle. At the end, when time is running out, the difficulty of defusing the bomb in a logic puzzle is lower compared to the cryptic puzzle. Design elements complemented the script, diegetic puzzles, and robot characterization to complete the immersive experience. This included dramatic lighting for the room, physical dossier props, background music as participants moved between different scenes, and videos of the locations stylized as security camera footage. By conceptualizing the experience through an artistic lens and integrating fundamental elements of theater and games, we designed it so it could stand alone as a source of entertainment, independent of the user study.

3.3 Conditions

After setting up the narrative and game framework, we investigated three conditions in our study, increasing the narrative and gameplay dimensions that Ruto and Prada mention in [61] that are fundamental to social interaction with agents in games and creating a richer player experience:

1. **Control Condition**: the participant experiences the baseline story structure as described in Section 3.2, with the two robot agents talking amongst themselves until the third act with the bomb defusal occurs and users are invited to verbally interact with the robots. This condition is most similar to a traditional theater show with a fourth wall, where the audience is expected to only watch the character interaction without directly participating.

2. **Increased Gameplay Agency**: the participant is asked about their progress in timed intervals when they work with the peer robot to solve the two puzzles (e.g. "what do you think we should do next?", "have you decoded the numbers?"), after which the

peer robot either confirms that the participant is on the right track or guides them towards the solution. We designed this form of skill-based interaction to create greater personalization in the experience and create an illusion that the player's puzzle-solving ability would influence the success of the mission [43].

3. **Increased Narrative Agency**: the participant is given opportunities to give personal expressions, identifying as themselves in the context of the story through small talk with the peer robot. They are also given co-authorship of the work by making choices in branching paths, which are common opportunities for agency in immersive theater [21].

These conditions manipulate how a series of story beats progress through the experience, where story beats are associated with either gameplay agency or narrative agency. Each beat has a baseline version that has no user participation, along with an increased agency version that allows for participation. Participants in the control condition only experience the baseline versions of each beat, while participants in the narrative agency condition experience the baseline version of the gameplay-related beats and agential version of the narrative-related beats. On the other hand, participants in the gameplay agency condition experience the baseline version of the narrative-related beats and agential version of the gameplay related beats. Manipulated story beats are described in detail in Section 3.5.

3.4 Technical Implementation

The system for controlling the experience was created so that the robot characters and media on the monitor could deliver scripted story beats at appropriate moments while adapting to participant interactions that could contain variable-length responses and/or branching dialogue paths based on the content of the response. To control the timing of when story beats were executed, we created (1) a speech recognition interface using a microphone in the study room and (2) a Wizard of Oz interface operated by the researcher.

In both interfaces, a computer was inside the study room and connected to the monitor and the same Wi-Fi network as the Misty and Vector robots. It also hosted a Python Flask server that received HTTP requests to execute story beats. Upon a receiving a request, the server sent messages for the robots to move and speak using Robotics Operating System (ROS) messages, with ROS nodes to directly interface with the Vector and Misty APIs also running. To control media, the server used an internal websocket connection to show or hide media elements in a custom Open Broadcaster Software (OBS) scene, which was displayed on the monitor. The programming interface for the server was designed to be flexible in creating new story beats and allowing metadata to be sent (e.g. the chosen restaurant name, correctness of participant progress) for multi-path story beats.

Automatically controlling story beats through speech was implemented using the Vosk offline speech recognition package for ROS [12], which continually publishes ROS messages containing detected speech from a node. The server then listened for specific keywords, corresponding to the last words said in each line delivered by the researcher at the beginning of the experience. This executed the corresponding story beat after the line and gave the illusion that the robots were actively responding to the researcher without being teleoperated. The package was very accurate in detecting keywords, and in cases where the server did not detect a keyword on the first try, the experimenter improvised an additional line that incorporated that keyword.

The Wizard of Oz interface was creating using PyQt for a graphical user interface. It was run on a laptop outside of the study room, which was connected on the same subnet as the study room computer to issue HTTP requests to the server. The researcher selected radio buttons corresponding to each story beat, and they clicked a button to both classify the participant's response for branching dialogue (if needed) and execute the story beat. We used a Wizard of Oz approach to enable fast prototyping of the verbal interactions with robots, with the researcher responsible for speech recognition and processing language into one of two or three discrete choices. We believe that future iterations of the experience could be practically deployed without relying on a Wizard of Oz controller, as state-of-the-art speech recognition models have low word error rates [46], and large language models are able to perform zero-shot text classification similar to the tasks required in the study (e.g. determining if a participant's solution to a puzzle step is correct) with high accuracy [57].

3.5 Study Protocol

The study began with the participant arriving outside of the study room, and the researcher obtained informed consent and told the participant that they would be role-playing as a detective in the Human-Robot Detective Agency. The researcher and participant then entered the study room, where the researcher introduced the peer robot and the advisor robot, with the robots autonomously delivering their pre-scripted lines based on the researcher's verbal cues. Participants were briefed on the conflict of the story and were told that they would be verbally responding to the robots when directly asked questions, though the robots would not always respond to them if participants talked aloud. This initial scene was designed to give the impression that the robots would automatically react to the events in the story's world.

The researcher then left the room, and the robots guided the participant through Scenario A. This involved introducing the participant to the peer robot, exploring an area of Chicago, and decoding a message on the screen. Table 3.1 highlights specific differences between conditions in Scenario A. Puzzle materials were given through a physical code sheet and were on a video monitor between the two robots. Scenario A was designed to introduce how participants would be able to interact with the robots in both the narrative and gameplay dimensions with low stakes and a low barrier to entry. This segment lasted around two minutes in the narrative portion and one minute in the puzzle-solving portion.

Beat	Agency	Baseline Experience	Increased Agency
1	Narrative	The peer robot introduces themselves to the participant.	The advisor robot prompts the participant to introduce themselves to the peer robot, and the peer robot asks about the participant's detective experience.
2	Narrative	The advisor robot asks the peer robot about popular locations for cybercrime, who responds.	The advisor robot asks the participant what they think popular locations for cybercrime are and why.
3	Narrative	The advisor robot asks the peer robot about the location to investigate, who responds with Millennium Park.	The advisor robot asks the participant about the location to investigate, who can choose from Millennium Park, Navy Pier, and the Magnificent Mile.
4	Gameplay	The peer robot decodes a billboard message, which involves (a) recognizing an animal alphabet cipher is encoded in pictures and (b) decoding the message, with each substep taking a fixed amount of time.	The peer robot guides the participant through decoding the billboard message, confirming their progress or providing the answer at the end of each timed substep.

Table 3.1: Beats for increased narrative or gameplay agency in Scenario A, where participants decode a hidden message in Chicago.

Participants then proceeded to Scenario B, in which they discuss restaurants in Chicago with the peer robot, gather evidence throughout a location, and solve a puzzle to help a restaurant recover a missing ingredient. Table 3.2 highlights specific differences between conditions in Scenario B. This scenario required participants to continue self-identifying as their character (i.e. recommend restaurants) and directly participate in the story (i.e. leave a voicemail about the Ghosts) in the narrative agency condition, while it included solving a multi-step puzzle in the gameplay agency condition. The scenario consisted of around five minutes of narrative material and six minutes of gameplay.

Finally, participants encountered Scenario C, in which they defused a bomb and debated what to do with it alongside the robot characters. This scenario was the same across the

Beat	Agency	Baseline Experience	Increased Agency
1	Narrative	The advisor robot asks the team about the neighborhood to investigate, and the peer robot says to go to Chinatown.	The peer robot defers the team's decision to the participant, who chooses either Greektown, Chinatown, or Pilsen to explores along with why they think that location could have a crime.
2	Narrative	The peer robot talks about their food recommendations in Chinatown.	The peer robot asks the participant about restaurant recommendations for their chosen neighborhood and/or Chicago.
3	Narrative	The team explores the restaurant, and the peer robot chooses the order of the locations that they investigate.	The peer robot asks the participant where they want to explore in the restaurant (from the cleaning closet, kitchen, and dining room), and they follow the participant's given order.
4	Gameplay	The peer robot finds the missing ingredient, which involves (a) matching receipts with ingredients onto menu items, (b) applying a math operation to each menu item number, (c) decoding the modified numbers to letters, and (d) reordering the receipts based on their jagged edges to get a word.	The peer robot guides the participant through solving the puzzle, confirming their progress or providing the answer at each substep.
5	Narrative	The advisor robot asks the team to record a voicemail for the restaurant owners about the missing ingredient, which the peer robot does.	The advisor robot asks the team to record a voicemail for the restaurant owners about the missing ingredient, which the peer robot then asks the participant to do.

Table 3.2: Beats for increased narrative or gameplay agency in Scenario B, where participants help a restaurant find a missing ingredient.

three condition, as we wanted players to experience the possibilities of both narrative and gameplay agency and see how earlier opportunities for agency would affect their behavior and willingness to engage with the robots. Specifically, players had to ask the advisor robot questions about the bomb (e.g. the number of wires it had) to defuse it within three minutes (gameplay agency) and settle a debate between the advisor robot and the peer robot about whether the bomb should be kept defused or should be planted at the antagonists' headquarters to get rid of them (narrative agency). The scenario included five minutes of explaining the rules and narrative material and up to three minutes of gameplay.

At the end of the 25-minute experience, the researcher re-entered the room, now out of character, and asked the participant to fill out a survey about their experience. This was followed by an interview, concluding the study. Participants were compensated with a $6 Amazon gift card for completing the study.

3.6 Measures

We collected subjective and objective data during the study to investigate our hypotheses.

3.6.1 Questionnaire

A Qualtrics survey with quantitative self-evaluation measures was given during the study. These included the following:

- **Short Flow State Scale**: we administer a short-form version of the Flow State Scale with nine items [31]. This measured statements about the experience (e.g. "the experience is extremely rewarding," "I had a strong sense of what I wanted to do") on 5-point Likert scales, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

- **Player Experience of Need Satisfaction**: we assess participants' sense of autonomy (e.g. "the game provides me with interesting options and choices"), competence (e.g. "I feel very capable and effective when playing"), relatedness (e.g. "I find the relationships I form in this game fulfilling"), and presence/immersion (e.g. "exploring the game world feels like taking an actual trip to a new place") during the experience using 7-point Likert scale questions ranging from 1 (*strongly disagree*) to 7 (*strongly agree*) [63].

- **Interactive IOS Scale**: we adopt the Interactive IOS Scale for Multiparty Interactions developed by Zhang et al. [85], which draws from Aron's Inclusion of the Other in the Self (IOS) scale and measures the interpersonal closeness between two or more entities by overlapping a series of circles [3]. We display circles that represent the peer robot, the advisor robot, and the participant, which participants freely arrange into the format that best represent their relationship. We then compute the distances between the center points of each circle to represent how close the participant feels to each robot.

- **Robotic Social Attributes Scale**: we use the warmth dimension of the RoSAS scale as a measure of how much participants would want to interact with the peer robot and the advisor robot [9]. The questionnaire was administered for each robot.

- **Additional Self-Evaluation**: we asked participants to rate if they "wanted to interact with Agent Lee and Agent Jay," "would participate in the experience in [their] free time," "participated in the gameplay," and "participated in the story" during the experience. We also asked participants the degree to which they felt awkward, vulnerable, and watched during the study. For each robot agent, we asked participants if they were "aware of [their] relationship" with them in the context of the story, "felt connected," and felt that the robot was "actively engaged" with them. All questions were asked using a Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*).

The survey also included open-ended questions on how participants felt during the experience, their impressions of the peer robot, and their impressions of the advisor robot.

3.6.2 Interview

A short interview took place after the questionnaire, in which participants were asked about the most memorable moments in the experience and how they felt about interacting with the robots. We also asked about their perceived degree of involvement in both the gameplay and narrative of the experience and if they would have liked more involvement, less involvement, or were satisfied with their involvement.

3.6.3 Objective Measures

We used direct observation of participant behavior as a measure of engagement. "Time on task" metrics [28] are coded from videos of participants in Scenario C, where we code the amount of time required to defuse the bomb for engagement in gameplay. We also measure the number of words that participants use to defend the argument of leaving the bomb defused or to retaliate to measure engagement in the narrative.

3.7 Participants

We recruited 47 participants from the University of Chicago community via direct recruitment, flyers, social media, and email. Data from one participant was discarded due to robot malfunction during the study. 21 participants identified as White, 23 as Asian, 4 as Black or African American, and 4 as another ethnicity. Participants who identified as two or more ethnicities were double-counted. We balanced the gender of participants between our three experimental conditions, beyond which we randomly assigned participants to a condition. 15 participants (7 male, 6 female, and 2 non-binary) were in the control condition, 15 participants (8 male, 6 female, and 1 non-binary) were in the gameplay agency condition, and 16 participants (8 male, 7 female, and 1 declined to identify) were in the narrative agency condition. Participation ranged in age from 18 to 34 (M = 22.1, SD = 3.23). There were no significant differences in age among the three conditions.

Using items from the Ten Item Personality Inventory [25], participants reported on their traits including extraversion (M = 3.63, SD = 1.48) and openness to new experiences (M = 5.16, SD = 1.10) on a scale from 1 (*definitely not associated*) to 7 (*definitely associated*).

Participants also rated if they had "significant experience" with role-playing experiences ($M = 4.15$, $SD = 2.13$), playing puzzles ($M = 4.46$, $SD = 1.75$), interacting with robots ($M = 3.00$, $SD = 1.78$), and programming ($M = 4.87$, $SD = 2.26$) on Likert scales ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). There was no significant differences among these potential covariates between the conditions.

CHAPTER 4

RESULTS

Quantitative data regarding flow, player need satisfaction, and perceived relationship with robot characters from the questionnaire were analyzed for differences across experimental conditions using one-way analysis of variance (ANOVA) tests, and we report F and p values. We then conducted Tukey's Honest Significant Differences test and reported the p value for comparing pairs among the three conditions. We report effect size as partial η^2 and also include qualitative data from participant interviews and open-ended responses in our analysis.

4.1 Manipulation Checks

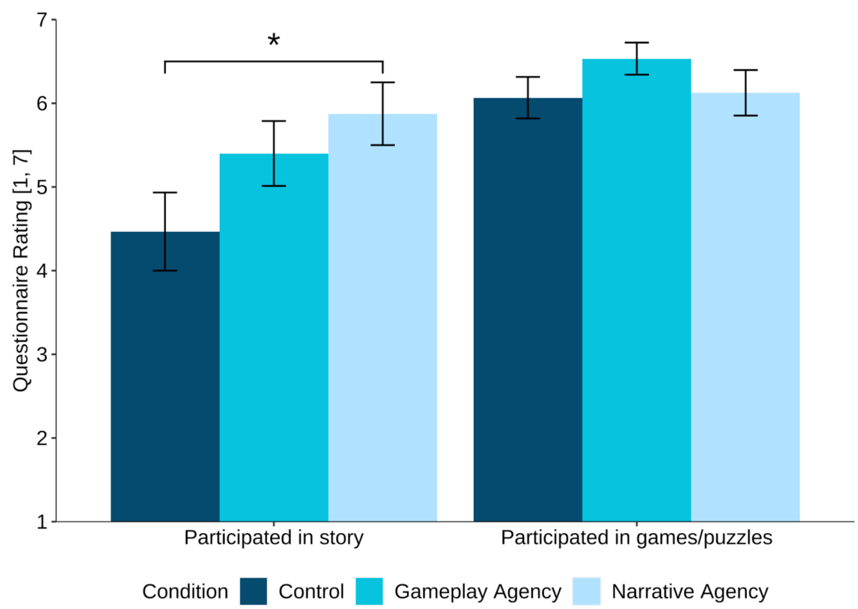


Figure 4.1: The manipulation check on conditions affecting perceptions of participation in the experience was successful in the narrative agency condition, but not in the gameplay agency condition. (*) denotes $p < 0.05$. Error bars depict one standard error from the mean.

To ensure the differences between conditions led to increased perceptions of agency in either the story or gameplay of the experience, we ran a manipulation check where participants rated how much they participated in the *experience's story* and the *experience's games/puzzles*. Participants felt like they had greater participation in the story with significant difference ($F = 3.05$, $p = 0.057$, partial $\eta^2 = 0.124$) in the narrative agency condition ($M = 5.88$, $SD = 1.50$, $p = 0.049$) compared to the control condition ($M = 4.47$, $SD = 1.81$). We also found that participants felt they had greater participation in the story while in the gameplay agency condition ($M = 5.40$, $SD = 1.50$) compared to the control condition, though without a significant difference. Our manipulation was therefore successful, and differences in measures seen in the narrative agency condition compared to the control condition can be attributed to the increased opportunities to participate in the story.

The manipulation check for gameplay agency was not statistically significant. Ratings of participants' participation in the experience's games were only marginally higher in the gameplay agency condition ($M = 6.53$, $SD = 0.74$, $F = 1.09$, $p = 0.374$, partial $\eta^2 = 0.048$) compared to the narrative agency ($M = 6.12$, $SD = 1.09$) or control conditions ($M = 6.07$, $SD = 0.96$), though the trends are in the right direction. We therefore cannot completely attribute feelings of participation in the experience's games as a factor for the differences in measures between the gameplay agency condition and control condition, though it may be a contributing factor.

4.2 Flow State

We examined each of the nine dimensions of flow state and found that participants in the gameplay agency condition experienced significantly more *unambiguous feedback* ($M = 4.20$, $SD = 0.94$, $p = 0.018$) compared to those in the control condition ($M = 3.07$, $SD = 1.16$, $F = 4.06$, $p = 0.024$, partial $\eta^2 = 0.159$). In addition, we found a main effect where increasing agency increased participants' *autotelic experience* depending on their experimental

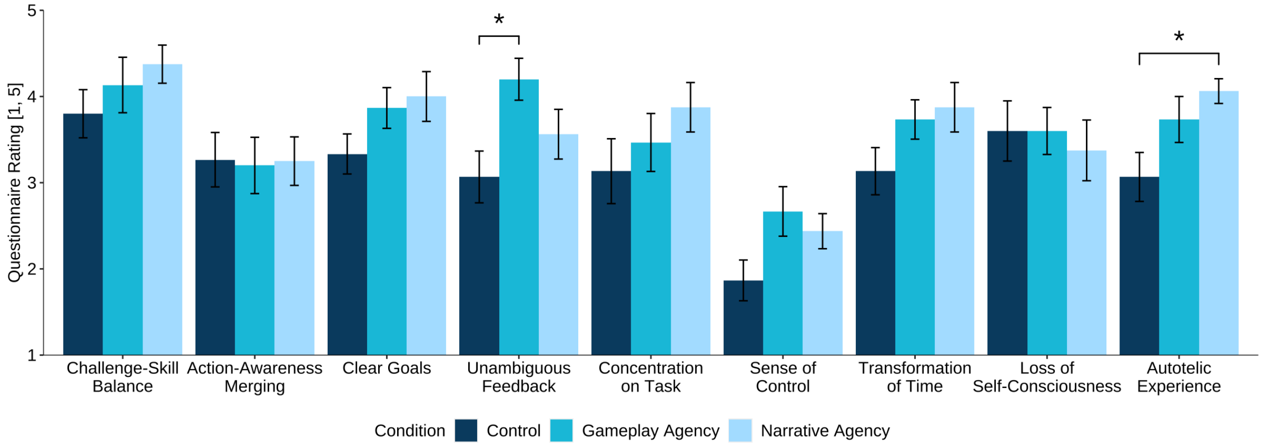


Figure 4.2: Participants found they had less ambiguous feedback during the experience with increased gameplay agency and had a greater autotelic experience (found it intrinsically rewarding) with increased narrative agency, which are two of the nine dimension of flow state (shown here). (*) denotes $p < 0.05$. Error bars depict one standard error from the mean.

condition ($F = 4.62$, $p = 0.015$, partial $\eta^2 = 0.177$). Participants in the narrative agency condition felt the experience was significantly more rewarding ($M = 4.06$, $SD = 0.57$, $p = 0.012$) compared to the control condition ($M = 3.07$, $SD = 1.10$). We found no significant differences in participants' perception of their autotelic experience between the gameplay agency condition ($M = 3.73$, $SD = 1.03$) and the other two experimental conditions.

Figure 4.2 shows additional dimensions of flow in the predicted direction, such as having *clear goals* ($M = 4.00$, $SD = 1.15$ for narrative agency; $M = 3.87$, $SD = 0.92$ for gameplay agency; $M = 3.33$, $SD = 0.90$ for control), a *sense of control* ($M = 1.87$, $SD = 0.92$ for narrative agency; $M = 2.67$, $SD = 1.11$ for gameplay agency; $M = 2.44$, $SD = 0.81$ for control), and a *transformation of time* ($M = 3.88$, $SD = 1.15$ for narrative agency; $M = 3.73$, $SD = 0.88$ for gameplay agency; $M = 3.13$, $SD = 1.06$ for control). However, none of these dimensions have statistically significant differences between conditions. We therefore only find moderate support for $H_{1(a)}$ and $H_{2(a)}$, that increasing participant agency in the narrative or gameplay of an experience respectively will increase their flow state.

4.3 Player Experience of Need Satisfaction

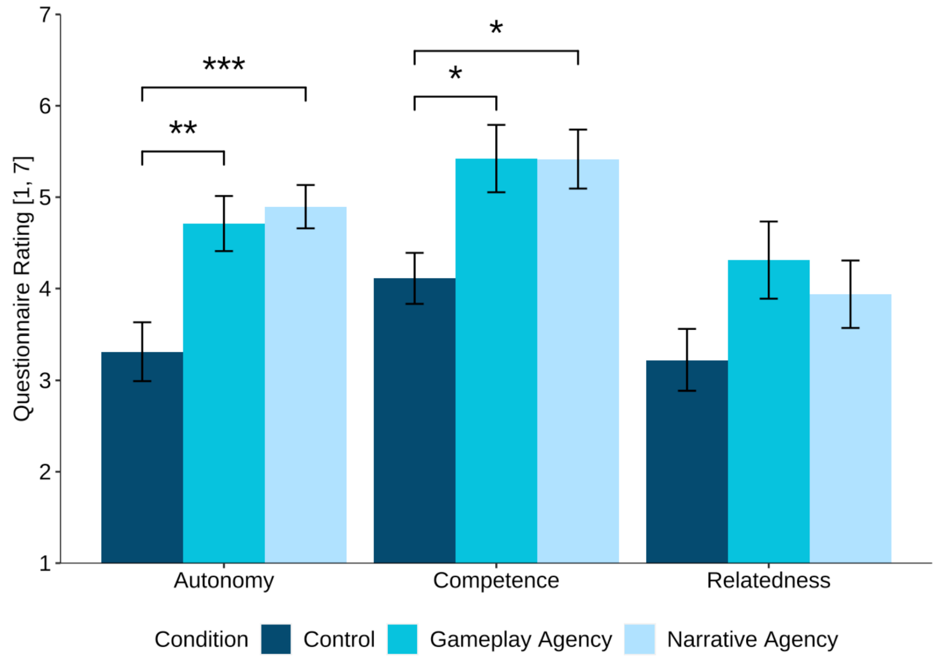


Figure 4.3: Participants felt more autonomous and competent when they have greater agency in either the narrative or gameplay of a role-playing experience. (*) denotes $p < 0.05$, (**) denotes $p < 0.01$, and (***) denotes $p < 0.001$. Error bars depict one standard error from the mean.

Using the Player Experience of Need Satisfaction scale, we recorded average aggregate values of participants' ratings of *autonomy*, *relatedness*, and *competence*. We found that participants felt like they had significantly greater autonomy when they had either greater gameplay agency ($M = 4.71$, $SD = 1.17$, $p = 0.004$) or narrative agency ($M = 4.90$, $SD = 0.95$, $p < 0.001$) compared to the control condition ($M = 3.31$, $SD = 1.24$, $F = 9.10$, $p < 0.001$, partial $\eta^2 = 0.297$). Participants also felt significantly more competent in the gameplay agency ($M = 5.42$, $SD = 1.43$, $p = 0.020$) and narrative agency conditions ($M = 5.42$, $SD = 1.29$, $p = 0.018$) compared to the control condition ($M = 4.11$, $SD = 1.08$, $F = 5.32$, $p = 0.009$, partial $\eta^2 = 0.198$). We saw a similar trend in feelings of relatedness, where participants found relationships they formed more important in the gameplay agency ($M = 4.31$, $SD = 1.63$) and narrative agency conditions ($M = 3.94$, $SD = 1.48$) compared to the control condition ($M = 3.22$, $SD = 1.30$), though without a significant difference ($p = 0.134$).

Participants hinted at their psychological needs being satisfied with increased agency, with a participant in the narrative agency condition saying that they appreciated having the two robots as "*helpers*" and felt related to them, such that while they "*felt the pressure of the timer, [they] never felt hopeless against it*" during the game aspects. Those in the gameplay condition enjoyed being able to "*work together with robot agents*" to solve the puzzles without "*feel[ing] stressed*" because "*the robot agents [would] be able to solve them*" through their knowledge. On the other hand, those in the control condition felt like "*[their] input didn't matter, so [they] tuned out*" due to a lack of autonomy. Overall, we find strong support for $H_{1(b)}$ and $H_{2(b)}$, where respectively increasing narrative agency or gameplay agency is associated with players better satisfying their intrinsic needs of competence, autonomy, and relatedness.

4.4 Immersion & Enjoyment

We found that participants rated their average aggregate immersion as higher in both the narrative agency ($M = 4.33$, $SD = 1.02$, $p = 0.025$) and gameplay agency conditions ($M = 4.67$, $SD = 1.06$, $p = 0.156$) compared to the control condition ($M = 3.62$, $SD = 1.08$, $F = 3.88$, $p = 0.028$, partial $\eta^2 = 0.153$), with a significant difference between the gameplay agency and control conditions. When we asked participants if they would want to participate in the experience during their free time and thus had a sense of enjoyment, participants in the narrative condition gave significantly higher ratings ($M = 5.56$, $SD = 1.37$, $p = 0.044$) than those in the control condition ($M = 4.20$, $SD = 1.66$, $F = 3.95$, $p = 0.027$, partial $\eta^2 = 0.155$). We also see a trend of higher ratings of enjoyment when players have more gameplay agency ($M = 5.53$, $SD = 1.55$, $p = 0.054$) compared to the baseline experience.

In addition, participants in the narrative agency condition described the experience as

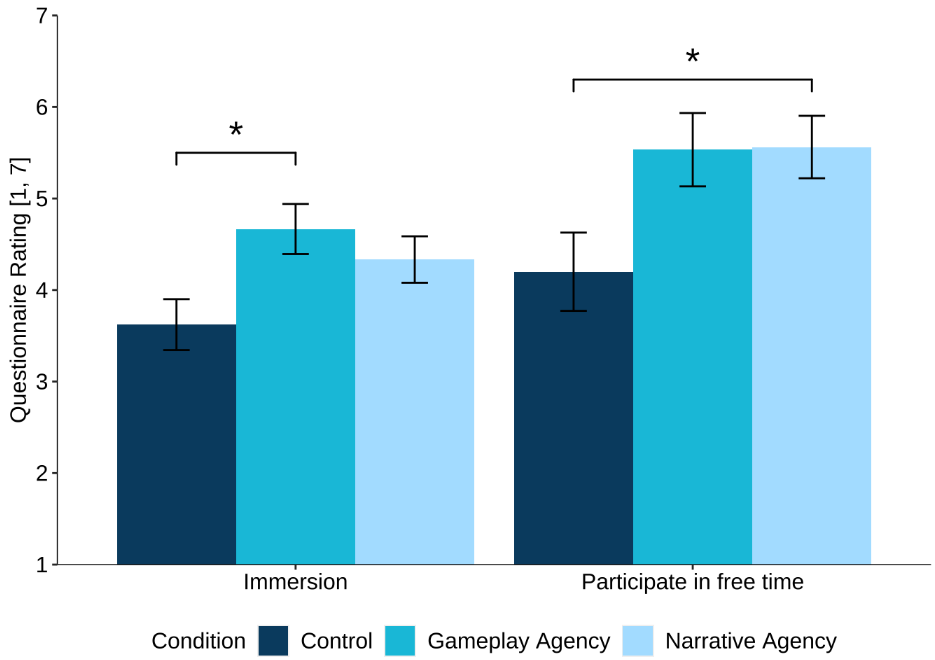


Figure 4.4: Participants felt more immersed in the gameplay agency condition compared to the control condition, and they would want to participate the narrative agency experience more in their free time compared to the baseline experience. (*) denotes $p < 0.05$. Error bars depict one standard error from the mean.

"*interesting and fun*," citing the "*novelty and humor*" of the experience as a contributing factor. A participant in the gameplay agency condition described it as "*talking to real people and helping them solve a real crime*," highlighting the immersive structure of the experience. On the other hand, those in the control condition "*felt like the communication was stilted*" between them and the robots, which "*made the team element feel less genuine.*" Some participants were also frustrated because the robots "*spent the majority of the time conversing with one another*," such that they felt less engaging. Combining both qualitative and quantitative results, we find moderate support for $H_{1(c)}$, that increasing narrative agency increases feelings of immersion and thus enjoyment.

4.5 Player Social Perceptions

Participants rated how awkward, watched, and vulnerable they felt during the experience. We found no significant differences across the three conditions (Figure 4.5), though the data do trend in the predicted direction for feeling watched, with higher ratings in the narrative agency condition ($M = 5.13$, $SD = 2.09$) compared to the gameplay agency ($M = 4.60$, $SD = 2.16$) or control conditions ($M = 4.07$, $SD = 1.83$).

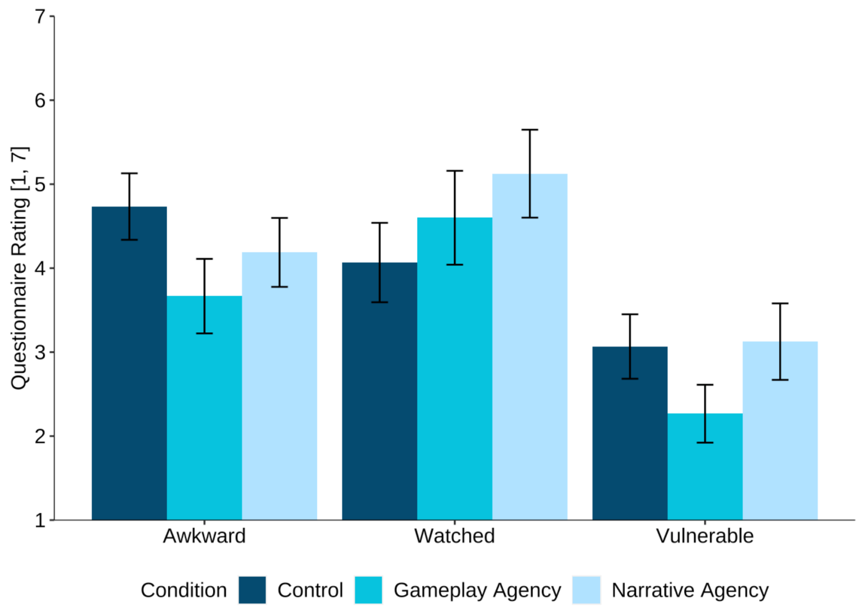


Figure 4.5: There were no significant differences in the degree to which participants felt awkward, watched, and vulnerable across conditions. Error bars depict one standard error from the mean.

Participant responses across conditions were also mixed, with some participants saying they "*felt uncomfortable talking to the robots*" because they were "*intruding on a private conversation*," while others "*felt good and comfortable with [their] interaction*" despite not having prior experience interacting with robots. One participant with no prior experience with robots found the experience "*confusing*" at first because they "*didn't know when [they were or weren't] supposed to talk with the robots*," yet they "*got the hang of it*" by the end. Overall, we find no support for H_3, that increasing agency and opportunity to role-play with robots will make people feel more uncomfortable.

4.6 Relationship with Robot Characters

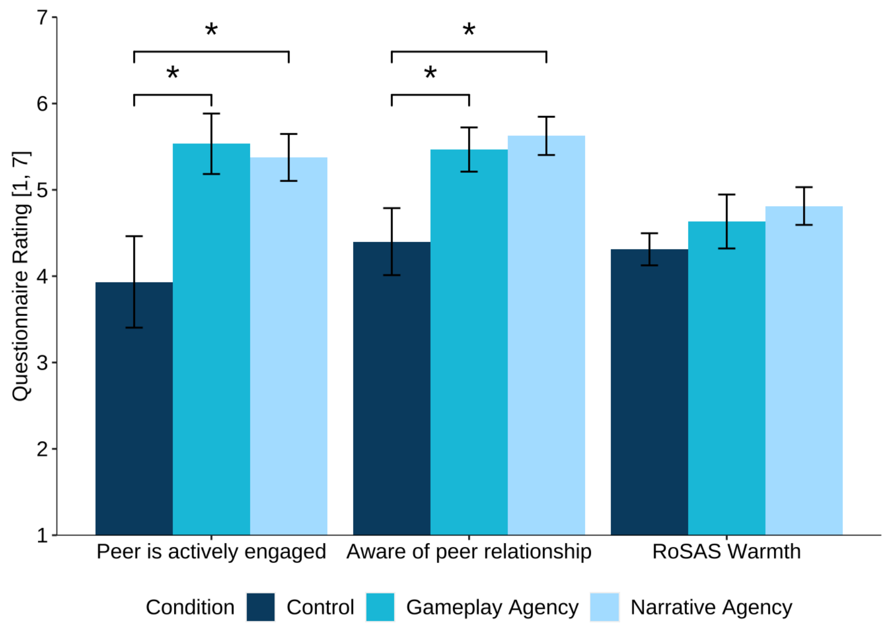


Figure 4.6: Participants felt the peer robot was more actively engaged with them and were more aware of their relationship with them when they experienced more agency. (*) denotes $p < 0.05$. Error bars depict one standard error from the mean.

Participants rated how much they felt each robot character was actively engaged with them during the experience and how aware they were of their relationship with the robot. They also evaluated the robots' warmth using the RoSAS subscale [9]. We found that participants viewed the peer robot as more engaged in both the narrative agency ($M = 5.38$, $SD = 1.09$, $p = 0.033$) and gameplay agency conditions ($M = 5.53$, $SD = 1.36$, $p = 0.018$) compared to the control condition ($M = 3.93$, $SD = 2.05$, $F = 4.93$, $p = 0.012$, partial $\eta^2 = 0.187$). We found similar trends in participants' awareness of their relationship with the peer robot, where those in the narrative agency condition ($M = 5.63$, $SD = 0.89$, $p = 0.014$) and the gameplay agency conditions ($M = 5.46$, $SD = 0.99$, $p = 0.039$) were significantly more aware of their relationship than those in the control condition ($M = 4.40$, $SD = 1.50$,

$F = 5.09$, $p = 0.010$, partial $\eta^2 = 0.192$). However, while ratings of warmth were in the predicted direction for the peer robot when experiencing greater narrative agency ($M = 4.81$, $SD = 0.87$) and gameplay agency ($M = 4.63$, $SD = 1.21$) compared to the control condition ($M = 4.31$, $SD = 0.72$), we did not find a significant difference between conditions.

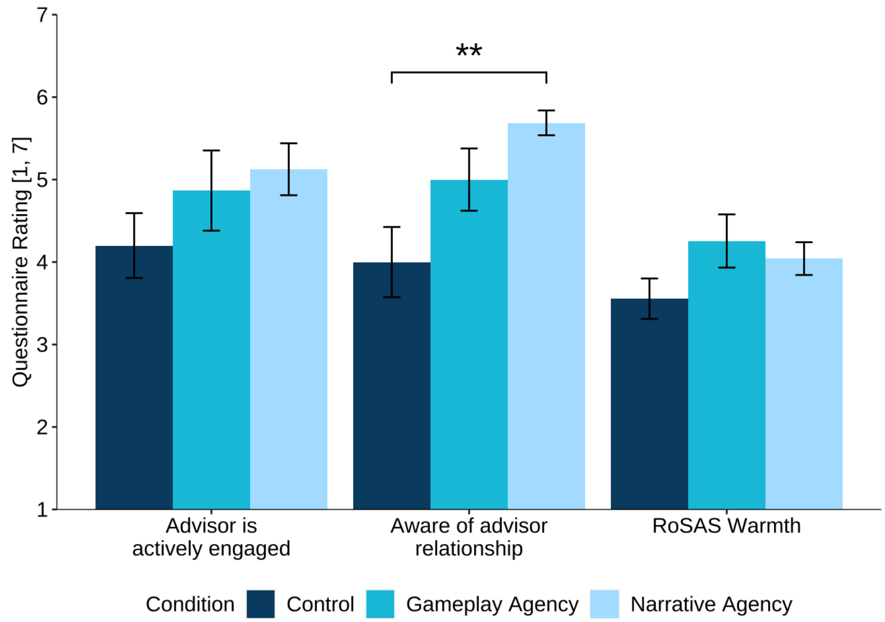


Figure 4.7: Participants were more aware of their relationship with the advisor robot in the context of the story when they had more narrative agency compared to the control condition. They also generally felt the advisor robot was more engaged and warmer with agency. (**) denotes $p < 0.01$. Error bars depict one standard error from the mean.

Perceptions of the advisor robot were similar, where we found a significant difference in participants' awareness of their relationship with the robot between the narrative agency condition ($M = 5.69$, $SD = 0.60$, $p = 0.002$) and the control condition ($M = 4.00$, $SD = 1.65$, $F = 6.50$, $p = 0.003$, partial $\eta^2 = 0.232$), with trends of higher ratings in the gameplay agency condition ($M = 5.00$, $SD = 1.46$, $p = 0.103$). While we do not find a significant difference in ratings of warmth and active engagement, we do find a general trend that increasing agency leads to higher perceptions of warmth ($M = 4.04$, $SD = 0.79$ for narrative agency; $M = 4.26$, $SD = 1.25$ for gameplay agency; $M = 3.56$, $SD = 0.95$ for control) and engagement ($M = 5.12$, $SD = 1.26$ for narrative agency; $M = 4.87$, $SD = 1.88$ for gameplay agency; $M = 4.20$, $SD = 1.52$ for control) from the advisor robot.

Finally, we measured the distance in pixels between the center of circles representing the participant, the advisor robot, and the peer robot in the Interactive IOS scale as a representation of participants' perceived closeness of the three entities. We found a general trend that participants view themselves as closer to both the advisor robot and the peer robot in the narrative agency condition ($M = 91.5$, $SD = 26.9$ for the peer robot; $M = 100.7$, $SD = 25.7$ for the advisor robot) compared to the gameplay agency condition ($M = 116.6$, $SD = 64.6$ for the peer robot; $M = 116.4$, $SD = 57.6$ for the advisor robot) and the control condition ($M = 108.0$, $SD = 38.9$ for the peer robot; $M = 118.5$, $SD = 25.4$ for the advisor robot), though this difference is not significant.

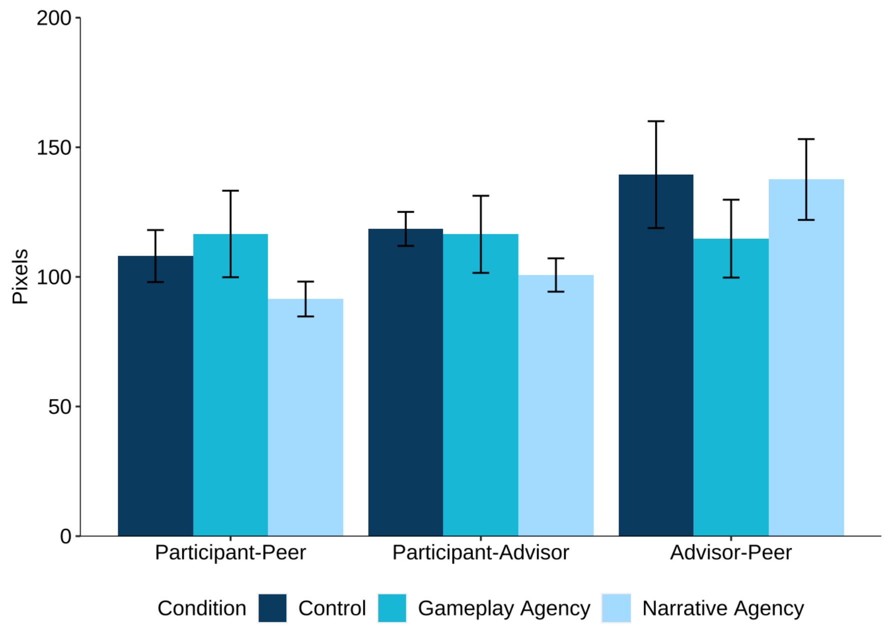


Figure 4.8: Using the Interactive IOS Scale, participants tended to see themselves as closer to both the advisor robot and the peer robot when having greater narrative agency compared to the other two conditions, though this difference is not significant. Error bars depict one standard error from the mean.

Accounting for the array of measures presented in this section, we find some support for H_4, that increasing agency will lead to participants feeling like they have a closer relationship to robot characters.

CHAPTER 5

DISCUSSION

Our study results show that when placing participants in an interactive entertainment experience with multiple robot characters, simple interactions that provide users with a sense of agency in either the gameplay or the narrative subsequently affect their flow state, need satisfaction, feelings of immersion, and perceived relationships with the robots.

Increasing gameplay agency by asking participants to make progress checks for correctness on narrative puzzles presented to both themselves and robot teammates increased satisfaction of their psychological needs of autonomy and competence. Players also felt like they had more unambiguous feedback and greater immersion when presented with gameplay agency, improving their flow state. This suggests that regularly inviting player feedback on objective game tasks and giving positive feedback through robots in live entertainment scenarios such as escape rooms or role-playing games with quests would be beneficial. The increased flow and satisfaction of player needs associated with agency in gameplay can cause greater engagement, player motivation, and enjoyment of experiences [16, 63]. Because gameplay agency is also associated with feelings that a peer robot is more actively engaged and causes participants to be more aware of their relationship with that robot, introducing passive gamification mechanics (e.g. finding or manipulating objects of interest) and centering interactions around them could also be a low-barrier method to build trust in short-term human-robot interactions, such as walkaround robot characters in theme parks.

Increasing narrative agency in the experience similarly increased player need satisfaction in autonomy and competence, flow state by creating an intrinsically rewarding experience, and desires to participate in similar experience in the future. These results suggest that interaction techniques from digital games can be effectively applied to live narrative experiences involving robot characters. For example, we created an illusion of agency by allowing users to make a branching decision (e.g. exploring the restaurant) that ultimately led to the same narrative ending [22]. These salient decision points enable a "pleasure of interactivity" and can be applied to general role-playing dialogue with robot characters (e.g. asking users about their preferences) that lead to the same dialogue line from the robot following a participant's response [50]. At the same time, the increased perception of agency caused by participants' dialogue may subsequently motivate engagement with robots and in-game tasks due to feeling reciprocal engagement from the robot characters [13, 49]. In addition, narrative agency was created by moments of self-identification with one's character in our narrative's world, such as when players are asked why they decided to join the detective agency. Consistent with self-identification influencing social relations in digital games [6], we believe these moments of agency caused higher perceived engagement of the peer robot and awareness of the relationship with both the advisor and peer robot in the narrative agency condition. These positive social effects can be extended to other entertainment robot characters by giving users an active "in-world" persona while role-playing as themselves by answering questions that apply to both the story's world and the user's everyday life. Consequently, narrative-based interactions could be incorporated in domains of human-robot interaction where engagement needs to be sustained. This may include creating a backstory for a robot second-language tutor that children can engage in, on top of treating it as a peer [4]. Similarly, healthcare robots could not only have a personality that aligns with their function [20], but they could also engage users in small decision points during their treatment that ultimately lead to the same outcome.

In addition, our study further supports the use of self-determination theory and flow theory to improve human-robot interactions, particularly in entertainment contexts. For example, our finding that increasing in-game agency helps satisfy players' needs for autonomy and competence is consistent with prior studies in digital interaction [30, 5] and educational robots [76], such that designs that impact perceptions of autonomy or competence (e.g. personalization options, dynamic task difficulty [56]) may similarly affect users' motivation and thus engagement with a social robot. Following [44], evaluating users' sense of flow state from a robot interaction may also be helpful in determining their sense of engagement beyond observable behavior.

Finally, our work demonstrates a novel use case of robots being used as interactive actors in an open-ended narrative context similar to immersive theater. While prior work has shown how robots can be effective as a passive-social medium similar to watching actors on television [26], or robots can be used as an interactive game master in a closed-form escape room interaction [41], people may tend to be more uncertain about open-ended or unexpected social interactions with robots [70]. However, our results indicate that participants do not necessarily have adverse feelings and instead respond positively in terms of enjoyment and having an autotelic experience when human-like robots present opportunities to interact with them. In fact, when presented in the context of a role-playing experience, participants may even have the *expectation* of interaction, and robots gazing at each other in the control condition may have led to lower perceptions of engagement and feelings of exclusion similar to those in [19]. This ease of interaction is also consistent with the Computer as Social Actors paradigm [53], where people can adapt to interacting with new technology by following human social cues. Participants in our study had a range of experience with robot interaction, yet they quickly adapted to interacting with the robots in our experience. Some participants "*thought of the robots as free agents*" due to their personalities, despite knowing that they were pre-programmed, and an open-ended survey question asking participants about their "impressions" of the robots tended to elicit responses regarding their personality and character motivations rather than physical features. Overall, participants believed that the experience would be more fun with the robot teammates and that the robots portrayed human interaction well. Robots therefore could have an integral part in shaping the future of live interactive entertainment, where autonomous robot characters could scale well in providing dynamic and personalized role-playing experiences to small groups compared to human actors.

Design Recommendations & Future Work

Based on participant reactions to our experience, we present design recommendations for creating engaging live games and interactive narrative experiences with robot characters, with potential areas for future research:

Use asymmetrical robots with personality to create humor and enjoyment. Participants commented on the "*personality and character*" of the robots, which had the distinct personalities and roles of a serious advisor character and a reckless and young peer robot. This created an inherent source of drama in the script, with moments where participants laughed at the dialogue. Diversity in robot personalities, in addition to differing physical appearances [24], may play a role in making interactions with multiple robots more comfortable, though further work can be done to investigate the most effective role pairings.

Ask players to make moral decisions to generate engagement. When asked about the most memorable part of the experience, participants frequently mentioned the moment where the advisor robot and peer robot debated what to do with the defused bomb in a moral dilemma. Creating interactive moments where participants need to make a decision that aligns with their own personality could make experiences with robots more interesting, engaging, and less artificial, as players begin to self-identify with their in-story character along with a robot character's morals [27]. This could be accomplished with minimal overhead through the illusion of choice, where players could be asked to make a discrete choice along with an open-ended justification that ultimately makes little impact on the narrative trajectory [22]. Because our study involved multiple forms of narrative agency, future work can investigate the *types* of narrative agency that are most effective in increasing flow and satisfying player needs.

Place robots in complementary roles to human players increase interaction.

From a gameplay agency perspective, participants thought the bomb defusal puzzle was the most engaging compared to solving cryptic puzzles with hints given by robots, as defusing the bomb required participants to actively ask questions to the advisor robot. This suggests that *complementarity* is an effective paradigm in interactive game design with robots, where two players both have information they need from each other to progress [66], rather than allowing one player take over the process of play and removing agency from the other player.

Provide proactive and personalized feedback from robots to generate flow. While prior work suggested the importance of proactive feedback from peer robots in puzzle games [41], we found that it is important to consider *how* that proactivity is implemented. Our approach of using fixed-time checkpoints on puzzle progress "*made it feel a bit awkward if [a participant] finished a section early*," as many participants did on easier puzzle steps, and other participants solved puzzles in a different order from our intended solution. Instead, we recommend incorporating the mechanics from [41] in addition to our approach, where participants are able to dynamically ask for hints and tell robots when they have solved a puzzle segment to move onto the next one.

Set clear expectations of robot interactions to decrease confusion. Participants were occasionally "*confused as to how important [their] involvement was*" and felt that the robots' "*inability to respond to most of [their] comments/inquiries meant that it was mostly a one-way form of engagement.*" Setting clearer expectations regarding what robots characters are capable of (e.g. an indicator for when speech recognition is on), particularly in a narrative context where the two robot characters speak freely with each other in scripted scenes, could be one way to offset participant expectations and build a more accurate mental model of how humans can interact with robots [37]. Future robot character implementations could also look into using large language models to generate dialogue where "*robots can respond to things [that participants say] that are unrelated to the plot*," which has been previously explored in video game writing and playwriting [77, 48].

Use social cues for smoother conversation flow between robots and humans. We found that pauses of more than one second between consecutive questions from robot characters (e.g. the peer robot saying "*what do you think? Which location is most ripe for serious cybercrime?*") due to their text-to-speech engines created awkward moments where users would begin answering their first question then be subsequently interrupted, disrupting flow. While we included head movements to indicate the flow of conversation, and robots moved their head down when they finished speaking, one participant said that "*it was hard to tell when there were natural lapses, and lot of times [the robots] and I were speaking over each other.*" Future dialogue-based interactions between two robot characters and a human should therefore be mindful of having long pauses or use incomplete or filled pauses to prevent users from preemptively thinking that it is their turn to speak [69].

Use social robots as dramatic characters to create entertainment. In all three conditions, participants tended to have a baseline level of engagement, which they attributed to how "*the script was pretty good at making [the experience] feel interactive without actually being interactive.*" We employed pauses for the user to think about decisions without necessarily having the agency to make them, and participants likened the baseline experience to an educational children's television show. Consequently, experience designers incorporating robots could create an *artificial* sense of participation through prompting while using existing paradigms of robots as passive actors in a staged dramatic context. Nonetheless, the results from our study highlight how introducing any form of agency or interactivity on top of an existing narrative experience may increase positive social perceptions of robot characters while better engaging users.

CHAPTER 6

CONCLUSION

We introduce the idea of using two robot characters with contrasting personalities to engage users in an immersive entertainment experience where participants role-played as detectives and solved puzzles alongside the robots. By increasing the amount of agency that users had to interact with the robots and make an impact on the experience's narrative or gameplay, we found that increasing agency in either the gameplay or narrative dimension helped increase flow state, players' psychological needs of autonomy and competence, enjoyment of the experience, and perceptions of the robots' relationship and engagement. We therefore demonstrate how concepts in flow theory and self-determination theory can be applied to human-robot interaction, suggesting that gamification and narrative role-playing techniques from other interactive narratives can be introduced to human-robot interactions to increase user motivation and thus engagement. While we created an enjoyable experience in all three conditions of our study due to the design of its narrative and gameplay, future work in HRI can involve investigating specific design paradigms regarding robot aesthetics, role-playing scenarios, and puzzle mechanics to determine optimal techniques for designing interactions with entertainment robots.

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