Press A or Wave: User Expectations for NPC Interactions and Nonverbal Behaviour in Virtual Reality

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Non-playable characters (NPCs) are important in games, as they can provide guidance to the player, create social engagement, and advance the game's narrative. Although much research exists regarding NPC interactions for traditional gaming environments, e.g. desktop or console, fewer works have considered this from a virtual reality (VR) perspective. Our work first uncovers the salient and unique dimensions of VR NPC interactions through observations of 47 existing games. We find that VR NPC interactions have an extended set of interaction mechanisms due to two key factors — interaction triggers and player constraints within the game, driven by the unique qualities of physical motion and immersion afforded by the medium. We augment these findings through a user study performed on 18 participants in a VR environment. Participant interactions with a responsive NPC allow us to delve deeper into understanding player perception and expectations of NPC behaviour and interactions. Our findings outline player expectations for NPC realism, player agency during NPC interaction, and NPC expected behaviour and feedback. We tie our findings into discussions on player agency within VR, highlighting design suggestions to develop NPCs to better fit within social behaviour expectations.

CCS Concepts: • **Human-centered computing → Empirical studies in HCI**.

Additional Key Words and Phrases: video games, NPC interactions, virtual reality

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1 Introduction

NPC interaction is a key component in making games feel fun and meaningful. Within games, players interact with NPCs in many different ways, including talking to them, purchasing items, and receiving quests [7]; NPCs can serve many functions within the game that facilitate the player's experience with the game world [105]. However, beyond their practical purpose, NPCs are important affective tools — through social interaction, players develop relationships with the NPCs [74] that impact their emotions, appreciation, and sense of meaningfulness in the overall experience [31, 39, 76]. Research into NPC design and behaviour has seen an abundance of academic attention, especially on modelling the dialogue and actions of intelligent NPCs — lifelike NPCs that replicate real-life behaviour and add a layer of immersion to the virtual experience [47, 60, 61, 81, 89, 97, 108, 115].

Whereas much of the prior research into NPCs has looked at games from traditional displays — i.e. a monitor, less has been done to investigate NPCs from an embodied VR perspective. The affordances of VR, such as presence [95, 99] and embodiment [44, 95], offer players an experience

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in which they feel as though they are "there", controlling a character in a virtual world. Thus, such a medium enhances feelings of interaction and immersion that already exist for games [87, 99]. Studies have shown that the interactivity of physical motion and the immersion in the virtual world have a direct impact on players' in-game behaviour and outcomes [40, 64]. When relating to realistic NPCs, we find and address an open research area on understanding how such idiosyncratic characteristics of VR environments affect the interactions and behaviours that players both currently have and ideally expect to have with interactive NPCs in VR, especially in the context of nonverbal communication cues.

Thus, our study looks to investigate the following research questions (RQs):

- **RQ1**: How are player-NPC interactions currently implemented in VR games on the market, and how do these interactions differ from non-VR games?
- **RQ2**: What are the salient dimensions for NPC interaction design in VR, focussing on the unique affordances of the medium?
- **RQ3**: What are player expectations and suggestions for NPCs and player-NPC interactions in VR?
- **RQ4**: How do player expectations contrast against present implementations of player-NPC interactions, and what does this imply for future design?

Thus, the main contribution of this work is a comprehensive investigation of NPCs in VR. We first perform an observational study on existing implementations of VR, addressing **RQ1**. The main goal of this first study is to highlight the dimensions that exist that are unique to the medium, and understand how currently implemented games may or may not take advantage of VR-specific interactions to augment traditional NPC behaviours. By investigating the games and identifying these specific dimensions for interactivity, we begin to address **RQ2**. The latter two RQs focus on players and their expectations, thus, we conduct a qualitative interview study that extends on our initial observations. This latter study highlights user expectations of NPC behaviour in VR and the benefits and disadvantages of various design considerations (**RQ3**). We contrast our findings from the interview study against our observational study, finding the gaps in which player expectations of NPC interactions are not presently satisfied by their implementations in on-the-market games (**RQ4**). With this, we develop suggestions for game design; thereby suggesting avenues for future, richer NPC interactions. We outline ways to create realistic NPCs that act in ways humans would, tying in with the literature on communication in social virtual environments. Lastly, we highlight the present technical challenges that exist and propose some future research directions that aim towards affording NPC behaviours in VR that match player expectations.

2 Related Works

To contextualize our work on NPCs in VR, we explore prior research within two key components: NPCs and their roles and behaviours, and VR and its applications and affordances. As much of the interaction with NPCs follows from social behaviour, we additionally contextualize our work by investigating social behaviour in VR.

2.1 Roles of NPCs

NPCs are virtual agents in games that inhabit the game world, which the player character can interact with to enrich their experience in the game. From a functional perspective, NPCs serve a variety of roles and purposes that help facilitate interaction between the player and the game [105]. Bartle first loosely taxonomized NPCs by their function and role, based on game mechanics such as "providing services", "providing loot", "assisting the player", etc. [7]; Warpefelt and Verhagen further refined this taxonomy [105]. The initial taxonomy suggests that players often engage with

NPCs via virtual social interaction; looking specifically at the social function of NPCs, Rato and Prada developed a taxonomy of social roles for NPCs in games [74]. However, looking beyond their function within the game, NPCs can also induce narrative effects outside of it: scripted NPCs can induce emotional connections that affect appreciation and perceived meaningfulness towards the players' experience [31, 39, 76]. As such, autonomous, virtual characters that act in realistic ways are key to unlocking emotionally immersive experiences [76] and consequential thinking [37]. Bartle highlighted that intelligent NPCs with personality quirks give reasons for players to care about the game and inspire a sense of awe [7]. The study of intelligent, realistic NPCs has thus been an imperative stride in ludological research and game development [33, 56, 81, 94] — succinctly put, Fink et al. stated that the behaviour of non-player characters is often crucial for the success of a game [29].

There has been a wealth of research into intelligent NPC design, especially on modelling actions [47, 81, 94, 108, 115] and dialogue [3, 21, 65, 102] in a realistic manner. Computational models such as decision trees or state machines are common in existing games [56, 81, 108]; furthermore, some past research has attempted to extend on such base systems e.g. through pheromone maps [108]. However, the rapid rise of ML and AI models has caused a major shift in computational direction: for example, van Stegeren and Myśliwiec fine-tuned the GPT-2 language model on existing RPG quests to develop the NPC dialogue for new quests [102]. In addition to the observable behavioural aspects of NPC, much research has also been done into modelling NPCs with abstract concepts like emotion, personality, social relationships, and memory [60, 61, 89, 97], all aiming to develop realistic NPCs that share real-world, human-like characteristics. For example, NPCs could respond to user data, which can be collected through questionnaires, biosensors, etc; such an adaptive game could model the player state and adjust game elements accordingly [73].

Much of the research regarding the modelling of NPCs looks at games that are developed for a 2D space and played on a monitor. However, how might things be different in a 3D embodied space? In such a world, what other characteristics of NPCs should be considered that have not been previously? With the development of VR technology offering such an opportunity, these questions leave a gap in NPC development which we investigate in this work — understanding how user perception and expectations for NPC interaction are affected by VR-idiosyncratic factors.

2.2 Affordances of VR, VR Games, and VR NPCs

VR offers the unprecedented opportunity to transport players into a virtual world that leaves the user unconscious of the interface [19]. The use of VR to generate this sense of immersion — the player's feelings of being "in the world" [12] — have been well studied by prior literature [24, 85]. Aspects of presence, feeling regarding being present in the VR environment [85, 87, 95, 99], as well as embodiment, owning and controlling a virtual body within the world [44, 95], are affordances that the medium of VR helps develop. Overall, immersion can increase enjoyment and takeaways from the VR experience when compared to non-VR experiences [99]; VR experiences have been shown to have the ability to develop and intensify emotional responses within a virtual world [32, 70].

Concepts such as immersion and emotional response bridge the gap between VR and its application in games [26, 41, 107]. Being immersed in a mediated world (such as a game) offers positive feelings of pleasure and "flow" — when individuals are so involved and focussed within an activity that they lose self-consciousness and awareness of the external world [22, 101]. Game developers and researchers have conceptualized games that engage the mind through sensory stimulation to transport the player into the VR world [20, 40, 116], where they can move around and interact with their physical body [112]. Applied to serious game contexts, VR has been used in the fields of healthcare and rehabilitation [50, 51, 86], education and training [63, 100, 103], etc. The players

engage in these learning environments as active participants which allows for explorative learning [16]; furthermore, the ability to navigate freely increases cognitive interest and presence within the game [28]. In this work, we contextualize our findings using these studied affordances of VR. We explore how NPC behaviour, a core part of many games, is influenced by aspects of immersion and presence, and how the players' feelings that they are part of the game influence how they expect the virtual agents within it to behave.

NPCs are heavily intertwined with games and other interactive virtual experiences. As VR has also experienced much academic interest in developing and researching such virtual experiences, there have been several prior works that investigate the impact of NPCs on the player in VR mediums. For example, Yu et al. found that the existence of an NPC audience with responsive feedback (e.g. as a non-interactable crowd cheering on the player character) allowed for higher performance and a better overall experience [114]; Guo et al. found that familiarity of the audience members in appearance and voice offered increased enjoyment and spurred positive emotions [34]. There has also been research involving the use of NPCs in VR game-like environments that focus more intimately on player interaction [17, 25, 58, 91, 94]. For example, Subandi et al. used NPCs in a VR shopping experience, designing the NPCs around themes such as rationality, intention, and reciprocity [91], Cheng et al. used NPCs as a medium for Japanese teaching, using dialogue and bowing motions as methods to incorporate conversational learning and culture into their VR application [17]. In these works, justification for their specific interaction designs (especially in the context of how these interactions differ uniquely from non-VR NPCs) has greatly varied from paper to paper. We highlight how, in developing NPCs in VR, developers can and should consider certain VR-specific design decisions (e.g. triggers, response to player motion, spatial constraints) that underlie the interactions in a more immersive environment to generate an increased sense of immersion and engagement within the VR world.

2.3 Social Interaction and Communication in VR

Social interactions with virtual agents and avatars are a major area of study within HCI research, especially within VR. Pan and Hamilton noted that VR can provide a suitable medium to study human social interaction due to its control of interactive situations and complex social situations [66]. As such, virtual agents have been studied for several purposes, such as helping users overcome fear and anxiety [72, 88] or studying human behaviour in moral scenarios [27]. The existence of such agents has been shown to help with functional outcomes such as instruction-following, but for some, it also simply makes the virtual experience more pleasant [62]. From a perspective of interactions between humans and non-human agents, Ke et al. identified two key aspects of design: persona, or the personification of the virtual agent that drives its role, and interactivity, the degree to which the agent acts realistically [43]. In regards to the latter, Pejsa discovered that nonverbal behaviours of conversational partners had a significant effect on interaction with the user [69]. The aspect of nonverbal behaviour, driven through dimensions of gesture, body language, and gaze [46, 49], has shown to affect the perception, liking, and trust of such virtual humans [2].

The existence of multi-human interactions in VR, especially through social VR, has become an important area of study in recent years [104]. The medium offers a space for humans to congregate, interact, and participate in activities collaboratively [54, 71, 111]. Many researchers have looked at these human-human interactions in VR, with avatars in a virtual world acting as the conduit for such interactions. In particular, nonverbal communication in these spaces has become a major topic for exploration. Maloney et al. note that nonverbal communication arises from immersive and embodied interactions that mimic offline face-to-face interaction [55]. Such communication conveys information about the person's affective state and identity [35], and is transmitted through body language, their distribution in space, etc. [35, 106]. Interactions and communication are also affected

by aspects such as avatar realism and appearance [78, 113], which affect feelings of social presence and realism. However, prior research has also highlighted limitations in nonverbal communication, such as the inability of most on-the-market VR headsets to capture facial behaviour for input [93]. With the idea of bridging NPCs with realistic human behaviour, we see the potential in drawing lessons from social VR and its relation to presence and applying them to autonomous virtual agents. Thus, in this work, we look at the unique dimensions that exist within social interactions between a player character and a non-player character in VR. Our research highlights such unexplored dimensions of VR NPCs, how such dimensions are currently implemented as game mechanics, and the players' expectations for them within VR.

3 Observations of Existing VR Games

3.1 Methodology

The motivation behind our first methodology lies in addressing **RQ1** — understanding NPC interactions in VR games distributed on the market. This knowledge allows us to understand the present developmental landscape and is crucial as it is the gateway to understanding the different dimensions of NPC interactions, how VR-specific actions feed into traditional NPC behaviour, etc. Thus, this section also begins to address **RQ2**. To garner this understanding of existing VR NPC interactions, we performed an observational study of NPCs in existing VR games, looking at what dimensions are different among them and, specifically, what features differentiate them from NPCs of non-VR games in terms of player interactions.

3.1.1 Game Selection and Study Protocol. We used Steam[1] as our database for game selection. To filter for VR games, we used the tag options "VR Only" (games only available for VR) and "VR Supported" (games that have the option to be played in VR). Upon some initial exploration of the tags, we decided to use both these VR-related tags in our analysis because both tags encoded sections of gameplay that were solely performed in VR. Although "VR Supported" games may be assumed to be less focussed on VR interactions because it is not the only input modality supported by the game, we did not identify this to be the case in our observation analysis.

Browsing anonymously on Steam, we filtered by each of these tags, selecting the top titles by a combination of sorting by *"relevance"* and *"top user reviews"*. We then further filtered our selection by those games that contain embodied NPCs (NPCs that inhabit a virtual body that the user can interact with). The number of games selected for the study was finalized based on the concept of data saturation [82] — as we observed more and more games, we noticed that the games that we were analyzing often had NPC interactions that were largely similar to those already explored (and that, especially, games of the same genre often had similar interaction behaviours). All in all, we were able to select a total of 47 games (listed in supplemental material).

To explore the NPC interactions for each of the games, we primarily relied on videos of VR playthroughs found online on platforms such as YouTube or Twitch, in the form of "Let's Plays" or livestreams (taking an approach similar to previous ludological studies [110]). This was primarily due to cost concerns; however, it was deemed to be adequate for the study — as the focus was to consider the dimensions of NPC interactions in a vacuum, the actual person playing the game was not particularly relevant so long as they engaged with the NPCs according to the game's context. In general, we tried to prioritize no-commentary gameplay videos (to fully exclude external player factors); however, we relied on gameplay with commentary if the above was not found. For each of the games, the researcher watched approximately 1 hour of gameplay (or until completion, if the game ended before 1 hour), and structurally noted down the interactions with each NPC

[1] https://store.steampowered.com/

as they arose. To develop the observational notes in a structured manner, a coding sheet was developed. This coding sheet was developed based on 1) prior background research into NPC and their roles and behaviours and 2) *a priori* knowledge of NPC interactions and VR (acknowledging the researchers as video game players and VR practitioners as well). The coding sheet encoded aspects of the interactions that were more contextually objective (e.g. "Role of NPC", "How an Interaction Starts"), to those that were more observationally descriptive (e.g. "NPC Movement and Body Language", "Response to Player Input"), along with metadata such as the game name and timestamp. Overall, it primarily captured semantic information regarding the videos. Categories were iteratively added and refined through the process.

3.1.2 Data Analysis. The observation converted video data into structured text; we then analyzed this textual data through a flexible thematic analysis approach [9, 11]. First, we familiarized ourselves with the data, before we developed and applied initial codes on each observational category. We took a largely deductive, semantic approach here — deductive because our observational categories were already largely drawn from prior research and knowledge; semantic because our data was largely content-based and objective (and thus less pertinent to researcher interpretation). These largely-descriptive codes [80] were iteratively refined into 47 final codes, some examples are "Move Towards the Player", "Locked Locomotion", "Head Motion", etc. We then grouped these codes into 7 broader categories that were more generally reflective of the overall dimensions of VR NPCs, such as "Triggering an NPC Interaction", "Player Input", "NPC Response to Player Input" (see supplemental material for full list). These formed the basis of our developed themes. During the analysis, we paid attention to the general approach of VR NPC implementations that was common across most games, but we also took care to note specific examples of distinct implementations that differentiate across the norm – these form examples that implement unique features for interaction. We note that, because our initial protocol looked at NPCs in VR from a deductive approach, the resulting dimensions from the analysis share many traits that are common among non-VR NPCs. However, as non-VR NPCs have been studied in depth within academia, we largely focus on, report, and discuss themes pertinent to the RQs — features that are idiosyncratic to NPC behaviour in VR. The qualitative data analysis was performed by the primary researcher but with the consultation and validation of the research team.

3.2 Results

Ultimately, our results centre around two main categories that arise as dimensions for VR NPCs — "Player-Driven Interaction Triggers" and "Player Agency and Constraints". These two main categories are distinct from non-VR interactions, forming important dimensions of consideration for the research. We note that within our observations, we found a key difference between combat and non-combat (social interactions). Combat interactions typically are continuous and unique in their form; as such, we primarily focus the presentation of our results on non-combat (social) interactions.

3.2.1 Player-Driven Interaction Triggers. Player-driven interaction triggers refer to the user-initiated events that drive interactive behaviour between themselves and the NPCs. We identified three main interaction triggers that affected behaviour at the start, during, and at the end of the NPC interaction.

- **Story** — triggered by the player's progression through the story or plot of the game. Such interaction triggers occur as a player consciously progresses through the game's narrative.
- **UI Buttons** — triggered by the player's click of UI buttons. This can be the buttons on the controller or buttons on a canvas within the game.

- **Physical Motion** — triggered by the player's continuous physical movements.

These triggers act as the event inputs to advance NPC interaction behaviour and have a variety of parameters that affect them, e.g. proximity (being close enough to an NPC to even have the option to interact). Notably, the first two of the list are extremely standard and ubiquitous in non-VR games; as such, VR games often directly port similar behaviour. An example of a story-based interaction trigger is when an NPC begins interaction once the player gets close to the NPC at a certain point in the game; an example of using UI buttons is when a player clicks a button on the controller to advance text dialogue. However, the embodiment of the player as a character in the game uniquely allowed for the last trigger — the capture and input of physical motion as input into the game to affect NPC behaviour. Although other systems such as the Nintendo Wii [83] and the Kinect [67] offer aspects of motion as input, the VR system offers unique opportunities due to the embodiment of the user directly as the player character in the game — e.g. when the player moves the controllers, they can see their embodied avatar's arms directly mirror their motion.

(a) (b) (c)

Fig. 1. (a) In *Skyrim VR*, players can communicate with both button presses (e.g. pressing A to talk), but also physical interaction (e.g. punching the character to start a fight). (b) In *Megadimension Neptunia VIIR*, the player can respond to the NPC's question by nodding or shaking their head. (c) In *No Man's Sky*, the player points at the NPC and performs a pulling motion to start the conversation.

However, NPC response to physical input was still quite rare within the observations and was often implemented in conjunction with other triggers in a game. We highlight the specific examples in our observations where physical motion triggers did occur. Some games used physical interaction with an NPC, i.e. using the controller to "touch" the NPCs, as a way to signal aggression on the user's part (e.g. *The Elder Scrolls V: Skyrim VR* [G117]) or potential affection (e.g. *VR Kanojo* [G121]). This physical interaction acts as a form of direct nonverbal communication with the NPCs. The consequence of such actions can vary among games, in *Skyrim VR*, for example, the NPC may attack the player (Figure 1a), whereas in games like *The Walking Dead: Saints & Sinners* [G123] and *Spice & Wolf VR2* [G124] (where you can feed characters by picking up a grape and bringing your hand close to the mouth), the NPC may emote, but the interaction is not fundamentally changed — the NPCs will return to their original script. Thus, in the former, the player's physical input had a more lasting impact on the direction of the story and the characters within the game, more similar to traditional discrete choice inputs [39]. Other than using controllers for physical input, head motion and direction were other potential forms of nonverbal input unique to VR. For games such as *Trover Saves The Universe* [G125] and *Megadimension Neptunia VIIR* [G120] (Figure 1b), players can nod or shake their head to signal affirmation or refutation to an NPC dialogue question, serving as replacements for traditional dialogue choice options that appear on the screen.

Apart from nonverbal behaviour as direct communication to the NPC, players can also communicate through physical input where the behaviour is not inherently meant to be "observed" by the NPC, for example, in *After the Fall* [G127], a player can ring a bell at a counter to call an NPC that will start an interaction with them. Furthermore, the aforementioned examples of using controllers and head motion for input typically were used to mirror human interaction in real life; however, there were examples of times in which the physical motion triggers were used more as a medium, especially when combined with other triggers such as buttons. For example, in *Cosmonious High* [G122], a player extracts button options by grabbing their (virtual) mouth and pulling the controller outwards. This provides options represented as emotions that the character can then select through hitting with their controllers. In *No Man's Sky* [G119], a player starts a conversation by pointing the controller at the NPC and pulling backwards (Figure 1c). These physical motion triggers were used to pass input to the game even though the gestures do not necessarily mirror real-life behaviour and actions for social interaction.

3.2.2 Player Agency and Constraints. In non-VR games, interactions with NPCs typically have some sort of locking mechanism — some may lock the player into place, others lock the player into completing the conversation. This is antithetical to the continuous embodiment that VR affords — VR allows players to have a heightened degree of control over character interactions; enhancing freedom through movement and perspective agency during an interaction. As such, in VR, interactions with NPCs were varied regarding the level of constraints on locomotion and dialogue completion that players had when interacting with NPCs. An example of an NPC interaction with no constraints is many of the interactions in *Skyrim VR*, where the player can walk around freely while the NPC is talking, and walking far away causes the NPC's voice to fizzle out and the conversation to end. In contrast, in *Survival Nation* [G128], even though the player can walk away from the NPC, the dialogue continues in the form of an on-screen text box. This is one way to force the player to hear the dialogue, which game developers may want to enforce if the dialogue is important to the story or the mechanics of the game. On the other extreme, in *No Man's Sky*, after the dialogue is started, the player's locomotion (but not head motion) fully locks until the player clicks to leave the conversation.

Overall though, it was rare for VR games to restrict motion, unless it made sense for plot or narrative purposes. For example, if your character is tied up (for example, certain points in *Skyrim VR* and *BONELAB* [G126]), your character is sitting in place (essentially all of *Spice & Wolf VR2*). In this case, the game plays more of a cutscene role as the characters can only observe their surroundings during the interaction. A common compromise (that somewhat offers an illusion of free movement) is by having the character constrained in an enclosed space (e.g. in a room, as in points in *Vertigo 2* [G129]). In such cases, constraints are enforced through tangible collisions in the virtual space — players cannot walk through the virtual walls. Such constraints on locomotion ultimately help enforce dialogue continuity as well, as a character in a fixed place can be forced to hear the dialogue to completion. However, when discussing collisions, we also noticed that the virtual world and NPCs were sometimes treated inconsistently. For example, in a game like *The Forest* [G118], there are instances in which the player's hand can go into and through the NPC even while they are bounded by locomotion, which does not mimic reality.

Notably, in essentially every observed NPC interaction, players always could freely control their perspective. This is in direct contrast to many non-VR games, where the camera may be fixed or programmed to rotate in specific perspectives, particularly in cutscenes. We note that this is an aspect that is typically enforced in development — SDKs for VR development by default allow for free camera (perspective) rotation. Fundamentally, many constraints boil down to direct versus indirect input. Direct input (i.e. where the game uses raw input such as motion) is constrained by

the user's physical capabilities which may not coincide with the virtual environment; disallowing certain moves could cause desynchronization between the physical and virtual environments. On the other hand, indirect input (i.e. where the game performs a logical conversion of input such as buttons), can be easily refused if it could cause desynchronization. Thus, the heavy emphasis on direct input in VR acts as a design constraint for developers to design for and consider within their games.

4 Interviews with Video Game Players

4.1 Methodology

Our first observational study provided insights into existing VR NPC interactions, their implementation in existing VR games, and design dimensions revolving around NPC behaviour unique to the VR medium. We transition into the second part of the work, in which we perform a user study to delve into player expectations and perceptions regarding NPC interactions in VR and how the dimensions unique to VR can generate forms of engagement. As such, this study mainly addresses **RQ3**.

4.1.1 Study Design and Procedure. To address the goals of the research, we aimed to delve into user expectations of NPCs in VR through semi-structured interviews. However, to provide users (who might not always be familiar with VR) with a grounded frame of reference, the study involved having the participant experience VR throughout the interview (see Figure 2). Within the virtual environment, users conversed with a virtual agent which was Wizard-of-Oz'd by a researcher themselves — a researcher would control the motion and actions of this virtual agent while also conducting the interview. However, in the study, participants were told to behave as though this agent was an NPC. The simulated experience took place in a virtual city, where the "NPC" would initially be standing at the corner of the street at a crosswalk; physically, the researcher and participant began separated in the same room, within earshot of each other. As the study progressed, different actions and interactions were acted out and discussed with the participants, according to an interview script. For example, the researcher would ask participants how they might expect to start an interaction with an NPC, and how the NPC should acknowledge this; while answering the question, some participants would walk towards the NPC and wave. Then, extending from this question might be further questions on existing methods of interaction triggers and how physical motion in particular might play a role in such a scenario — participants pondered on the pros and cons of different triggers. Overall, the virtual world helped facilitate this — participants could see the world, control their NPC to mimic their motion and see the feedback from the NPC.

The choice of a self-developed prototype was driven by the desire to give active feedback and provide a diverse set of actions and interactions during the study experience. Using a developed game would not provide the same degree of desired freedom in simulation in creating a diverse set of NPC interactions that can behave in human ways. For example, if the participant mentioned they expected a specific motion as a response from the NPC, it would be difficult to predict and pre-program the complete set of possible responses; however, if a human who has a high degree of freedom over their motion at all times controls the NPC, this becomes simple. Thus, existing VR simulation environments lack the flexibility to simulate the diverse expected set of NPC interactions and behaviours. Thus, this necessitated the development of the described virtual world. The realm of behavioural interactions in the virtual world was extremely simple, extending largely to motion. As the development was performed in VRChat SDK, the realm of interactions followed similarly — notably, the participant could control the locomotion of their character, perspective rotation, and they could jump. The motion of the controllers as well as their headset would control the head and hand positions of the avatar respectively. When participants described possible visuals that went

beyond this (e.g. subtitles), this was an imagined scenario. We acknowledge that the Wizard-of-Oz approach of simulating an NPC using a human is not perfect [77] — it trades off a level of the artificiality of NPC interaction (wizard recognition by the participant) for increased flexibility and control over the VR environment and NPC behaviour by the researcher.

Past work by Abril et al. discussed the differences in interaction with a virtual agent under the conditions of being told that the agent is human-controlled versus a non-human NPC [1]. In particular, they did not find a significant difference between these two conditions in terms of complementary (i.e. coordination between agents facilitated through the mechanics of social relations [30]) anthropomorphic projection (i.e. the level in which the participant inferred unobservable characteristics such as intentions, emotions, human characteristics, etc.). Nonetheless, we acknowledge our approach's effect on participant behaviour, as they were aware of the interviewer's control over the NPC (e.g. in terms of attribution of anthropomorphic characteristics and emotional activation [1]).

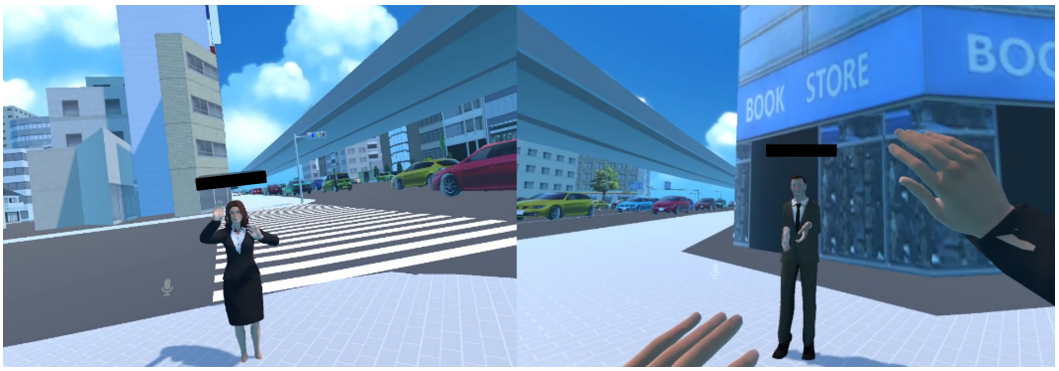

Fig. 2. On the left — the perspective from the NPC (researcher) of the participant in the virtual world; on the right — the simultaneous perspective from the participant of the NPC (researcher). The participant (the female avatar) is physically waving in conjunction with a question on aspects of physical motion triggers. Potentially identifying information (i.e. VRChat usernames) has been blacked out.

This virtual world was developed in Unity using the VRChat SDK to support multi-user environments. The world was also configured with various modes that could be controlled by the researcher. These modes could add or remove other NPCs (which were either idle or moved in a preprogrammed manner). Before immersing the participant in VR, we started with a few introductory questions about their prior experiences with NPCs in their own gameplay experiences. Afterwards, the researcher helped the participant set up for VR while also setting themselves up for the study. The base questions of the semi-structured interview primarily delved into how participants might expect NPC behaviour to be demonstrated in a VR context, what trade-offs they might incur, and in what scenarios they may be more or less appropriate. In particular, the dimensions of VR NPCs explored in the observational study were expanded upon in this study. For example, participants were asked what sort of inputs they expected NPCs to respond to and how, as well as what constraints might be placed on a player during NPC interaction. Participants were also encouraged to offer new ideas to the existing design space.

4.1.2 Participant Recruitment. A call for participation was made on our institute's paid studies listing page. The eligibility criteria for participants were those who were 18 years or older and had experience playing video games. This latter criterion was used to recruit participants who

would have already had experiences with game design and NPC interactions, and thus had prior expectations towards the roles and behaviour of NPCs. All participants came to the lab in person, as the experiment required using a VR headset. Before the study, participants signed a consent form regarding data collection and usage; audio from the study was recorded with consent. Video recordings of the participants' and researchers' perspectives in the virtual world were also made with permission; however, 6 of these recordings were lost due to a critical hard drive issue (regardless, they are not used in data analysis). The user study was piloted extensively to improve the design and questions; the final analysis was performed on 18 total participants (ages ranging from 18 to 26, mean of 21.2; gender distribution of 8 females, 8 males, and 2 non-binary). Each session lasted around an hour and participants were compensated at a rate of $16 CAD / hr.

As the study pertained to interactions with NPCs in VR, we collected demographic information regarding participant experiences with games and with VR. 14 of the participants had previous experience with using VR; in terms of frequency, 12 had used it "once or a few times in the past", 1 used it at a frequency of "once a month", and 1 used it at a frequency of "once a week". In terms of experience with playing video games, every participant had experience with playing them. 4 participants recorded a frequency of gaming of "nearly everyday", 2 had a frequency of "a few times a week", 5 participants had a frequency of "once a week", 6 had a frequency of "once a month", and 1 participant indicated they had only played games "once or a few times in the past".

4.1.3 Data Analysis. The data analysis was performed on the transcribed interviews from the audio data through a thematic analysis approach [9]. We took a largely deductive approach, as we aimed to contextualize these findings around the dimensions of VR explored in the observational study and the affordances of VR that have been outlined in prior research [10]. As a result, the initial coding was somewhat grounded within these *a priori* labels. This first round of coding was largely descriptive, capturing the relevant semantic content of the data [80]; these codes were refined and then grouped into broader categories through iteration. This semantic approach for analysis was driven by our research goals for this study, which focussed on presenting more direct, literal findings based on user responses captured by the interview data. At the end of the process, we had 29 final codes (e.g. "Freedom in Player Perspective", "Player Movement during Interaction", etc.) and 6 total categories (e.g. "Interaction Constraints", "NPC-Driven Triggers", "Player-Driven Triggers", "NPC Metabehaviour and Roles", etc) — the full list can be found in the supplemental material. These categories helped us make initial sense of the codes in the data, we used these categories as a basis to explore the data more structurally and develop themes. Some of the developed themes were essentially translations of these categories, others required us to dig deeper to unearth the more interesting findings (especially ones pertinent to VR specifically). The qualitative data analysis was performed by the primary researcher but with consultation and validation by the research team.

4.2 Results

As with the observational study, our results primarily focus on aspects that are more unique to NPCs in VR.

4.2.1 Expectations for NPCs and NPC Realism. All participants talked about the different roles that NPCs serve and what they add to games in general, which can vary greatly from game to game. For some games, NPCs were mentioned as a plot device to propel the story forward, e.g. *"So in order to move you along, and to get me the player, the user to perform certain actions or move in a certain way, they'll come up to you and talk to you"* (P5). Some participants described NPCs as a conduit between the real world and the game world — *"they create a parallel between this world and the game world"* (P13), and that *"projecting your own real-life experience... when you experience this virtual world you would expect the whoever lives in it to respond appropriately"* (P9), which makes

the game for more realistic in general — *"[without NPCs] I think, yeah, it would make the game feel a lot less realistic"* (P15).

This aspect of realism for NPCs was discussed more deeply — participants stated that the level of NPC realism would depend both on the game and their role in the game. For example, P16 mentions that for an NPC that just gives them something *"if you draw a blob, I don't think anyone really cares"*, but for a story-driven game *"the characters are part of the storyline, and I think it's important"*. This was a common sentiment — for more story-based games, the realism and characterization of the NPCs were much more important to the players. Two participants discussed how VR could play a part in enhancing realistic NPC interactions — *"[VR] is a replication of a real-life experience... so this is closer to real life"* (P1) and *"in VR, it's more like, now it really matters whether or not they're looking at you, and the type of feedback that they give"* (P4). These mechanics of interaction in VR are explored further in the subsequent sections.

4.2.2 Player-Driven Interaction Triggers — Interactions at a Distance. We explored the interaction trigger of physical motion and contrasted it against other traditional triggers. The concept of having physical motion as an event trigger was discussed in every interview and the most common way this came up was through gesturing. Participants indicated that gesturing had the advantage of being a much more realistic way of starting an interaction with the NPC — *"waving, for example, it can definitely add a little more realism"* (P15), and *"[on a] controller, you're just pushing buttons and looking for a response, but that's not how you're gonna go about your real-world interactions"* (P17). However, users also raised a variety of questions and potential challenges that could arise with gesturing as a trigger, such as choosing and distinguishing which NPCs you can gesture to and how — *"it doesn't signal like... this is a character that you can interact with"* (P13), designing suitable gestures while decoding user intention — *"a con would be like an accidental wave or a gesture that's too hard"* (P11), and intuitiveness for new VR users — *"VR is relatively new... people are switching over from computers; they were used to pressing buttons"* (P12).

The first con — distinguishing and choosing the NPC that is being gestured — was explored through the input parameters of proximity and angle between the player and the NPC. Participants often indicated that, in contrast to traditional games, it would feel more realistic and tie more into their expectations if interactions begin when both parties can see each other in VR, and a trigger is tied directly to those parameters — *"if you're gonna serve like an interaction with someone, yeah, they should be able to see you"* (P17) and *"if I see this person in real life, I wouldn't start shouting at them from far away unless I really wanted to grab their attention. And that would maybe be similar in VR"* (P13). P17 contrasted this potential perspective-based face-to-face interaction against non-VR games — *"if you went up behind the character in the console game, you probably would be able to [start the interaction]"*. P15 mentioned that this interaction paradigm could be a possible frustration, i.e. *"for [the] player who would then have to try and like, move around and try and try and get in the right place"*, but noted an easy fix in *"just having the NPC turn around"*. Overall, during NPC interaction, the realism aspect of VR manifests in the expected face-to-face nature users expect; this synchronous matching can arise from a combination of user and NPC motion.

The second con — designing suitable gestures that compromise between too easy (and thus accidentally triggered) and too hard (and thus overly precise in terms of motor function) would be an important consideration for developers. If a gesture is too loosely defined, it may trigger accidentally. This is particularly notable in VR in which controller motion is continuous and controllers additionally double as both physical markers and menu triggers — e.g. *"there's probably a small chance of accidents... I can still move my hands around like I would and because there's not so much control over the precise gestures"* (P5). On the other hand, gestures that are too difficult may give rise to problems when there is a disparity between action and feedback, i.e. a player may

want *"for it to go off when I want it to go off"* (P11). Gesture design relates to the final con as well — designing gestures that feel natural even for people who are switching over from traditional game input systems.

4.2.3 Interaction Constraints and A Tradeoff of Agency. Participants noted that interaction constraints on locomotion offered a tradeoff between a game's agency and a player's agency. Locking the player within the dialogue could remove the player's agency — *"it makes it annoying if you're locked into place, it just takes away the agency if you will"* (P14); tying it specifically into the aspect of physical freedom in VR — *"if the game still needs to do things like lock you in, I feel like it's almost like the VR isn't doing the thing that it shouldn't be doing"* (P8), *"we're lacking that freedom of movement that we have in VR"* (P15). However, participants indicated that this could be done to force the player into listening to the game and the story, perhaps belying the developer's or game's agency, i.e. *"It makes it harder for people to break away from the dialogue, especially if it's kind of story important"* (P15), *"I can't think of a better way to force or you know to get them to give the information necessary to the player"* (P14).

One common compromise brought up by participants was to have an enclosed boundary in which the interaction occurs, e.g. *"I think definitely, you should be able to move around, but maybe there should be boundaries to that"* (P13), *"if I just started moving away... I think there might be a blockage like maybe I can't go past a certain area"* (P16). Within the observations, this constraint sometimes manifested as a physical barrier (e.g. stuck in a room), but participants brought up ideas of a more abstract circle of interaction in which staying in the visualized radius could denote interaction, *"NPCs should have like a radius which you can hear them and they can hear you"* (P17). This visualization is important — one key consideration participants mentioned is the intentionality of players' motion during interaction, especially on whether they intend to continue interaction with the NPC. A lack of discrete locomotive constraints could reduce how the game can compel the players to listen, but for players who want to listen — *"annoying for players who accidentally navigate out"* (P10), a problem for which smart visualization on constraints could potentially address.

Regarding perspective constraints, it was widely agreed among the participants that forcing the perspective into specific directions or point-of-views would be jarring, e.g. *"it would be a lot more disorienting in VR"* (P6). However, some participants stated that light camera motion when demanded by the plot or mechanics of the game, e.g. the player character staggering when attacked, could be interesting to explore when combined with haptic feedback: *"I feel like maybe a slight movement of your vision or something like a rumble would be possible"* (P11), *"... if I were to see my character stumbling even if I'm not stumbling in real life, and maybe some sort of haptic feedback"* (P13).

4.2.4 NPC Expected Behaviour and Feedback. Players had expectations on how NPCs should behave, and although many of the behaviour patterns followed comparably from non-VR games, players emphasized the aspect of gesture and body language from the NPC's side. Participants indicated that, similarly to how players can gesture at the NPCs to obtain their attention, NPCs can do similar to the player to communicate, e.g. *"waving, or like, pointing at me or something"* (P6) to tell the player to interact with them, or *"maybe like some kind of like, hand signal just like a wave goodbye"* (P17) to indicate the end of an interaction. Participants did note that in VR, it is more difficult to gauge the effect of such gesture-based events due to the lack of constraints on perspective, *"the player could just not be looking while [the NPC] could be waving"* (P3). This would have to be supplemented by additional cues if the game wanted to force the player to interact, such as sound, *"I think it should just sound like the normal like real life"* (P1) or visual indicators, *"a symbol that appears on the left or right side of your field of vision"* (P15).

Tied to this was the theme of NPC body language and gestures as important communicative elements during conversation. During the study, the participants interacted with a simulated NPC that appeared human, and participants discussed how body language and facial expressions would play a large part in the interaction, e.g. *"if like a person kind of goes and touches their head and like, we know that they may be feeling nervous"* (P18) or *"if I put my arms out to the side like this, it's a bigger physical presence, which normally signals like aggression or dominance"* (P7). Tying into the aspect of VR, one participant mentioned that the relative closeness between PC and NPC that can be afforded by VR may potentially help in the precise portrayal of these emotions, e.g. *"very core emotions... I feel like that'd be very easily portrayed in VR because you can get up very close"* (P11). Ultimately, in a face-to-face, realistic VR environment, participants valued the use of body language and facial expression as a communicative tool; one that might not always be present in non-VR games.

4.2.5 Tangible Interactions and NPC Collisions. Tangible interactions — where there exists some aspect of collision between the PC and the NPC — were discussed in depth, both from a user-initiated and NPC-initiated perspective. The embodied nature of the player as the player character within the game fundamentally changes the nature of such tangible interactions. For instance, participants generally noted that the aspect of player and NPC collisions would likely have to follow the laws of physics if player-initiated — e.g. if the player were to push or punch the NPC — *"Oh, I'd definitely feel like it'd be more off-putting the more that it altered physics of the real world. Like, if I were to hit you, and my hand went through you, it would feel really weird"* (P11) or *"I would expect him to be knocked at least. Not for me to go through them, that just kind of takes away from the immersiveness"* (P14). However, on the other hand, if the NPC were to initiate, participants had contrasting opinions on the effect depending on the context. Tangible collisions move the player, and as found prior, participants found forced movement, especially of their perspective in VR, often jarring. When presented with an example in which an NPC would collide with the player through walking into them, P18 noted that *"I think in this case, making them kind of intangible might be alright"*.

A notable dilemma is the fact that whereas a player's hands have continuous motion in free space, the game may want to restrict the player's hand motion for some reason, e.g. if a player were to punch a solid wall within the game, there may be a mismatch between what they see in the game and what they are doing outside it. For NPC interactions, this may occur if the game requires a sort of precise gestural motion that involves both the NPC and the player, for instance, a handshake or high-five. The player can attempt to perform such motions if prompted by the NPC, but there is no way to guarantee that the user's hand position will map to the physical collision limitations in the game. Players noted that in such a scenario, it would be inevitable to take some control away from the player to play out the action, either partially *"if you sort of put your hand and then it registers as you doing the handshake, then it would kind of limit the degrees of freedom"* (P9) or fully, *"it should lock in and like play an animation of the hands shaking"* (P1). As such, this suggests the inevitability of enforced constraints to match the continuity of movement within the real world into the game world that aims to mimic a level of physical reality. To enhance this mimicry, some participants expected tangible interactions to be accompanied by haptic feedback to further emphasize its analogy towards real-world physical touch, e.g. *"I would also expect some sort of vibration or some sort of feedback to indicate to me that I have punched [an NPC]"* (P13).

5 Discussion and Future Work

The findings from our observational and user studies tie together to address the first 3 RQs. Regarding **RQ1** and **RQ2** we find that player-NPC interactions in prevailing VR games are predominantly

triggered through story and controller buttons; response to physical input (afforded by embodiment in VR) was still a rare occurrence among games. This form of nonverbal behaviour is triggered through the player's body language, which the NPC can respond to. Moreover, the aspect of player agency and constraints also differs in VR — VR typically affords full control of the player over the character, yet games may constrain the player during an interaction. We find that games can use contextual cues, such as walls in the game, to force the player into a confined space and essentially coerce an NPC interaction to occur until completion.

From our user study, we address **RQ3**, finding that participants in VR emphasized the significance of NPC realism through immersive interactions such as body language and gestures. We also found that considerations regarding player agency and interaction constraints were important experiential dimensions to consider when designing realistic and engaging player-NPC interactions.

In the following discussion sections, we discuss the implications of our findings, the potential applications of our findings towards game development, and what technical challenges still exist when discussing the mismatch between expectations for NPC behaviour and present implementations of these behaviours (addressing **RQ4**).

5.1 Player Expectation and Present Implementations

The primary mismatch between the current implementations of NPCs in VR games and player expectations arises from expectations regarding triggers and constraints. Through our observations, it was quite rare for the physical motion of players to play a major part in the social NPC behaviour during interactions, contrasting against the fact that physical motion is a characteristic property of VR in general. In essence, it seemed as though this aspect of games was oft-neglected when taking into account the affordances of VR: the interactions of NPCs in VR often felt like a direct port of existing NPC interactions in 2D (with the same set of triggers and constraints), rather than reconsidering the design space for NPC behaviour from the ground up.

When we consider that many of the goals within NPC academic study aim to develop intelligent, realistic NPCs that mimic lifelike behaviour [7, 108], it seems imperative that interaction triggers and constraints should aim to match real-life as well. However, in real life, people do not go up to a person and click a button to start an interaction; instead, people might use verbal cues (such as talking) or gestural cues (such as waving) [68]. Clicking a button is a limitation within traditional games of not having the ability to use gestures as input; however, within VR — this limitation is alleviated as, at minimum, both head and hand movement are tracked (and full body motion can be monitored through added trackers as well). Matching this, players within the study presented physical motion input as being much more natural compared to traditional methods, and expected NPCs to behave as such. A similar idea follows for constraints — in real life, people are not locked into place when talking to someone — they have the potential to move while listening, and can even choose to not listen at all.

As such, our first design recommendation is for developers to take advantage of the medium, its affordances in terms of embodiment and presence, and its expressiveness and freedom for interactive inputs. Li et al. highlight how gestures are an important part of VR — they provide possibilities to create interactions that feel like communicating with real people, increasing authenticity, immersion, and interactivity [53]. However, we recognize that there exists nuance and extra consideration in development — there are issues regarding gestural recognition, learnability across systems, and accessibility. The latter is a crucially important consideration as VR games are generally reliant on physical motion [96], and as such, we believe games should always provide an accessible alternative (such as the use of buttons). Nonetheless, current games that take in body language, e.g. head motion in *Megadimension Neptunia VIIR* to represent yes/no, represent a first, lightweight step towards such an end of realistic social interaction; even implementing recognition of simple gestures can

be interesting. Nonverbal input conveys information similar to player dialogue and choice, and developers can use this to improve the novelty and realism of the game. Future research could look at emotion recognition from VR-captured motion (e.g. along the lines of past research [42, 52]), and increasingly powerful AI systems can use this information to regulate NPC emotions and behaviour smartly [6, 76]. Furthermore, although our work is primarily focussed on nonverbal interactions, verbal cues (i.e. through a player's voice interaction) have had a history of research as well and can be incorporated symbiotically towards developing NPCs that act humanlike [4, 5, 38]. For example, Isnard et al. developed a humanoid in VR that can provide emotional understanding through voice timbre and specialization [38].

5.2 Realistic NPC Interactions and Virtual Social Behaviour

Our research and prior background work highlight the importance of nonverbal communication in social interactions. Nonverbal behaviour can convey emotions in ways beyond dialogue, adding richness in terms of conveyed emotions, personality, etc [35, 106]. Although quite a substantial amount of literature for virtual nonverbal communication falls under player-player interaction, the assumption that intelligent NPCs should act lifelike [7] provides an extension towards our findings on player-agent interaction. Our research highlighted player expectations for such behaviour, especially conveyed through body language and motion, for both the NPC and the player. For nonverbal communication from the NPC, the intimacy afforded in VR allows for exaggerated effects of body language and facial expression to be observed by the player. Such aspects might not always be visible or clear in a non-VR game. NPCs can also convey information through movement behaviours [23]. Overall, the extended presentation of nonverbal expressions adds an added nuance and complexity to NPCs beyond solely dialogue. This limitation of dialogue has been studied in multi-user environments — we point to the literature on social VR that shows that nonverbal communication is more natural, similar to offline communication, and can afford social comfort and privacy [55].

Nonverbal behaviour is a two-way street, and in VR, players can express their nonverbal communication through their controllers and head motion. The physical motion and constraints of VR are highly tied to the aspect of player nonverbal behaviour within the virtual world — offering both the opportunity to convey such information but also limitations on its extent. Aspects of nonverbal communication have been studied extensively in scenarios such as social VR, in which it plays a major role in immersive interactions to mimic face-to-face identity [55]; it also offers insight into affective state and player identity [35]. Games could potentially use such inputs to alter the game and NPC interactions in different, interesting ways — as a form of continuous player "choice" during interaction. Furthermore, the fact that the player can express nonverbal communication and the NPC can receive and respond to it can drive the concept of synchrony [36], a key part of human communication that has been attempted to be replicated in VR [92].

As such, our second design recommendation is for developers to borrow ideas from social interactions with virtual agents and avatars — to better infuse emotional expression and imbue dialogue with meaningful cues in NPCs. Such outcomes would help enhance the experience in thoughtful, realistic ways, which we believe would increase the appreciation of the experience.

5.3 Open Questions and Potential Future Explorations

Despite the recommendations made, we recognize that there still exist present technological limitations in implementing it into game development and design. In this section, we aim to address some of the technical questions and potential future explorations in this area.

5.3.1 Input Design and Decoding. From our findings, players emphasized the use of natural, realistic body language as possible interaction triggers for NPC response. Cinieri et al. have highlighted how feelings, empathy, and emotions drawn from physiological factors can drive human-avatar-based communication [18]. However, designing suitable and responsive gestures and then communicating to the player that they can gesture in those ways is not a simple task. In social VR situations, humans have an implicit understanding of body language; however, it is more difficult to translate this into an algorithm. However, the rise of machine learning techniques makes this a more fruitful and achievable endeavour, as past research has used such techniques in gesture classification [8, 98]. Although much of the research in academia relates to gesticulation with hands rather than controllers, we believe that this nonetheless provides interesting insights into smart design. For instance, Krupka et al. suggest dimensions such as finger position and hand orientation are possible dimensions for recognition [48], and Rautaray et al. developed a classification for gesture based on captured camera images [75]. Furthermore, as VR continues to develop, further body behaviour inputs can be captured beyond simple controller and head motion, for example, capturing a player's finger digits [84] or even their breathing [90]. Such body language can then be translated into discrete, usable inputs into the game, such as emotional state [14, 109].

As insinuated in the findings, input recognition should be precisely done to not be too difficult, but also sufficiently distinct enough that normal motion is not misinterpreted as an input signal — a challenge that informs gesture design. Other considerations include the learnability, accessibility, and standardization of the gesture set. Compared to buttons which tend to have a standard mapping across games (and can easily map to whatever function is required within the game), gestures that track continuous motion can be harder to standardize, especially because the action being performed may depend on the game's context. We suggest that to start, developers can begin to develop a standard set of gestures inspired by present research and implementation [15, 57]. Furthermore, we note that present gesture recognition may be less accurate compared to button input. To deal with such issues, we recommend using a "fuzzy" recognition — if the system is unsure about the input, the game can treat it as an ambiguous input and handle it in a way that satisfies either possibility, prompt the player for the input again, etc. (similar to [45]). We are careful to note that gesture design and recognition is a challenging, unsolved problem — work on standardization, transferability, benchmarking, etc. are all areas of present and future research [13, 53, 79].

Overall, as mentioned earlier, initial attempts in VR games such as decoding head nodding and shaking provide an initial first foray into the encoding of bodily expression, but we envision that future endeavours could integrate a more continuous, more complex recognition approach. However, beyond simple implementation and incorporation, there are still active challenges in the interpretation of such interactions. Such challenges focus on understanding how to use these inputs to simulate realistic social behaviour, discussed in the next section.

5.3.2 Body Language Usage. After decoding body language, the question then becomes how to use it in an interesting way in a game. When body language and locomotion act as input in the game, it becomes analogous to a "choice" that the player makes within the game. In contrast to the oft-described discrete choices that probe the player for a response, body-related behaviour provides continuous input. Discrete choices provide opportunities for autonomy and agency for players in the game — by giving them the option to personalize their outcome, it closes the gap between player and player character and opens up opportunities for immersion and self-identification [110]. As such, choices can contribute to the meaningfulness and appreciation of the overall virtual experience [39]. Past work has looked at modelling a player's personality through discrete choices; we suggest that this can be extended to a continuous outcome. From this perspective, a player's body language can be decoded into a continuous flow of emotion and personality, which can

then affect how NPC interactions occur and the interactions generated throughout the game. For example, if a player gestures violently or stands uncomfortably close to the NPC, the NPCs can understand the information and act scared — overall, body movements can convey anger, sadness, etc. as much as dialogue can. However, more research would need to be done to understand to what extent this is appropriate and makes the game more fun. Although choice has many benefits within games, it also induces a mental load for the player [110] — at what point might players feel overwhelmed by constantly being monitored and tracked within the game?

6 Limitations and Extensions

Our observations were mainly based on popular and well-rated games found on Steam, as such, they may tend towards the more mainstream and higher-budget. Although this provided a more systematic approach for observational selection, there have been many examples of small, indie games as the ones that defy traditions and break new ground within their genres. As such, our findings may be more biased towards the mainstream VR approach towards NPCs. An extension of our work could be to explore a more diverse set of VR games that might have novel interactions, including more experimental games to both compare and contrast the findings. Furthermore, we could potentially even explore poorly-received games to potentially understand how NPC interactions might be received negatively.

There were a few limitations within the study protocol itself. Firstly, because the "NPC" in the study was Wizard-of-Oz'd by a human, participants may not be able to fully separate the person from the NPC, and such, may create responses that treat the NPC more as a real person rather than a virtual agent. Being in the same room due to space constraints exacerbates this limitation, as the illusion is hindered by limited physical distance. However, under the assumption that NPCs generally strive for human-like behaviour anyway, this limitation may be somewhat alleviated; nonetheless, future work should aim for methodological improvements to better preserve the illusion. Secondly, both the "NPC" and the interviewee were avatarized as realistic human avatars in a realistic virtual world, and interviewees sometimes brought up mention of real life during the interview. As the type of avatar and its appearance can have effects on social interaction [59, 113], it may be important to extend our research into avatars that may not always be grounded in realism. Finally, the data analysis was largely performed by a single researcher (although validated and checked with the other researchers). This may introduce levels of coding bias during the analysis of the qualitative data, especially given the semantic, positivist lean of our analysis process. The robustness and accuracy of the qualitative analysis process could be checked and improved by having multiple researchers in the process, using metrics for inter-coder reliability for coding agreement.

Lastly, given the deductive approach of our methodologies throughout the work, which are highly influenced by existing findings and research, we acknowledge that a different methodology could approach the research problem from a more inductive approach. For example, a potential study design could involve the researcher and participants building NPCs from the ground up, e.g. through participatory design sessions. This more inductive framework could be beneficial for knowledge creation — in uncovering innovative and new design ideas. This somewhat ties into the demographics of our interviewees, which leaned toward young university students who have experience with games. Even though the experience with games was useful in terms of providing a broad level of conversation during the interviews, it may introduce bias by drawing from deductive experiences with non-VR games when thinking about implementations in VR. As such, it may be useful to have participants without experience with games to aid in developing a model for virtual agents in VR from the ground up, without prior assumptions about the nature of NPCs in general.

7 Conclusion

In this work, we performed a comprehensive study on NPCs in VR — looking at present implementations of them in existing games through an observational study, and understanding player expectations for them in an interview study. We found that the two key dimensions that uniquely extend NPC interaction into VR are player-driven interaction triggers (especially that of physical motion), and player constraints. Our interviews add to these findings, highlighting player expectations for VR realism, and how players define the shape and mechanics of an NPC interaction before, during, and after the process. We find that players value the trigger of physical motion uniquely afforded in VR and the continuity of their physical agency during interaction. We highlight areas in which players' expectations and present implementations might mismatch, tie our findings to prior research into social behaviour and VR, and define open questions and potential future explorations in the quest to create the "ideal" NPC in VR.

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